Lower Duwamish Waterway Group

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

Final Feasibility Study

Lower Duwamish Waterway

Seattle, Washington

Volume II - Appendices

PREPARED BY:

AECOM

710 SECOND AVE, SUITE 1000

SEATTLE, WA 98104

OCTOBER 31, 2012

FOR SUBMITTAL TO:

THE U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 10
SEATTLE, WA

THE WASHINGTON STATE DEPARTMENT OF ECOLOGY
NORTHWEST REGIONAL OFFICE
BELLEVUE, WA

List of Appendices

Lower Duwamish Waterway Group

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

Appendix A
Inverse Distance Weighting Methodology for Interpolating Surface Sediment Chemistry

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

List of Tables

List of Figures

List of Attachments

A.1 Introduction

This appendix documents the methodology used to interpolate concentrations of human health risk-driver contaminants in surface sediments of the Lower Duwamish Waterway (LDW).[1] A draft memorandum on this topic was previously submitted to the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) (RETEC|ENSR 2007). EPA subsequently issued draft comments (EPA 2008), which stated that:

> *"…the agencies have no major concerns with the chosen methodology and the subsequent updates made to streamline the IDW interpolation and RMSE calculations. The IDW model seems reasonable given the geographic location, the type of data collected, and the ease of interpreting the results."*

A second memorandum synthesized the first memorandum and was submitted to EPA and Ecology for the purposes of: 1) addressing specific comments from EPA on the inverse distance weighting (IDW) parameterizations for arsenic and total polychlorinated biphenyls (PCBs) presented in the first memo; and 2) providing information for the parameterization of carcinogenic polycyclic aromatic hydrocarbons (cPAHs), which were not interpolated when the first memorandum was submitted (ENSR 2008). A third memorandum describing the use of Thiessen polygons to interpolate surface sediment concentrations of dioxins/furans was submitted to EPA and Ecology for review in early 2010 (AECOM 2010), after collection of additional dioxin/furan surface sediment data in 2009 and 2010. This appendix summarizes the data analysis and findings presented in these three memoranda.

Early in the feasibility study (FS) process, the IDW interpolation of LDW surface sediment total PCB concentrations was developed in consultation with EPA and Ecology (Windward 2006; RETEC 2006). The interpolation method was described in the document *Technical Memorandum: GIS Interpolation of Total PCBs in LDW Surface Sediment* (Windward 2006; hereinafter referred to as the 2006 interpolation memo). The Lower Duwamish Group (LDWG) streamlined the interpolation method from that described in the 2006 interpolation memorandum to better support application of the bed composition model (BCM; RETEC 2007). Specifically, the streamlined method enables interpolation over the entire LDW in a single computational step, as opposed to requiring separate interpolations within each reach, as was done previously and documented in the 2006 interpolation memo. This modification eliminated the additional manipulations previously required to reconcile interpolated results in areas where the three reaches overlap.

The risk drivers parameterized for IDW interpolation are total PCBs, arsenic, and cPAHs. The possibility of using IDW to interpolate the dioxin/furan concentrations was

1 An explanation of the IDW method is provided in Attachment A-1.

investigated, but sufficient data coverage was not available over the study area to adequately parameterize for IDW (AECOM 2010).

The Sediment Management Standards (SMS) contaminants are evaluated as individual points rather than being spatially interpolated (and Thiessen polygons were used to determine the extent of point exceedances). The IDW interpolation analysis discussed in this appendix was completed a couple of years ago and therefore used the remedial investigation (RI) baseline surface sediment dataset. The RI baseline dataset represented the data available when these evaluations were conducted (RETEC|ENSR 2007). The FS uses the FS baseline dataset, which includes more recent data, and the same parameterization methods summarized in this appendix. Because of the inclusion of newer data, the interpolated maps based on the FS baseline dataset that are used in this FS differ slightly from those included in this appendix. The spatially-weighted average concentrations (SWACs) associated with the more recent interpolations used in this FS are also slightly different from those reported in this appendix.

A.2 Geographic Framework for Interpolation

The FS uses a single-step interpolation over the entire study area compared to the methods described in the 2006 memo, where interpolation was applied separately for the three reaches (Windward 2006) (Table A-1).[2] This has the following advantages:

- Eliminates the multiple computations previously required to accommodate the merging of interpolated values for the three separate reaches, an important time-saving benefit, especially if post-remediation scenarios of the BCM involve re-interpolation following insertion of post-remedy bed sediment replacement values.
- Allows calculation of the cross-validation root mean square error (CV-RMSE) in the 0.4 river mile (RM) of overlaps (i.e., between the north and middle reaches and between the middle and south reaches) that were excluded from CV-RMSE calculation previously.
- Eliminates error introduced in the 0.4-RM overlaps created by the averaging function. The averaging function gives more weight to the premosaic value in a

[2] The three reaches defined in the 2006 memorandum allowed the IDW to account for differences in the orientation of the waterway. A mosaic function was used to merge the three reaches into a single layer with 0.4 mile of overlap between merged areas. The mosaic function combines two or more overlapping grid cells into a single output. The mosaic function used in the 2006 interpolation memorandum used the Hermite cubic proximity algorithm, which incorporates the overlap width and distance of each grid cell from the overlap edge to calculate a weighted mean of the overlapping grid-cell values.

cell than would be accorded if the cell was initially influenced by all available data points, as is the case in an LDW-wide interpolation scheme.

The LDW study area encompasses 441 acres from RM 0 to RM 5.0. This area includes an additional 10 acres not included in the RI. These additional 10 acres were added as the result of revisions to shoreline, under-pier areas, and top-of-bank delineation.

A.3 IDW Interpolation Methodology

The LDW-wide IDW methodology is similar to that described previously (Windward 2006), except that the geographic template spans the entire study area instead of being segmented into three reaches. Previously, each reach of the river was mapped using an ellipse with a reach-specific search radius and directionality oriented to the flow of the river. To map the LDW as a single unit, a common ellipse with no angle (circle) is required. This reduces the dimensional element of parameterization to determine an appropriate search radius. Therefore, optimization of the interpolation parameters focuses on the exponential power, search radius, and maximum/minimum number of closest samples (nearest neighbors) used to interpolate grid-cell concentrations, using the following systematic approach:[3]

- Vary the exponential power (1 to 10), search radius (75 to 250 feet [ft]), and the maximum/minimum number of neighboring samples (1 to 10), then interpolate grid-cell concentrations.
- Use the CV-RMSE, the observed RMSE, and the number of false predictions to identify a "common" set of interpolation parameters that yield the lowest error.
- Generate an LDW-wide sediment concentration map by IDW interpolation using the "common" set of parameters. Calculate and compare the number of acres predicted to fall within specified concentration ranges, and compare false positive/false negative predictions.

Two variants of RMSE statistics were used to optimize the IDW interpolation parameters. First, the "observed RMSE" compares differences between each empirical data point and its underlying interpolated grid-cell value. Second, the CV-RMSE compares the same metric but generates sequential interpolations (one for each data point) by removing that co-located data point prior to interpolation. Thus, cross-validation excludes the empirical concentration from the interpolation dataset and then compares the empirical and interpolated concentrations. CV-RMSE gauges interpolative

3 Total PCBs were the only risk driver parameterized on a reach-specific basis in the 2006 interpolation memo. Therefore, as an additional point of comparison, this memorandum presents results of applying the selected total PCB (i.e., LDW-wide) parameters and the 2006 interpolation memorandum parameters to the three reaches using the complete RI surface sediment dataset.

sensitivity to variability in the dataset. As dataset variability increases, so too does the CV-RMSE.

Interpolative accuracy was also evaluated by comparing the frequency of false predictions. The false prediction frequency varies directly with the RMSE. For this comparison, the types and numbers of false predictions were counted relative to concentration ranges.[4] The concentration ranges identified for total PCBs, arsenic, and cPAHs are shown in Table A-2. The ranges span the generally anticipated magnitude of natural and area background concentrations (as they were understood at the time in the initial FS process) and risk-based threshold concentrations. The ranges for total PCBs and arsenic also span the SMS sediment quality standard (SQS) and cleanup screening level (CSL) values.[5]

Interpolation yields a "false" prediction when the interpolated sample concentration at a specific location falls within a higher (false positive) or lower (false negative) concentration range than the empirical data point. For example, an interpolated total PCB concentration of 65 micrograms per kilogram dry weight (µg/kg dw) co-located with an empirical value falling in the range of 0 to 60 µg/kg dw is termed a "false positive." Similarly, an interpolated total PCB concentration of 300 µg/kg dw co-located with an empirical value falling in the range of 720 to 1,300 µg/kg dw is termed a "false negative."

A.4 Results

This section presents the cross-validation error statistics, false negative/positive predictions, and estimated IDW SWACs by concentration range for total PCBs, arsenic, and cPAHs.

Before running these analyses, the "nearest neighbor" parameter (i.e., the maximum and minimum number of samples within the search radius (R) that can be used in the interpolation) was prescreened to determine its sensitivity on the IDW interpolation. Error statistics for total PCBs, arsenic, and cPAHs were calculated using a power (P) of 5 and a circular search radius of 150 ft (P5/R150). This power and search radius combination falls in the middle of the ranges tested. Table A-3 shows that the CV-RMSE

4 The magnitude of error between predicted and actual concentrations was considered less important than whether or not the predicted value is above or below some risk- or feasibility-based threshold. For example, there is a two-fold difference between a predicted cPAH value of 2,000 and an actual value of 4,000, but both cPAH values are well above the 10^{-6} risk-based threshold concentration for site-wide netfishing (380 µg toxic equivalent (TEQ)/kg dw). For this reason, concentration ranges provide better context for parameter evaluation than point value comparisons.

5 For total PCBs, this comparison assumes an average total organic carbon content of 1.9% for surface sediment.

and RMSE are relatively insensitive to the maximum and minimum number of samples within the range tested. A fixed maximum/minimum value of 10/1 was selected for evaluating optimal search radius and power parameters for total PCBs, arsenic, and cPAHs, as described below.

A.4.1 Total PCB Results

Results of the reach-by-reach parameter evaluation for total PCBs are presented in Table A-4. Within each reach, changes in CV-calculated mean absolute error as a function of power are statistically insignificant (by t-test). However, the observed-RMSE declines sharply in the vicinity of an exponential power of 3 to 5, suggesting that an appropriate LDW-wide set of parameters lies within that range. The decline in observed-RMSE with power reflects how this parameter influences the interpolation to more closely mirror the measured dataset.

LDW-wide IDW parameters evaluated for total PCBs and their associated error statistics are also shown in Table A-4. Combinations of powers from 1 through 10 were tested while varying the search radii between 75 ft and 250 ft. The influence of search radius on the CV-RMSE was very limited. In all cases, the CV-RMSE ranged between approximately 7,800 and 9,660. Within each search radius grouping, the CV-calculated mean absolute errors were statistically indistinguishable across the range of power values, as determined by non-parametric analysis of variance[6] (Kruskal-Wallis test; $\alpha = 0.05$; p-values ranged from 0.396 to 0.916). Thus, no statistical difference exists between the calculated CV-RMSEs within each search radius grouping.

A power of 5 and a circular search radius of 150 ft (P5/R150) were selected for further scrutiny on an LDW-wide basis. A circular search radius of 150 ft was selected because it aligns well with the spatial scales of the river and sample point distribution. Also, as discussed above, interpolation results are insensitive to radii in the range tested. Further, this search radius is consistent with the 2006 interpolation memo, which recommended an ellipse with a major axis of 150 ft and a minor axis of 75 ft. A power of 5 was selected because the observed RMSE in the reach-by-reach analysis was lowest in the vicinity of 5.

Table A-5 compares RMSE results for total PCBs obtained using the P5/R150 parameter set relative to those calculated using the 2006 interpolation memorandum parameters. The results are grouped to enable a reach-by-reach comparison of the methods. In

6 Normality of the dataset was assessed prior to statistical testing. Given the number of samples in the dataset, the Kolmogorov-Smirnov normality test was used rather than the Shapiro-Wilk test, which is restricted to datasets with 50 or fewer samples. Natural log (LN)-transformation of the data improved normality, but results of the Kolmogorov-Smirnov normality test indicated that transformed data were still not normal (p-values = 0.000). Thus, the non-parametric Kruskal-Wallis test was used for statistical testing rather than analysis of variance.

addition, LDW-wide summary statistics are provided. The reach-by-reach comparison shows method comparability on a CV-RMSE basis. Indeed, the reach-specific CV-calculated absolute errors generated by the two methods are not statistically different (Mann-Whitney test[7]; α = 0.05; p-values ranged from 0.238 to 0.486). The observed RMSE values using P5/R150 are considerably lower. This reflects the influence of the power parameter on the degree to which the distance of a measured data point from a grid-cell location affects the interpolation. On an LDW-wide basis, the calculated CV-RMSE values using P5/R150 are within the range of values established reach-by-reach using the 2006 interpolation memorandum parameters (Table A-5). The observed LDW-wide RMSE values generated by the P5/R150 interpolation are generally lower than the reach-by-reach values resulting from the 2006 interpolation memorandum parameters. This demonstrates that the P5/R150 predictions better mirror the actual dataset, an observation that is further illustrated in Table A-6, which compares the prediction accuracy for total PCBs (measured versus predicted) on reach-by-reach and LDW-wide bases.[8] The number of stations correctly assigned to concentration ranges is appreciably higher by LDW-wide interpolation using P5/R150.

Table A-7 presents the calculated surface areas of sediment (in acres) grouped by total PCB concentration range. The reach-by-reach and LDW-wide interpolation methods estimate roughly the same numbers of affected acres above and below a total PCB concentration of 240 µg/kg dw.[9] Above 240 µg/kg dw, the number of estimated acres in each total PCB concentration range is essentially equivalent between the two methods. Table A-7 also compares the SWACs for each method. The differential in SWAC values (360 µg/kg dw vs. 375 µg/kg dw) is only 4%. When taken in conjunction with the cross-validation results, the LDW-wide P5/R150 interpolation provides equivalent, if not better prediction accuracy, than the 2006 interpolation memorandum parameters.

The SWAC values obtained using LDW-wide IDW interpolation parameters compare favorably to the corresponding results obtained in the RI, which used different methods (Table A-8). In some cases, the area interpolated varied (e.g., variable river miles) depending upon the intended use of the specific statistics. Overall, the results of the various methods used to date and the proposed IDW parameterization compare very well.

---

7 Normality of the dataset was assessed prior to statistical testing. Given the number of samples in the dataset, the Kolmogorov-Smirnov normality test was used rather than the Shapiro-Wilk test, which is restricted to datasets with 50 or fewer samples. LN-transformation of the data improved normality, but results of the Kolmogorov-Smirnov normality test indicated that transformed data were still not normal (p-values < 0.048). Thus, the non-parametric Mann-Whitney test was used rather than a t-test.

8 When an error in estimation occurs, the model tends to overpredict (i.e., gives a false positive).

9 This dry weight concentration value is the approximate equivalent of the SQS for total PCBs [12 mg/kg organic carbon] assuming an average total organic carbon [TOC] value for LDW surface sediment of 1.9%.

Based on this analysis, the recommended IDW parameters for interpolating total PCBs in this FS are a circular search radius of 150 ft and an exponential power of 5. These parameters yield results comparable to interpolated conditions mapped using the 2006 interpolation memorandum (reach-by-reach) IDW parameters (Figure A-1). The empirical (measured) data points are superimposed on the FS IDW interpolation (Figure A-2), which enables a qualitative comparison of interpolative accuracy.

A.4.2 Arsenic Results

For arsenic, the CV-RMSE and observed RMSE values were first calculated on a reach-by-reach basis assuming fixed values for search radius (500 ft) and the maximum/minimum number of samples (10/1). The results show that the error statistics are insensitive to power above a value of approximately 3 (Table A-9). Combinations of powers from 1 through 5 and 10 were tested while varying the search radii between 75 ft and 250 ft. The CV-RMSE and observed RMSE values from LDW-wide interpolation are insensitive to power above a value of approximately 3 (Table A-9). Within each search radius grouping, the CV-calculated absolute errors were statistically indistinguishable across the range of power values, as determined by non-parametric analysis of variance (Kruskal-Wallis test; $\alpha = 0.05$; p-values ranged from 0.975 to 0.998). The influence of search radius on the CV-RMSE was also small. In all cases, the CV-RMSE ranged between 55 and 70.

Table A-10 compares the frequency of false predictions for the following power and search radius combinations: P3/R150, P3/R250, P5/R150, and P5/R250. The lowest number of false predictions occurs using the P5/R150 combination. Table A-11 presents sediment surface areas and calculated SWAC values using the different power and search radius combinations. Again, the results show a general lack of sensitivity to the specific parameters used. For example, the SWAC ranges from 15 to 16 mg/kg dw. Given this lack of sensitivity and the slightly lower level of false predictions, P5/R150 is a statistically justifiable and reasonable set of parameters for arsenic.

Figure A-3 shows that the arsenic surface sediment concentration maps generated by IDW (P5/R150) and Thiessen polygons are very similar. Figure A-4 shows the arsenic surface sediment concentration map generated by IDW (P5/R150) with the sample data points superimposed for comparison. Arsenic was not evaluated with as much rigor as total PCBs nor compared to any RI methods because the RI only interpolated total PCBs with IDW.

A.4.3 cPAH Results

Observed RMSE and CV-RMSE statistics were calculated for several combinations of exponential power (range: 1 to 10) and search radii (range: 75 ft to 250 ft) on an LDW-wide basis (Table A-12). At all search radii, the observed RMSE values trend from highest to lowest as the exponential power is increased from 1 to 10. This is an expected outcome because increasing power correspondingly increases the influence of any given observed point concentration on the interpolated value at that location. At a particular power, the observed RMSE values are essentially identical regardless of search radius. Similarly, the results in Table A-12 show that the declining trends in observed RMSE flatten out and remain approximately constant above a power of 5. The relatively high CV-RMSE values shown in Table A-12 compared to the observed RMSE value are a reflection of variability in the dataset.

Within each search radius grouping, the CV-calculated absolute errors were statistically indistinguishable across the range of power values, as determined by a non-parametric analysis of variance (Kruskal-Wallis test; $\alpha = 0.05$; p-values ranged from 0.997 to 1.000). Thus, there is no statistical difference between the calculated CV-RMSEs within each search radius grouping.

Table A-13 compares the frequency of false predictions for the following power and search radius combinations: P5/R150, P5/R175, P6/R150, and P6/R175. These combinations were selected for further consideration because they represent a region of the parameter continuum where the observed RMSE values are low (and constant), and the CV-RMSE values are mid-range. The fewest false predictions occur using the P6/R150 or P6/R175 combinations.

Table A-14 presents sediment surface areas (within each concentration range) and calculated SWAC values using the different power and search radius combinations. The results show a lack of sensitivity within this grouping of parameters. For example, the different SWAC values vary by no more than 2 µg TEQ/kg dw. Based on the foregoing analysis, P6/R150 is a statistically justifiable and reasonable set of parameters for interpolating cPAH by IDW and is used in this FS.

Figure A-5 shows the cPAH surface sediment concentration map generated by IDW (P6/R150) with the empirical data points superimposed on the map for comparison.

A.4.4 Dioxins/Furans Interpolation Approach

Data for dioxins/furans are not as numerous as for other risk-driver contaminants. For this reason, the Thiessen polygon method was selected for use in the FS. In a memorandum prepared and submitted to EPA and Ecology in March 2010, IDW and Thiessen polygon interpolation methods were explored. Based on the lack of change observed in the SWAC (between the IDW and Thiessen polygons) and on visual inspection of the maps, Thiessen polygons are considered adequate for the spatial characterization of dioxin/furan concentrations. However, polygons that extend from one bank to another (across the navigation channel) should be used with caution because it has been observed that concentrations upstream and downstream of a given location have greater similarity than those in a cross-channel direction.

A.5 Conclusions

Interpolation parameters suitable for IDW-interpolation of LDW surface sediment chemistry data were developed for total PCBs, arsenic, and cPAHs. These parameters are applied on an LDW-wide geographic framework as opposed to three separate reaches as was done previously (Windward 2006). As a result of these analyses, the following input parameters were used in the FS:

- Power of 5, maximum/minimum nearest neighbors 10/1, circular search radius 150 for total PCBs
- Power of 5, maximum/minimum nearest neighbors 10/1, circular search radius 150 for arsenic
- Power of 6, maximum/minimum nearest neighbors 10/1, circular search radius 150 for cPAHs.

These parameters were selected because they represent the best-optimized parameters from the cross-validation results. For dioxins/furans, Thiessen polygons were used in the FS for mapping because of the smaller dataset.

A.6 References

AECOM 2010. *Range-finding Investigation into Using Inverse Distance Weighting for Interpolating Dioxin/Furan Surface Sediment Concentration Data*. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington State Department of Ecology, Bellevue, WA. Prepared by AECOM, Inc. Seattle, WA. March 12, 2010.

ENSR 2008. *Inverse Distance Weighting Methodology for Interpolating Surface Sediment Chemistry in the Lower Duwamish Waterway*. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington State Department of Ecology, Bellevue, WA. Prepared by ENSR, Inc. Seattle, WA. August 15, 2008.

EPA 2008. Draft EPA and Ecology comments on LDWG's Notes from March 14, 2008 mapping meeting, and December 11, 2007 *Updated Methodology for Interpolating Surface Sediment Chemistry in the Lower Duwamish Waterway*. Prepared for Lower Duwamish Waterway Group by EPA Region 10. May 2, 2008.

RETEC 2006. *Technical Memorandum: Draft Preliminary Screening of Alternatives, Lower Duwamish Waterway Superfund Site*. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington State Department of Ecology, Bellevue, WA. Prepared by The RETEC Group, Inc. Seattle, WA. September 27, 2006.

RETEC 2007. *Bed Composition Model for the Lower Duwamish Waterway Feasibility Study: Mechanics of Model Application.* Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington State Department of Ecology, Bellevue, WA. Prepared by the RETEC Group, Inc. Seattle, WA. August 28, 2007.

RETEC|ENSR 2007. *Updated Methodology for Interpolating Surface Sediment Chemistry in the Lower Duwamish Waterway Feasibility Study - Draft Memorandum.* Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington State Department of Ecology, Bellevue, WA. Prepared by The ENSR Corporation (dba The RETEC Group, Inc.) Seattle, WA. December 11, 2007.

Windward 2006. *Technical Memorandum: GIS Interpolation of Total PCBs in LDW Surface Sediment.* Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington State Department of Ecology, Bellevue, WA. Prepared by Windward Environmental LLC, Seattle, WA. April 21, 2006.

Table A-1 IDW Parameters for Total PCBs Identified in the 2006 Interpolation Memorandum

LDW Study Area Reach	Power[a]	Search Radius (ft) and Angle[b,c]	Search Radius Shape[d]	Maximum/Minimum Nearest Neighbors[e]
North	1	150 x 75, 0	cross-axis quadrants	2/1
Middle	1	150 x 75, 300	axis quadrants	6/2
South	1	150 x 150, 300	axis quadrants	4/4

Source: 2006 Interpolation Memo (Windward 2006).

Notes:

a. Power: The weighting parameter applied to the interpolation. As the power increases, the weighting of a sample result at distance from the sample location diminishes.
b. Search Radius Shape: The division of the search shape (circle/ellipse) into quadrants and the orientation of those quadrants.
c. Angle: The orientation of the search radius relative to north (north=0/360, south=180).
d. Search Radius Shape (Major/Minor Axis): The length (in ft.) of the axes of an ellipse, major being the longer of the two.
e. Maximum/Minimum Nearest Neighbors: The maximum and minimum number of closest samples used to interpolate a grid cell.

ft = feet; IDW = inverse distance weighting; LDW = Lower Duwamish Waterway; PCB = polychlorinated biphenyl

Table A-2 Concentration Ranges Used to Compare Interpolation Results

Total PCB Concentration Range (µg/kg dw)	Arsenic Concentration Range (mg/kg dw)	cPAH Concentration Range (µg TEQ/kg dw)
≤ 60	≤12	≤90
>60-120	>12-16	>90-150
>120-240	>16-20	>150-380
>240-480	>20-57[a]	>380-900
>480-720	>57-93[b]	>900
>720-1,300	>93[b]	
>1,300		

Notes:

a. The SMS sediment quality standard value for arsenic is 57 mg/kg dw.
b. The SMS cleanup screening level value for arsenic is 93 mg/kg dw.

cPAH = carcinogenic polycyclic aromatic hydrocarbon; mg/kg dw = milligrams per kilogram dry weight; µg/kg dw = micrograms per kilogram dry weight; PCB = polychlorinated biphenyl; SMS = Sediment Management Standards; TEQ = toxic equivalent

Table A-3 Prescreening – Error Statistics for Maximum/Minimum Number of Neighboring Samples Using P5/R150

Parameter	Maximum Number of Neighboring Samples					
	1	2	4	6	8	10
Total PCBs P5/R150						
CV-RMSE	10300	9200	9100	9200	9100	9100
Observed RMSE	290	250	260	260	280	260
Total False Positive/Negative	6	13	13	13	14	14
Arsenic P5/R150						
CV-RMSE	70	69	69	69	69	69
Observed RMSE	1	0	0	0	0	0
Total False Positive/Negative	2	5	5	5	5	5
cPAH P5/R150						
CV-RMSE	840	770	740	740	740	740
Observed RMSE	23	26	27	27	27	27
Total False Positive/Negative	3	11	11	11	11	11

Notes:
1. P5/R150 – Power of 5 and circular search radius of 150 feet.
2. CV-RMSE and observed RMSE units are micrograms per kilograms dry weight (µg/kg dw) for total PCBs, µg TEQ/kg dw for cPAH, and milligrams per kilograms dry weight (mg/kg dw) for arsenic.
3. Minimum number of neighboring samples is 1 in all cases.

cPAH = carcinogenic polycyclic aromatic hydrocarbon; CV-RMSE = cross-validation root mean square error; P = power; PCB = polychlorinated biphenyl; R = radius; RMSE = room mean square error; TEQ = toxic equivalent

Table A-4 Cross-validation Error Statistics for the LDW-wide Interpolation of Total PCBs

Circular Search Radius (ft)	Power	Cross-Validation			Observed RMSE
		Mean Error	Mean Absolute Error	RMSE	
North Reach					
250	1	41	523	2,887	622
	2	41	522	2,883	1,043
	3	5	503	2,895	152
	4	-33	495	2,956	11
	5	-20	494	2,926	32
	10	-37	500	2,972	11
150	5	-37	510	2,978	27
	10	-51	510	3,012	10
Mid Reach					
250	1	131	1,835	5,815	3,271
	2	148	1,860	5,983	1,418
	3	142	1,896	6,204	878
	5	132	1,959	6,563	841
	10	139	2,050	7,149	865
150	5	130	1,963	6,567	382
	10	139	2,053	7,153	865
South Reach					
250	1	330	2,494	12,070	6,075
	2	326	2,475	12,880	3,224
	3	306	2,466	13,510	2,247
	5	280	2,481	14,160	1,185
	10	252	2,508	15,010	403
150	5	287	2,579	14,357	394
	10	260	2,573	15,240	431
LDW-wide PCBs					
250	1	145	1,415	7,829	3,584
	2	136	1,411	8,330	1,040
	3	119	1,418	8,722	390
	4	107	1,429	8,961	273
	5	100	1,440	9,131	255
	10	83	1,468	9,656	275
150	1	125	1,412	7,831	3,583
	2	124	1,412	8,330	1,040
	3	113	1,422	8,724	390
	4	105	1,434	8,963	273
	5	99	1,444	9,132	255
	10	84	1,480	9,657	275

Table A-4 Cross-validation Error Statistics for the LDW-wide Interpolation of Total PCBs (continued)

Circular Search Radius (ft)	Power	Cross-Validation Mean Error	Cross-Validation Mean Absolute Error	Cross-Validation RMSE	Observed RMSE
LDW-wide PCBs *(continued)*					
75	1	53	1,371	8,019	3,403
	2	82	1,404	8,448	1,027
	3	88	1,424	8,771	389
	4	86	1,437	8,986	273
	5	83	1,445	9,146	255
	10	71	1,464	9,659	275

Notes:
1. A maximum of 10 and minimum of 1 "nearest neighbor" data points were used in all interpolations.
2. Results are insensitive to a power beyond 5. Results using a power of 10 are provided as an outer bound reference point.

ft = feet; LDW = Lower Duwamish Waterway; PCB = polychlorinated biphenyl; RMSE = root mean square error

Table A-5 Cross-validation Error Statistics for the Reach-wide Interpolation of Total PCBs

Reach and Interpolation Method	Count	Mean Error	Mean Absolute Error	Cross-Validation RMSE	Observed RMSE
2006 Interpolation Memo Method [a]					
North Reach	416	-8	455	2,770	820
Middle Reach	583	56	1,753	5,714	3,479
South Reach	505	223	2,459	12,298	6,593
P5/R150 [b]					
North Reach	416	-37	509	2,978	27
Middle Reach	583	129	1,963	6,567	382
South Reach	505	284	2,550	9,132	394
LDW-wide	1,327	99	1,444	9,132	255

Notes:
a. Values were generated using the reach-specific parameters in Table A-1 (i.e., data from 2006 Interpolation Memo [Windward 2006]).
b. Results were obtained by interpolating within the individual reaches using the P5/R150 parameters.

LDW = Lower Duwamish Waterway; P = power; PCB = polychlorinated biphenyl; R = radius; RMSE = root mean square error

Table A-6 Summary of LDW-wide Observed False Predictions for Total PCBs by Concentration Range

PCB Range (µg/kg dw)	2006 Interpolation Memo Parameters [a]		P5/R150	
	False Positives	False Negatives	False Positives	False Negatives
North Reach				
≤ 60	17	0	2	0
>60-120	27	0	7	0
>120-240	11	6	1	0
>240-480	9	3	1	0
>480-720	1	4	0	0
>720-1,300	0	5	0	2
>1,300	0	1	0	0
Subtotal	*65*	*19*	*11*	*2*
Middle Reach				
≤60	23	0	2	0
>60-120	39	0	6	0
>120-240	44	3	5	0
>240-480	39	2	4	1
>480-720	14	4	1	0
>720-1300	19	4	3	0
>1,300	0	2	0	0
Subtotal	*178*	*15*	*21*	*1*
South Reach				
≤60	33	0	6	0
>60-120	20	4	0	0
>120-240	32	5	4	0
>240-480	27	4	2	0
>480-720	9	1	1	0
>720-1,300	13	3	1	0
>1,300	0	1	0	0
Subtotal	*134*	*18*	*14*	*0*
Grand Total	377	52	46	3
LDW-wide PCBs				
≤60	62	0	2	0
>60-120	81	7	1	0
>120-240	61	17	2	0
>240-480	51	14	2	1
>480-720	18	10	2	0
>720-1,300	20	17	1	2
>1,300	0	3	0	0
Grand Total	293	68	10	3

Source: *2006 Interpolation Memo* (Windward 2006).
Notes:
a. Prediction accuracy is based on comparing the interpolated station value to the concentration range that the measured value falls within.

LDW = Lower Duwamish Waterway; µg/kg dw = micrograms per kilogram dry weight; P = power; PCB = polychlorinated biphenyl; R = radius

Table A-7 Estimated Sediment Surface Areas by Concentration Range for Total PCBs

Total PCB Concentration Range (µg/kg dw)	2006 Interpolation Memo Parameters		P5/R150	
	Area (acres)	Cumulative Area (acres)	Area (acres)	Cumulative Area (acres)
≤60	72	72	106	106
>60-120	106	178	106	212
>120-240	153	331	118	330
>240-480	55	386	59	388
>480-720	13	399	16	404
>720-1,300	11	410	10	414
>1,300	19	430	16	430
Total Area of LDW	***430***		***430***	
SWAC (µg/kg dw)	375		360	

Source: *2006 Interpolation Memo* (Windward 2006).

Notes:

1. Total LDW surface area was 430 acres when this analysis was conducted.

LDW = Lower Duwamish Waterway; µg/kg dw = micrograms per kilogram dry weight; P = power; PCB = polychlorinated biphenyl; R = radius; SWAC = spatially-weighted average concentration

Table A-8 Surface Sediment Mapping Methods and Estimated Total PCB SWACs used in the RI/FS Documents

Document and Table or Section	Total PCB Concentration	Unit	Measure	Method	River Mile	Dataset [b]	Use
Food Web Model (FWM) [a]							
Table E.4-1	380	µg/kg dw	SWAC	IDW – 2006 Memo	0.0 - 5.25	RI Baseline	FWM calibration
Remedial Investigation (RI) [a]							
Section 5.2.1	370	µg/kg dw	SWAC	IDW – 2006 Memo	0.0 - 6.0	RI Baseline	Nature and extent
Comparison of Various Approaches							
Whole-river SWAC	380	µg/kg dw	SWAC	IDW – 2006 Memo	0.0 - 5.0	RI Baseline	Base conditions for application of the BCM
	360	µg/kg dw	SWAC	IDW – Proposed P5	0.0 - 5.0	RI Baseline	
	350	µg/kg dw	SWAC	Thiessen polygon	0.0 - 5.0	RI Baseline	

Notes:

a. The 2006 interpolation memo method was used for the SWAC calculations.

b. This analysis was conducted in 2007 at initiation of the FS; therefore, the RI baseline dataset was used in the analysis.

BCM = bed composition model; FS = feasibility study; FWM = food web model; IDW = inverse distance weighting; LDW = Lower Duwamish Waterway; µg/kg dw = micrograms per kilogram dry weight; RI = remedial investigation; P = power; PCB = polychlorinated biphenyl; SWAC = spatially-weighted average concentration

Table A-9 Cross-validation Error Statistics for the LDW-wide Interpolation of Arsenic

Circular Search Radius (ft)	Power	Cross-Validation			Observed RMSE
		Mean Error	Mean Absolute Error	RMSE	
North Reach Arsenic					
500	1	1.3	16.0	64	14
	2	0.9	15.7	66	6
	3	0.1	15.4	67	3
	4	-0.5	15.4	67	1
	5	-1.0	15.4	67	1
	10	-1.7	15.4	67	0
Mid Reach Arsenic					
500	1	0.0	3.4	6	2
	2	0.1	3.6	6	1
	3	0.2	3.7	6	1
	4	0.2	3.8	6	1
	5	0.2	3.9	6	1
	10	0.2	4.1	7	1
South Reach Arsenic					
500	1	-1.9	9.3	61	20
	2	-2.2	8.8	60	2
	3	-2.1	8.9	61	1
	4	-1.8	9.2	64	1
	5	-1.4	9.5	67	1
	10	-0.5	10.8	80	1
LDW-wide Arsenic					
250	1	-0.8	9.9	55	8
	2	-0.9	9.9	55	1
	3	-1.0	10.1	56	1
	4	-1.1	10.3	57	1
	5	-1.0	10.5	59	0
	10	-0.9	11.2	65	1
150	1	-0.3	11.4	69	6
	2	-0.6	11.2	68	1
	3	-0.8	11.4	68	1
	4	-1.0	11.5	69	1
	5	-1.1	11.6	69	1
	10	-1.2	11.8	69	1
75	1	-1.3	11.7	70	5
	2	-1.3	11.8	70	1
	3	-1.3	11.8	69	1
	4	-1.3	11.8	69	1
	5	-1.3	11.8	70	0

Notes:
1. A maximum of 10 and minimum of 1 "nearest neighbor" data points were used in all interpolations.
2. Results are insensitive to a power beyond 5. Results using a power of 10 are provided as an outer bound reference point.

ft = feet; LDW = Lower Duwamish Waterway; RMSE = root mean square error

Table A-10 Summary of LDW-wide Observed False Predictions for Arsenic by Concentration Range

Arsenic Range (mg/kg dw)	P3/R250[a]		P5/R250		P3/R150		P5/R150	
	False Positives	False Negatives	False Positives	False Negatives	False Positives	False Negatives	False Positives	False Negatives
≤12	23	0	11	0	20	0	10	0
>12-16	4	0	2	0	3	0	2	0
>16-20	1	2	1	1	1	2	1	1
>20-57	0	1	0	1	0	1	0	1
>57-93	0	0	0	0	0	0	0	0
>93	0	0	0	0	0	0	0	0
Subtotal	*28*	*3*	*14*	*2*	*24*	*3*	*13*	*2*
Total False Predictions	***31***		***16***		***27***		***15***	

Notes:

a. Power and search radius parameter combination (e.g., P5/R150 = power of 5 and circular search radius of 150 feet)

LDW = Lower Duwamish Waterway; mg/kg dw = milligrams per kilogram dry weight; P = power; R = circular search radius

Table A-11 Estimated Sediment Surface Areas by Concentration Range for Arsenic

Arsenic Concentration Range (mg/kg dw)	IDW Interpolation Parameters							
	P5/R250[a]		P3/R250		P5/R150		P3/R150	
	Area (Acres)	Cumulative Area (Acres)	Area (Acres)	Cumulative Area (Acres)	Area (Acres)	Cumulative Area (Acres)	Area (Acres)	Cumulative Area (Acres)
≤12	254	254	250	250	261	261	259	259
>12-16	111	365	115	365	103	365	105	364
>16-20	30	395	29	394	31	396	31	395
>20-57	29	424	29	423	29	425	29	424
>57-93	2	426	2	425	1	426	2	426
>93	4	430	5	430	4	430	4	430
SWAC (mg/kg dw)	**16**		**16**		**15**		**15**	

Notes:

1. Total LDW surface area was 430 acres when this analysis was conducted.

a. Power and search radius parameter combination (e.g., P5/R150 = power of 5 and circular search radius of 150 feet.)

IDW = inverse distance weighting; LDW = Lower Duwamish Waterway; mg/kg dw = milligrams per kilogram dry weight; P = power; R = circular search radius; SWAC = spatially-weighted average concentration

Table A-12 Cross-validation Error Statistics for the LDW-wide Interpolation of cPAHs

Circular Search Radius (ft)	Power	Cross-Validation			Observed RMSE
		Mean Error[a]	Mean Absolute Error[b]	RMSE	
250	1	5.5	311	645	180
	2	11.1	317	668	63
	3	11.7	326	697	44
	4	10.3	333	719	33
	5	8.8	338	737	27
	6	7.8	342	752	24
	7	7.3	345	765	23
	8	7.1	347	776	23
	9	7.2	350	786	22
	10	7.4	352	794	23
225	1	5.5	310	648	179
	2	10.7	318	672	63
	3	11.1	327	699	44
	4	9.7	334	720	33
	5	8.4	339	738	27
	6	7.4	342	752	24
	7	7.0	345	765	23
	8	6.9	348	776	23
	9	6.9	350	786	22
	10	7.1	352	794	23
200	1	4.5	311	651	179
	2	10.0	319	674	63
	3	10.4	327	700	44
	4	9.1	333	721	33
	5	7.7	338	738	27
	6	6.8	342	753	24
	7	6.3	345	765	23
	8	6.2	348	776	23
	9	6.3	350	786	22
	10	6.5	352	794	23
175	1	1.4	311	655	172
	2	7.0	320	679	63
	3	7.6	329	703	44

Table A-12 Cross-validation Error Statistics for the LDW-wide Interpolation of cPAHs (continued)

Circular Search Radius (ft)	Power	Cross-Validation			Observed RMSE
		Mean Error[a]	Mean Absolute Error[b]	RMSE	
175	4	6.6	335	723	33
	5	5.5	339	740	27
	6	4.8	343	754	24
	7	4.6	346	766	23
	8	4.7	348	777	23
	9	5.0	351	787	22
	10	5.4	353	794	23
150	1	2.1	316	663	171
	2	6.5	324	686	63
	3	7.1	332	707	44
	4	6.4	337	726	33
	5	5.7	342	741	27
	6	5.4	345	756	24
	7	5.4	348	768	23
	8	5.6	350	779	23
	9	6.4	357	788	22
	10	6.5	354	796	23
125	1	7.5	334	697	166
	2	9.0	338	709	64
	3	8.4	343	723	44
	4	7.1	346	737	33
	5	6.2	349	751	27
	6	5.8	352	763	24
	7	5.8	354	775	23
	8	6.0	355	785	23
	9	6.4	357	793	22
	10	6.8	358	801	23
100	1	10.0	342	717	158
	2	9.7	343	719	64
	3	8.6	345	728	44
	4	7.4	348	740	33
	5	6.7	350	752	27
	6	6.3	352	764	24
	7	6.3	353	775	23
	8	6.5	355	785	23
	9	6.8	356	793	22
	10	7.1	358	800	23

Table A-12 Cross-validation Error Statistics for the LDW-wide Interpolation of cPAHs (continued)

Circular Search Radius (ft)	Power	Cross-Validation			Observed RMSE
		Mean Error[a]	Mean Absolute Error[b]	RMSE	
75	1	4.1	345	714	133
	2	5.7	347	725	63
	3	6.7	350	737	44
	4	7.1	353	749	33
	5	7.2	355	761	27
	6	7.3	356	771	24
	7	7.5	358	781	23
	8	7.7	359	790	23
	9	7.9	360	797	22
	10	8.2	361	804	23

Notes:

1. Minimum of 1 and maximum of 10 "nearest neighbor" samples used in all interpolations.
2. cPAH interpolation error units in micrograms toxic equivalent per kilograms dry weight (µg TEQ/kg dw).
3. Sample count is 828.

a. Mean Error: The average difference between the observed sample location and the interpolated value at the same location with the sample removed when computing the interpolated value.

b. Mean Absolute Error: The average of the absolute value of the difference between the observed sample location and the interpolated value at the same location with the sample removed when computing the interpolated value.

Shading within table identifies recommended parameters.

cPAH = carcinogenic polycyclic aromatic hydrocarbon; ft = feet; LDW = Lower Duwamish Waterway; RMSE = root mean square error

Table A-13 Summary of LDW-wide Observed False Predictions for cPAHs by Concentration Range

cPAH Range (µg TEQ/kg dw)	P5/R150[a]		P5/R175		P6/R150		P6/R175	
	False Positives	False Negatives	False Positives	False Negatives	False Positives	False Negatives	False Positives	False Negatives
0-90	3	0	3	0	2	0	2	0
>90-150	4	0	4	0	3	0	3	0
>150-380	4	0	4	0	3	0	3	0
>380-900	0	0	0	0	0	0	0	0
>900	0	0	0	0	0	0	0	0
Total False Predictions	***11***		***11***		***8***		***8***	

Notes:

1. Prediction accuracy is based on comparing the predicted grid-cell value with the concentration range that the empirical value falls within.

a. Power and search radius parameter combination (e.g., P5/R150 = power of 5 and circular search radius of 150 feet)

cPAH = carcinogenic polycyclic aromatic hydrocarbon; LDW = Lower Duwamish Waterway; µg TEQ /kg dw = micrograms toxic equivalent per kilogram dry weight; P = power; R = radius

Table A-14 Estimated Sediment Surface Areas by Concentration Range for cPAHs

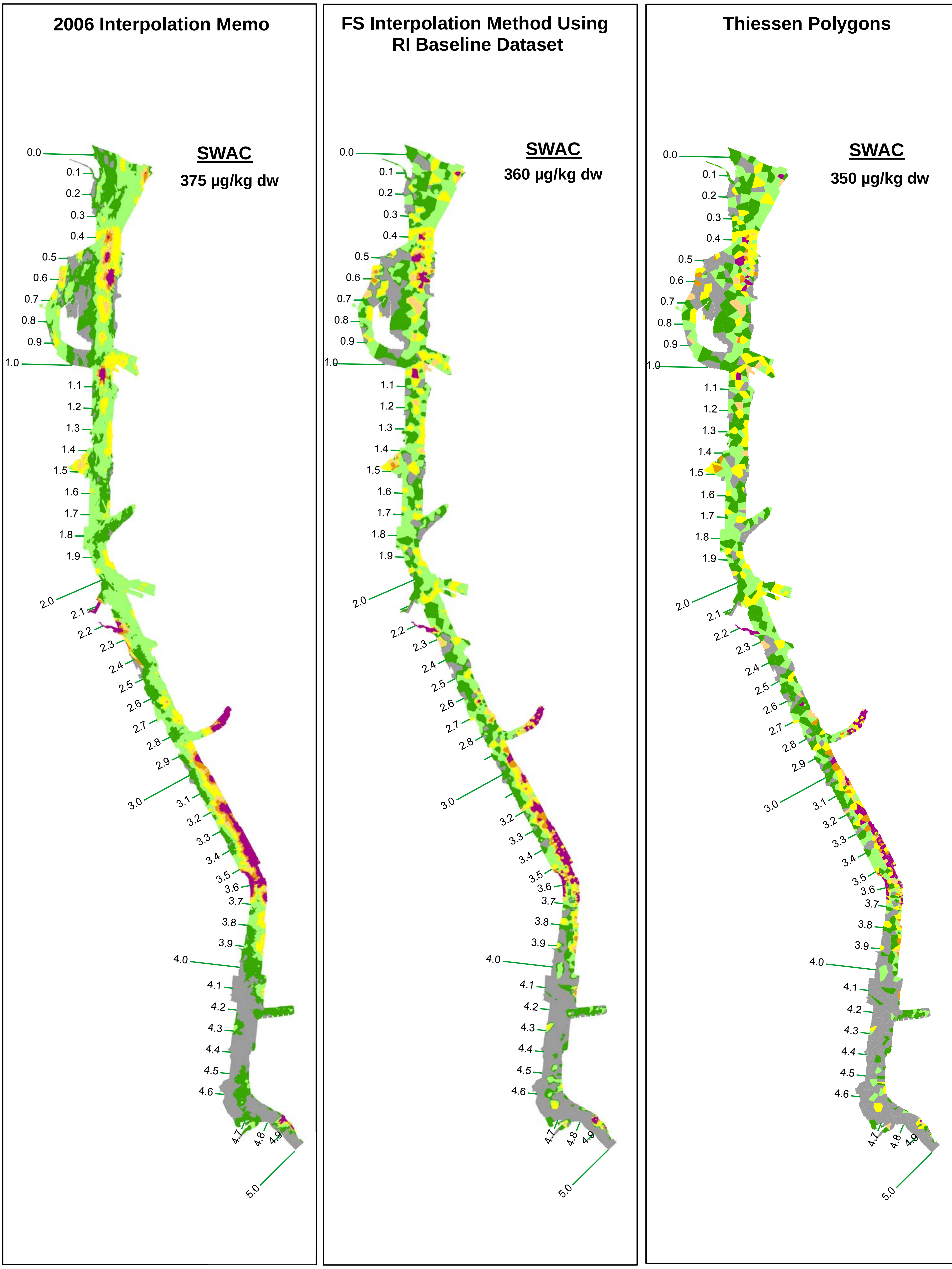
cPAH Concentration Range (µg TEQ/kg dw)	P5/R150[a]		P5/R175[a]		P6/R150[a]		P6/R175[a]	
	Area (acres)	Cumulative Area (acres)	Area (acres)	Cumulative Area (acres)	Area (acres)	Cumulative Area (acres)	Area (acres)	Cumulative Area (acres)
≤90	69	69	65	65	71	71	67	67
>90-150	55	124	56	121	55	126	56	122
>150-380	157	281	159	279	156	282	158	281
>380-900	121	402	123	402	119	402	121	402
>900	28	430	27	430	28	430	28	430
SWAC (µg TEQ/kg dw)	377		378		376		377	

Notes:

1. Total LDW surface area was 430 acres when this analysis was conducted.

a. Power and search radius parameter combination (e.g., P5/R150 = power of 5 and circular search radius of 150 feet)

cPAH = carcinogenic polycyclic aromatic hydrocarbon; LDW = Lower Duwamish Waterway; P = power; µg TEQ /kg dw = micrograms toxic equivalent per kilogram dry weight; R = radius; SWAC = spatially-weighted average concentration



Notes:
1. Replication of 2006 Interpolation Memo grid created using parameters outlined in that memo.
2. The FS interpolation was created using the following parameters: power 5, nearest neighbors 10/1, circular search radius 150 ft, with the RI baseline surface sediment dataset.
3. Slight differences are noted in the SWACs calculated in the 2006 Interpolation Memo (Windward 2006) and the replicated analysis in this memo because slightly different datasets were used (risk assessment dataset vs. RI baseline surface sediment dataset).
4. The Thiessen polygons were generated using total PCB surface sediment sample locations from the RI baseline surface sediment dataset.

Total PCBs Concentration (µg/kg dw)

River Mile Marker

- ≤ 60
- > 60-120
- > 120-240
- > 240-480
- > 480-720
- > 720-1,300
- > 1,300

0 1,000 2,000 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

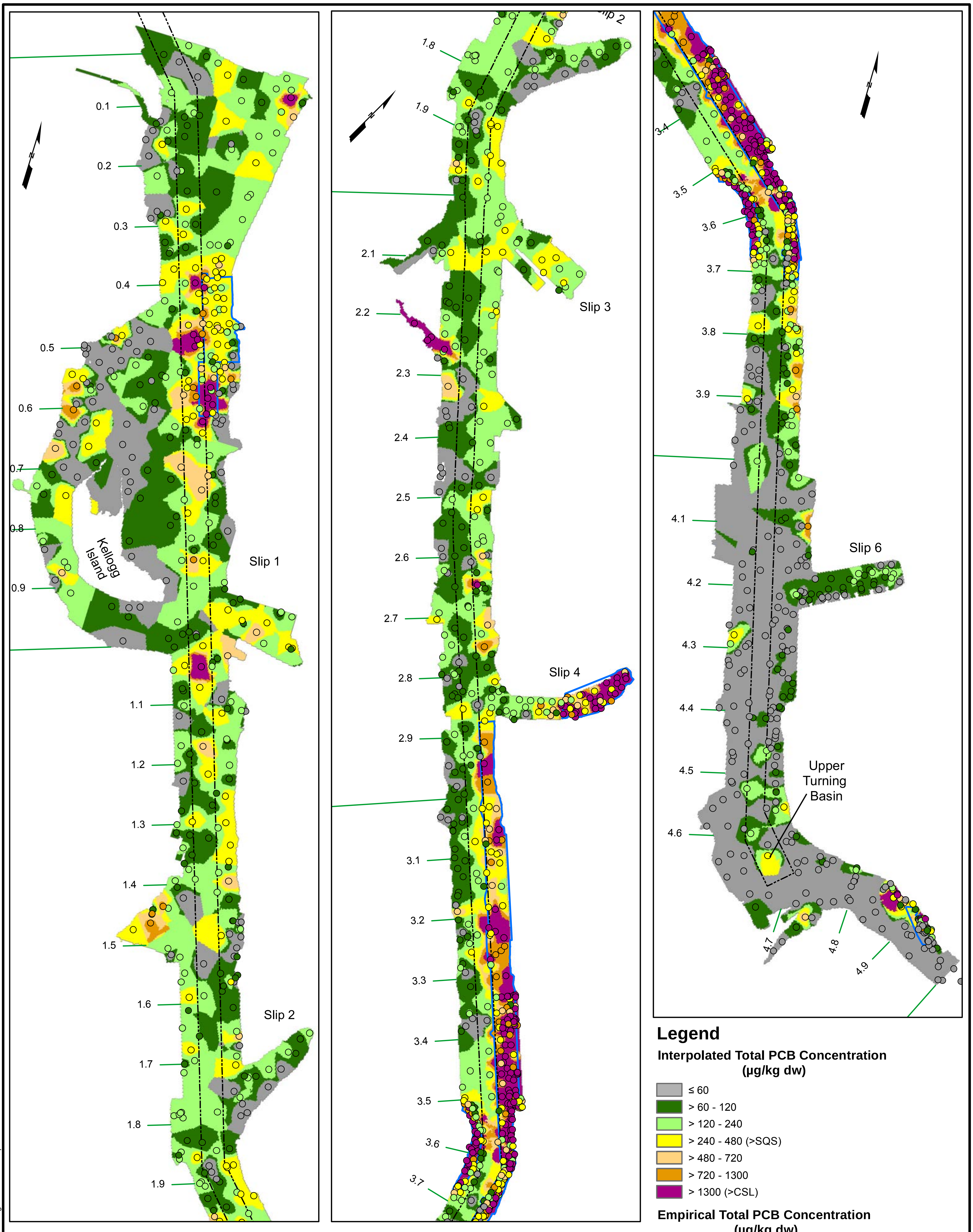
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Comparison of Total PCB Surface Sediment Maps Using Different Interpolation Methods

DATE: 10/31/12 | DWN. BY: MI/sea

FIGURE A-1

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix A\MXDs\Figure A-1Multiple Powers3.mxd



Legend

Interpolated Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1300
- > 1300 (>CSL)

Empirical Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1,300
- > 1,300 (>CSL)

Early Action Area
Navigation Channel
River Mile Marker

Feet
0 200 400 800

Notes:
1. Grid interpolated using the following parameters: power 5, nearest neighbors 10/1, circular search radius 150 ft.
2. Total PCB concentrations binned as multiples of SMS criteria, assuming 2% TOC.
3. Sampling dates of the data range from 1991 to 2006.
4. Total PCB data from RI baseline dataset dated Feb. 9, 2007.

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix A\Figure A-2PCBInterp.mxd

AECOM

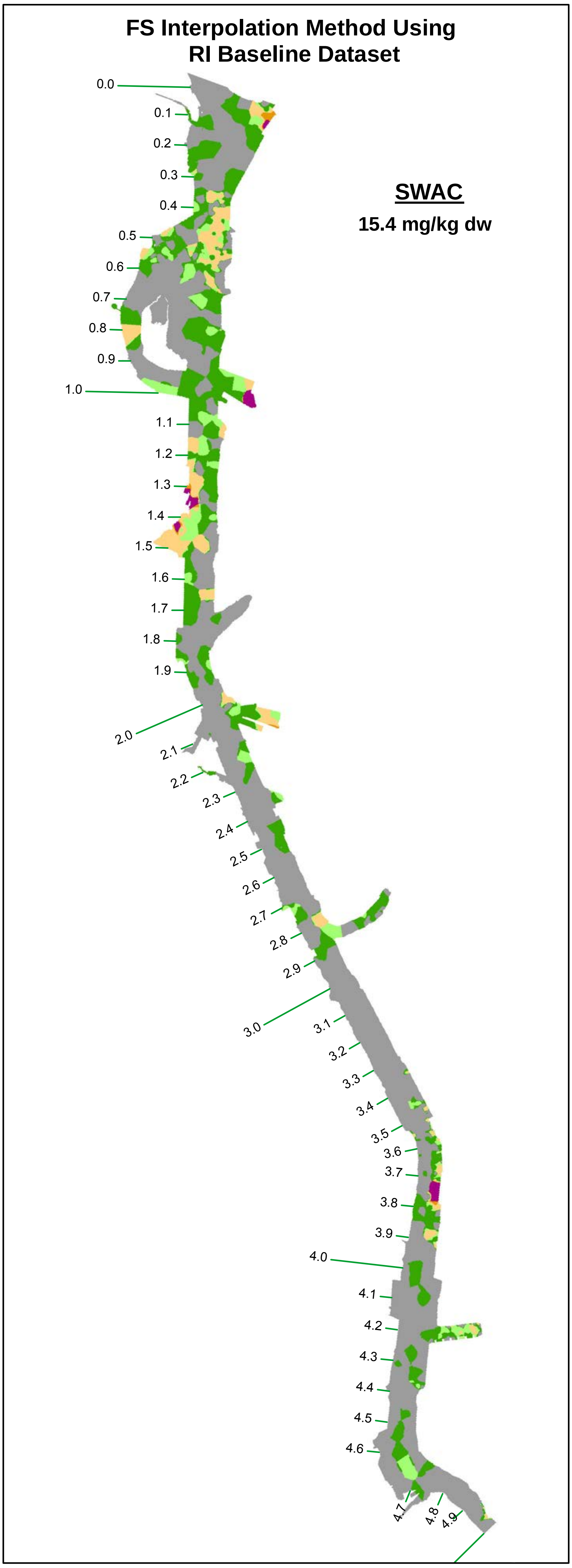
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

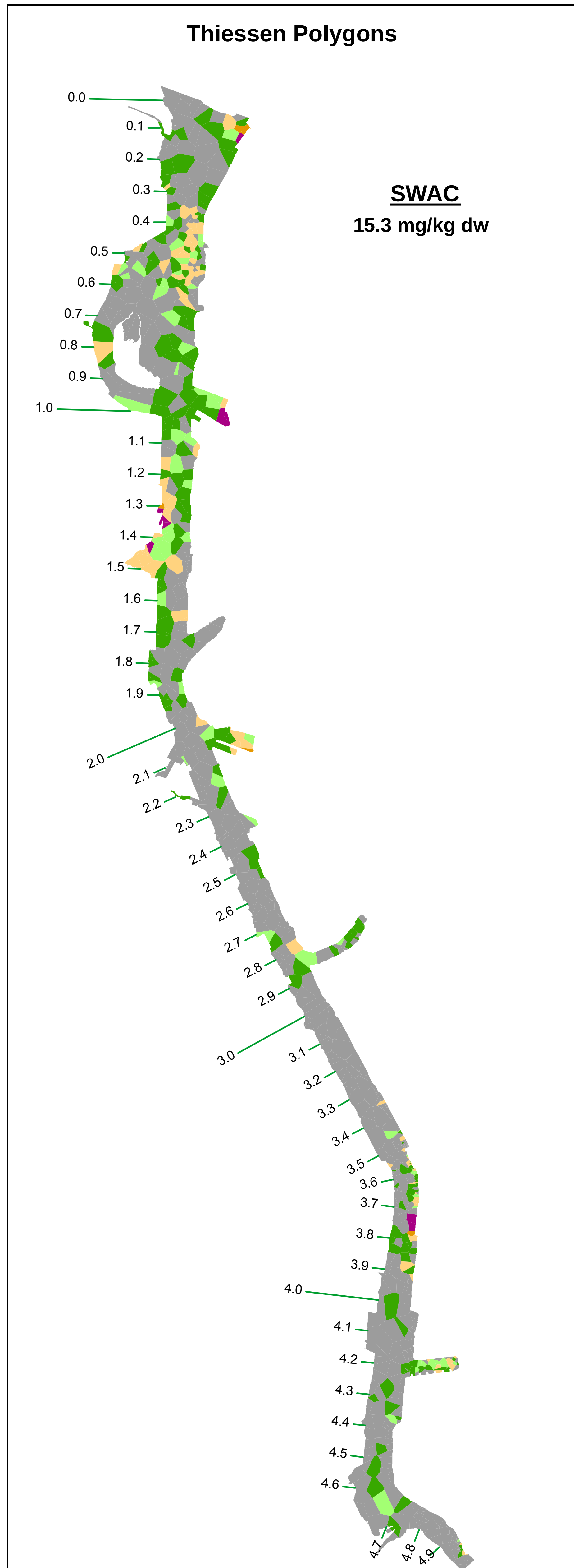
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Comparison of Empirical vs. Interpolated Total PCB Concentrations in Surface Sediment

FIGURE A-2





Notes:
1. The FS interpolation was created using the following parameters: power 5, nearest neighbors 10/1, circular search radius 150 ft, with the RI baseline surface sediment dataset.
2. The Thiessen polygons were generated using arsenic surface sediment sample locations from the RI baseline surface sediment dataset.

River Mile Marker

Arsenic Concentration (mg/kg dw)

- ≤ 12
- >12 - 16
- >16 - 20
- >20 - 57
- >57 - 93
- > 93

0 2,000 Feet

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

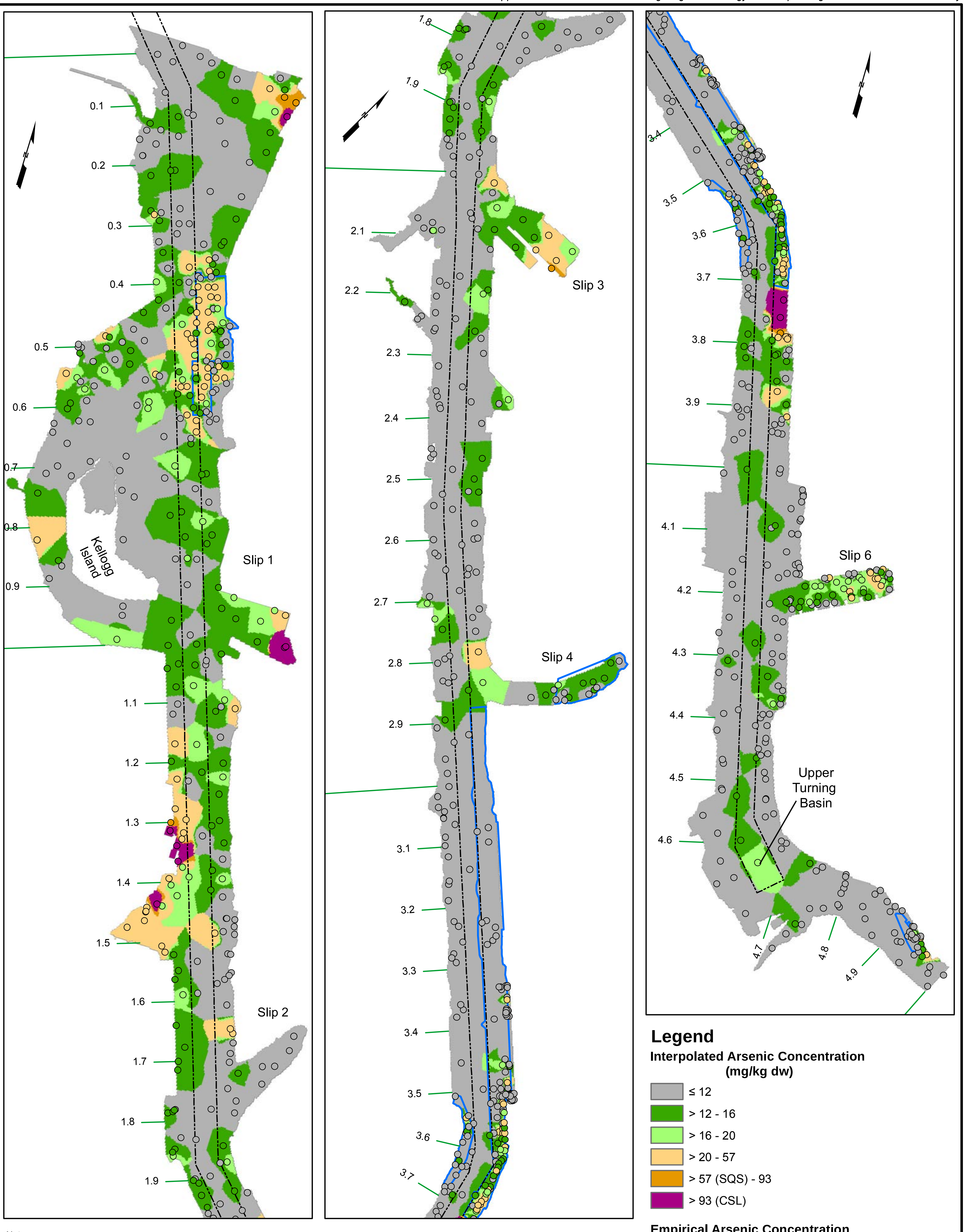
Comparison of Arsenic Surface Sediment Maps Using Thiessen Polygons and IDW Interpolation

DATE: 10/31/12 | DWN. BY: MI/sea | **FIGURE A-3**

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix A\Figure A-3Arsenic ConcentrationV2.mxd



Legend

Interpolated Arsenic Concentration (mg/kg dw)

- ≤ 12
- > 12 - 16
- > 16 - 20
- > 20 - 57
- > 57 (SQS) - 93
- > 93 (CSL)

Empirical Arsenic Concentration (mg/kg dw)

- ≤ 12
- > 12 - 16
- > 16 - 20
- > 20 - 57
- > 57 (SQS) - 93
- > 93 (CSL)

Early Action Area
Navigation Channel
River Mile Marker

Notes:
1. Grid interpolated using the following parameters: power 5, nearest neighbors 10/1, circular search radius 150 ft.
2. Arsenic concentrations binned as multiples of SMS criteria.
3. Sampling dates of the data range from 1991 to 2006.
4. Arsenic data from RI baseline dataset dated Feb. 9, 2007.

0 200 400 800 Feet

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix A\Figure A-4ASInterp.mxd

AECOM

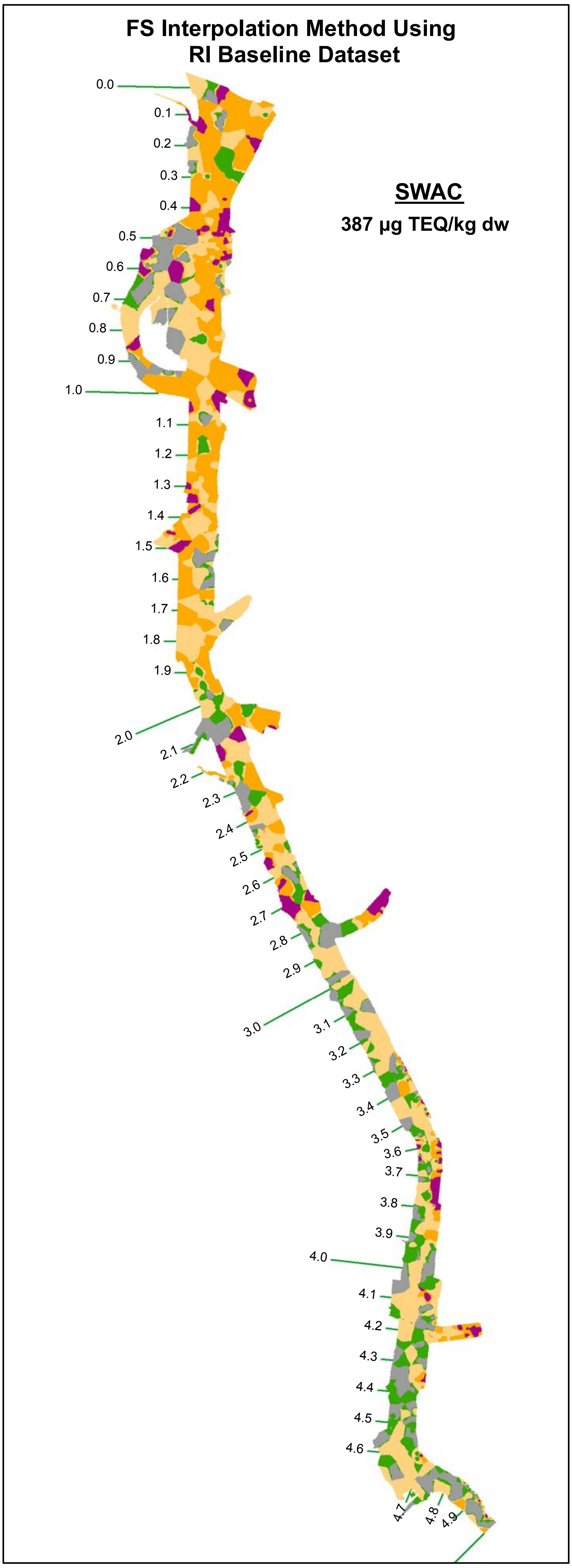
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

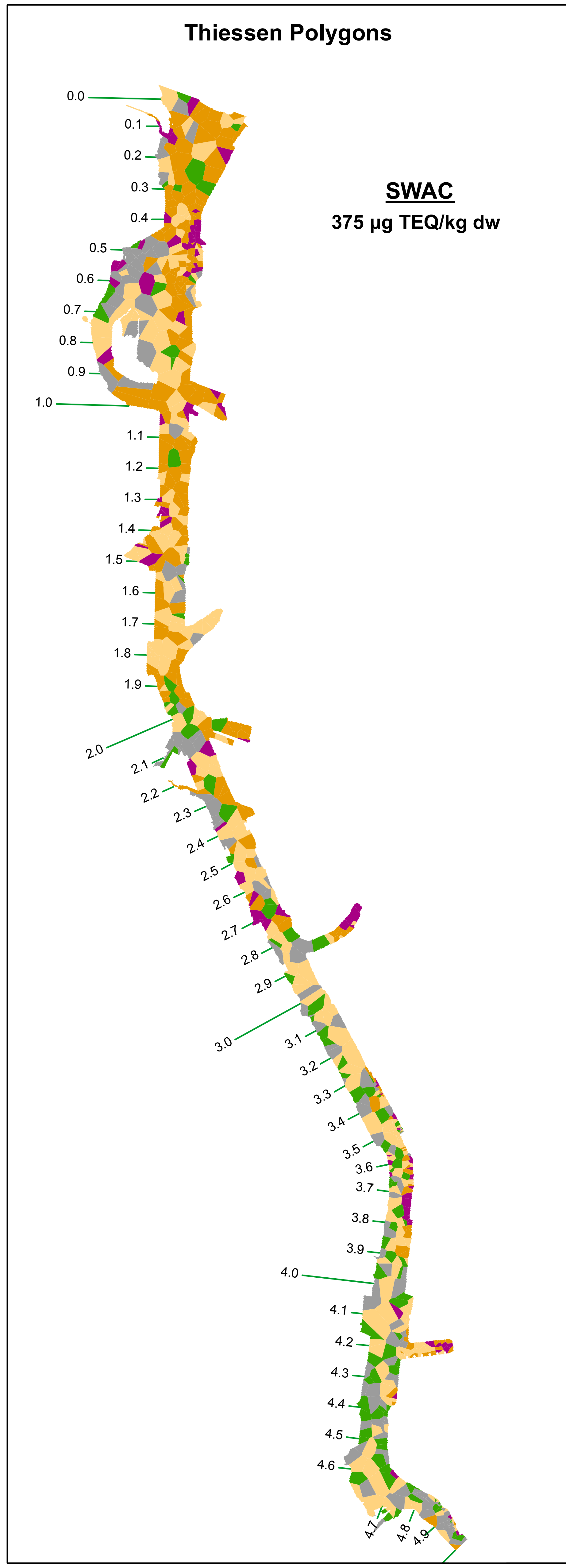
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN: MVI/sea | Revision: 0

Comparison of Empirical vs. Interpolated Arsenic Concentrations in Surface Sediment

FIGURE A-4





Notes:
1. The FS interpolation was created using the following parameters: power 6, nearest neighbors 10/1, circular search radius 150 ft, with the RI baseline surface sediment dataset.
2. The Thiessen polygons were generated using cPAH surface sediment sample locations from the RI baseline surface sediment dataset.

cPAH Concentration (µg TEQ/kg dw)

River Mile Marker

- ≤ 90
- > 90 - 150
- >150 - 380
- >380 - 900
- > 900

N

0 2,000 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Comparison of cPAH Surface Sediment Maps Using Thiessen Polygons and IDW Interpolation

DATE: 10/31/12 | DWN. BY: MI/sea

FIGURE A-5

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix A\Figure A-5cPAHConcentration.mxd

Legend

Interpolated cPAH Concentration (µg TEQ/kg dw)

- ≤ 90
- > 90 - 150 (> Beach play 10^{-6} RBTC)
- > 150 - 380 (> Netfishing 10^{-6} RBTC)
- > 380 - 900 (> Clamming 10^{-6} RBTC)
- > 900

Empirical cPAH Concentration (µg TEQ/kg dw)

- ≤ 90
- > 90 - 150 (> Beach play 10^{-6} RBTC)
- > 150 - 380 (> Netfishing 10^{-6} RBTC)
- > 380 - 900 (> Clamming 10^{-6} RBTC)
- > 900

Notes:
1. Grid interpolated using the following parameters: power 6, nearest neighbors 10/1, circular search radius 150 ft.
2. cPAHs binned based on netfishing, clamming, and beach play risk-based threshold concentrations (RBTCs).
3. The sampling dates of the data range from 1991 to 2006.
4. cPAH data from RI baseline dataset dated Feb. 9, 2007.

Early Action Area
Navigation Channel
River Mile Marker

0 200 400 800 Feet

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix A\Figure A-6cPAHInterp.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0

Comparison of Empirical vs. Interpolated cPAH Concentrations in Surface Sediment

FIGURE A-6

Attachment A-1

The Inverse Distance Weighting Method

The Inverse Distance Weighting Method

The Inverse Distance Weighting (IDW) interpolator within the geographic information systems (GIS) operates on the assumption that entities in close proximity to one another are more alike than those farther away. IDW uses the values of surrounding measured locations to predict the value of unmeasured locations. The measured values closest to the prediction location will have a larger impact on the predicted value than those farther away. Thus, IDW interpolation weights measured values at locations closer to a prediction location more than those farther away.

The General Formula (esri 2003)

The general formula is:

$$\hat{Z}(s_o) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

where:

$\hat{Z}(s_0)$ is the value we are trying to predict for location s_0.

N is the number of measured sample points surrounding the prediction location that will be used in the prediction.

λ_i are the weights assigned to each measured point that we are going to use. These weights will decrease with distance.

$Z(s_i)$ is the observed value at the location s_i.

The formula to determine the weights is the following:

$$\lambda_i = d_{i0}^{-p} \Big/ \sum_{i=1}^{N} d_{i0}^{-p} \qquad \sum_{i=1}^{N} \lambda_i = 1$$

As the distance becomes larger, the weight is reduced by a factor of p.

The quantity d_{i0} is the distance between the prediction location, s_0, and each of the measured locations, s_i.

Parameters that Influence IDW Interpolations

The two primary parameters that affect interpolation methods are exponential power and search radius. These are discussed below.

Exponential Power

The power parameter (p) controls how the weighting factor decreases with distance from a measured location. Weights are proportional to the inverse distance raised to the power p. The greater the power, the less effect distant points have on the value for a predicted location. As a result, the predicted location's value nears the value of the closest point. The converse is also true.

The Search Neighborhood

The search neighborhood also has a significant impact on the resultant interpolation and acts to limit the extent of the data used to determine the unknown location's value. The search neighborhood has three major components: search radius, shape, and minimum/maximum number of neighbors. The search radius is used to limit the distance from an unknown location that the interpolation method can extend in search of known values. This is done, in part, to improve processing speeds. Also, the similarity of measured values to interpolated point values is expected to diminish with distance.

The shape of the search radius is influenced by the available data and the surface to be created. If there are no discernable directional influences on the weighting of the data, the shape of the search radius should be a circle to consider known sample locations equally in all directions. If there is a directional influence in the data, it can be accounted for by adjusting the shape of the search radius to account for the directionality within the dataset.

When choosing the number of neighbors (minimum/maximum) used for interpolating the value of an unknown location, it is important to consider enough points to yield a good prediction, and few enough points to be practical.

The minimum parameter ensures that at least that specified number of neighbors is used for interpolating the unknown value. The maximum parameter places an upper limit on the number of (nearest) neighboring and measured sample locations used to interpolate the unknown value.

References

esri 2003. ArcGIS GeoStatistical Analyst Documentation.

Lower Duwamish Waterway Group

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

Appendix B
Updated Beach Play Risk Estimates, Species-Specific RBTC Calculations, and the Puget Sound Tissue Dataset

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM
710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Windward environmental LLC
200 W Mercer St # 401 ♦ Seattle, Washington ♦ 98119

Table of Contents

List of Tables

List of Figures

B.1 Introduction

This appendix presents the following additional risk-related information to support the feasibility study (FS):

- Section B.2 presents the details of the updated beach play risk estimates based on the FS dataset that support the updated risk estimates presented in Section 3 of the FS.
- Section B.3 presents the species-specific tissue risk-based threshold concentrations (RBTCs) and methodology for calculating these values. These species-specific RBTCs are presented in Section 3.3 of the FS.
- Section B.4 presents the non-urban Puget Sound tissue dataset that was compiled for the four human health risk drivers (i.e., total polychlorinated biphenyls [PCBs], inorganic arsenic, carcinogenic polycyclic aromatic hydrocarbons [cPAHs], dioxins/furans). The dataset is also presented in Section 3.3 of the FS and is compared with the tissue RBTCs. This appendix provides the details on dataset development, as well as additional summary statistics and figures that show the locations where these data were collected. Risk estimates for the three RME seafood consumption scenarios are also presented in this section.

B.2 Updated Risk Estimates for RME Beach Play Scenario

This section describes the calculation of updated beach play reasonable maximum exposure (RME) risk estimates using the FS dataset. The available data are described, followed by a discussion of the calculation of exposure point concentrations (EPCs) and a brief discussion of risk estimates.

B.2.1 Available Data

Estimates of risks associated with beach play were presented in the baseline human health risk assessment (HHRA; Windward 2007) based on the HHRA dataset. Since that time, several surface sediment sampling events have been conducted. One of these events was a targeted sampling of surface sediment in beach play areas in 2009 and 2010 (Windward 2010b). The main objective of this sampling was to supplement the existing dioxin/furan data for the Lower Duwamish Waterway (LDW), although additional data for all four human health risk drivers (i.e., total PCBs, inorganic arsenic, cPAHs, and dioxins/furans) were also collected from the beach play areas. As a result, more surface sediment chemistry data were available for the FS than for the HHRA. Data used in the HHRA have been combined with more recently collected data to form the FS dataset. Figures B-1 through B-4 present the available data for the four human health risk drivers in the beach play areas. In the HHRA, these four contaminants accounted for the majority of the risks associated with beach play.

B.2.2 Updated EPC Calculation

To update beach play risks, new EPCs for the risk drivers were calculated using the FS dataset. The HHRA (Windward 2007) described the general approach for EPC calculation based on the number of detected concentrations. When six or more locations within a beach play area had detected concentrations, ProUCL software was used to estimate an upper confidence limit on the mean (UCL), which served as the EPC. When one to five locations had detected concentrations, the higher of the maximum detected concentration or one-half of the maximum reporting limit (RL) was used as the EPC. When no locations had detected concentrations, one half the maximum RL was used as the EPC. These same general data rules were applied in this update.

At some beach play areas, both grab samples and composite samples were available (Figures B-1 through B-4). Thus, it was necessary to decide how the two data types would be used in developing updated EPCs; these decisions were made in consultation with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). The following additional data guidelines were developed:

- Data from the separate analyses of composite and grab samples within a beach play area were not combined.
- The data type (grab or composite) that included the most samples (or subsamples in the case of composites) and the best spatial coverage for a particular beach play area was selected to generate the EPC for a given beach.

Table B-1 identifies the data used to calculate the EPC for each risk driver and beach play area using the FS dataset. For comparison, Table B-1 also provides the EPCs that were used in the HHRA for each area (Windward 2007). Specific decisions regarding each of the beach play areas are described below, followed by a brief discussion of the risk estimates.

For Area 1, two composite samples covered the majority of the beach play area, and the number of subsamples that were included in the two composite samples outnumbered the grab samples. Therefore, the updated EPCs were based on the spatially-weighted averages of the two composite samples for all four risk drivers. One composite sample represented a 20,126-square-foot area, and the other composite sample represented a 28,645-square-foot area (i.e., 41% and 59% of the total beach play area, respectively).

With only a single exception (described below), updated EPCs for Areas 2, 3, 4, 5, and 8 were calculated using data only from grab samples for all four human health risk drivers. For Areas 2, 3, 4, and 8, only grab sample data were available so these data were used for the EPC calculation.

For Area 5, both composite and grab sample data were available. For PCBs, arsenic, and cPAHs, more grab samples were available than subsamples in the composite samples and the spatial coverage of the grab samples was better, so the grab samples were used for EPC calculations in this area. For dioxins/furans, two composite samples and two grab samples were collected in Area 5. Because of the limited spatial coverage and because fewer than six samples were available, the maximum concentration was selected as the EPC for dioxins/furans.

For Area 6, the number of subsamples included in the composite sample (n = 8) was greater than the number of grab samples available for the area (n = 2 for PCBs; n = 1 for arsenic and cPAHs; n = 0 for dioxins/furans). The spatial extent of Area 6 was also well represented by the composite sample. Therefore, the composite sample data were used to calculate the updated EPCs for all four human health risk drivers for Area 6.

For Area 7, the grab sample data were used to calculate updated EPCs for PCBs, arsenic, and cPAHs because the spatial coverage was better and more grab samples were analyzed for these risk drivers than there were subsamples in the composite samples. For dioxins/furans, the composite data were used because more subsamples were included in the composite sample (n = 8), and the spatial coverage of the composite sample was greater when compared with the one grab sample analyzed for dioxins/furans.

To provide additional information for risk communication, EPCs were also calculated separately for Duwamish Waterway Park (which is part of Area 5, see Figures B-1 through B-4). Data from a composite sample were used to calculate updated EPCs for all four human health risk drivers for Duwamish Waterway Park because the spatial extent of that composite sample was specifically determined in consultation with EPA and stakeholders to represent intertidal exposures at the park.

In addition, Areas 4 and 5 were each modified by dividing the original beach area presented in the HHRA into two parts as follows:

- **Area 4**: In the HHRA, this beach area included intertidal areas ranging from river mile (RM) 2.0W to 2.4W and the inlet at RM 2.2W. This beach area was divided into two parts. The first part included all sediment samples except those in the inlet at RM 2.2W (referred to as Area 4 modified – without inlet). The other part included only those samples in the inlet at RM 2.2W (referred to as Area 4 modified – inlet only).

- **Area 5**: In the HHRA, this beach area included three separate beaches, all located between RM 2.5W and RM 3.4W. This area was divided into two parts. The first part (referred to as Area 5 modified – south) included the two southernmost sections of Area 5. The other part (referred to as Area 5 modified – north) included only the northernmost section of Area 5.

These modifications were made to facilitate remedial decision-making (i.e., clarify which portions of the beach play areas were causing most of the risk). To assess risks in these areas, it was necessary to calculate EPCs for each of these Area 4 and Area 5 subareas. For Area 4, grab sample data from areas within the beach play area but outside the inlet in Area 4 were used to calculate EPCs for Area 4 modified – without inlet, and grab samples from only the inlet in the beach play area were used to calculate EPCs for Area 4 modified – inlet only (Figures B-1 through B-4). For Area 5, data from the two southernmost sections were used to calculate EPCs for Area 5 modified – south (i.e., data from the northernmost of the three disjointed sections that comprise this beach play area were excluded), and data from the northernmost section of Area 5 was used to calculate EPCs for Area 5 modified – north. For total PCBs, arsenic, and cPAHs, grab sample data were used because they provided better spatial coverage and more grab samples were available than subsamples in each of the composite samples analyzed. For dioxins/furans in Area 5 modified – south, the available data were limited to one grab sample and two composite samples. Because of the limited spatial coverage and because fewer than six samples were available, the maximum concentration was selected as the EPC for dioxins/furans.

B.2.3 Updated Risk Estimates

Based on these updated EPCs, updated excess cancer and non-cancer risk estimates were calculated for the beach play areas (Table B-2) and summarized below. Based on the FS dataset, the estimated total excess cancer risks (all four human health risk drivers combined) ranged from 4 in 1,000,000 (4×10^{-6}) to 6 in 10,000 (6×10^{-4}) for the eight individual beach play areas (Table B-2). The estimated total excess cancer risks for beach play were lower for Areas 1, 3, 7, and 8 based on the FS dataset compared with estimated total excess cancer risks based on the HHRA dataset. The other beach play areas (Areas 2, 4, 5, and 6) had higher risk estimates based on the FS dataset, with Area 4 having the greatest increase in the estimated risk. This increase was largely the result of high PCB concentrations in two post-remedial investigation (RI) samples that were collected from the head of the inlet at RM 2.2W.

The estimated total excess cancer risk for Duwamish Waterway Park presented in the HHRA uncertainty section (Section B.6.3.3.2 of the HHRA; Windward 2007) was 4×10^{-6}, based only on total PCBs, arsenic, and cPAHs, because no dioxin/furan data were available for Duwamish Waterway Park when the HHRA was completed. The updated total excess cancer risk for Duwamish Waterway Park using the FS dataset for total PCBs, arsenic, cPAHs, and dioxins/furans was 2×10^{-6}.

As discussed above, Areas 4 and 5 were each divided into two parts (referred to as Area 4 modified [without inlet and inlet only] and Area 5 modified [north and south]). Risks were calculated for each of these parts to investigate which portions of the beach play areas were contributing the most to the risk estimate. The estimated total excess cancer risk for Area 4 modified – without inlet (1×10^{-5}) was much lower than that for the entire Area 4 (6×10^{-4}) because of the higher concentrations of arsenic, dioxins/furans, cPAHs, and especially total PCBs, within the inlet. The estimated total excess cancer risk for Area 4 modified – inlet only was 3×10^{-3}. Therefore, the majority of the risk for Area 4 was from exposures to sediments in the inlet. The estimated total excess cancer risk for Area 5 modified – south (4×10^{-6}) was also much lower than that for the entire Area 5 (3×10^{-5}) because of the higher concentrations of cPAHs and dioxins/ furans in the northerly segment (Figures B-3 and B-4). The estimated total excess cancer risk for Area 5 modified – north was 5×10^{-5}. Although the difference in the risk estimates for the two parts of Area 5 modified were not as large (as compared with the two parts of Area 4 modified), the majority of the risk in Area 5 is from exposure to sediment in the northernmost beach segment.

In the HHRA (Windward 2007), non-cancer hazard quotients (HQs) for beach play did not exceed 1 for any of the areas evaluated (Table B-2). Using the FS dataset, the highest non-cancer HQ for total PCBs increased from 1 (in Area 4; Figure B-1), as presented in the HHRA, to 187, largely as a result of two samples with very high total PCB concentrations (2,900,000 µg/kg dw and 230,000 µg/kg dw) from the head of the inlet at RM 2.2W. If those two high total PCB concentrations are omitted, the non-cancer HQ for total PCBs for Area 4 would be 2 (similarly, the excess cancer risk would decrease from 6×10^{-4} to 6×10^{-6} if these two samples were excluded). The non-cancer HQ for total PCBs for Area 4 modified – without inlet was 0.4. This again suggests the area of most concern is the inlet at Area 4. None of the other beach play areas had non-cancer HQs greater than 1 for any risk driver.

B.3 Calculation of Species-Specific Tissue RBTCs

Tissue RBTCs for the three human health RME seafood consumption scenarios, and the risk equations and parameters used to calculate the tissue RBTCs, were presented in Section 8 of the RI (Windward 2010a) and summarized in Section 3.3 of the FS. The tissue RBTCs presented in the RI represent the ingestion-weighted average concentrations in tissue that correspond to certain risk thresholds for each scenario. At the request of EPA, species-specific RBTCs were also developed. The methodology and the resulting species-specific RBTCs are presented in this section.

Two main factors influence species-specific RBTCs: 1) the relative ingestion rates for the various items in the market basket diet (i.e., the percentages of various seafood types that people eat), and 2) the relative tissue contaminant concentrations among the food items. Both factors may change in the future. Thus, these species-specific RBTCs are: 1) meaningful only in the context of the suite of exposure assumptions that make up the exposure scenario and 2) uncertain because the relative contaminant concentrations in various species may be different in the future in response to a variety of factors.

The RBTCs are presented as ranges when possible to acknowledge the uncertainty in the relative contaminant concentrations in different species. These ranges of species-specific RBTCs may be compared with tissue data from other parts of Puget Sound (as was done in Section 3.3 of the FS) and with data that may be collected as part of future long-term monitoring in the LDW, within the context of the overall exposure scenario and risk level that they represent.

The following subsections present the methodology used to calculate these values and the bases of the species-specific tissue RBTCs for all four risk drivers.

B.3.1 Methodology

This section describes the methodology used to calculate species-specific RBTCs. To clarify this process, this section provides a step-by-step process for species-specific RBTC derivation. As an example, the following steps were used to calculate a species-specific RBTC for the 1×10^{-4} risk level for total PCBs based on the Adult Tribal RME scenario. Species-specific RBTCs for this scenario, corresponding to the 1×10^{-4}, 1×10^{-5}, and 1×10^{-6} excess cancer risk levels and an HQ of 1, are provided in Section B.3.2.

1. **Overall RBTC**: The starting point for calculating a species-specific RBTC is the ingestion-weighted RBTC (as presented in Section 8 of the RI and Section 3.3 of the FS). These ingestion-weighted RBTCs, which are also referred to as "overall RBTCs," are calculated based on the overall seafood ingestion rate (IR) and other scenario-specific parameters (e.g., body weight and exposure duration). The overall tissue RBTC for total PCBs at the 1×10^{-4} risk level for the Adult Tribal RME scenario based on Tulalip data is 42 µg/kg wet weight (ww) (Table B-3).

2. **Ingestion-weighted average concentration equation**: To calculate species-specific RBTCs, the ingestion-weighted RBTC must be broken down into its component pieces, which represent all the components of the diet (Equation 1).

$$\begin{aligned} C_{ingestionweighted} = {} & (IR\%_{clam} \times C_{clam}) + (IR\%_{crabEM} \times C_{crabEM}) + (IR\%_{crabWB} \times C_{crabWB}) \\ & + (IR\%_{perch} \times C_{perch}) + (IR\%_{ES-WB} \times C_{ES-WB}) + (IR\%_{ES-fil} \times C_{ES-fil}) \end{aligned}$$ **Equation 1**

Where IR% is the species-specific percentage of the total seafood ingestion rate; C is the species-specific tissue contaminant concentration; and $C_{ingestion\text{-}weighted}$ is the ingestion-weighted average contaminant concentration discussed in Step 1.

For the Adult Tribal RME scenario based on Tulalip data, Equation 2 presents the same equation but with the actual ingestion rate percentages and the overall RBTC of 42 µg/kg ww substituted, as appropriate.

$$\begin{aligned} 42 = {} & (44.8\% \times C_{clam}) + (29.6\% \times C_{crabEM}) + (9.3\% \times C_{crabWB}) + (8.4\% \times C_{perch}) \\ & + (0\% \times C_{ES-WB}) + (7.8\% \times C_{ES-fil}) \end{aligned}$$ **Equation 2**

Note that the species-specific percentages of the total seafood ingestion rate provided in this equation are slightly different from those reported in the HHRA (Windward 2007); those percentages were adjusted by EPA in an errata to the HHRA (Windward 2009). In cases where there were no data for an individual contaminant of potential concern (COPC) in mussel tissue, the percentage of the consumption rate attributed to mussels was distributed proportionally to the other consumption groups (see Table B-4). At the ingestion-weighted RBTC of 42 µg/kg ww (i.e., the overall RBTC), the "C" for each species is equal to the species-specific total PCB RBTC for the 1 × 10^{-4} risk level for the Adult Tribal RME scenario based on Tulalip data.

3. **Species-to-species relationship**: As shown in Equation 2, six different variables (i.e., the concentrations of the different consumption categories) remain once all the ingestion rates have been substituted. This equation cannot be solved for a single species concentration (i.e., single variable) unless the concentration relationships among the various species are known and are assumed to be constant over time. The relationship among species (represented by ratios, as shown in Equation 3) can be approximated based on empirical data from the LDW or data predicted using the food web model (FWM). In this example, relationships among the concentrations in various species were derived based on the HHRA tissue dataset for the LDW. Thus, to calculate the total PCB concentration of a single species (e.g., clams) in the market basket, it is necessary to use the ratio of the average total PCB concentration for that species to the ingestion-weighted average total PCB concentration (which is calculated as shown in Step 4).

4. **Solving the equation for species-specific RBTCs**: Based on the assumptions in Step 3, Equation 2 can be simplified to Equation 3 and solved for a single species (in this example, clams).

$$C_{clam} = \frac{RBTC_{overall} \times Average_{clam}}{C_{ingestionweighted}}$$

Equation 3

In this example, the overall RBTC is equal to 42 µg/kg ww, and based on the HHRA empirical dataset, the average clam concentration is equal to 140 µg/kg ww, and the ingestion-weighted tissue concentration is equal to 394 µg/kg ww (Table B-3). Note that the ingestion-weighted concentration of 394 µg/kg ww was calculated by substituting the empirical tissue concentrations from the HHRA dataset into Equation 1, as shown in Equation 4.

$$\begin{aligned} C_{ingestionweighted} &= 394 = (44.8\% \times 140) + (29.6\% \times 170) + (9.3\% \times 890) + (8.4\% \times 1700) \\ &+ (0\% \times 2200) + (7.8\% \times 700) \end{aligned}$$

Equation 4

To calculate the clam RBTC, these values are substituted into Equation 3, as shown in Equation 5.

$$C_{clam} = RBTC_{clam} = \frac{RBTC_{overall} \times Average_{clam}}{Average_{ingestionweighted}} = \frac{42 \times 140}{394} = 15$$

Equation 5

This approach assumes that relative contaminant concentrations among the species remain the same even when conditions change. This proportionality calculation is then repeated for the other tissue types that comprise the diet. Different species-to-species relationships may be calculated if multiple empirical datasets or model outputs are available, which in turn would result in a range of RBTCs (rather than a single number). This concept is further explored in Section B.3.2.

B.3.2 Species-Specific RBTCs for Risk Drivers

Following the methodology described in Section B.3.1, species-specific RBTCs were calculated for the risk drivers identified for the LDW: total PCBs, inorganic arsenic, and cPAHs (Tables B-5 through B-9). Species-specific RBTCs could not be derived for dioxins/furans because no site-specific empirical data were available to calculate the ratios that describe concentration relationships among the species. Data and methods used to establish the species-specific RBTCs for each risk driver are summarized below.

Species-specific RBTCs for total PCBs were developed based on three sources of species-to-species relationship information: 1) the LDW HHRA empirical dataset (as in the example in Section B.3.1), 2) the LDW 2007 empirical dataset, and 3) the calibrated FWM. Because the calibrated FWM predicts concentrations for each species in the scenario-specific diets, it can also be used to estimate the concentration relationships among the different species. Because the relationships were similar, but not exactly the same based on the three sources of information, a range of species-specific RBTCs were developed for each RME seafood consumption scenario/risk level combination for total PCBs, as presented in Tables B-5 through B-7.

It was not possible to calculate a range of species-specific RBTCs for inorganic arsenic or cPAHs because the 2007 tissue samples were not analyzed for these contaminants for all market basket species and because no FWM exists for these risk drivers. Therefore, species-specific RBTCs for inorganic arsenic and cPAHs are presented as single values.

B.4 Non-Urban Puget Sound Tissue Dataset

To help provide context for tissue RBTCs, a tissue dataset of samples collected from non-urban areas away from known contaminated sites in Puget Sound was compiled for each of the four risk drivers (i.e., total PCBs, arsenic, cPAHs, and dioxins/furans).

Section B.4.1 describes the criteria used to develop the non-urban Puget Sound tissue dataset and provides detailed tables and figures showing the data included in this dataset. Section B.4.2 presents human health risk estimates calculated based on the non-urban Puget Sound tissue dataset.

B.4.1 Dataset Development

The non-urban Puget Sound tissue dataset consists of data from various studies. For total PCBs and arsenic, the tissue data from some of these studies were presented in the LDW RI; this RI dataset served as a starting point for these two risk drivers. In addition, data for all four risk drivers were obtained from Ecology's Environmental Information Management (EIM) database. It is important to note that the non-urban Puget Sound dataset has been compiled from various sources, and the datasets from these sources were generally used as reported without further data quality reviews. In addition, the sampling and analytical methods used to produce these datasets varied from study to study. Thus, although these data provide a general indication of the concentrations of these risk drivers in tissues collected throughout Puget Sound, they should not be regarded as a single dataset generated using a consistent methodology that is representative of Puget Sound.

Once the preliminary data had been compiled, criteria for using the data in the non-urban Puget Sound tissue dataset were determined in consultation with EPA and Ecology. The following list summarizes the criteria for including data in this dataset:

- **Species**: Only those species representative of the consumption categories evaluated in the LDW HHRA (i.e., benthic fish, pelagic fish, crabs, clams, and mussels) were included in the dataset. Available data for other species, including shrimp, oysters, and other fish species (e.g., salmon and rockfish[1]) were excluded.

- **Proximity to urban areas:** In consultation with EPA and Ecology, sampling locations near urban areas were excluded from the non-urban Puget Sound tissue dataset. Examples of excluded areas include: Commencement Bay (Tacoma), Elliott Bay (Seattle), Budd Inlet (Olympia), Port Gardner (Everett), Sinclair Inlet (Bremerton), Port Angeles Harbor, and Bellingham Bay.

- **Proximity to known contaminated sources:** In consultation with EPA and Ecology, sampling locations near known contaminant sources were excluded based on consideration of the type, distance, and magnitude of any known sources identified in the Integrated Site Information System (ISIS) and EIM

[1] Rockfish were not included in the non-urban Puget Sound dataset as a surrogate pelagic species for two reasons: 1) rockfish were not included in the LDW market basket because "adult rockfish are likely to constitute a very small component of a seafood consumption scenario because existing data suggest that adult rockfish abundance is low in the LDW" (Windward 2004), and 2) their long life spans may contribute to higher contaminant concentrations than in other pelagic fish with shorter life spans.

databases. Examples of sampling locations excluded based on proximity to a known source include the areas of Fidalgo Bay/March Point (near Anacortes), Point Wells (near Edmonds), Port Washington Narrows (near Bremerton), and Keyport (near Poulsbo).

- **Inorganic arsenic data quality**: For inorganic arsenic, only those data collected as part of the LDW RI/FS specifically for the purpose of evaluating Puget Sound tissue concentrations were used in this dataset. This RI/FS dataset was sufficiently large to meet the goals associated with the non-urban Puget Sound dataset and had already undergone extensive review and validation, whereas the analytical methods and the data quality of the relatively small number of additional available samples analyzed for inorganic arsenic were less well known.

The resulting non-urban Puget Sound tissue dataset contains different numbers of samples for the various risk drivers and tissue types, depending on data availability. Acceptable data are summarized in Tables B-10 through B-13; sampling locations are shown on Figures B-5 through B-12. In summary, the following numbers of samples were available for each risk driver (after filtering based on criteria listed above):

- **Total PCBs**: 344 tissue samples, including 242 fish samples, 17 crab edible-meat samples, 15 crab whole-body samples,[2] and 70 clam samples;
- **Inorganic arsenic**: 81 tissue samples, including 33 fish samples, 12 crab edible-meat samples, 12 crab whole-body samples, and 24 clam samples;
- **cPAHs**: 28 samples, including 1 fish sample, 8 crab edible-meat samples, 7 crab whole-body samples, 1 mussel sample, and 11 clam samples;
- **Dioxins/furans**: 106 samples, including 11 fish samples, 27 crab edible-meat samples, 25 crab whole-body samples, and 43 clam samples.

Fish sample counts included both benthic fish and pelagic fish (although relatively few pelagic fish data were available), crab sample counts were divided by tissue type (i.e., edible-meat and whole-body samples), and clam sample counts included various clam species.

B.4.2 Risk Estimates Based on the Non-Urban Puget Sound Tissue Dataset

This section provides risk estimates calculated using the non-urban Puget Sound tissue dataset. In consultation with EPA, it was agreed that a market basket approach would be used to more closely approximate the approach taken in the LDW HHRA. However, because the available non-urban Puget Sound data did not perfectly match all of the

2 Crab whole-body samples for all risk drivers were calculated based on concentrations in edible meat and hepatopancreas samples, as described in Tables B-10 through B-13.

seafood consumption categories used in the LDW HHRA, a simplified approach was used. The following five consumption categories were used to calculate risks based on the Puget Sound tissue dataset: clams, mussels, crab edible meat, crab whole-body, and fish (pelagic and benthic fish combined) (Table B-4).

In the LDW HHRA, concentrations of the four risk drivers in seafood were represented by an upper confidence limit (UCL). This approach was not selected for the non-urban Puget Sound risk estimates because the compiled dataset represents various studies, sample sizes, and methods. Instead, risk estimates for the four risk drivers were calculated based on the minimum, mean, and maximum values for each consumption category (Table B-14). These values were used to calculate the ingestion-weighted concentrations that were presented in Figures 3-3 through 3-6 in Section 3 of the FS (see Section B.3.1 for details on how these values were calculated).

Excess cancer risk estimates (both for the individual risk drivers and as total risk estimates across all four risk drivers) are shown in Figures B-13 through B-15 and in Table B-15 for the three RME scenarios. Total excess cancer risks ranged from 1×10^{-5} to 6×10^{-5} using minimum exposure values, from 5×10^{-5} to 3×10^{-4} using mean exposure values, and from 2×10^{-4} to 9×10^{-4} using maximum exposure values. Total excess cancer risks were greater than the MTCA threshold of 1×10^{-5} for all scenarios and exposure values with one exception: the total excess cancer risk for the Child Tribal RME scenario using the minimum exposure values was 1×10^{-5}. Additionally, risk estimates for the individual risk drivers were compared with MTCA's 1×10^{-6} excess cancer risk threshold. For inorganic arsenic and dioxin/furan TEQ, excess cancer risks were greater than this threshold regardless of the statistic used (i.e., when minimum, mean, or maximum values were used; Table B-15). For total PCBs and cPAHs, excess cancer risks were greater than this threshold for all scenarios when maximum values were used and for some scenarios (i.e., the Adult Tribal RME and/or Adult API RME scenarios; see Table B-15) when either the minimum or mean values were used.

As shown in Figures B-13 through B-15, the majority of the total excess cancer risk for each of the RME scenarios was attributable to inorganic arsenic and dioxins/furans. The risks associated with inorganic arsenic in the non-urban Puget Sound dataset were attributable primarily to clams (as was the case in the LDW HHRA). Risks associated with dioxins/furans were attributable primarily to clams for risks based on the mean and maximum concentrations but were attributable primarily to fish for risks based on the minimum concentrations. Risks associated with total PCBs and cPAHs were lower, together contributing 5% or less to the total excess cancer risk.

For both total PCBs and inorganic arsenic, non-cancer HQs were less than 1 when using the minimum and mean exposure values. When the maximum exposure values were used, HQs for the three RME scenarios ranged from 0.6 to 3 (Table B-15). The only HQs greater than 1 were those calculated using the maximum exposure values for the Child Tribal RME scenario (the total PCB HQ was equal to 2, and the inorganic arsenic HQ was equal to 3). The proportional contributions of the various seafood consumption categories to the HQs for total PCBs and inorganic arsenic were similar to those to the excess cancer risks (Figures B-13 through B-15). Thus, clams were the primary contributor to the inorganic arsenic HQs, while fish were the primary contributor to the total PCB HQ.

Figures B-16 through B-19 present a comparison of excess cancer risks and non-cancer HQs estimated for the non-urban Puget Sound tissue dataset and those estimated for the LDW HHRA tissue dataset for both total PCBs and inorganic arsenic. For both the non-urban Puget Sound and LDW tissue datasets, the risk estimates shown in these figures were calculated using mean exposure values. The excess cancer risk estimates and non-cancer HQs calculated for total PCBs based on the LDW data were approximately 120 to 200 times higher than those calculated based on the non-urban Puget Sound dataset. For inorganic arsenic, excess cancer risks and non-cancer HQs calculated based on the LDW dataset were also higher than those based on the non-urban Puget Sound dataset; although, unlike PCBs, LDW excess cancer risks and non-cancer HQs were only approximately 5 times higher than those in non-urban Puget Sound locations. The majority of risk for inorganic arsenic (in both these datasets) is attributable to clam consumption. Similar figures were not created for cPAHs because of low detection frequencies in the non-urban Puget Sound tissue dataset. Similar figures were not created for dioxins/furans because insufficient tissue data were available from the LDW to calculate a market basket risk estimate.

B.5 References

Ecology 2000. *Results of a screening analysis for metals and organic compounds in shellfish from Padilla Bay and vicinity*. Publication No. 00-03-008. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. May 2000.

Ecology 2009. *Port Angeles Harbor Sediment Characterization Study, Port Angeles, WA: Sediment Investigation Report*. Draft. Toxics Cleanup Program, Washington State Department of Ecology, Lacey, WA. October 2009.

Era-Miller B. 2006. *South Puget Sound verification of 303(d) listings for chemical contaminants in fish and shellfish tissue*. Publication No. 06-03-026. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. July 2006.

King County 1995. *Water Quality Assessment*. Water Pollution Control Division, King County Department of Natural Resources, Seattle, WA. October 1995.

King County 2000. *Water Quality Status Report for Marine Waters, 1998*. King County Department of Natural Resources, Seattle, WA. July 2000.

King County 2001. *Water Quality Status Report for Marine Waters, 1999 and 2000*. King County Department of Natural Resources, Seattle, WA. September 2001.

King County 2002. *Water Quality Status Report for Marine Waters, 2001*. King County Department of Natural Resources, Seattle, WA. November 2002.

King County 2005. *Water Quality Status Report for Marine Waters, 2002 and 2003*. King County Department of Natural Resources and Parks, Seattle, WA. August 2005.

King County 2006. *Water Quality Status Report for Marine Waters, 2004*. King County Department of Natural Resources and Parks, Seattle, WA. August 2006.

King County 2009. *Water Quality Status Report for Marine Waters, 2005-2007*. King County Department of Natural Resources and Parks, Seattle, WA. April 2009.

Malcolm Pirnie. 2007. *Phase 2 Addendum Remedial Investigation for the Marine Environment Near the Former Rayonier Mill Site*, Port Angeles, Washington. Prepared for Rayonier, Jacksonville, Florida. Malcolm Pirnie, Seattle, WA. Agency Review Draft, February 2007.

Parametrix 2003. Shellfish tissue sampling report and human health risk assessment, former Pope & Talbot, Inc. Mill Site, Port Gamble Bay, Washington. Parametrix, Bremerton, WA. October 2003.

Puget Sound Estuary Program (PSEP) 1991. *Dioxin and furan Concentrations in Puget Sound crabs*. EPA 910/9-91-040. Prepared for the Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Office of Coastal Waters. PTI Environmental Services, Inc., Bellevue, WA. September 1991.

SAIC 2008. *Dioxin/furan concentrations at the non-dispersive open-water dredged material disposal sites in Puget Sound.* Prepared for Washington State Department of Natural Resources. Prepared by Science Applications International Corporation, Bothell, WA. July 2008.

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

West, J.E., S.M. O'Neill, G. Lippert, S. Quinnell 2001. *Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound ambient monitoring program fish component 1989-1999.* Washington Department of Fish and Wildlife, Olympia, WA. August 2001.

Windward Environmental, LLC 2004. Lower Duwamish Waterway Remedial Investigation. *Technical memorandum: Rockfish in the Lower Duwamish Waterway.* Windward Environmental LLC, Seattle, WA. 2004.

Windward 2005a. Lower Duwamish Waterway Remedial Investigation. *Data report: Chemical analyses of benthic invertebrate and clam tissue samples and co-located sediment samples.* Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. May 20, 2005.

Windward 2005b. Lower Duwamish Waterway Remedial Investigation. *Data report: Fish and crab tissue collection and chemical analyses.* Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 27, 2005.

Windward 2006. Lower Duwamish Waterway Remedial Investigation. *Data report: Arsenic concentrations in clam tissue samples and co-located sediment samples collected from background areas in 2005.* Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. April, 3, 2006.

Windward 2007. Lower Duwamish Waterway Remedial Investigation. *Baseline Human Health Risk Assessment*. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. November 12, 2007.

Windward 2009. Lower Duwamish Waterway Remedial Investigation. *Remedial Investigation Report, Appendix B, Baseline Human Health Risk Assessment.* Errata: adjustment to Tulalip Tribes seafood consumption rates and the impact on risk estimates. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 17, 2009.

Windward 2010a. Lower Duwamish Waterway Remedial Investigation. *Remedial Investigation Report.* Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 9, 2010.

Windward 2010b. Lower Duwamish Waterway Remedial Investigation. Technical Memorandum *2009/2010 Surface Sediment Sampling Results for Dioxins and Furans and Other Chemicals.* Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 19, 2010.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
Total PCBs									
1	HHRA	µg/kg dw	3/5	29	3.1 J – 119	19 – 20	maximum detect	120	
	FS	µg/kg dw	2/2 composites	56	26 – 86	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	51	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	µg/kg dw	6/7	100	7.6 J – 290	20	95% KM (t) UCL	180	
	FS	µg/kg dw	7/8	160	7.6 J – 560	20	95% KM (t) UCL	290	ProUCL using only grab data.
3	HHRA	µg/kg dw	11/14	89	2.2 J – 419 J	16 – 17	95% KM (Chebyshev) UCL	240	
	FS	µg/kg dw	14/18	93.5	2.2 J – 419 J	0.8 – 17	95% KM (Chebyshev) UCL	220	ProUCL using only grab data.
4	HHRA	µg/kg dw	12/12	2,800	11 J – 23,000	n/a	95% Adjusted gamma UCL	11,000	
	FS	µg/kg dw	28/29	109,000	11 J – 2,900,000	40	99% KM (Chebyshev) UCL	1,100,000	ProUCL using only grab data.
4 modified[a]	FS – without inlet	µg/kg dw	20/21	443	19.6 – 4,700	40	97.5% KM (Chebyshev) UCL	1,900	ProUCL using only grab data.
	FS – inlet only	µg/kg dw	8/8	395,000	11 J – 2,900,000	n/a	95% Adjusted gamma UCL	5,200,000	ProUCL using only grab data.
5	HHRA	µg/kg dw	31/32	100	24 J – 655	20	95% KM (Chebyshev) UCL	190	
	FS	µg/kg dw	34/36	124	24 J – 860	20	95% KM (Chebyshev) UCL	250	ProUCL using only grab data.
5 modified[b]	FS – south	µg/kg dw	26/28	98.3	24 J – 655	20	95% KM (Chebyshev) UCL	200	ProUCL using only grab samples from southerly two segments of Area 5.
	FS – north	µg/kg dw	8/8	215	52 – 860	n/a	95% Adjusted gamma UCL	480	ProUCL using only grab samples from northerly segment of Area 5.
6	HHRA	µg/kg dw	2/2	540	100 – 970	n/a	maximum detect	970	
	FS	µg/kg dw	1/1 composite	860	860	n/a	composite sample (LDW-SS529-comp)	860	EPC is based on single composite sample collected over an average depth of 41 cm.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
7	HHRA	µg/kg dw	10/14	63	9.8 J – 340	19 – 40	97.5% KM (Chebyshev) UCL	230	
	FS	µg/kg dw	16/22	48	9.8 J – 340	19 – 40	95% KM (BCA) UCL	85	ProUCL using only grab data.
8	HHRA	µg/kg dw	12/18	56	6.1 J – 520	20 – 40	97.5% KM (Chebyshev) UCL	230	
	FS	µg/kg dw	15/22	54.6	6.1 J – 520	20 – 40	95% KM (BCA) UCL	100	ProUCL using only grab data.
Duwamish Waterway Park	HHRA	µg/kg dw	4/5	54	24 J – 104	20	maximum detect	104	
	FS	µg/kg dw	1/1 composite	280	280	n/a	composite sample (LDW-SS533-comp)	280	EPC based on single composite sample collected over an average depth of 43 cm.
Arsenic									
1	HHRA	mg/kg dw	4/4	6.5	3.5 – 14.9	n/a	maximum detect	15	
	FS	mg/kg dw	2/2 composites	17.5	9.6 – 25.3	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	16	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	mg/kg dw	5/5	12.1	3.62 – 20.7	n/a	maximum detect	21	
	FS	mg/kg dw	6/6	13.1	3.62 – 20.7	n/a	95% Student's t UCL	19	ProUCL using only grab data.
3	HHRA	mg/kg dw	6/9	8.5	7.2 – 18.3	3.1 – 6.6	95% KM (percentile bootstrap) UCL	13	
	FS	mg/kg dw	10/13	8.39	5.3 – 18.3	3.1 – 6.6	95% KM (percentile bootstrap) UCL	11	ProUCL using only grab data.
4	HHRA	mg/kg dw	10/10	8.2	2.7 – 17.3	n/a	95% Student's t UCL	11	
	FS	mg/kg dw	25/25	9.35	1.8 – 48.7	n/a	95% approximate gamma UCL	12	ProUCL using only grab data.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
4 modified[a]	FS – without inlet	mg/kg dw	18/18	7.21	1.8 – 17.3	n/a	95% Student's t UCL	8.8	ProUCL using only grab data.
	FS – inlet only	mg/kg dw	7/7	14.9	2.6 – 48.7	n/a	95% approximate gamma UCL	35	ProUCL using only grab data.
5	HHRA	mg/kg dw	22/22	8.1	3.94 – 11.8	n/a	95% Student's t UCL	8.9	
	FS	mg/kg dw	26/26	8.88	3.94 – 19.1	n/a	95% approximate gamma UCL	10	ProUCL using only grab data.
5 modified[b]	FS – south	mg/kg dw	20/20	7.78	3.94 – 11.5	n/a	95% Student's t UCL	8.5	ProUCL using only grab samples from southerly two segments of Area 5.
	FS – north	mg/kg dw	6/6	12.5	6.9 – 19.1	n/a	95% Student's t UCL	16	ProUCL using only grab samples from northerly segment of Area 5.
6	HHRA	mg/kg dw	1/1	9.8	9.8	n/a	maximum detect	9.8	
	FS	mg/kg dw	1/1 composite	93.8	93.8	n/a	composite sample (LDW-SS529-comp)	94	EPC is based on single composite sample collected over an average depth of 41 cm.
7	HHRA	mg/kg dw	9/9	8.9	5.05 J – 13.8	n/a	95% Student's t UCL	11	
	FS	mg/kg dw	14/14	8.2	3.5 – 13.8	n/a	95% Student's t UCL	9.7	ProUCL using only grab data.
8	HHRA	mg/kg dw	11/11	8.7	5.8 – 15.6	n/a	95% Student's t UCL	10	
	FS	mg/kg dw	15/15	8.25	5.8 – 15.6	n/a	95% approximate gamma UCL	9.4	ProUCL using only grab data.
Duwamish Waterway Park	HHRA	mg/kg dw	4/4	7.0	4.9 – 9.2	n/a	maximum detect	9.2	
	FS	mg/kg dw	1/1 composite	4.3	4.3	n/a	composite sample (LDW-SS533-comp)	4.3	EPC based on single composite sample collected over an average depth of 43 cm.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
cPAH TEQ									
1	HHRA	µg/kg dw	3/4	330	23 – 1,200	9.1	maximum detect	1,200	
	FS	µg/kg dw	2/2 composites	380	360 J – 390 J	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	380	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	µg/kg dw	5/5	700	81 J – 3,000	n/a	maximum detect	3,000	
	FS	µg/kg dw	6/6	1,070	81 J – 3,000	n/a	99% Chebyshev (Mean, SD) UCL	7,000	ProUCL using only grab data.
3	HHRA	µg/kg dw	7/9	660	38 – 2,900	35 – 36	95% KM (Chebyshev) UCL	2,100	
	FS	µg/kg dw	10/13	517	38 – 2,800 J	4.3 – 36	95% KM (Chebyshev) UCL	1,500	ProUCL using only grab data.
4	HHRA	µg/kg dw	9/10	200	19 – 750	9.1	97.5% KM (Chebyshev) UCL	730	
	FS	µg/kg dw	23/25	510	19 – 4,800 J	9.1 – 18	95% KM (Chebyshev) UCL	1,400	ProUCL using only grab data.
4 modified[a]	FS – without inlet	µg/kg dw	16/18	275	19 – 1,900	9.1 – 18	95% KM (Chebyshev) UCL	740	ProUCL using only grab data.
	FS – inlet only	µg/kg dw	7/7	1,110	37 – 4,800	n/a	95% approximate gamma UCL	4,000	ProUCL using only grab data.
5	HHRA	µg/kg dw	22/22	210	15 J – 1,000 J	n/a	95% Chebyshev (MVUE) UCL	410	
	FS	µg/kg dw	26/26	424	15 J – 4,400 J	n/a	99% Chebyshev (Mean, SD) UCL	2,200	ProUCL using only grab data.
5 modified[b]	FS – south	µg/kg dw	20/20	93.1	15 J – 190	n/a	95% Student's t UCL	110	ProUCL using only grab samples from southerly two segments of Area 5.
	FS – north	µg/kg dw	6/6	1,530	220 – 4,400	n/a	95% approximate gamma UCL	3,900	ProUCL using only grab samples from northerly segment of Area 5.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
6	HHRA	µg/kg dw	1/1	440	440	n/a	maximum detect	440	
	FS	µg/kg dw	1/1 composite	7,100	7,100 J	n/a	composite sample (LDW-SS529-comp)	7,100	EPC is based on single composite sample collected over an average depth of 41 cm.
7	HHRA	µg/kg dw	8/9	77	24 J – 150	9.4	95% KM (t) UCL	110	
	FS	µg/kg dw	12/14	73	21 J – 150	9.4 – 17	95% KM (t) UCL	98	ProUCL using only grab data.
8	HHRA	µg/kg dw	11/11	230	49 – 620	n/a	95% Student's t UCL	320	
	FS	µg/kg dw	14/15	194	49 – 620	45	95% KM (BCA) UCL	270	ProUCL using only grab data.
Duwamish Waterway Park	HHRA	µg/kg dw	4/4	58.8	32 – 110	n/a	maximum detect	110	
	FS	µg/kg dw	1/1 composite	61	61 J	n/a	composite sample (LDW-SS533-comp)	61	EPC based on single composite sample collected over an average depth of 43 cm.
Dioxin/Furan TEQ									
1	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	2/2 composites	2.42	2.06 J – 2.77 J	n/a	weighted composite samples (41% LDW-SS502-comp; 59% LDW-SS503-comp)	2.5	EPC based on concentrations of two composite samples weighted by area. One of the two composites contained sediment collected over an average depth of 43 cm.
2	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1	74.5	74.5 J	n/a	maximum detect	74.5	EPC based on single grab sample.
3	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1	4.31	4.31 J	n/a	maximum detect	4.31	EPC based on single grab sample.
4	HHRA	ng/kg dw	1/1	412	412 J	n/a	maximum detect	412	
	FS	ng/kg dw	4/4	110	1.69 J – 412 J	n/a	maximum detect	412	EPC based on maximum grab sample.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Beach Play Area	Dataset	Unit	No. Samples with Detected Concentrations/ Total No. Samples	Mean Value	Range of Detects	Range of RLs	Statistic Used	EPC	Notes on FS Dataset EPCs
4 modified[a]	FS – without inlet	ng/kg dw	3/3	9.25	1.69 J – 17.0 J	n/a	maximum detect	17	EPC based on maximum grab sample.
	FS – inlet only	ng/kg dw	1/1	412	412 J	n/a	maximum detect	412	EPC based on single grab sample.
5	HHRA	ng/kg dw	1/1	2.2	2.2 J	n/a	maximum detect	2.2	
	FS	ng/kg dw	4/4 (2 composites and 2 grab samples)	n/a[c]	1.71 J – 35.7 J	n/a	maximum detect	35.7	Maximum of available data (2 composite samples and 2 grab samples).
5 modified[b]	FS – south	ng/kg dw	3/3 (2 composites and 1 grab sample)	n/a[c]	1.71 J – 6.28 J	n/a	maximum detect	6.28 J	Maximum of available data (2 composite samples and 1 grab sample).
	FS – north	ng/kg dw	1/1 (grab sample)	37.5	35.7 J	n/a	maximum detect	35.7	EPC based on single grab sample.
6	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1 composite	8.99	8.99 J	n/a	composite sample (LDW-SS529-comp)	8.99	EPC is based on single composite sample collected over an average depth of 41 cm.
7	HHRA	ng/kg dw	1/1	1.7	1.7	n/a	maximum detect	1.7	
	FS	ng/kg dw	1/1 composite	3.73	3.73 J	n/a	composite sample (LDW-SS544-comp)	3.73	EPC based on single composite sample.
8	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1	3.79	3.79 J	n/a	maximum detect	3.79	EPC based on a single grab sample.
Duwamish Waterway Park	HHRA	ng/kg dw	0/0	n/a	n/a	n/a	n/a	n/a	
	FS	ng/kg dw	1/1 composite	6.28	6.28 J	n/a	composite sample (LDW-SS533-comp)	6.28	EPC based on single composite sample collected over an average depth of 43 cm.

Table B-1 Exposure Point Concentrations and Summary Statistics for Beach Play Areas Using the FS and HHRA Datasets (continued)

Notes:

1. In some cases, the FS dataset appears smaller than the HHRA dataset because a composite sample was used to represent the average concentration of the area.

a. Area 4 modified divided the original Area 4 into two parts. Area 4 modified without inlet excludes samples from the inlet at RM 2.2W. Area 4 modified – inlet only includes only samples from the inlet.

b. Area 5 modified divided the original Area 5 into two parts. Area 5 modified – north includes only the northernmost beach. Area 5 modified – south includes only the two southernmost beaches and excludes the northerly section.

c. Because data were a mixture of composite and grab samples, a mean value was not calculated.

BCA = bias-corrected accelerated; cPAH = carcinogenic polycyclic aromatic hydrocarbon; dw = dry weight; EPC = exposure point concentration; FS = feasibility study; HHRA = human health risk assessment; J = estimated concentration; kg = kilograms; KM = Kaplan-Meier (method for calculating a UCL); LDW = Lower Duwamish Waterway; µg = micrograms; mg = milligrams; MVUE = minimum-variance unbiased eliminator; n/a = not applicable; ng = nanograms; RL = reporting limit; SD = standard deviation; t = t-distribution (statistical method used to calculate the mean for a normally distributed set of samples); TEQ = toxic equivalent; UCL = upper confidence limit on the mean

Table B-2 Updated Risk Estimates for Beach Play Areas

Beach Play Area	Risk Driver	Excess Cancer Risk Estimate		Non-Cancer HQ	
		HHRA Dataset	FS Dataset	HHRA Dataset	FS Dataset
1	Total PCBs	7×10^{-8}	3×10^{-8}	0.02	0.009
	Arsenic	5×10^{-6}	5×10^{-6}	0.1	0.1
	cPAHs[a]	1×10^{-5}	4×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**2×10^{-5}**	**9×10^{-6}**	**n/a**	**n/a**
2	Total PCBs	1×10^{-7}	1×10^{-7}	0.03	0.05
	Arsenic	7×10^{-6}	6×10^{-6}	0.2	0.2
	cPAHs[a]	4×10^{-5}	8×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	3×10^{-6}	n/a[b]	n/a[b]
	Total risk[c]	**5×10^{-5}**	**9×10^{-5}**	**n/a**	**n/a**
3	Total PCBs	1×10^{-7}	1×10^{-7}	0.04	0.04
	Arsenic	4×10^{-6}	4×10^{-6}	0.1	0.1
	cPAHs[a]	3×10^{-5}	1×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**3×10^{-5}**	**1×10^{-5}**	**n/a**	**n/a**
4	Total PCBs	6×10^{-6}	6×10^{-4}	1	187
	Arsenic	4×10^{-6}	4×10^{-6}	0.1	0.1
	cPAHs[a]	8×10^{-6}	1×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	1×10^{-5}	1×10^{-5}	n/a[b]	n/a[b]
	Total risk[c]	**3×10^{-5}**	**6×10^{-4}**	**n/a**	**n/a**
4 modified (without inlet)[d]	Total PCBs	n/a	1×10^{-6}	n/a	0.4
	Arsenic	n/a	3×10^{-6}	n/a	0.09
	cPAHs[a]	n/a	9×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	6×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**1×10^{-5}**	**n/a**	**n/a**
4 modified (inlet only)[d]	Total PCBs	n/a	3×10^{-3}	n/a	883
	Arsenic	n/a	1×10^{-5}	n/a	0.3
	cPAHs[a]	n/a	4×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	2×10^{-5}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**3×10^{-3}**	**n/a**	**n/a**
5	Total PCBs	1×10^{-7}	1×10^{-7}	0.04	0.04
	Arsenic	3×10^{-6}	3×10^{-6}	0.09	0.1
	cPAHs[a]	5×10^{-6}	3×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	8×10^{-8}	1×10^{-6}	n/a[b]	n/a[b]
	Total risk[c]	**8×10^{-6}**	**3×10^{-5}**	**n/a**	**n/a**
5 modified – south[e]	Total PCBs	n/a	1×10^{-7}	n/a	0.04
	Arsenic	n/a	3×10^{-6}	n/a	0.08
	cPAHs[a]	n/a	1×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	2×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**4×10^{-6}**	**n/a**	**n/a**

Table B-2 Updated Risk Estimates for Beach Play Areas (continued)

Beach Play Area	Risk Driver	Excess Cancer Risk Estimate		Non-Cancer HQ	
		HHRA Dataset	FS Dataset	HHRA Dataset	FS Dataset
5 modified – north[e]	Total PCBs	n/a	3×10^{-7}	n/a	0.08
	Arsenic	n/a	6×10^{-6}	n/a	0.2
	cPAHs[a]	n/a	4×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-6}	n/a[b]	n/a[b]
	Total risk[c]	**n/a**	**5×10^{-5}**	**n/a**	**n/a**
6	Total PCBs	5×10^{-7}	5×10^{-7}	0.1	0.1
	Arsenic	3×10^{-6}	3×10^{-5}	0.1	0.9
	cPAHs[a]	5×10^{-6}	8×10^{-5}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	3×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**9×10^{-6}**	**1×10^{-4}**	**n/a**	**n/a**
7	Total PCBs	1×10^{-7}	5×10^{-8}	0.04	0.01
	Arsenic	4×10^{-6}	3×10^{-6}	0.1	0.1
	cPAHs[a]	1×10^{-6}	1×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	6×10^{-8}	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**5×10^{-6}**	**4×10^{-6}**	**n/a**	**n/a**
8	Total PCBs	1×10^{-7}	6×10^{-8}	0.04	0.01
	Arsenic	3×10^{-6}	3×10^{-6}	0.1	0.09
	cPAHs[a]	4×10^{-6}	3×10^{-6}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	1×10^{-7}	n/a[b]	n/a[b]
	Total risk[c]	**7×10^{-6}**	**6×10^{-6}**	**n/a**	**n/a**
Duwamish Waterway Park	Total PCBs	6×10^{-8}	1×10^{-7}	0.01	0.05
	Arsenic	3×10^{-6}	1×10^{-6}	0.09	0.04
	cPAHs[a]	1×10^{-6}	7×10^{-7}	n/a[b]	n/a[b]
	Dioxins/furans	n/a	2×10^{-7}	n/a[b]	n/a[b]
	Total risk	**4×10^{-6}**	**2×10^{-6}**	**n/a**	**n/a**

Notes:

a. cPAHs are presented as benzo(a)pyrene TEQs. Because of the potential for the increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (2005), the risk estimate for beach play RME for cPAHs is based on dose adjustments across the 0-to-6-year-old age range of children. See Section B.5.1 of the HHRA (Windward 2007) for more information.

b. Non-cancer HQs were not calculated for cPAHs or dioxins/furans because no non-cancer RfDs are available for these COCs.

c. Total HHRA excess cancer risk estimates include the risks associated with all COPCs. The total FS excess cancer risk estimates include only the risk drivers listed in this table. In the HHRA (Windward 2007), risks from other COPCs made up 1% or less of the total excess cancer risk for any given beach play area; thus, if the risks for these other COPCs were added, it is unlikely that the total risk estimates presented here would change. No total risks are presented for non-cancer HQs because these sums are not directly interpretable for risk assessment (i.e., HQs are for different endpoints).

d. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2W. Risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only.

e. Area 5 was modified to examine the influence of higher concentrations in the northernmost section. Risks are presented both for Area 5 modified – south and Area 5 modified -- north.

COC = contaminant of concern; COPC = contaminant of potential concern; cPAH = carcinogenic polycyclic aromatic hydrocarbon; EPA = U.S. Environmental Protection Agency; FS = feasibility study; HHRA = human health risk assessment; HQ = hazard quotient; n/a = not applicable; PCB = polychlorinated biphenyl; RfD = reference dose; RME = reasonable maximum exposure; TEQ = toxic equivalent

Table B-3 Average Total PCB Concentrations in the HHRA Tissue Dataset and Species-Specific RBTCs at the 1 × 10^{-4} Risk Level for the Adult Tribal RME Scenario Based on Tulalip Data

Dataset or RBTC Type[a]	Average Total PCB Concentration (µg/kg ww)					
	Clam	Crab EM	Crab WB	Perch WB	English Sole Fillet	Ingestion-Weighted Average
Empirical dataset: HHRA dataset[b]	140	170	890	1,700	700	394
Calculated species-specific RBTCs using the HHRA dataset	15	18	95	181	75	42

Notes:

a. This table presents values used for the example species-specific RBTC calculations discussed in Section B.3.1. Tables B-5 through B-9 present the full range of species-specific RBTCs for all risk driver-scenario-risk level combinations.

b. Includes data collected between 1992 and 2005.

EM = edible meat; HHRA = human health risk assessment; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-4 Seafood Consumption Categories and Consumption Rates Used in the Puget Sound Risk Calculations

Consumption Category	Consumption Rate (g/day)[a]			Comparison with LDW HHRA Consumption Categories
	Adult Tribal RME (Tulalip data)	Child Tribal RME (Tulalip data)	Adult API RME	
Fish	15.6 (15.8 with no mussels)	6.2 (same with no mussels)	7.3 (8.0 with no mussels)	Consumption category is combination of benthic fish and pelagic fish consumption categories in the LDW HHRA.
Clams	43.4 (43.7 with no mussels)	17.4 (17.5 with no mussels)	29.0 (31.8 with no mussels)	Consumption category is the same as that in the LDW HHRA, except it includes all available clam species.
Mussels	0.8	0.3	4.6	Consumption category is the same as that in the LDW HHRA
Crab – edible meat	28.7 (28.9 with no mussels)	11.5 (11.6 with no mussels)	5.7 (6.3 with no mussels)	Consumption category is the same as that in the LDW HHRA.
Crab – whole-body	9.0 (9.1 with no mussels)	3.6 (same with no mussels)	4.9 (5.4 with no mussels)	Consumption category is the same as that in the LDW HHRA.

Notes:

a. Consumption rates are the same as those used in the LDW HHRA (Windward 2007, 2009). Additionally, as was done in the LDW HHRA for COPCs for which no mussel data were available, the proportion of the consumption rate attributed to mussels was distributed proportionally to the other consumption groups when no mussel data were available.

API = Asian and Pacific Islanders; COPC = contaminant of potential concern; g/day = grams per day; HHRA = human health risk assessment; LDW = Lower Duwamish Waterway; RME = reasonable maximum exposure

Table B-5 Species-Specific Tissue RBTCs for Total PCBs for the Adult Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Basis for Species-Specific Ratios	Risk Level	Total PCB RBTC (µg/kg ww)					
		Ingestion-weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish Fillet
RBTCs for 1 × 10^{-4} risk level							
Empirical data: HHRA database[a]	1 × 10^{-4}	42	15	18	95	181	75
Empirical data: 2007 LDW data	1 × 10^{-4}	42	32	12	53	138	97
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-4}	42	12	18	92	152	128
RBTC ranges for 1 × 10^{-4}		**42**	**12 – 32**	**12 – 18**	**53 – 95**	**138 – 181**	**75 – 128**
RBTCs for 1 × 10^{-5} risk level							
Empirical data: HHRA database[a]	1 × 10^{-5}	4.2	1.5	1.8	9.5	18	7.5
Empirical data: 2007 LDW data	1 × 10^{-5}	4.2	3.2	1.2	5.3	14	9.7
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-5}	4.2	1.2	1.8	9.2	15	13
RBTC ranges for 1 × 10^{-5}		**4.2**	**1.2 – 3.2**	**1.2 – 1.8**	**5.3 – 9.5**	**14 – 18**	**7.5 – 13**
RBTCs for 1 × 10^{-6} risk level							
Empirical data: HHRA database[a]	1 × 10^{-6}	0.42	0.15	0.18	0.95	1.8	0.75
Empirical data: 2007 LDW data	1 × 10^{-6}	0.42	0.32	0.12	0.53	1.4	0.97
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-6}	0.42	0.12	0.18	0.92	1.5	1.3
RBTC ranges for 1 × 10^{-6}		**0.42**	**0.12 – 0.32**	**0.12 – 0.18**	**0.53 – 0.95**	**1.4 – 1.8**	**0.75 – 1.3**
RBTCs for HQ = 1							
Empirical data: HHRA database[a]	HQ = 1	17	6.0	7.3	38	73	30
Empirical data: 2007 LDW data	HQ = 1	17	13	4.8	21	56	39
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	HQ = 1	17	4.7	7.3	37	62	52
RBTC ranges for HQ = 1		**17**	**4.7 – 13**	**4.8 – 7.3**	**21 – 38**	**56 – 73**	**30 – 52**

Notes:
a. Includes data collected between 1992 and 2005.

dw = dry weight; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ =hazard quotient; LDW = Lower Duwamish Waterway; µg/kg = micrograms per kilogram; ng/L = nanograms per liter; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-6 Species-Specific Tissue RBTCs for Total PCBs for the Child Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Basis for Species-Specific Ratios	Risk Level	Total PCB RBTC (µg/kg ww)					
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish Fillet
RBTCs for 1 × 10⁻⁴ risk level							
Empirical data: HHRA database[a]	1×10^{-4}	230	82	100	523	1,000	412
Empirical data: 2007 LDW data	1×10^{-4}	230	176	65	291	760	534
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1×10^{-4}	230	64	100	509	840	706
RBTC ranges for 1 × 10^{-4}		**230**	**64 – 176**	**65 – 100**	**291 – 523**	**760 – 1,000**	**412 – 706**
RBTCs for 1 × 10^{-5} risk level							
Empirical data: HHRA database[a]	1×10^{-5}	23	8.2	10	52	100	41
Empirical data: 2007 LDW data	1×10^{-5}	23	18	6.5	29	76	53
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1×10^{-5}	23	6.4	10	51	84	71
RBTC ranges for 1 × 10^{-5}		**23**	**6.4 – 18**	**6.5 – 10**	**29 – 52**	**76 – 100**	**41 – 71**
RBTCs for 1 × 10^{-6} risk level							
Empirical data: HHRA database[a]	1×10^{-6}	2.3	0.82	1.0	5.2	10	4.1
Empirical data: 2007 LDW data	1×10^{-6}	2.3	1.8	0.65	2.9	7.6	5.3
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1×10^{-6}	2.3	0.64	1.0	5.1	8.4	7.1
RBTC ranges for 1 × 10^{-6}		**2.3**	**0.64 – 1.8**	**0.65 – 1.0**	**2.9 – 5.2**	**7.6 – 10**	**4.1 – 7.1**
RBTCs for HQ = 1							
Empirical data: HHRA database[a]	HQ = 1	7.8	2.8	3.4	18	34	14
Empirical data: 2007 LDW data	HQ = 1	7.8	6.0	2.2	9.9	26	18
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	HQ = 1	7.8	2.2	3.4	17	28	24
RBTC ranges for HQ = 1		**7.8**	**2.2 – 6.0**	**2.2 – 3.4**	**9.9 – 18**	**26 – 34**	**14 – 24**

Notes:
a. Includes data collected between 1992 and 2005.

dw = dry weight; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; LDW = Lower Duwamish Waterway; µg/kg = micrograms per kilogram; ng/L = nanograms per liter; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-7 Species-Specific Tissue RBTCs for Total PCBs for the Adult API RME Seafood Consumption Scenario

Basis for Species-Specific Ratios	Risk Level	Total PCB RBTC (µg/kg ww)						
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish WB	Benthic Fish Fillet
RBTCs for 1 × 10^{-4} risk level								
Empirical data: HHRA database[a]	1 × 10^{-4}	140	46	56	293	559	723	230
Empirical data: 2007 LDW data	1 × 10^{-4}	140	96	35	158	412	560	290
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-4}	140	38	60	305	503	803	422
RBTC ranges for 1 × 10^{-4}		**140**	**38 – 96**	**35 – 60**	**158 – 305**	**412 – 559**	**560 – 803**	**230 – 422**
RBTCs for 1 × 10^{-5} risk level								
Empirical data: HHRA database[a]	1 × 10^{-5}	14	4.6	5.6	29	56	72	23
Empirical data: 2007 LDW data	1 × 10^{-5}	14	9.6	3.5	16	41	56	29
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-5}	14	3.8	6.0	30	50	80	42
RBTC ranges for 1 × 10^{-5}		**14**	**3.8 – 9.6**	**3.5 – 6.0**	**16 – 30**	**41 – 56**	**56 – 80**	**23 – 42**
RBTCs for 1 × 10^{-6} risk level								
Empirical data: HHRA database[a]	1 × 10^{-6}	1.4	0.46	0.56	2.9	5.6	7.2	2.3
Empirical data: 2007 LDW data	1 × 10^{-6}	1.4	1.0	0.35	1.6	4.1	5.6	2.9
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	1 × 10^{-6}	1.4	0.38	0.60	3.0	5.0	8.0	4.2
RBTC ranges for 1 × 10^{-6}		**1.4**	**0.38 – 0.96**	**0.35 – 0.60**	**1.6 – 3.0**	**4.1 – 5.6**	**5.6 – 8.0**	**2.3 – 4.2**
RBTCs for HQ = 1								
Empirical data: HHRA database[a]	HQ = 1	24	7.9	9.6	50	96	124	39
Empirical data: 2007 LDW data	HQ = 1	24	16	6.1	27	71	96	50
FWM results: sediment = 380 µg/kg dw; water = 1.2 ng/L	HQ = 1	24	6.6	10	52	86	138	72
RBTC ranges for HQ = 1		**24**	**6.6 – 16**	**6.1 – 10**	**27 – 52**	**71 – 96**	**96 – 138**	**39 – 72**

Notes:
a. Includes data collected between 1992 and 2005.

API = Asian and Pacific Islander; dw = dry weight; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; LDW = Lower Duwamish Waterway; µg/kg = micrograms per kilogram; ng/L = nanograms per liter; PCB = polychlorinated biphenyl; RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body; ww = wet weight

Table B-8 Species-Specific Tissue RBTCs for Inorganic Arsenic for the RME Seafood Consumption Scenarios

Basis for Species-Specific Ratios	Risk Level	Inorganic Arsenic RBTC (mg/kg ww)						
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish WB	Benthic Fish Fillet
Adult Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	0.056	0.12	0.0022	0.0073	0.0056	n/a	0.00039
Empirical data: HHRA database[a]	1×10^{-5}	0.0056	0.012	0.00022	0.00073	0.00056	n/a	0.000039
Empirical data: HHRA database[a]	1×10^{-6}	0.00056	0.0012	0.000022	0.000073	0.000056	n/a	0.0000039
Empirical data: HHRA database[a]	HQ = 1	0.25	0.54	0.010	0.033	0.025	n/a	0.0017
Child Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	0.30	0.65	0.012	0.039	0.030	n/a	0.0021
Empirical data: HHRA database[a]	1×10^{-5}	0.030	0.065	0.0012	0.0039	0.0030	n/a	0.00021
Empirical data: HHRA database[a]	1×10^{-6}	0.0030	0.0065	0.00012	0.00039	0.00030	n/a	0.000021
Empirical data: HHRA database[a]	HQ = 1	0.12	0.26	0.0048	0.016	0.012	n/a	0.00083
Adult API RME Scenario								
Empirical data: HHRA database[a]	1×10^{-4}	0.19	0.30	0.0056	0.018	0.014	0.014	0.00097
Empirical data: HHRA database[a]	1×10^{-5}	0.019	0.030	0.00056	0.0018	0.0014	0.0014	0.000097
Empirical data: HHRA database[a]	1×10^{-6}	0.0019	0.0030	0.000056	0.00018	0.00014	0.00014	0.0000097
Empirical data: HHRA database[a]	HQ = 1	0.37	0.59	0.011	0.035	0.027	0.026	0.0019

Notes:

a. Includes data collected between 1992 and 2005. Inorganic arsenic data were not collected for all consumption categories in 2007.

API = Asian and Pacific Islander; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; mg/kg = milligrams per kilogram; n/a = not applicable (not part of the diet for this scenario); RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; WB = whole-body

Table B-9 Species-Specific Tissue RBTCs for cPAHs for the RME Seafood Consumption Scenarios

Basis for Species-Specific Ratios	Risk Level	cPAH RBTC (µg TEQ /kg ww)						
		Ingestion-Weighted	Clams	Crab EM	Crab WB	Pelagic Fish WB	Benthic Fish WB	Benthic Fish Fillet
Adult Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	11	24	0.69	1.2	1.2	n/a	0.61
Empirical data: HHRA database[a]	1×10^{-5}	1.1	2.4	0.069	0.12	0.12	n/a	0.061
Empirical data: HHRA database[a]	1×10^{-6}	0.11	0.24	0.0069	0.012	0.012	n/a	0.0061
Child Tribal RME Scenario based on Tulalip data								
Empirical data: HHRA database[a]	1×10^{-4}	12	26	0.75	1.3	1.3	n/a	0.66
Empirical data: HHRA database[a]	1×10^{-5}	1.2	2.6	0.075	0.13	0.13	n/a	0.066
Empirical data: HHRA database[a]	1×10^{-6}	0.12	0.26	0.0075	0.013	0.013	n/a	0.0066
Adult API RME Scenario								
Empirical data: HHRA database[a]	1×10^{-4}	39	61	1.8	3.1	3.2	5.7	1.6
Empirical data: HHRA database[a]	1×10^{-5}	3.9	6.1	0.18	0.31	0.32	0.57	0.16
Empirical data: HHRA database[a]	1×10^{-6}	0.39	0.61	0.018	0.031	0.032	0.057	0.016

Notes:
a. Includes data collected between 1992 and 2005. cPAH tissue data were not collected in 2007.

API = Asian and Pacific Islander; cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; FWM = food web model; HHRA = human health risk assessment; HQ = hazard quotient; µg/kg = micrograms per kilogram; n/a = not applicable (not part of the diet for this scenario); RBTC = risk-based threshold concentration; RME = reasonable maximum exposure; TEQ = toxic equivalent; WB = whole-body

Table B-10 Total PCB Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year(s)	Detection Frequency	Individuals per Composite (Average)	Total PCB Concentration[a] (µg/kg ww)			Source
						Mean[b]	Minimum	Maximum	
Clams									
Butter clam	soft parts	Various locations[c]	1994 – 2005	0/42	NS	nc	2.5 U	6.5 U	King County 1995, 2000, 2001, 2002, 2005, 2006, 2009
Butter clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	2.5 U	2.5 U	Ecology 2000
Littleneck clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	2.5 U	2.5 U	Ecology 2000
Littleneck clam	soft parts	Salsbury Point	2003	0/2	NS (10-20)	nc	2.5 U	2.6 U	Parametrix 2003
Geoduck	edible meat	Freshwater Bay[d]	2006	8/8	1	0.64	0.24	1.43	Malcolm Pirnie 2007[e]
	gut ball			5/5	1	1.35	0.92	2.10	
Horse clam	edible meat	Dungeness Bay[d]	2006	8/8	1	0.12	0.09	0.14	Malcolm Pirnie 2007[e]
	gut ball			5/5	1	1.26	0.95	1.49	
Horse clam	edible meat	Freshwater Bay[d]	2006	8/8	1	0.14	0.10	0.23	Malcolm Pirnie 2007[e]
	gut ball			5/5	1	1.66	1.35	2.14	
Crabs									
Dungeness crab	edible meat	Padilla/Fidalgo Bay	1999	2/2	5	1.3	1.2 J	1.4 J	Ecology 2000
Dungeness crab	edible meat	Dungeness Bay[d]	2006	7/7	1	1.02	0.46	1.92	Malcolm Pirnie 2007[e]
	hepatopancreas			7/7	1	25.0	13.1	49.5	
	calculated whole-body[f]			7/7	1	8.44	4.39	16.0	
Dungeness crab	edible meat	Freshwater Bay[c]	2006	8/8	1	0.62	0.43	0.99	Malcolm Pirnie 2007[e]
	hepatopancreas			8/8	1	17.8	8.80	32.3	
	calculated whole-body[f]			8/8	1	5.96	3.03	10.7	

Table B-10 Total PCB Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites (continued)

Species	Tissue Type	Sampling Location	Sampling Year(s)	Detection Frequency	Individuals per Composite (Average)	Total PCB Concentration[a] (µg/kg ww)			Source
						Mean[b]	Minimum	Maximum	
Benthic fish									
English sole	fillet	PSAMP – non urban[g]	1989 – 1999	117/189	15.2	11.6	1.3	50.8	West et al. 2001
English sole	fillet	PSAMP – near urban[g]	1989 – 1999	36/42	13.6	15.9	2.0	75.4	West et al. 2001
English sole	fillet	Case Inlet/Dana Passage	2005	3/3	4.7	8.5	5.6 J	13.2 J	Era-Miller 2006
English sole	fillet	Pickering Passage	2005	0/2	5	nc	5.5 U	5.6 U	Era-Miller 2006
English sole	fillet	South Puget Sound	2005	2/2	20	6.5	6.1 J	6.8 J	Era-Miller 2006
Rock sole	fillet	Carr Inlet	2005	0/1	5	nc	5.5 U	5.5 U	Era-Miller 2006
Rock sole	fillet	Case Inlet/Dana Passage	2005	0/1	5	nc	5.5 U	5.5 U	Era-Miller 2006
Rock sole	fillet	Hale Passage	2005	0/2	5	nc	5.1 U	5.5 U	Era-Miller 2006

Note: Rows highlighted in light green indicate new total PCB tissue concentrations in fish and shellfish collected from Puget Sound locations outside of known contaminated sites, not previously reported in the RI (Windward 2010a).

a. For PCB Aroclors, the total PCB concentration represents the sum of detected concentrations of up to nine individual PCB Aroclors for a given sample. For samples in which none of the individual Aroclors were detected, the maximum RL for an individual PCB Aroclor in that sample is used as the concentration. For PCB congeners, the total PCB concentration represents the sum of the detected PCB congener concentrations for a given sample.

b. Mean concentrations were calculated using one-half of the RL for non-detect values. A mean value was not calculated when there were no detected values.

c. Locations include Edmonds, Carkeek Park, Golden Gardens, Alki Point, Vashon Island, and Normandy Park. Data for clams collected by King County were compiled from seven King County reports (1995, 2000, 2001, 2002, 2005, 2006, 2009).

d. Dungeness Bay and Freshwater Bay were the reference sites used in the Rayonier Mill RI near Port Angeles, Washington (Malcom Pirnie 2007).

e. The total PCB concentrations in this study were analyzed as PCB congeners.

f. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Total PCB concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

g. PSAMP data are from various non-urban and near-urban sites around Puget Sound (Figure B-5).

cm = centimeters; J = estimated concentration; µg/kg = micrograms per kilogram; nc = not calculated (no detected values); NS = not specified; PCB = polychlorinated biphenyl; PSAMP = Puget Sound Ambient Monitoring Program; RI = remedial investigation; RL = reporting limit; U = not detected; ww = wet weight

Table B-11 Inorganic Arsenic Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Inorganic Arsenic Concentration (mg/kg ww)			Source
						Mean[a]	Minimum	Maximum	
Clams									
Various species[b]	soft parts	Bainbridge Island	2004	6/6	22.0	0.201	0.0440 J	0.485 J	Windward 2005a
Various species[b]	soft parts	Seahurst Park	2004	6/6	21.7	0.443	0.0980 J	0.616 J	Windward 2005a
Eastern soft-shell clam	soft parts	Dungeness NWR	2005	6/6	11.7	0.0637	0.0470	0.112	Windward 2006
Eastern soft-shell clam	soft parts	Vashon Island	2005	6/6	19.8	0.145	0.0930	0.227	Windward 2006
Crabs									
Dungeness and slender crabs[c]	edible meat	Blake Island	2004	6/6	4.3	0.023	0.020	0.030	Windward 2005b
	hepatopancreas			2/2	13	0.31	0.27	0.34	
	calculated whole-body[d]			6/6	4.3	0.11	0.098	0.13	
Dungeness and slender crabs[c]	edible meat	East Passage	2004	6/6	5	0.018	0.010 J	0.040	Windward 2005b
	hepatopancreas			2/2	15	0.08	0.08	0.08	
	calculated whole-body[d]			6/6	5	0.037	0.032 J	0.052	
Pelagic fish									
Shiner surfperch	whole-body	Blake Island	2004	6/6	10	0.02	0.01	0.03	Windward 2005b
Shiner surfperch	whole-body	East Passage	2004	2/3	5.7	0.008	0.009 J	0.01 J	Windward 2005b
Benthic fish									
English sole	fillet	Blake Island	2004	2/6	4	0.003	0.002	0.01 U	Windward 2005b
	whole-body			6/6	4	0.02	0.01	0.03	
English sole	fillet	East Passage	2004	1/6	4	0.002	0.003 U	0.004 J	Windward 2005b
	whole-body			6/6	4	0.01	0.007 J	0.02	

Notes:

a. Mean concentrations were calculated using one-half of the RL for non-detect values.

b. Composite clam tissue samples from Seahurst Park and Bainbridge Island included multiple species (butter clam, cockle, bent-nose clam, white sand macoma, horse clam, and littleneck clam).

c. Each composite sample was made up of either Dungeness or slender crab specimens. Half the total number of samples is from each species.

d. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Arsenic concentrations in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

cm = centimeters; mg/kg = milligrams per kilogram; NWR = National Wildlife Refuge; J = estimated concentration; RI = remedial investigation; RL = reporting limit; U = not detected; ww = wet weight

Table B-12 Carcinogenic PAH Concentrations in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Carcinogenic PAH[a] (µg TEQ/kg ww)			Source
						Mean[b]	Minimum	Maximum	
Clams									
Butter clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	0.851 U	0.851 U	Ecology 2000
Littleneck clam	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	0.878 U	0.878 U	Ecology 2000
Littleneck clam	soft parts	Salsbury Point	2003	0/2	NS (10-20)	nc	0.114 U	0.114 U	Parametrix 2003
Geoduck	soft parts	Freshwater Bay[c]	2002	1/3	1	0.123	0.114 U	0.142	Malcolm Pirnie 2007
Geoduck	soft parts	Dungeness Bay[c]	2002	1/3	1	0.133	0.114 U	0.171	Malcolm Pirnie 2007
Geoduck	soft parts	Dungeness Bay	2008	1/1	2	0.069	0.069	0.069	Ecology 2009
Mussels									
Bay mussel	soft parts	Padilla/Fidalgo Bay	1999	0/1	50	nc	0.860 U	0.860 U	Ecology 2000
Crabs									
Dungeness crab	edible meat	Padilla/Fidalgo Bay	1999	0/2	5	nc	0.935 U	1.63 U	Ecology 2000
	hepatopancreas			0/1	5	nc	0.896 U	0.896 U	
	calculated whole-body[d]			0/1	5	nc	0.923 U	0.923 U	
Dungeness crab	edible meat	Dungeness Bay[c]	2002	0/3	1	nc	0.114 U	0.114 U	Malcolm Pirnie 2007
	hepatopancreas			0/3	1	nc	0.114 U	0.114 U	
	calculated whole-body[d]			0/3	1	nc	0.114 U	0.114 U	
Dungeness crab	edible meat	Freshwater Bay[c]	2002	0/3	1	nc	0.114 U	0.114 U	Malcolm Pirnie 2007
	hepatopancreas			0/3	1	nc	0.114 U	0.114 U	
	calculated whole-body[d]			0/3	1	nc	0.114 U	0.114 U	
Benthic fish									
Starry flounder	fillet	Dungeness Bay[c]	2002	0/1	1	nc	0.114 U	0.114 U	Malcolm Pirnie 2007

Notes:

a. cPAH TEQs were calculated by summing the products of individual PAH concentrations and compound-specific PEFs for the seven individual cPAH compounds (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene). cPAH TEQs were considered detected if one or more of the individual cPAH compounds were detected. For non-detect cPAH compounds, one-half the RL was multiplied by the PEF when calculating cPAH TEQs.

b. A mean value was not calculated when there were no detected values.

c. Dungeness Bay and Freshwater Bay were the reference sites used in the Rayonier Mill RI near Port Angeles, Washington (Malcom Pirnie 2007).

d. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. cPAH TEQs in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

µg/kg = micrograms per kilogram; nc = not calculated (no detected values); NS = not specified (range of individuals); cPAH = carcoinogenic polycyclic aromatic hydrocarbon; PEF = potency equivalency factor; RI = remedial investigation; TEQ = toxic equivalent; U = not detected; ww = wet weight

Table B-13 Dioxins/Furans in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Dioxins/Furans[a] (ng TEQ/kg ww) Mean	Minimum	Maximum	Source
Clams									
Butter clam	soft parts	Padilla/Fidalgo Bay	1999	1/1	50	0.907	0.907	0.907	Ecology 2000
Littleneck clam	soft parts	Padilla/Fidalgo Bay	1999	1/1	50	1.63	1.63	1.63	Ecology 2000
Littleneck clam	soft parts	Salsbury Point	2003	2/2	NS (10-20)	0.249	0.232	0.266	Parametrix 2003
Geoduck	whole-body	Dungeness Bay[b]	2002	3/3	1	0.263	0.220	0.297	Malcolm Pirnie 2007
Geoduck	edible meat	Freshwater Bay[b]	2006	8/8	1	0.025	0.016	0.038	Malcolm Pirnie 2007
	gut ball		2006	5/5	1	0.068	0.055	0.099	
	whole-body		2002	3/3	1	0.226	0.212	0.238	
Horse clam	edible meat	Dungeness Bay[b]	2006	8/8	1	0.038	0.011	0.161	Malcolm Pirnie 2007
	gut ball		2006	5/5	1	0.045	0.029	0.061	
	whole-body		2002	3/3	1	0.259	0.209	0.318	
Horse clam	edible meat	Freshwater Bay[b]	2006	8/8	1	0.033	0.017	0.062	Malcolm Pirnie 2007
	gut ball		2006	5/5	1	0.060	0.047	0.075	
	whole-body		2002	3/3	1	0.252	0.247	0.259	
Geoduck	whole-body	Dungeness Bay	2008	1/1	1	1.42	1.42	1.42	Ecology 2009
Horse clam	whole-body	Dungeness Bay	2008	2/2	4.5	1.5	1.42	1.57	Ecology 2009
Crabs									
Dungeness crab	edible meat	Dungeness Bay/Skagit Bay	1991	1/1	3	0.332	0.332	0.332	PSEP 1991
	hepatopancreas			2/2	3	2.12	1.64	2.60	
	calculated whole-body[c]			1/1	3	0.844	0.844	0.844	
Dungeness crab	edible meat	Padilla/Fidalgo Bay	1999	2/2	5	1.27	1.16	1.37	Ecology 2000
Dungeness crab	edible meat	Dungeness Bay[b]	2002, 2006	10/10	1	0.102	0.044	0.273	Malcolm Pirnie 2007
	hepatopancreas			10/10	1	0.736	0.266	1.43	
	calculated whole-body[c]			10/10	1	0.315	0.132	0.589	

Table B-13 Dioxins/Furans in Fish and Shellfish Collected from Non-Urban Puget Sound Locations Outside of Known Contaminated Sites (continued)

Species	Tissue Type	Sampling Location	Sampling Year	Detection Frequency	Individuals Per Composite (Average)	Dioxins/Furans[a] (ng TEQ/kg ww)			Source
						Mean	Minimum	Maximum	
Dungeness crab	edible meat	Freshwater Bay[b]	2002, 2006	11/11	1	0.112	0.027	0.381	Malcolm Pirnie 2007
	hepatopancreas			11/11	1	0.397	0.182	0.706	
	calculated whole-body[c]			11/11	1	0.224	0.089	0.422	
Dungeness crab	edible meat	Anderson-Ketron disposal site	2007	3/3	5	0.467	0.214	0.716	SAIC 2008
	hepatopancreas			3/3	5	13.5	11.5	14.9	
	calculated whole-body[c]			3/3	5	4.51	3.90	5.12	
Benthic fish									
Rock sole	whole- body	Dungeness Bay[b]	2002	1/1	1	0.152	0.152	0.152	Malcolm Pirnie 2007
Rock sole	whole-body	Freshwater Bay[b]	2002	3/3	1	0.320	0.257	0.417	Malcolm Pirnie 2007
	fillet			2/2	1	0.179	0.166	0.191	
Starry flounder	fillet	Dungeness Bay[b]	2002	2/2	1	0.663	0.404	0.923	Malcolm Pirnie 2007
English sole	whole-body	Anderson-Ketron disposal site	2007	3/3	5	0.286	0.172	0.345	SAIC 2008

Notes:

a. Dioxin/furan TEQs were calculated by summing the products of individual congener concentrations and congener-specific TEFs. A dioxin/furan TEQ value was considered detected if one or more of the congeners were detected. For non-detect congeners, the TEF was multiplied by one-half the RL.

b. Dungeness Bay and Freshwater Bay were the reference sites used in the Rayonier Mill RI near Port Angeles, Washington (Malcom Pirnie 2007).

c. Data from composite hepatopancreas samples were mathematically combined with data from composite samples of edible meat to form composite samples of edible meat plus hepatopancreas. Dioxin/furan TEQs in whole-body (i.e., edible meat plus hepatopancreas) crab were calculated assuming 69% (by weight) edible meat and 31% hepatopancreas, based on the relative weights of these tissues in a 16.6-cm Dungeness crab dissected by Windward in 2004 (unpublished data).

cm = centimeters; ng/kg = nanograms per kilogram; NS = not specified (range of individuals); RI = remedial investigation; RL = reporting limit; TEF = toxic equivalency factor; TEQ = toxic equivalent; U = not detected; ww = wet weight

Table B-14 Exposure Concentrations Used for the Non-Urban Puget Sound Risk Calculations

Risk Driver and Seafood Consumption Category	Detection Frequency	Exposure Concentration		
		Minimum[a]	Mean[b]	Maximum[a]
Total PCBs[c] (µg/kg ww)				
Clams	24/70	0.09	0.3	1.43
Mussels	nd	nd	nd	nd
Crab – edible meat	17/17	0.43	0.86	1.92
Crab – whole-body	15/15	3.03	7.1	16
Fish (benthic fish fillet)[d]	158/242	1.3	11	75.4
Inorganic arsenic (mg/kg ww)				
Clams	24/24	0.044 J	0.21	0.62 J
Mussels	nd	nd	nd	nd
Crab – edible meat	12/12	0.01	0.02	0.04
Crab – whole-body	12/12	0.032	0.075	0.13
Fish (benthic fish fillet, pelagic fish)[d]	11/21	0.002	0.008	0.03
Fish (benthic fish fillet and whole-body, pelagic fish)[d]	23/33	0.002	0.01	0.03
cPAHs [e] (µg TEQ/kg ww)				
Clams	3/11	0.069	0.088	0.171
Mussels	0/1	0.860 U	0.860 U	0.860 U
Crab – edible meat	0/8	0.114 U	0.406[f]	1.63 U
Crab – whole-body	0/7	0.114 U	0.230[f]	0.923 U
Fish (benthic fish fillet)[d]	0/1	0.114 U	0.114[f]	0.114 U
Dioxins/furans [g] (ng TEQ /kg ww)				
Clams	43/43	0.011	0.26	1.63
Mussels	nd	nd	nd	nd
Crab – edible meat	27/27	0.027	0.24	1.37
Crab – whole- body	25/25	0.089	0.81	5.12
Fish (benthic fish fillet)[d]	4/4	0.166	0.421	0.923
Fish (benthic fish fillet and whole-body)[d]	11/11	0.152	0.332	0.923

Notes:

a. Minimum and maximum values are minimum or maximum detected concentrations when available. For cPAH TEQ, no detected results were available for the mussel, crab, and fish consumption categories, and thus the non-detect results were used.

b. Mean values were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan Meier mean for the dataset.

c. For PCB Aroclors, the total PCB concentration represents the sum of detected PCB Aroclors for a given sample. For samples in which none of the individual Aroclors were detected, the maximum RL for any of the Aroclors in that sample is used as the concentration. For PCB congeners, the total PCB concentration represents the sum of the detected PCB congener concentrations for a given sample.

d. Exposure concentrations for the fish consumption category were calculated two ways when whole-body benthic fish data were available: both with and without whole-body benthic fish data. The Adult and Child Tribal RME scenarios based on Tulalip data assume that no consumption of whole-body benthic fish occurs, and thus the concentrations calculated without whole-body benthic fish data are used for these scenarios. The Adult API RME scenario assumes that some whole-body benthic fish is consumed, and thus the exposure concentrations that include whole-body benthic fish data are used for this scenario.

e. cPAH TEQs were calculated by summing the products of individual PAH concentrations and compound-specific PEFs for the seven individual cPAH compounds (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k) fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene). cPAH TEQs were considered detected if one or more individual cPAH compounds were detected. For non-detect cPAH compounds, one-half the RL was multiplied by the PEF when calculating cPAH TEQs.

f. There were no detected values for these consumption categories, and thus these mean values were based on cPAH TEQs calculated using half RLs (as described in footnote e).

g. Dioxin/furan TEQs were calculated by summing the products of individual congener concentrations and congener-specific TEFs. A dioxin/furan TEQ value was considered detected if one or more congeners were detected. For non-detect congeners, the TEF was multiplied by one-half the RL.

API = Asian and Pacific Islander; cPAH = carcinogenic polycyclic aromatic hydrocarbon; µg/kg = micrograms per kilogram; mg/kg = milligrams per kilogram; nd = no data; ng/kg nanograms per kilogram; PCB = polychlorinated biphenyl; PEF = potency equivalency factor; RL = reporting limit; RME = reasonable maximum exposure; TEF = toxic equivalency factor; TEQ = toxic equivalent; U = not detected; ww = wet weight

Table B-15 Risks Calculated for the Three RME Seafood Consumption Scenarios Using the Non-Urban Puget Sound Tissue Dataset

Seafood Consumption Scenario	Excess Cancer Risks			Non-Cancer HQs		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Total PCBs						
Adult Tribal RME (Tulalip data)	2×10^{-6}	7×10^{-6}	4×10^{-5}	0.04	0.2	0.9
Child Tribal RME (Tulalip data)	3×10^{-7}	1×10^{-6}	6×10^{-6}	0.08	0.4	2
Adult API RME	4×10^{-7}	2×10^{-6}	1×10^{-5}	0.03	0.1	0.6
Inorganic Arsenic						
Adult Tribal RME (Tulalip data)	5×10^{-5}	2×10^{-4}	5×10^{-4}	0.1	0.4	1
Child Tribal RME (Tulalip data)	9×10^{-6}	4×10^{-5}	1×10^{-4}	0.2	0.9	3
Adult API RME	2×10^{-5}	8×10^{-5}	2×10^{-4}	0.09	0.4	1
cPAHs						
Adult Tribal RME (Tulalip data)	9×10^{-7}	2×10^{-6}	9×10^{-6}	n/a	n/a	n/a
Child Tribal RME (Tulalip data)	2×10^{-7}	3×10^{-7}	2×10^{-6}	n/a	n/a	n/a
Adult API RME	4×10^{-7}	5×10^{-7}	2×10^{-6}	n/a	n/a	n/a
Dioxins/Furans						
Adult Tribal RME (Tulalip data)	9×10^{-6}	6×10^{-5}	3×10^{-4}	n/a	n/a	n/a
Child Tribal RME (Tulalip data)	2×10^{-6}	1×10^{-5}	6×10^{-5}	n/a	n/a	n/a
Adult API RME	2×10^{-6}	2×10^{-5}	1×10^{-4}	n/a	n/a	n/a

Notes:

API = Asian and Pacific Islander; cPAH = carcinogenic polycyclic aromatic hydrocarbon; HQ = hazard quotient; n/a = not applicable; PCB = polychlorinated biphenyl; RME = reasonable maximum exposure

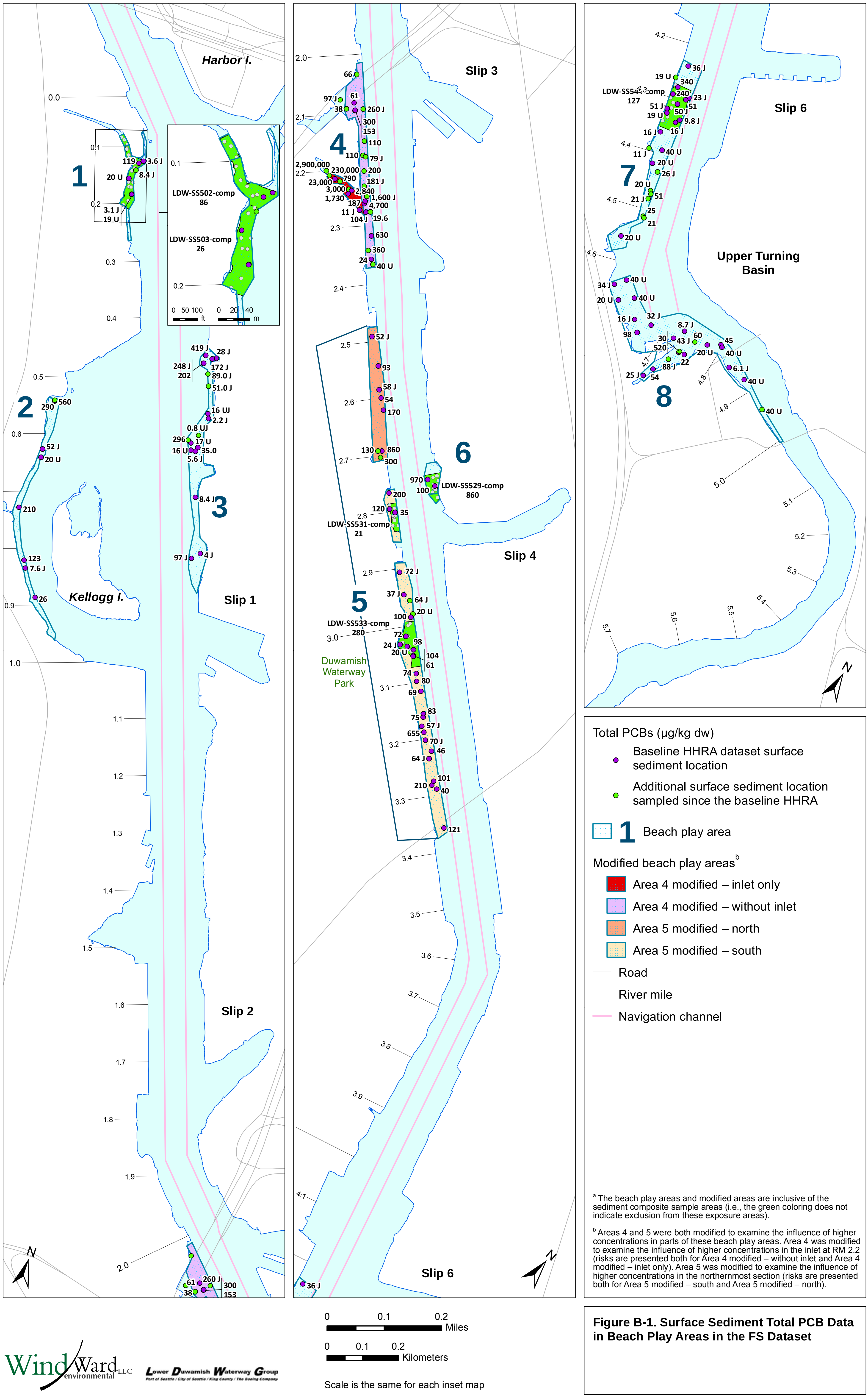
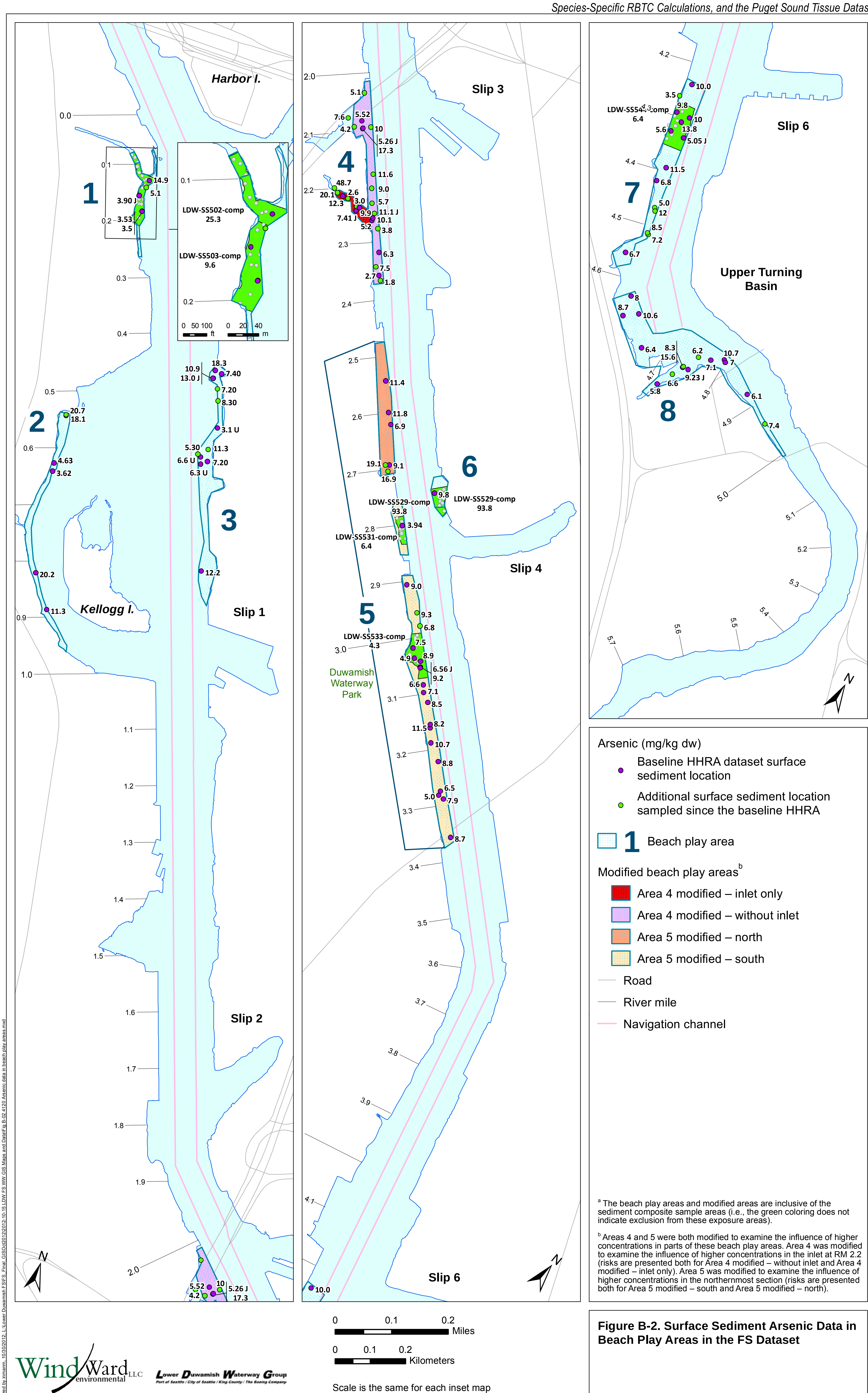


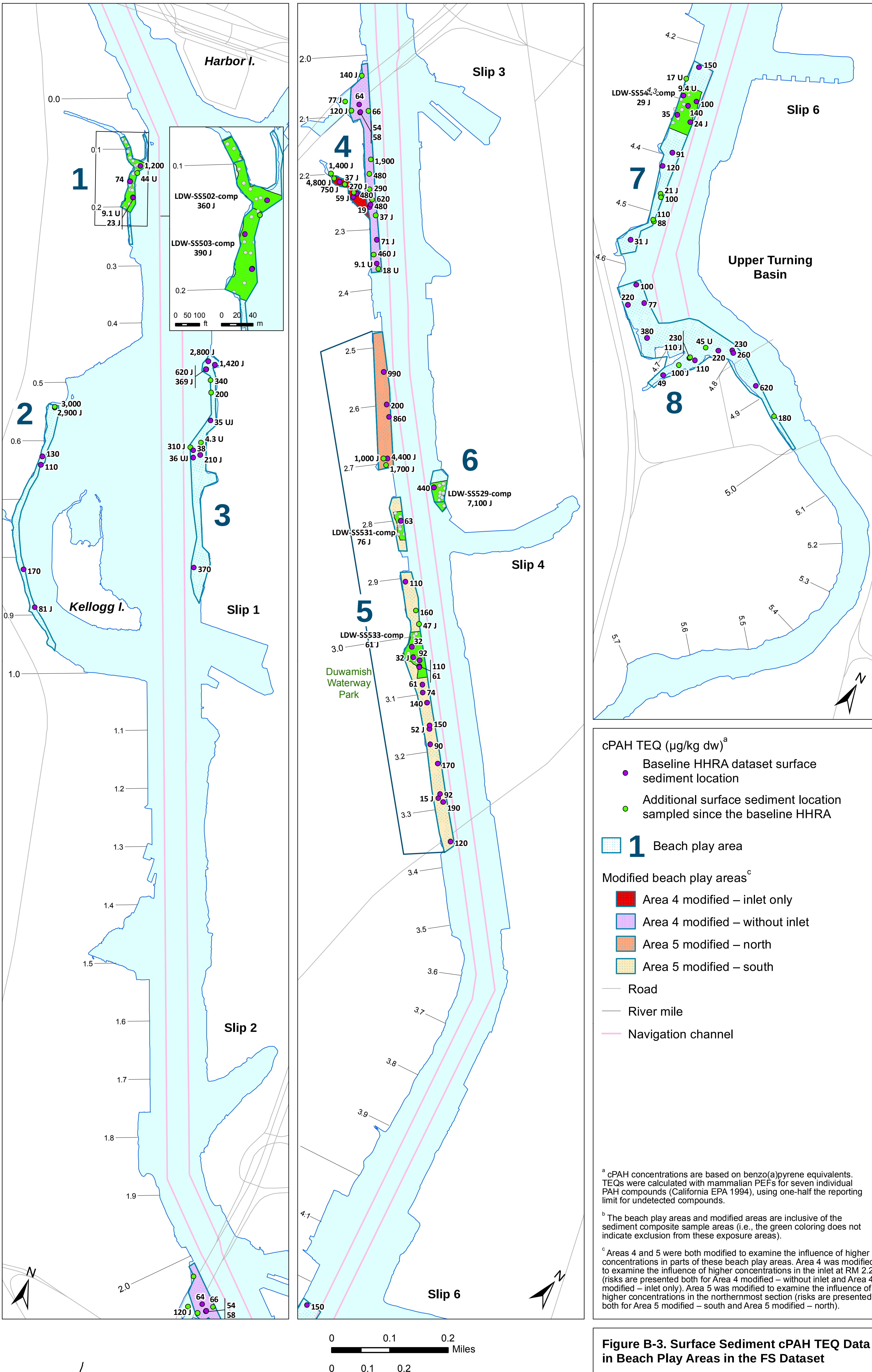
Figure B-1. Surface Sediment Total PCB Data in Beach Play Areas in the FS Dataset



[a] The beach play areas and modified areas are inclusive of the sediment composite sample areas (i.e., the green coloring does not indicate exclusion from these exposure areas).

[b] Areas 4 and 5 were both modified to examine the influence of higher concentrations in parts of these beach play areas. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2 (risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only). Area 5 was modified to examine the influence of higher concentrations in the northernmost section (risks are presented both for Area 5 modified – south and Area 5 modified – north).

Figure B-2. Surface Sediment Arsenic Data in Beach Play Areas in the FS Dataset



[a] cPAH concentrations are based on benzo(a)pyrene equivalents. TEQs were calculated with mammalian PEFs for seven individual PAH compounds (California EPA 1994), using one-half the reporting limit for undetected compounds.

[b] The beach play areas and modified areas are inclusive of the sediment composite sample areas (i.e., the green coloring does not indicate exclusion from these exposure areas).

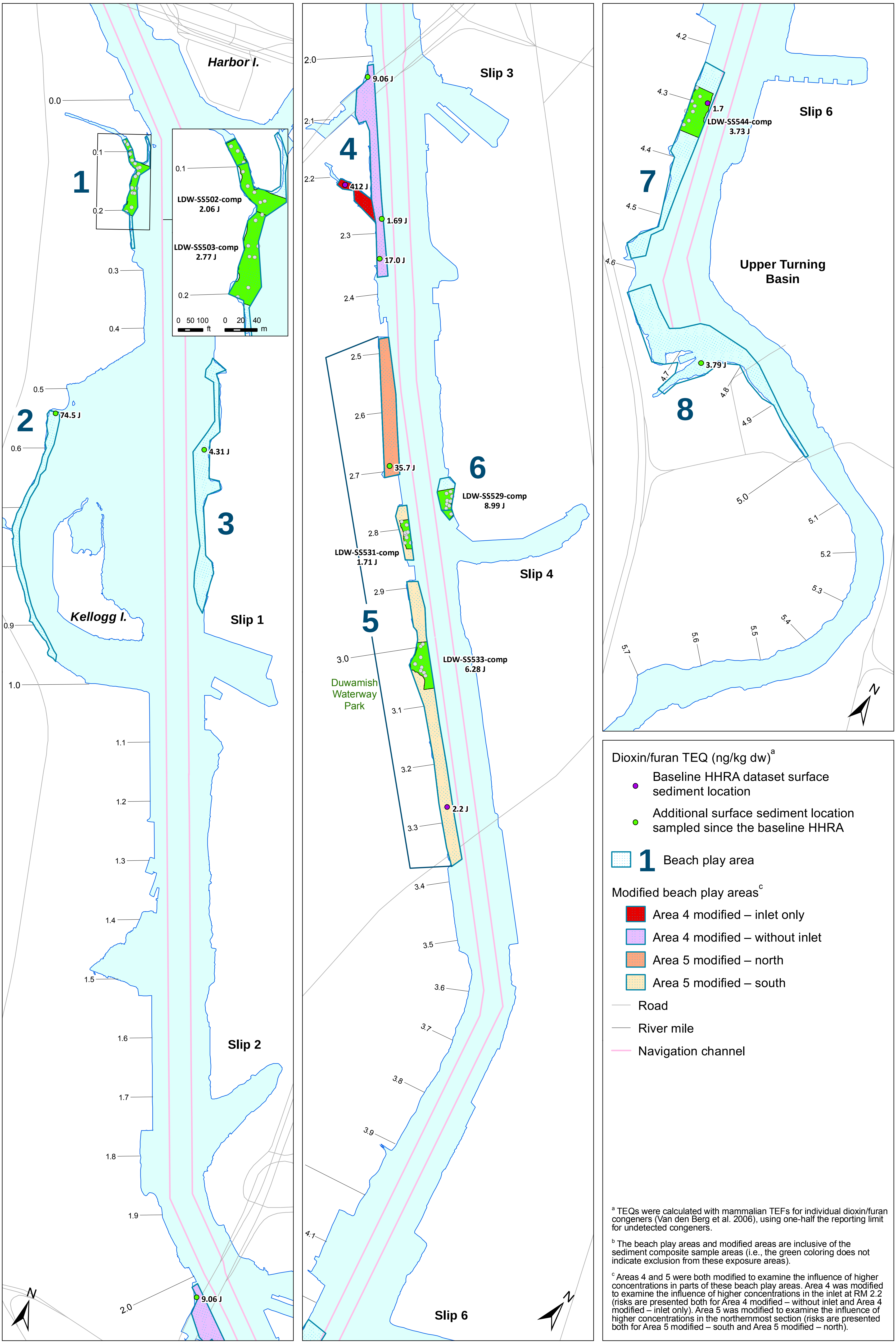
[c] Areas 4 and 5 were both modified to examine the influence of higher concentrations in parts of these beach play areas. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2 (risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only). Area 5 was modified to examine the influence of higher concentrations in the northernmost section (risks are presented both for Area 5 modified – south and Area 5 modified – north).

Figure B-3. Surface Sediment cPAH TEQ Data in Beach Play Areas in the FS Dataset

Prepared by inmanm, 10/30/2012; L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\2012-10-15 LDW FS WW GIS Maps and Data\Fig B-03 4120 cPAH data in beach play areas.mxd

Windward environmental LLC

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company



[a] TEQs were calculated with mammalian TEFs for individual dioxin/furan congeners (Van den Berg et al. 2006), using one-half the reporting limit for undetected congeners.

[b] The beach play areas and modified areas are inclusive of the sediment composite sample areas (i.e., the green coloring does not indicate exclusion from these exposure areas).

[c] Areas 4 and 5 were both modified to examine the influence of higher concentrations in parts of these beach play areas. Area 4 was modified to examine the influence of higher concentrations in the inlet at RM 2.2 (risks are presented both for Area 4 modified – without inlet and Area 4 modified – inlet only). Area 5 was modified to examine the influence of higher concentrations in the northernmost section (risks are presented both for Area 5 modified – south and Area 5 modified – north).

Figure B-4. Surface Sediment Dioxin/Furan TEQ Data in Beach Play Areas in the FS Dataset

Windward LLC environmental

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Prepared by inmanm, 10/30/2012; L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\2012-10-15 LDW FS WW GIS Maps and Data\Fig B-04 4120 Dioxin and furan data in beach play areas.mxd

Figure B-5. Non-Urban Puget Sound Sampling Locations for Fish Tissue Analyzed for PCBs

Figure B-6. Non-Urban Puget Sound Sampling Locations for Clam Tissue Analyzed for PCBs

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Windward environmental LLC

Figure B-7. Non-Urban Puget Sound Sampling Locations for Crab Tissue Analyzed for PCBs

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

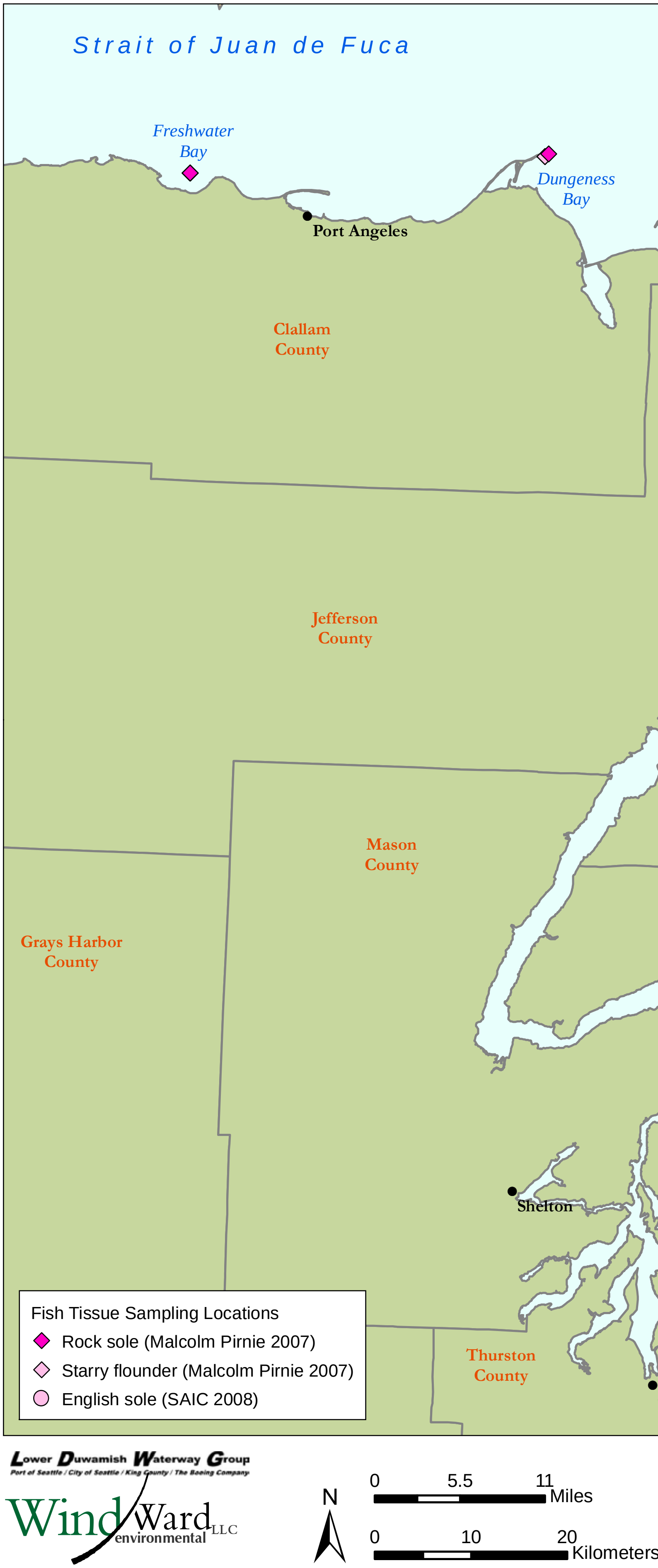
Windward environmental LLC

Figure B-8. Non-Urban Puget Sound Sampling Locations for Tissue Analyzed for Inorganic Arsenic

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Windward environmental LLC

Figure B-9. Non-Urban Puget Sound Sampling Locations for Seafood Tissue Analyzed for cPAHs



Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Windward environmental LLC

Figure B-10. Non-Urban Puget Sound Sampling Locations for Fish Tissue Analyzed for Dioxins/Furans

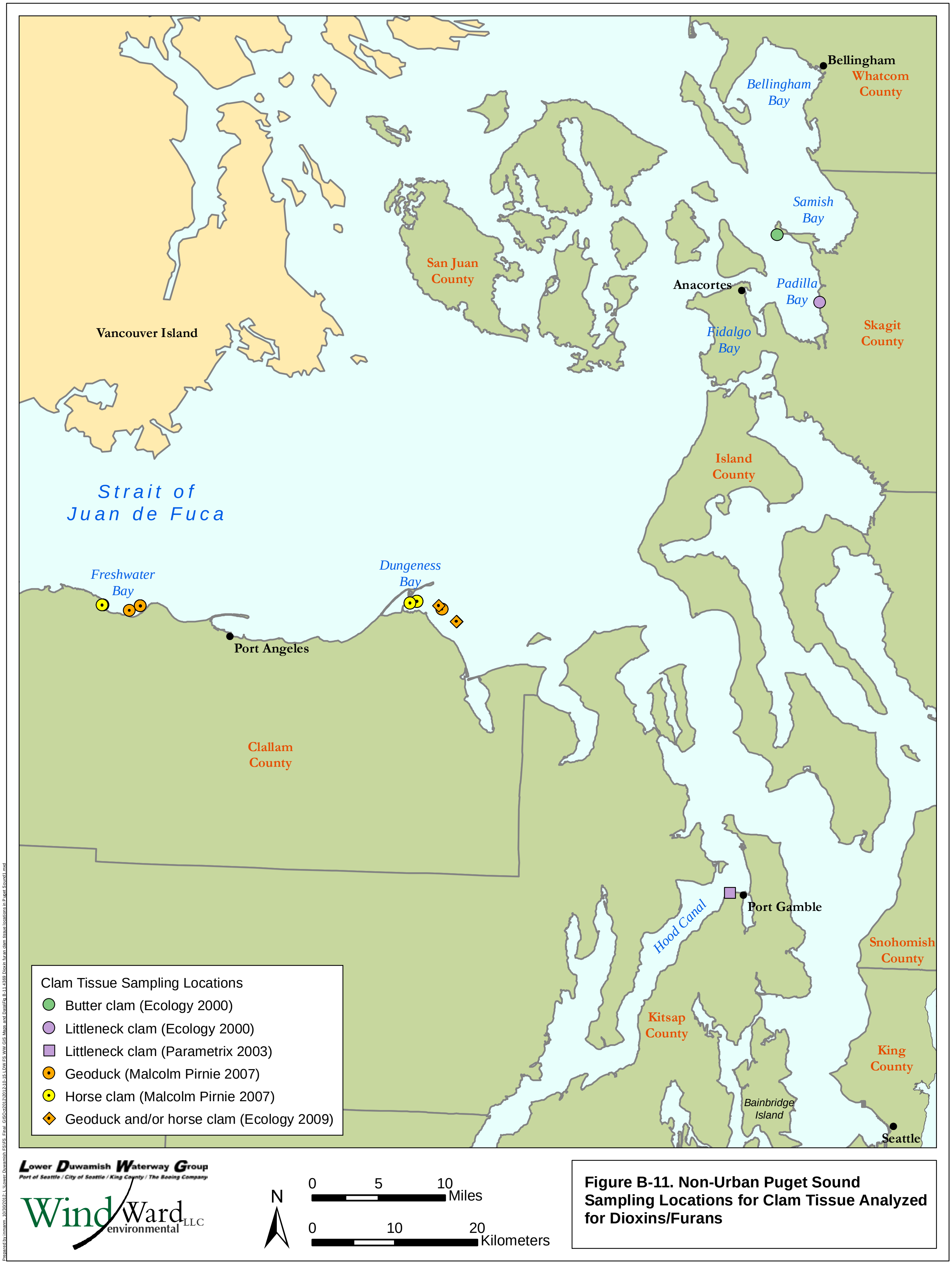


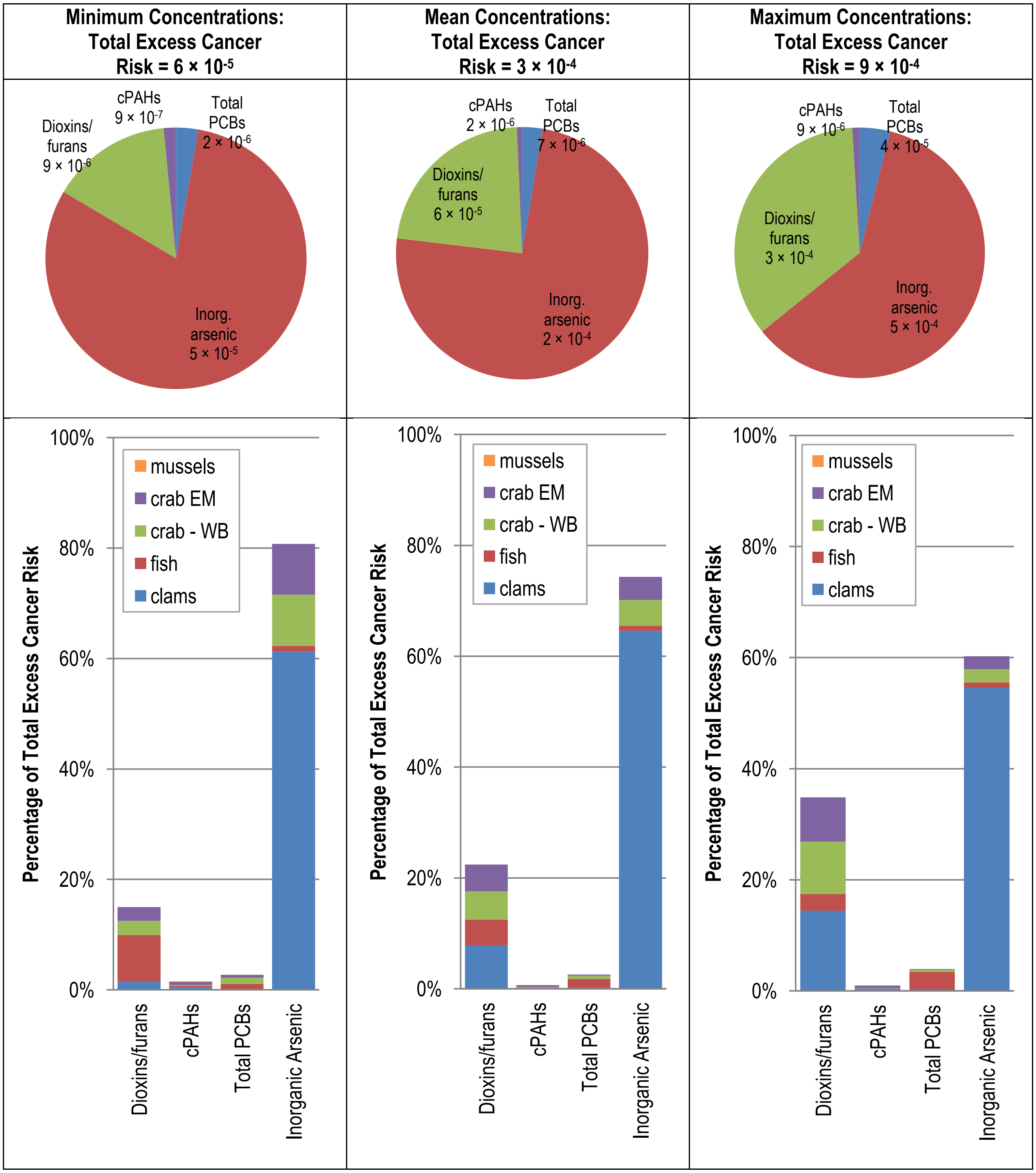
Figure B-11. Non-Urban Puget Sound Sampling Locations for Clam Tissue Analyzed for Dioxins/Furans

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Windward environmental LLC

Figure B-12. Non-Urban Puget Sound Sampling Locations for Crab Tissue Analyzed for Dioxins/Furans

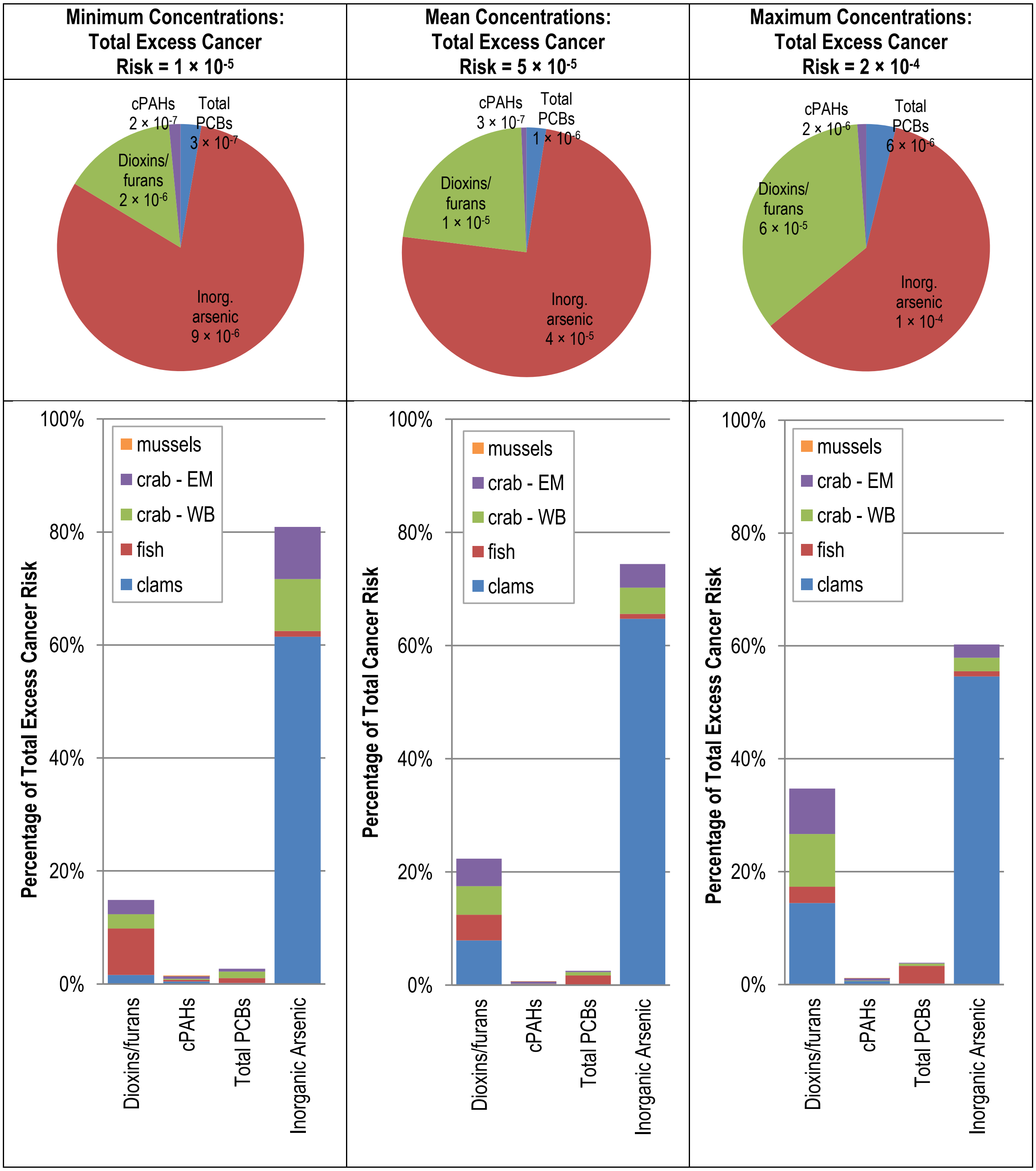
Figure B-13 Excess Cancer Risk Estimates Calculated Using the Non-Urban Puget Sound Tissue Dataset for the Adult Tribal RME Seafood Consumption Scenario Based on Tulalip Data



Notes: Minimum and maximum concentrations are based only on detected concentrations. Mean concentrations were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan-Meier mean for the dataset.

cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; PCB = polychlorinated biphenyl; WB = whole-body

Figure B-14 Excess Cancer Risk Estimates Calculated Using the Non-Urban Puget Sound Tissue Dataset for the Child Tribal RME Seafood Consumption Scenario Based on Tulalip Data

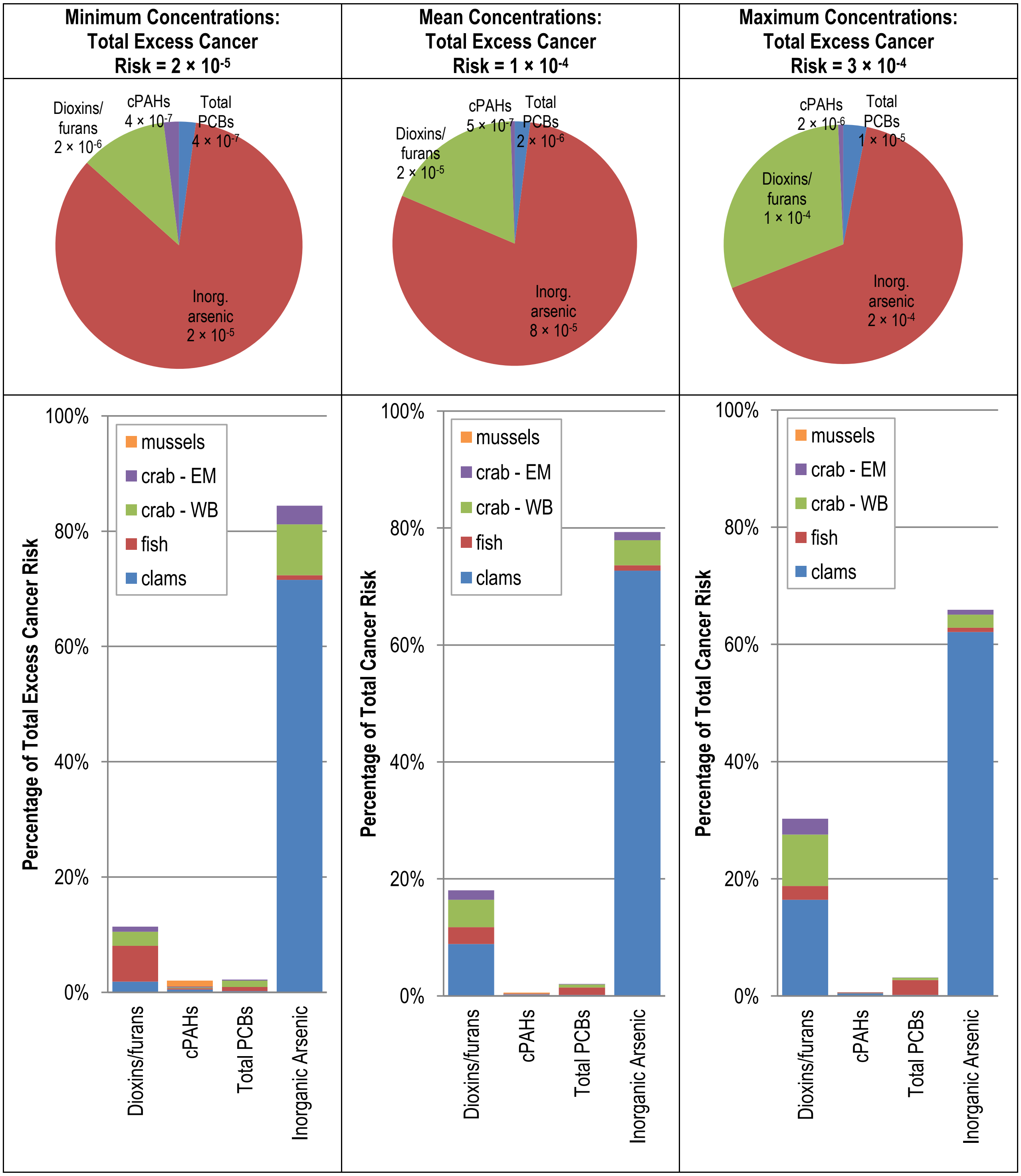


Notes:

Minimum and maximum concentrations are based only on detected concentrations. Mean concentrations were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan-Meier mean for the dataset.

cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; PCB = polychlorinated biphenyl; WB = whole-body

Figure B-15 Excess Cancer Risk Estimates Calculated Using the Non-Urban Puget Sound Tissue Dataset for the Adult API RME Seafood Consumption Scenario



Notes: Minimum and maximum concentrations are based only on detected concentrations. Mean concentrations were calculated arithmetically when there were no non-detect results. When non-detect results were present in a given dataset, ProUCL 4 was used to calculate the Kaplan-Meier mean for the dataset.
cPAH = carcinogenic polycyclic aromatic hydrocarbon; EM = edible meat; PCB = polychlorinated biphenyl; WB = whole-body

Figure B-16 Comparison of Total PCB Excess Cancer Risk Estimates Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW

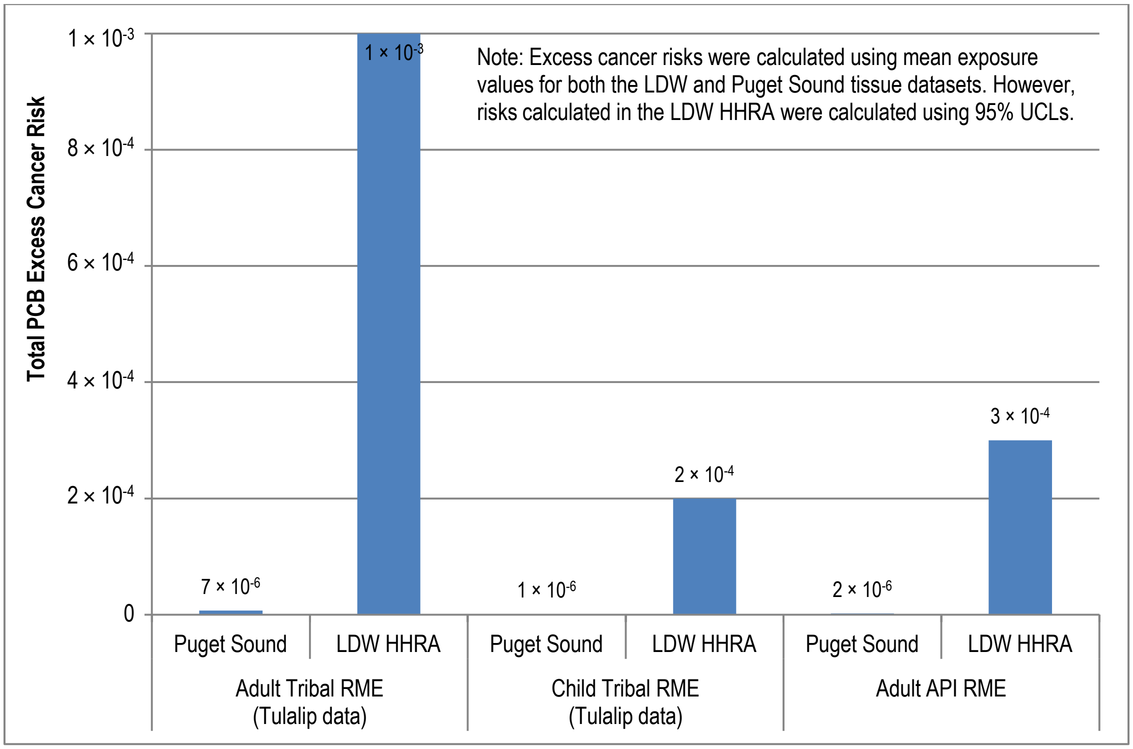


Figure B-17 Comparison of Inorganic Arsenic Excess Cancer Risk Estimates Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW

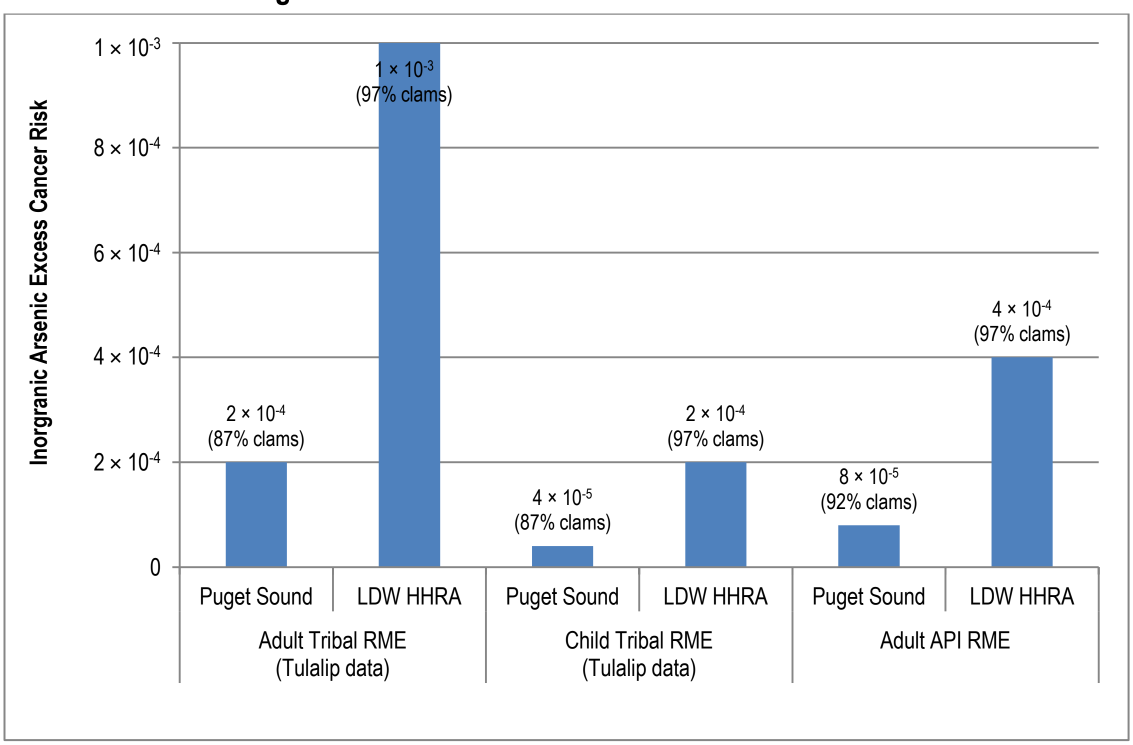


Figure B-18 Comparison of Total PCB Non-Cancer HQs Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW

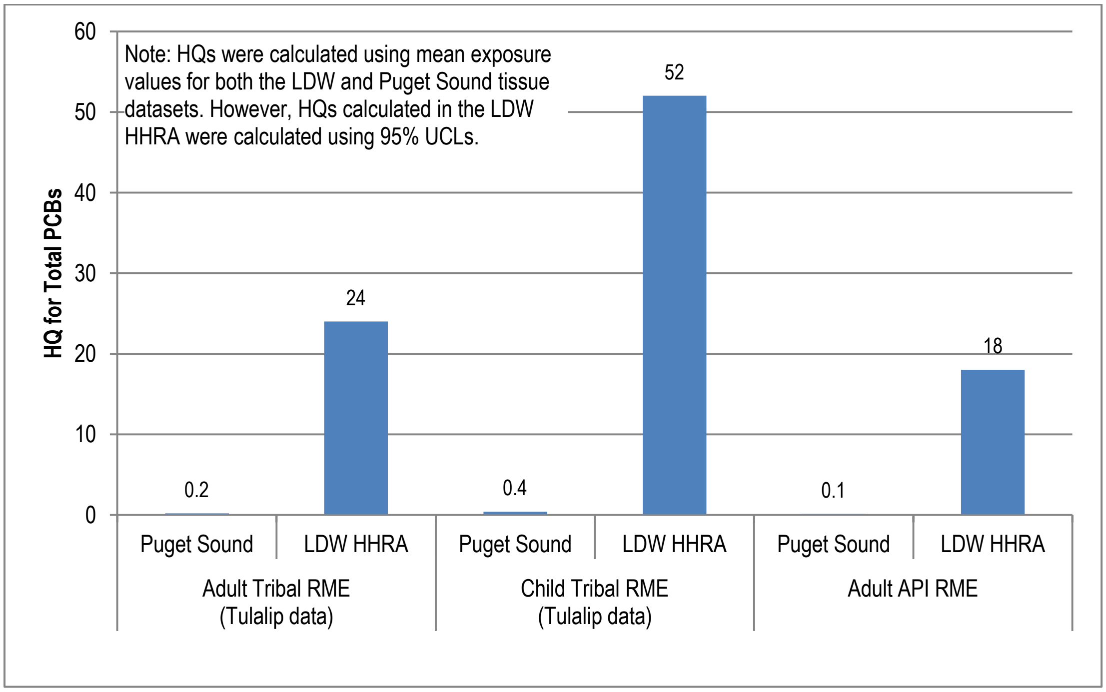
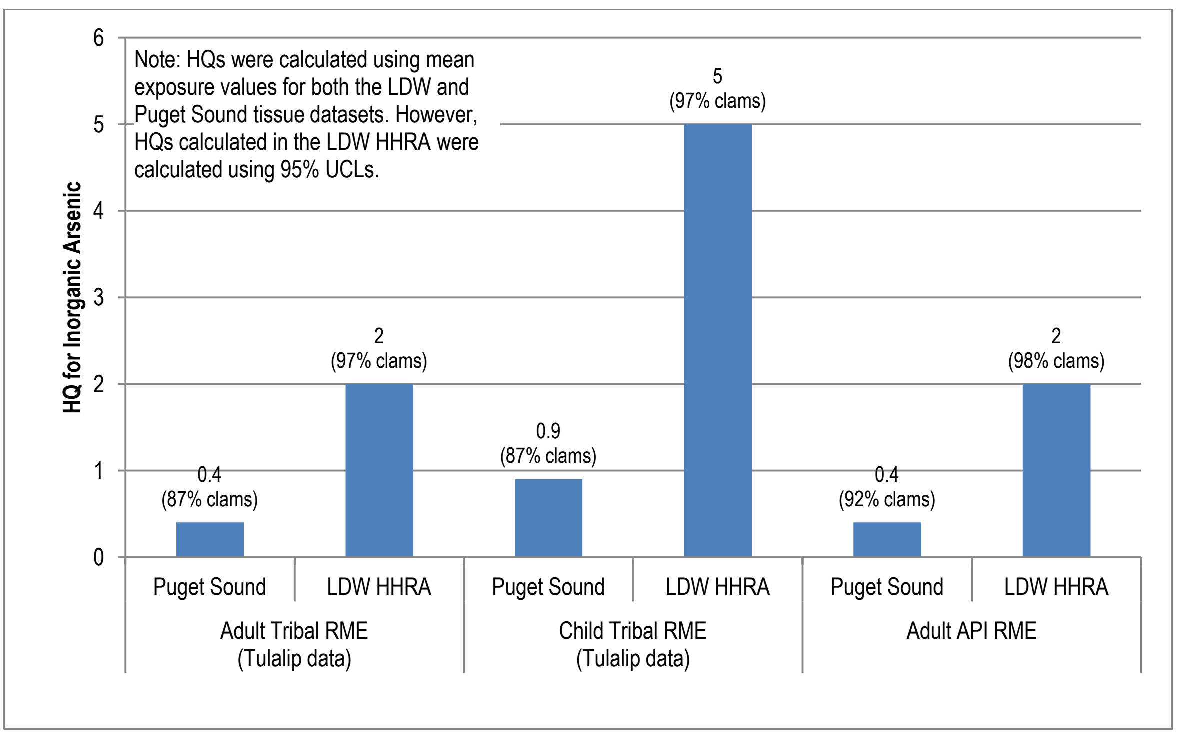


Figure B-19 Comparison of Inorganic Arsenic Non-Cancer HQs Based on Non-Urban Puget Sound Tissue Data and Tissue Data from the LDW



Lower Duwamish Waterway Group

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

Appendix C
Sediment Modeling Memoranda

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 • Seattle, Washington • 98104

Table of Contents

Part 1: Bed Composition Model for the Lower Duwamish Waterway Feasibility Study: Mechanics of Model Application

AECOM Environment
710 Second Avenue, Suite 1000, Seattle, WA 98104
T 206.624.9349 F 206.623.3793 www.aecom.com

AECOM

Memorandum

Date: August 28, 2007[1]

To: Lower Duwamish Waterway Group

From: AECOM

Subject: Bed Composition Model for the Lower Duwamish Waterway Feasibility Study: Mechanics of Model Application

Introduction

This memorandum describes the Bed Composition Model (BCM) proposed for use in the *Lower Duwamish Waterway* (LDW) *Feasibility Study* (FS) to estimate long-term changes in the chemistry of the surface sediment bed. Briefly, the BCM imports results from the Sediment Transport Model (STM; QEA 2007) onto interpolated chemical distribution maps prepared in the ArcGIS® Geographic Information System (GIS) for the LDW. A computational algorithm is then applied to estimate changes in chemical concentrations with time (10 and 30 years) resulting from the physical processes of sediment burial, resuspension, and mixing. The BCM accommodates sediment loading to the study area from upstream and lateral inflows. It also has the capability of differentiating sediment particle size fractions and associated fraction-specific chemistry.

This memorandum was prepared to facilitate discussions with the U.S. Environmental Protection Agency (EPA) and the Washington Department of Ecology (Ecology) about the basis for and mechanics of the BCM. Consistent with the *Feasibility Study Work Plan* (FSWP; RETEC 2007a), the FS will document the BCM and its output in the context of natural recovery. BCM results will be used to inform the selection of remedial action levels and the assembly and analysis of remedial alternatives. Final application of the BCM for evaluating remedial alternatives and natural recovery in the FS (e.g., selection of input values) will be determined in consultation with EPA and Ecology.

The BCM will initially be used to predict temporal changes in the concentrations of total PCBs and arsenic, as there are sufficiently complete datasets available on the chemistry of these risk drivers in both the surface sediment bed and external inputs. The methodology cannot be applied to chemicals with limited surface sediment datasets that preclude interpolation (e.g., dioxins/furans) or where there is insufficient information on external inputs. Therefore, this memorandum also describes a location-specific methodology for evaluating long-term concentration changes with time for other risk drivers and chemicals of concern (COCs) not suited to the BCM methodology.

[1] Revised June 18, 2010 to be consistent with revisions to the FS requested by the agencies.

General Description of the BCM Framework

The BCM is constructed within a GIS framework, and consists of the following steps:

1. Develop chemical concentration (i.e., total PCBs, arsenic) maps using Inverse Distance Weighting (IDW) interpolation on a 10-ft by 10-ft grid.
2. Map the output of the STM surface sediment bed composition (i.e., percent contributions of three different types of solids: suspended solids from the upstream inflow, suspended solids from lateral inflows, and bed sediments) onto the interpolated chemical concentration grids for a specific time period (e.g., 10 years).
3. Create an attribute table from the GIS grids that contains the information derived in steps 1 and 2. Export the table into Excel® 2007.
4. Develop chemical input values that represent the solids-associated concentration(s) of risk drivers (i.e., total PCBs, arsenic) for three types of solids:
   - Upstream (i.e., Green River)
   - Lateral (i.e., storm water, combined sewer overflows [CSOs], and streams)
   - Where active remedial actions occur (e.g., dredging or capping), a post-remedy bed sediment replacement value.
5. For a specific potential remedial alternative, define the areas where active remedial measures (e.g., dredging, capping) could occur and identify the underlying grid-cells that will be assigned a post-remedy bed sediment replacement value. Within the Excel® 2007 worksheet, define and enter the post-remediation (time = 0) bed concentrations for the targeted chemical in each applicable 10-ft x 10-ft grid-cell.
6. Within the Excel worksheet, apply the BCM time-dependent bed composition algorithm to each GIS 10-ft x 10-ft grid cell using input parameters derived in the previous two steps. (Note: this step generates a new sediment bed chemical concentration for each grid cell.)
7. From the resulting BCM output, calculate the spatially-weighted average concentration (SWAC), the 95% upper confidence limit (UCL) on the SWAC, and, if required, plot the output as a chemical distribution map.

Each of these steps is described in more detail below.

Interpolated Chemical Concentration Maps

Interpolated chemical concentration maps provide the initial condition against which future changes can be predicted with the BCM. To date, two interpolation methods have been used to create bed maps for the LDW Remedial Investigation and Feasibility Study (RI/FS): Thiessen polygons and Inverse Distance Weighting (IDW). IDW interpolation of total PCBs was used in the technical memorandum *Draft Preliminary Screening of Alternatives* (PSA; RETEC 2006) and is being used in the RI (Windward, in prep), and are planned for application in the FS. Thiessen polygons for total PCBs were used in the human health risk assessment (Windward 2007) as a means of spatially representing the observed data and to calculate SWACs and 95% UCLs on the mean for net-fishing and clamming exposure areas. Interpolated arsenic concentration maps have not been prepared for any RI/FS documents to date. The IDW methods and assumptions used previously for total PCB interpolation were documented in the technical memorandum *GIS Interpolation of Total PCBs in LDW Surface Sediment* (Windward 2006) and in Appendix B of the PSA (RETEC 2006). The methods described in that memo for total PCBs were re-evaluated for both total PCBs and arsenic to: 1) identify a set of IDW parameters that allowed for interpolation of total PCB concentrations for the whole LDW as a single unit, 2) develop IDW parameters to interpolate arsenic concentrations, and 3) provide a simple method for calculating an LDW-wide UCL on a SWAC derived from an IDW-interpolated chemical concentration map. The dataset used to evaluate the parameters included the Round 3 data, which were not yet available at the time of the 2006 technical memorandum (Windward 2006).

The IDW methodology and parameters developed for total PCBs and arsenic specifically for use in the FS, and methods for calculating a 95% UCL on a SWAC, will be the subject of a separate memorandum to EPA and Ecology.

Mapping Output of the STM to the GIS Chemical Distribution Maps

The next step in the BCM is to map the surface sediment bed composition predicted by the STM onto the interpolated chemical distribution maps. The STM report presents results of the long-term (30 years) sediment transport simulation in the LDW (QEA 2007). The STM predicts changes in the composition of the surface sediment bed over time and in response to inputs from external sediment inflows. External sediment inputs are defined for upstream (i.e., Green River) and lateral (i.e., storm drains, CSOs, and streams) inflows. Bed sediments are treated as a third type of solid. The STM output yields the composition of the sediment bed in each grid-cell as the fraction or percentage of each type of solid contributing to the sediment in that location (Figures 1 through 3). Model results are saved at 5-year intervals in GIS attribute tables. The methods and output examples are presented in Section 4 of the STM report (QEA 2007).

The STM grid (727 cells over 398 acres) and the chemical distribution grid (>186,000 cells over 430 acres) differ both in the total area covered and in the size of individual cells. The rule adopted to account for cell-size disparity was to uniformly assign STM bed composition percentages to all chemical distribution grid-cells falling fully within a given STM cell. For example, Figure 4(A) shows the STM-predicted lateral load compositions for the section of the LDW between river mile (RM) 0.3 to 2.0. In this example, chemical distribution grid-cells that lie fully within the STM cell having a lateral composition percentage of 27.2% are assigned the same lateral composition value of 27.2% (Figure 4B). In cases where an STM grid boundary crosses a chemical distribution grid-cell, the composition assigned to the grid-cell is that for the dominant STM cell (i.e., the one that occupies greater than 50% of the chemistry grid-cell area).

Some chemical distribution grid-cells located along the edges of the LDW study area are not overlain by an STM cell (Figure 4). Chemical distribution grid-cells not collocated with a STM cell were assumed to have a composition corresponding to the nearest adjacent (i.e., along lateral transect) STM cell. As shown in Figure 4, chemical distribution grid-cells lying outside an STM cell (Figure 4B) were assigned a value based upon the value of the nearest neighboring cell (Figure 4C). In this manner, all chemical distribution grid-cells were assigned a composition corresponding to the percent contribution from the upstream and lateral inflows, and from the initial sediment bed.

Composition and Chemical Concentration Attribute Table

Following the mapping exercise, the surface sediment bed composition and chemical concentrations for each grid-cell are exported from the GIS attribute table to an Excel® 2007 workbook. Excel® 2007 has the capacity to process and store the information for all 180,000 grid-cells that are generated for each model run of the BCM. In addition, the BCM calculations are performed within Excel® 2007. This allows for transparency and quality control because Excel, unlike GIS, retains the formulas used. Table 1 is an example that shows the GIS coordinates (X,Y), the 10- and 30-year surface sediment bed composition percentages (bedded sediments, upstream, and lateral), a check on each grid-cell to ensure the percentages total 100 percent, and, in this example, the initial dry weight concentration of total PCBs, total organic carbon content (%), and the organic carbon normalized concentration of total PCBs for each grid-cell.

Chemical Composition Input Parameters

Estimates of the concentrations of chemicals associated with each of the three types of solids (i.e., upstream, lateral, and LDW surface sediments[2]) are required as inputs to the BCM. An initial set of chemical concentrations was provided in the technical memorandum *Initial Bed Sediment Composition Model Range-Finding Parameters for Total PCBs and Arsenic* (RETEC 2007b) for use in the BCM range-finding exercise. That memorandum specifically developed an initial range of total PCB and arsenic concentrations for upstream and lateral inflows, and for post-remedy bed sediment replacement values. The range development work attributed uniform chemical concentrations to the multitude of lateral inflows, as there is insufficient information available for establishing unique input concentrations for individual inflows.

Input parameters for additional risk-drivers (e.g., cPAH) may also be developed in consultation with EPA and Ecology as needed, after completion of this initial modeling effort for total PCBs and arsenic.

BCM Time-Bed Composition Algorithm

Changes in the chemical concentrations of surface sediment over time are calculated as a function of the initial surface sediment concentrations (time=0)[3] and the STM-predicted changes in bed composition (i.e., changes in percent composition of the three types of solids). For each 10-ft by 10-ft grid-cell in the interpolated chemical concentration maps, the following simple algorithm is used to predict changes in bed sediment concentrations at specified time intervals:

$$C_{(time)} = C_{lateral} * fraction_{lateral} + C_{river} * fraction_{river} + Cbed * fraction_{bed} \quad (1)$$

Where:

$C_{lateral}$ represents the concentration of a chemical (i.e., total PCBs or arsenic) on “lateral” inflow solids

C_{river} represents the concentration of a chemical on “upstream” (i.e., Green River) solids

C_{bed} represents the chemical concentration in the surface sediment bed at time = 0.

The bed fraction ($fraction_{bed}$) represents the fraction of sediment in each grid-cell derived from the initial (time=0) LDW sediment bed. Depending on the scenario being modeled, the bed sediment chemical concentration assigned to this parameter at any given location may be:

- The initial sediment condition in the absence of any remediation (i.e., “no action” or monitored natural recovery alternative)
- The sediment condition present in an area immediately after active remediation (which might include capping, dredging, or a combination of dredging and capping).

In areas experiencing net sediment deposition, the bed sediment fraction will decrease over time as it is diluted by the settling of sediments from the lateral ($fraction_{lateral}$) and upstream ($fraction_{river}$) inflows. In its current form, the BCM does not specifically account for the potential movement (i.e., erosion and

---

[2] Bedded sediment values can be either the interpolated initial chemical concentrations in surface sediments or post-remedy bed sediment replacement values applied within a remediated area.

[3] “time = 0” corresponds to the time when active remedial measures of a specific remedial alternative are completed. For a “no action” alternative, “time = 0” sediment concentrations correspond to the initial interpolated surface sediment chemical concentration maps.

redeposition) of bed sediment throughout the study area. The effect of erosion and redeposition of bed sediment relative to other transport processes was previously computed as part of the STM (QEA 2007). Redeposition of suspended bed sediments was estimated to constitute 2.5% of total deposition in Reach 1, 5.4% in Reach 2, and 2.5% in Reach 3 over 30 years. These percentages show that erosion and redeposition represent a minor contribution relative to the combined lateral and upstream inputs.

In all areas that are not actively remediated, the chemical concentrations within the sediment bed (C_{bed}) at time = 0 are assumed to be equivalent to those interpolated from the initial surface sediment dataset. To account for uncertainties, a range of concentrations will be evaluated for the post-remedy bed sediment replacement value in areas that are actively remediated, $C_{lateral}$, and C_{river} (RETEC 2007b).

Evaluation of Potential Remedial Alternatives

Remedial alternatives for the LDW will be developed and evaluated in the FS as described in the FSWP (RETEC 2007a). The effectiveness of each alternative over the short-term (5 to 10 years) and long-term (10 to 30 years) will be evaluated, in part, using the BCM. In the case of a “no action” alternative, only ranges of chemical input parameters for upstream and lateral inflows will be used to assess changes in surface sediment bed concentrations at 10 and 30 years. C_{bed}, in this case, is the initial interpolated chemical concentration in the surface sediment at any given location.

Alternatives that include an active remediation component (e.g., dredging, capping) combined with natural recovery will also be evaluated using a range of upstream and lateral inflow chemical concentrations. In addition, a range of post-remedy bed sediment replacement values will be applied within the boundaries of the active remediation areas.

The direct outputs from the BCM are the LDW-wide SWAC, 95% UCL on the SWAC, and concentration values for each grid-cell at specified time intervals. Interpolated chemical base maps can be constructed from the output, which, in turn, enables scrutiny of localized effects (e.g., individual recreational areas or areas around outfalls) with respect to changes in point concentration, SWAC, and 95% UCLs over time. The BCM can be run over a range of shorter time intervals (e.g., 5-year intervals) to allow an evaluation of changes in bed sediment concentrations over time. Finally, the effects of varying chemical concentrations associated with the two types of solids (i.e., upstream and lateral loads) on bed sediment concentrations can be plotted and used to evaluate the impacts of source control activities.

Use of the STM Output to Evaluate Other COCs

The FS will evaluate long-term concentration changes (i.e., restoration time frame) for other chemicals of concern that exceed preliminary remediation goals on a location-specific basis. Such evaluations will be performed where, for example, a sediment quality standard (SQS) is exceeded at a specific sample station or a group of stations exceed the SQS within a sediment management area. Equation (1) can be used on a point basis. However, for many COCs, the terms $C_{lateral}$ and C_{river} are supported by limited or no data and are therefore difficult to quantify. In some cases, this limitation can be addressed by assuming that the chemical contribution from external inflows is small compared to the initial sediment bed concentrations. This assumption is supported by the influx of suspended solids being dominated by the upstream (Green River) component, which contains low (near background) concentrations of many COCs. In these cases, the sum of the external input terms in equation (1) (i.e., $C_{lateral}$*$fraction_{lateral}$ + C_{river}*$fraction_{river}$) is very low relative to C_{bed}*$fraction_{bed}$ and may be neglected thereby reducing Equation (1) to:

$$C_{(time)} = C_{bed} * fraction_{bed} \quad (2)$$

Thus, in many cases, it can be expected that the STM output of bed fractions as a function of time will provide a good approximation of the chemical concentration changes expected for the other COCs at particular locations.

The concept of bed half-life, as described in the STM (QEA 2007) and derived from Equation (2), may be a convenient and mathematically equivalent method of expressing changes in chemical concentration. Existing data from sediment core analyses may provide an opportunity to empirically check the validity of the half-life concept if the rate of change in chemical concentrations with depth can be transposed to a rate of change with time.

Handling Uncertainty

Translating the STM output to the interpolated chemical distribution maps requires accepting certain limits on the predictive application of the BCM. Figures 1 through 3 show the predicted bed composition for a 30-year STM simulation (Figures 4-3 through 4-5 from the STM report, QEA 2007). The "active" modeled portion of the bed of the LDW extends from RM 0.0 to RM 4.8, whereas the study area for the interpolated chemical distribution maps in the FS is from RM 0.0 to 5.0. The riverbed upstream of RM 4.8 is assumed to have a "hard bottom" in which no erosion or deposition of suspended sediment occurs but bed load transport is allowed. Thus, the BCM is limited to RM 0.0 to 4.8. Long-term changes in sediment concentrations in the region from RM 4.8 to 5.0 will need to be addressed in the FS by a different approach than the BCM described herein.

Uncertainties in the concentration ranges for the post-remedy bed sediment replacement value, $C_{lateral}$ and C_{river}, will be evaluated (RETEC 2007b). Experience at other sediment remediation sites shows that chemical concentrations in the sediment bed (C_{bed}) shortly after the completion of active remediation cannot conservatively be assumed to be zero (NRC 2007; EPA 2005; Anchor 2003). This occurs because there is always some degree of residual surface contamination from the resettling of contaminated sediments suspended during remedial activities. The degree of residual contamination is dependent on the type of remedial activity, specific design elements, construction methods, best management practices, engineering controls, contingency measures, etc., the effects of which cannot be accurately predicted through modeling. (The STM does not estimate the degree of residual contamination in actively remediated areas.) Therefore, it will be necessary to assume a post-remedy bed sediment replacement value as an input parameter to the BCM using various lines of evidence and best professional judgment.

Summary

LDWG plans to use the BCM methodology presented herein to aid in the development and evaluation of sediment remedial alternatives in the FS. Concentrations of PCBs and arsenic in solids from lateral and upstream inflows are reasonably well described, and initial model runs are being performed for these chemicals. Information on the concentrations of chemicals other than PCBs and arsenic in suspended solids from upstream and lateral inflows is limited, so application of this model to these other chemicals may be limited or require generalized assumptions. LDWG is currently proceeding with computational runs using the BCM. Preliminary results of these runs will be evaluated and presented to EPA and Ecology at the August 30, 2007 meeting.

Attachments

Table 1 Example Attribute Table Produced in GIS and Exported to Excel® 2007

Figure 1 STM-Predicted Baseline Sediment Solids Composition in Surface Sediments (0-10 cm) at the End of 30-Year Period

References

Anchor, 2003. *Literature Review of Effects of Resuspended Sediments Due to Dredging Operations*. Prepared for the Los Angeles Contaminated Sediments Task Force, Los Angeles, California. Prepared by Anchor Environmental CA LP, Seattle, Washington. June.

EPA 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. December 2005.

NRC 2007. *Sediment Dredging at Superfund Megasites: Assessing the Effectiveness*. National Research Council Committee on Sediment Dredging at Superfund Megasites. National Academies Press. Washington, DC.

QEA 2007. *Sediment Transport Modeling Report*. Prepared for Lower Duwamish Waterway Group for submittal to US Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. Prepared by Quantitative Environmental Analysis, LLC, Montvale, NJ. July 18, 2007.

RETEC 2006. *Technical Memorandum: Draft Preliminary Screening of Alternatives, Lower Duwamish Waterway Superfund Site*. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. Prepared by the RETEC Group, Inc. Seattle, WA. September 27, 2006.

RETEC 2007a. *Final Feasibility Study Work Plan for the Lower Duwamish Waterway Superfund Site*. Prepared for Lower Duwamish Waterway Group for submittal to US Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. Prepared by the RETEC Group, Inc. Seattle, WA. May 4, 2007.

RETEC 2007b. *Technical Memorandum: Initial Bed Sediment Composition Model Range-Finding Parameters for Total PCBs and Arsenic*. Prepared for Lower Duwamish Waterway Group for submittal to US Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. Prepared by the RETEC Group, Inc. Seattle, WA. July 17, 2007.

Windward 2006. *Technical Memorandum: GIS Interpolation of Total PCBs in LDW Surface Sediment*. Prepared for Lower Duwamish Waterway Group for submittal to US Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. Prepared by Windward Environmental LLC, Seattle, WA. April 21, 2006.

Windward 2007. *Baseline Human Health Risk Assessment, Lower Duwamish Waterway*. Prepared for Lower Duwamish Waterway Group for submittal to US Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. Prepared by Windward Environmental LLC, Seattle, WA. July 14, 2007.

Table 1 Example Attribute Table Produced in GIS and Exported to Excel® 2007

Grid Cell	GRID LOCATION[1]		STM OUTPUT								CHEMICAL INTERPOLATION		
			10-YEAR COMPOSITION (%)				30-YEAR COMPOSITION (%)				INITIAL SURFACE SEDIMENT CONCENTRATIONS[2]		
	X	Y	Bed	Upstream	Lateral	Total Check	Bed	Upstream	Lateral	Total Check	Total PCBs (µg/kg dw)	TOC (%)	Total PCBs (mg/kg OC)
1	1266078.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	161.00	1.58	10.19
2	1266088.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	160.99	1.58	10.19
3	1266098.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	160.92	1.58	10.18
4	1266108.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	160.51	1.58	10.15
5	1266118.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	158.30	1.59	9.95
6	1266128.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	149.72	1.62	9.22
7	1266138.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	133.64	1.69	7.92
8	1266148.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	122.81	1.73	7.09
9	1266158.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	119.29	1.75	6.83
10	1266168.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	118.38	1.75	6.77
11	1266178.34	211399.00	35.73	63.08	1.19	100.00	2.45	95.84	1.71	100.00	118.14	1.75	6.75
12	1266188.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	118.08	1.75	6.75
13	1266198.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	118.07	1.75	6.75
14	1266208.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	118.08	1.75	6.75
15	1266218.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	118.13	1.75	6.75
16	1266228.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	118.26	1.75	6.76
17	1266238.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	118.62	1.75	6.77
18	1266248.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	119.64	1.75	6.82
19	1266258.34	211399.00	34.04	64.80	1.16	100.00	2.04	96.32	1.64	100.00	122.57	1.76	6.97
20	1266898.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.01	1.31	10.46
21	1266908.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.00	1.31	10.46
22	1266918.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.00	1.31	10.46
23	1266928.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.00	1.31	10.46
24	1266938.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.00	1.31	10.46
25	1266948.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.00	1.31	10.46
26	1266958.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.00	1.31	10.46
27	1266968.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.00	1.31	10.46
28	1266978.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.01	1.31	10.46
29	1266988.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.03	1.31	10.46
30	1266998.34	211399.00	65.88	33.21	0.91	100.00	20.34	77.86	1.81	100.00	137.08	1.31	10.46
31	1267008.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	137.23	1.31	10.45
32	1267018.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	137.58	1.32	10.45
33	1267028.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	138.39	1.33	10.44
34	1267038.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	140.05	1.34	10.45
35	1267048.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	143.09	1.36	10.48
36	1267058.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	148.06	1.40	10.59
37	1267068.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	155.36	1.44	10.83
38	1267078.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	165.12	1.48	11.18
39	1267088.34	211399.00	63.31	35.73	0.97	100.00	17.79	80.41	1.80	100.00	177.20	1.52	11.67

Notes:

[1] NAD83 Washington State Plane North Coordinates in feet (FIPS 4601)

[2] This map was overlaid with an interpolated total organic carbon (TOC) map to determine carbon-normalized (OC) values for each grid cell.

Figure 1 STM-predicted baseline sediment solids composition in surface sediments (0-10 cm) at the end of 30-year period

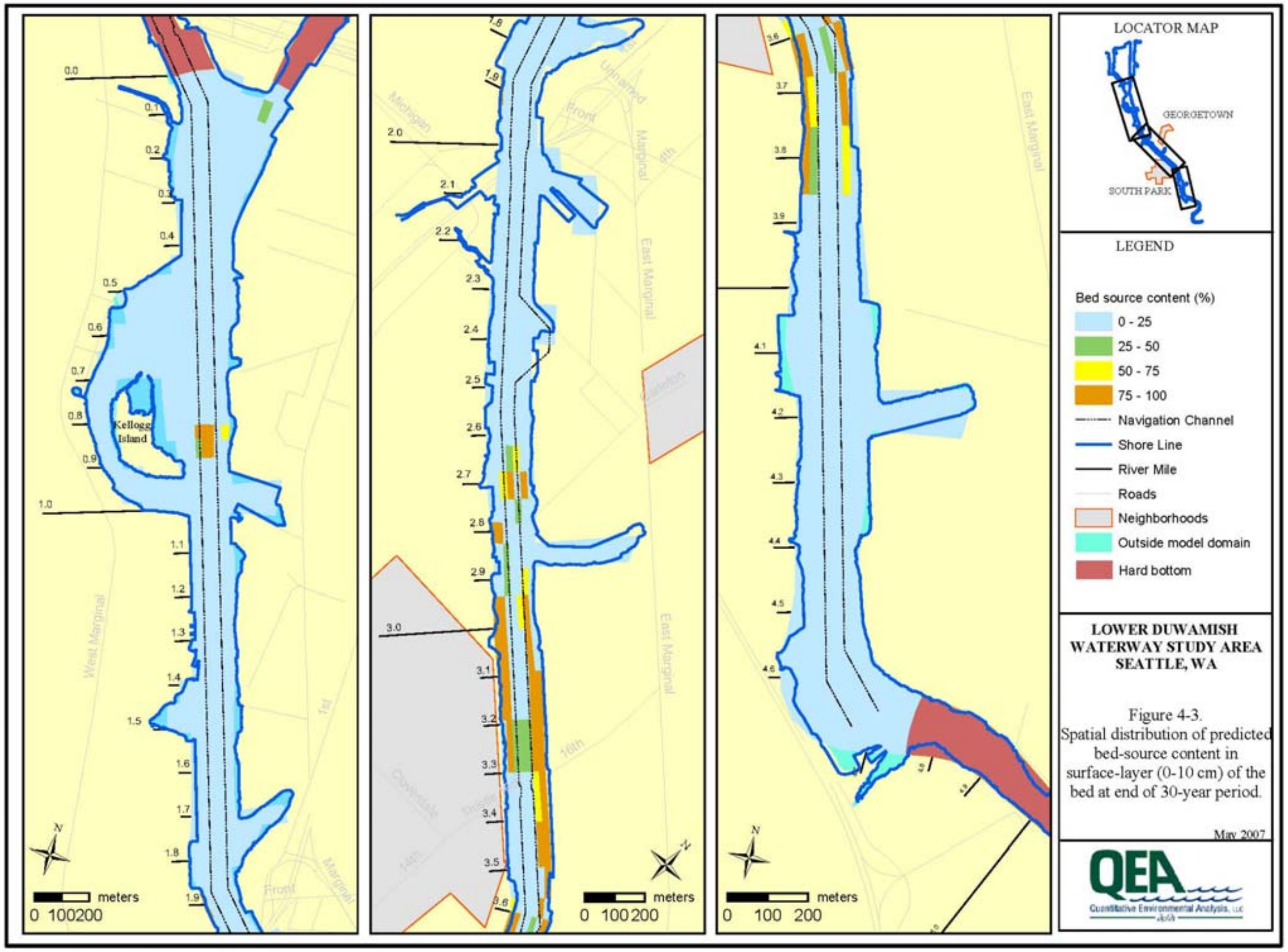


Figure 2 STM-predicted upstream sediment solids composition in surface sediments (0-10 cm) at end of 30-year period

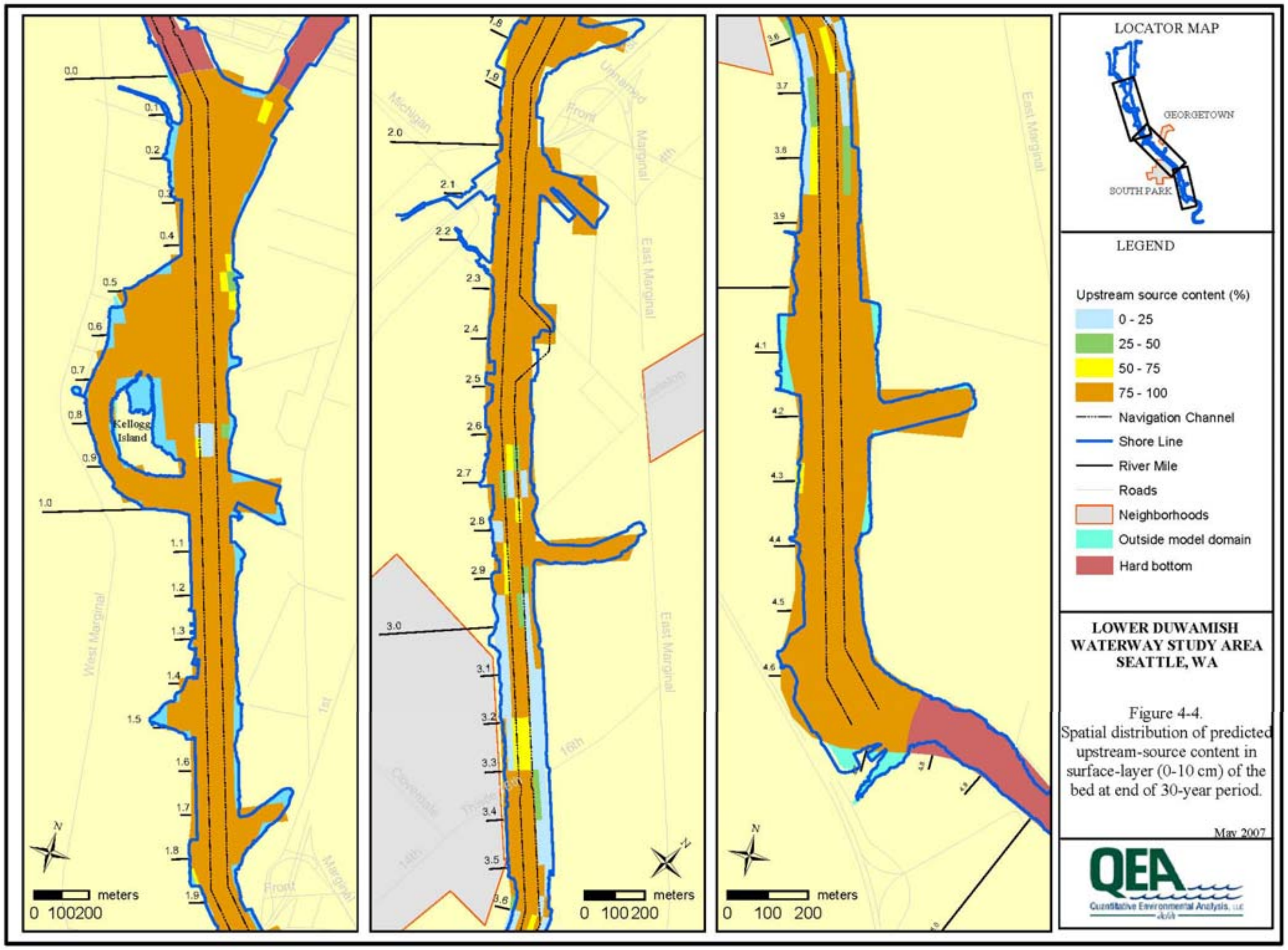
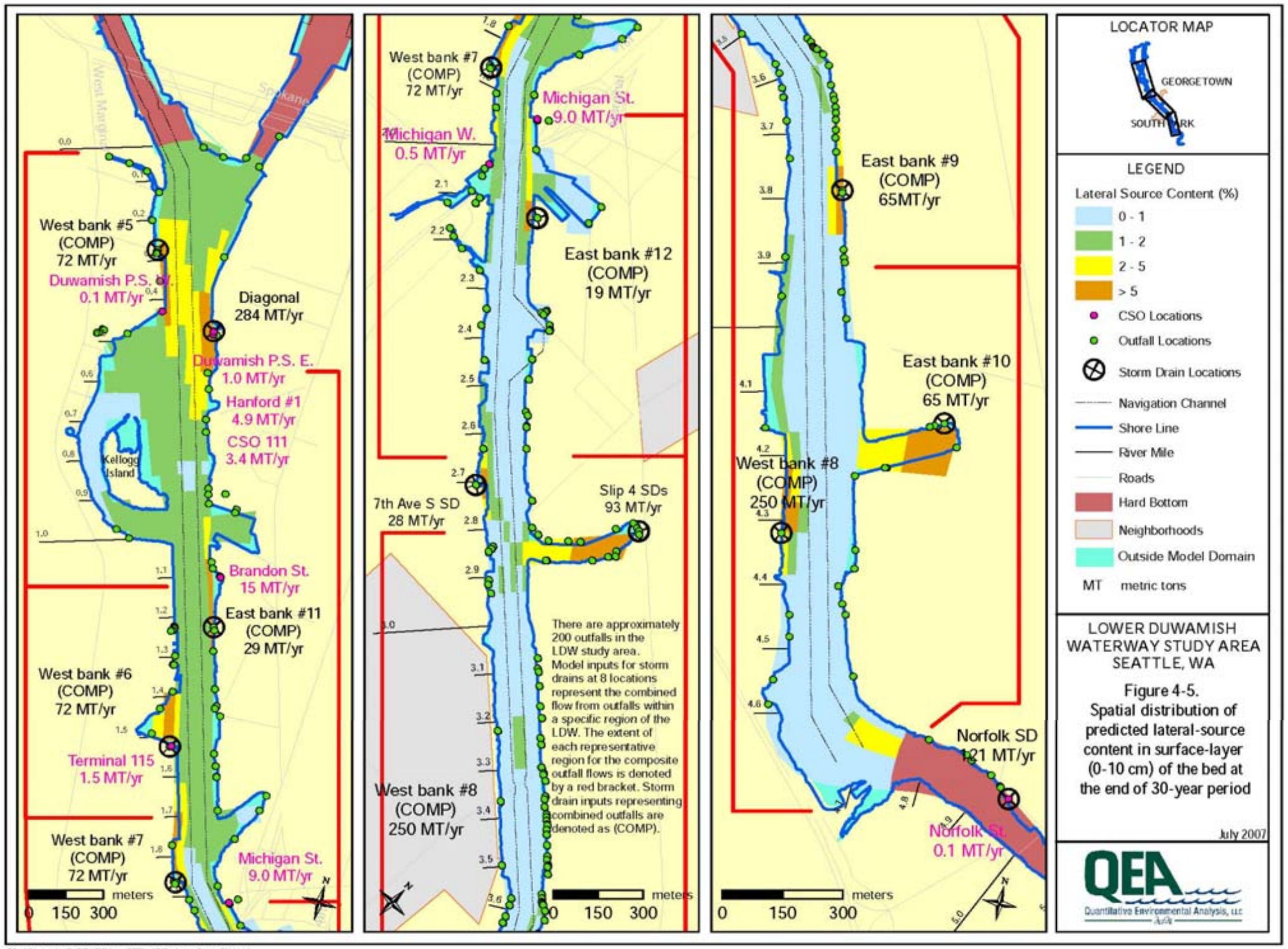
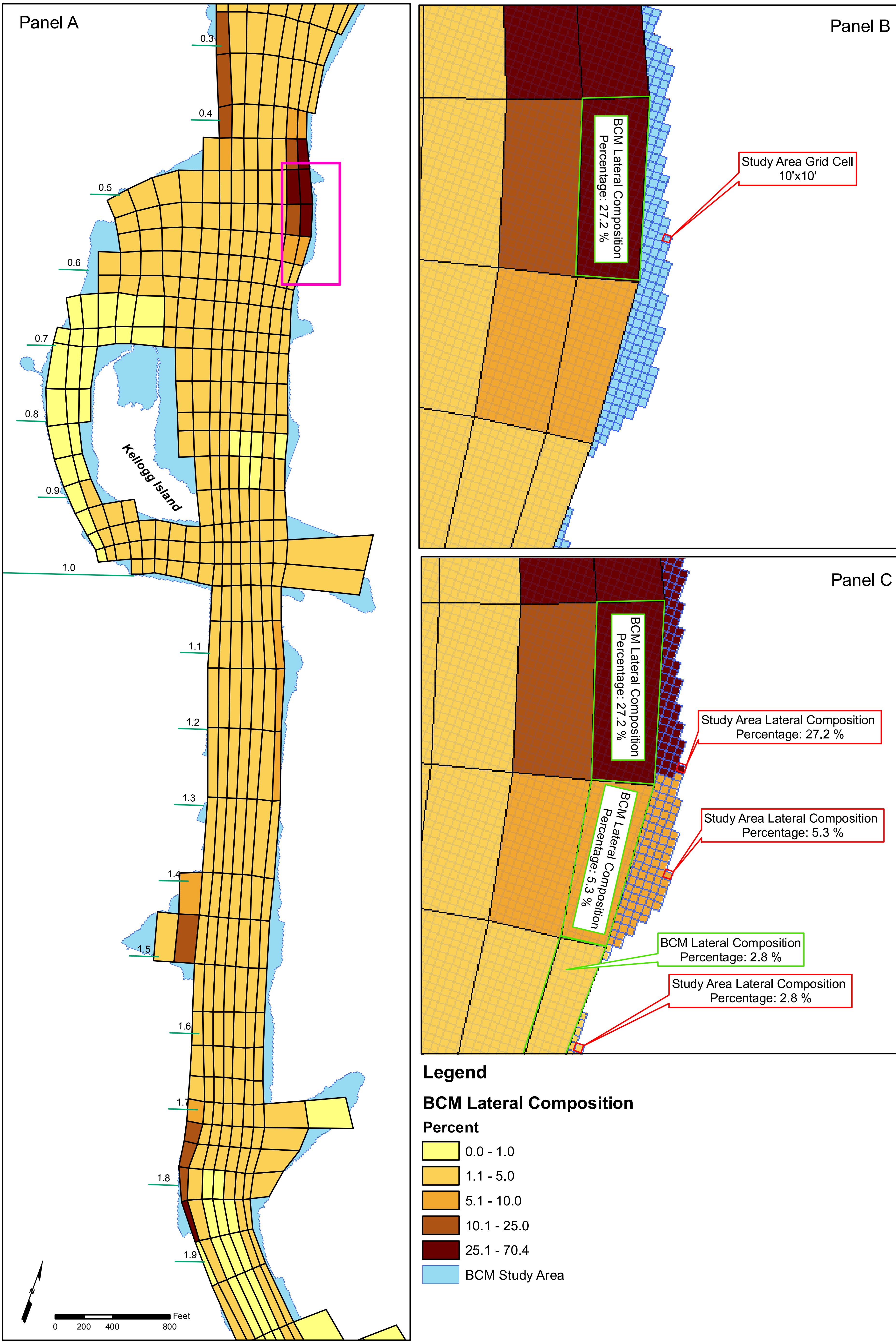


Figure 3 STM-predicted lateral solids composition in surface sediments (0-10 cm) at the end of 30-year period





F:\PROJECTS\GIS\Lower Duwamish FS\Projects\SDM Input Parameters\SDM input parameter memo\BCM Memo6.mxd (Creted in ArcGIS 9.2)

ENSR | AECOM

Merged with ENSR in 2007 RETEC

STM Modeling ENSR, Lower Duwamish Waterway, WA (05482015-615)			**Transposing STM Composition Results onto the Chemical Distribution Grid**
DATE: 8/17/07	DWRN:MVI/Sea	Revision: 6	**FIGURE 4**

Part 2: Mathematical Basis for the LDW Bed Composition Model

AECOM Environment
710 Second Avenue, Suite 1000, Seattle, WA 98104
T 206.624.9349 F 206.623.3793 www.aecom.com

AECOM

Draft Memorandum

Date: April 17, 2009

To: Lower Duwamish Waterway Group

From: Mike Riley, SSPA; Nicole Ott, AECOM

Subject: Mathematical Basis for the LDW Bed Composition Model

Introduction

This memorandum describes the mathematical basis for the bed composition model (BCM) proposed for use in the Lower Duwamish Waterway (LDW) feasibility study (FS) to estimate long-term changes in the chemistry of the surface sediment bed. Briefly, the BCM estimates the change in chemical concentrations in bed sediments over time due to sediment inflows from upstream sources (Green/Duwamish River) and lateral sources (storm drains, combined sewer overflows [CSOs], and streams) and chemical concentrations in the sediment bed at some specified initial point in time.

BCM Time-bed Composition Algorithm

Changes in the chemical concentrations in surface sediment over time are calculated as a function of the initial surface sediment concentrations (referred to as time=0)[1] and the changes in bed composition (i.e., changes in percent composition from the three sources of solids) predicted by the sediment transport model (STM) over some time period. The three sources of solids are lateral, upstream, and original sediment bed.

The basic equation for the BCM is:

$$dC/dt = d(C_{bed}*f_{bed} + \Sigma C_i*f_i)/dt \qquad \text{Equation (1)}$$

Where:

C	is the chemical concentration at some time **t**
C_{bed}	is the chemical concentration in the original bed sediment at time **t**
f_{bed}	is the fraction of the original bed sediment at time **t**
C_i	is the chemical concentration associated with inflows (lateral and upstream) at time **t**
f_i	is the fraction of inflow sediment at time **t**

[1] "time = 0" corresponds to the time when active remedial measures of a specific remedial alternative are completed. For a "no action" alternative, "time = 0" sediment concentrations correspond to the initial interpolated surface sediment chemical concentration maps. Composition (or fraction) of bed at time=0 is 100% original bed, 0% lateral, and 0% upstream sources.

Using the assumptions that: 1) the concentration in the original bed and concentrations in the inflows do not change significantly over time (dt), and 2) that all lateral inflow discharge points have the same chemical concentration in a particular time period, the concentration at a given time is dependent on the change in composition over that time period. Then, Equation (1) becomes:

$$C_{(time)} = C_{lateral} * f_{lateral(time)} + C_{upstream} * f_{upstream(time)} + C_{bed} * f_{bed} \qquad \text{Equation (2)}$$

Where:

$C_{lateral}$	represents the concentration of a chemical (i.e., total PCBs or arsenic) on lateral inflow solids
$f_{lateral}$	is the fraction of sediment from lateral inflows
$C_{upstream}$	represents the concentration of a chemical on upstream (i.e., Green/Duwamish River) solids
$F_{upstream}$	is the fraction of sediment from the Green/Duwamish River
C_{bed}	represents the chemical concentration in the surface sediment bed at time=0

The bed fraction (f_{bed}) represents the fraction of sediment at any point in the LDW. Depending on the scenario being modeled, the bed sediment chemical concentration assigned to this parameter at any given location may be:

- The initial sediment condition in the absence of any remediation (i.e., “no action” or monitored natural recovery alternative)
- The sediment condition present in an area immediately after active remediation (which might include capping, dredging, or a combination of dredging and capping).

In areas experiencing net sediment deposition, the bed sediment fraction will decrease over time as it is diluted by the settling of sediments from the lateral ($f_{lateral}$) and upstream (f_{river}) inflows. In its current form, the BCM does not specifically account for the potential movement (i.e., erosion and redeposition) of bed sediment throughout the study area. The effect of erosion and redeposition of bed sediment relative to other transport processes was previously estimated as part of the STM (QEA 2007). Redeposition of suspended bed sediments was estimated to constitute 2.5% of total deposition in Reach 1, 5.4% in Reach 2, and 2.5% in Reach 3 over 30 years. These percentages show that erosion and redeposition represent a minor contribution relative to the combined lateral and upstream inputs.

The BCM approach is a conservative method for estimating changes in chemical concentration in bed sediment over time for any chemical that is expected to decline in concentration associated with inflows over time. For instance, with the combined benefit of limited PCB commercial use, reduction in the primary sources of PCBs, and continued source control efforts from adjacent upland areas, the inflows that drain the Duwamish watershed can be expected to decline over time. Total PCB concentrations can be expected to decline in lateral and upstream inflows even though the assumption used in the BCM is that the concentrations will stay relatively constant.

Part 3: Lines of Evidence for the Development of BCM Input Parameters

Memorandum

To: Merv Coover, Anne Fitzpatrick, AECOM

From: Debra Williston, King County Department of Natural Resources and Parks; Beth Schmoyer, Seattle Public Utilities

Date: March 17, 2010

Re: BCM Lateral Input and Sensitivity Values for the LDW FS

The bed composition model (BCM) requires lateral input values for chemical concentrations associated with particles discharged to the LDW from storm drains, combined sewer overflows (CSOs), and streams. This text describes how the BCM lateral input values were selected for total PCBs, arsenic, cPAHs, and dioxins/furans.

The source tracing dataset for the LDW was used to establish BCM lateral values for PCBs, arsenic, and cPAHs for the FS. The dataset consists of storm drain solids data collected by various parties, including Seattle Public Utilities (SPU), The Boeing Company, and King County. SPU compiled and categorized the data by sample type and geographic area. The dataset includes samples of storm drain solids collected from on-site and right-of-way catch basins, as well as in-line grab samples and in-line sediment trap samples. Over 500 samples have been collected within drainage basins tributary to the LDW and analyzed for metals and semivolatile organic compounds. Over 900 samples have been analyzed for PCBs. Samples were collected from throughout drainage basins tributary to the LDW. However, because source control activities initially focused on the early action areas, these areas typically have the highest number of source tracing samples (see Figure 1). Table 1 provides a summary of the numbers and types of samples for these three chemicals.

Table 1: Numbers of storm drain solids samples collected within drainage basins tributary to the LDW

	Arsenic	Total PCBs	cPAHs
Onsite catch basins	137	345	114
Right-of-way catch basins	123	133	121
Inline grab samples	175	303	166
Sediment trap samples	141	172	142
Total	576	953	543

The lateral input values selected for use in the BCM should account for improvements in storm drain solids chemical concentrations resulting from source control efforts in the LDW drainage basin. In order to simulate potential lateral inputs after implementation of various degrees of source control, the source tracing datasets were screened to remove all values above various concentrations. Summary statistics were then generated for each level of assumed source control. These included sample count, detection frequency, minimum, maximum, median, mean, and 10th, 25th, 75th, and 90th percentiles (see Attachment A). The intent was to have a mid or base case BCM input value and a range about that value from high to low to investigate the sensitivity of the BCM to that input value. The following three BCM input values were therefore selected:

- BCM High Sensitivity Value – Conservative representation of current conditions assuming modest level of source control (e.g., management of high priority sources).
- BCM Input (Mid or Base Case) Value – Pragmatic assessment of what might be achieved in the next decade with anticipated levels of source control.
- BCM Low Sensitivity Value – Best that might be attainable in 30 to 40 years with increased coverage and continued aggressive source control.

The assumed level of source control was based on best professional judgment of the source control work group and what is currently known about the distribution within the LDW drainage basin and the ongoing source(s) of each chemical of concern. These reflect potential levels of source control that could occur over time. The screening values used in these analyses are not intended to be target values for source control.

While the screening values differed for PCBs, arsenic, and cPAHs, the same summary statistics were used to select the input (base case), low, and high BCM lateral values. For the input or base case value, the mean value was used. For the low and high value, the median and 90th percentile values were selected, respectively.

The evaluations of the source tracing dataset for total PCBs, arsenic, and cPAHs are described in the following sections. A somewhat different approach, also described below, was used for dioxins/furans because of the considerably smaller datasets available for dioxins/furans.

Total PCBs

PCBs were detected in 84 percent of the storm drain solids samples. Concentrations exceeded the lowest apparent effects threshold (LAET) value of 130 ug/kg dw in 67 percent of the samples and exceeded the second lowest apparent effects threshold (2LAET) value of 1,000 ug/kg dw in 41 percent of the samples. PCBs have been found in various building materials (e.g., paint, caulk, and other sealants) and there is also a continued global source from atmospheric deposition. Although PCBs are no longer manufactured, it is expected that the historical reservoir of PCB-containing materials will continue to act as a source to the LDW for many years. Therefore, complete elimination of PCBs will not be possible. However, inputs to the LDW from lateral sources are expected to be reduced with continued source control activities.

Unlike other chemicals, PCBs exhibited a distinct geographic distribution, with hotspots identified at Terminal 117 (T117), Rainier Commons, North Boeing Field/Georgetown Steam Plant, and Boeing Plant 2/Jorgensen Forge (Figure 2). The latter two have been sampled extensively and make up a significant portion of the overall source tracing data set. The Rainier Commons area does not have as large a dataset but it shows a distinctive hot spot when compared to other areas in the LDW. Therefore, prior to generating summary statistics for total PCBs, the data from Rainier Commons, North Boeing

Field/Georgetown Steam Plant, and Boeing Plant 2/Jorgensen Forge were flow-weighted to avoid skewing the summary statistics used to establish inputs for the BCM model. Flow-weighting takes into account the relative contribution of a chemical by adjusting the concentration based on the land area and estimated annual runoff volume relative to the total contributing area in the LDW (Table 2). Data from the T117 hot spot were not included with the storm drain solids data for this analysis because these T117 data are a mix of soil and street dirt samples. Recent storm drain data indicate that the interim action completed in 2004 has largely controlled the PCBs at this site. Therefore, the soil and street dirt samples were not included in the lateral source tracing dataset.

Table 2: Total PCBs Flow-Weighting Information

Subasin	Area (acre)	Average Annual Runoff (Mgal/yr)	Percent of Total Runoff[a]	Description
LDW SD basin	8,936	4,065	100%	Total area draining to LDW
North Boeing Field/Georgetown Steamplant	110	69.7	1.8%	Area of North Boeing Field downstream of the runway that drains to Slip 4
Boeing Plant 2/Jorgensen Forge	132	87	2.2%	All of Boeing Plant 2 from Slip 4 to Jorgensen property
Rainier Commons	1.2	0.8	0.02%	Portion of Rainier Commons property that drains to LDW via the Diagonal Ave S CSO/SD storm drain system
Remaining	8,693	3,908	96.1%	Remaining LDW storm drainage basin

a. Factor used to flow-weight PCB\s concentrations for each geographic area.

For purposes of the FS, three screening values were considered to generate a reasonable range of BCM lateral values for PCBs. If all samples with total PCB concentrations above a screening value of 5,000 ug/kg dw are removed from the dataset, the mean of the remaining data is 300 ug/kg dw[1]; this value was selected to represent the BCM input or base case value. The screening value of 5,000 ug/kg dw was chosen to account for the presence of PCBs in building materials on older structures that may exist within drainage basins tributary to the LDW. These types of sources will be difficult to identify and control in the near term. Other lines of evidence support the use of 300 µg/kg dw as a reasonable input value. The mean total PCB concentration in all of the right-of-way catch basin samples was 689 ug/kg dw and dropped to 291 ug/kg dw when the three samples from catch basins located immediately downstream of the Rainier Commons site (23,000, 17,000, and 17,500 ug/kg dw) were removed. Right-of-way catch basin sample are less likely to be affected by high concentrations associated with activities on a particular property, and more likely to be representative of area-wide inputs such as vehicular traffic and atmospheric deposition. Sediment trap samples are also considered to reflect average conditions, because they represent contributions from all the runoff upstream of the sampling station. The mean total PCB concentration in all of the

[1] PCB values are rounded to one significant figure for the BCM model.

sediment trap samples outside of North Boeing Field was 371 ug/kg dw, or 284 ug/kg when the one sample greater than 10,000 ug/kg dw was removed.

Screening values of 2,000 and 10,000 ug/kg dw were selected for purposes of defining the low and high BCM sensitivity values, respectively. If all samples with total PCB concentrations above a screening value of 2,000 ug/kg dw are removed from the dataset, the median of the remaining data is 100 ug/kg dw, and this was selected as the low BCM sensitivity value. If all samples with total PCB concentrations above a screening value of 10,000 ug/kg dw are removed from the dataset, the 90th percentile value of the remaining data is 1,000 µg/kg dw, and this was selected as the high BCM sensitivity value. The high value is not intended to represent what sources could be throughout the drainage basins tributary to the LDW. This high value is used only to determine sensitivity of the model; it is not an estimate of actual source loads or a target value for source control work. Table 3 summarizes the BCM lateral input and sensitivity values for PCBs.

Arsenic

Arsenic was detected in 52 percent of the storm drain solids samples, but concentrations were relatively low, with only 5 percent of the samples exceeding the sediment quality standard (SQS, 57 mg/kg dw) and only 3 percent exceeding the cleanup screening level (CSL, 93 mg/kg dw). Samples containing elevated concentrations were not clustered in any geographic area. For this reason, the source tracing data were not flow-weighted for the evaluation of BCM inputs (Figure 3). Arsenic is a naturally occurring metalloid found in the Green/Duwamish river basin at concentrations ranging from non-detect to 20 mg/kg dw (http://www.ecy.wa.gov/programs/tcp/sites/tacoma_smelter/extended_footprint_study_kc/e_f_s.html). Arsenic will always be present in lateral inputs to the LDW.

Two different screening values (the SQS and CSL) were used to reflect different potential levels of source control. If all samples with arsenic concentrations above a screening value of 93 mg/kg dw (the CSL) are removed from the dataset, the mean of the remaining data is 13 mg/kg dw (this value was selected to represent the BCM input or base case value) and the 90th percentile is 30 mg/kg dw (this value was selected to represent the high BCM sensitivity value). If all samples with arsenic concentrations above a screening value of 57 mg/kg dw (the SQS) are removed from the dataset, the median of the remaining data is 9 mg/kg dw (this value was selected to represent the low BCM sensitivity value). The high value is not intended to represent what sources could be throughout the drainage basins tributary to the LDW. This high value is used only to determine sensitivity of the model; it is not an estimate of actual source loads or a target value for source control work. Table 3 summarizes the BCM lateral input and sensitivity values for arsenic.

cPAHs

cPAHs were detected in 93 percent of the storm drain solids samples. Unlike PCBs, cPAHs have many ongoing sources, primarily associated with combustion sources such as vehicle emissions, home heating oil use, and wood burning. As a result, cPAHs will continue to be deposited on roadways and other land surfaces in the basin, and transported to the LDW in urban runoff. Therefore, this chemical will be difficult to control. Consequently, a more cautious approach was taken with the source tracing dataset.

Data for cPAHs were not flow-weighted because cPAH concentrations in the storm drain solids samples do not show a distinct geographic distribution (Figure 4). Higher concentrations of cPAHs are found throughout the basin. A single screening value (25,000 ug TEQ/kg dw) was used based on best professional judgment regarding the difficulty of effectively controlling this chemical group. cPAHs are present at concentrations >25,000 ug TEQ/kg dw at various locations throughout drainage basins tributary to the LDW, typically in onsite drainage structures (catch basins and oil/water separators) at sites engaged in transportation-related activities (e.g., bus and airport operations), maintenance facilities, service stations, foundries, and fast food facilities. This screening value is considered an appropriate representation of source control effectiveness in controlling significant sources. If all samples with cPAH concentrations above the screening value of 25,000 ug TEQ/kg dw are removed from the dataset, the mean of the remaining data is 1,400 ug TEQ/kg dw[2] (selected to represent the BCM input or base case value); the median is 500 ug TEQ/kg dw (selected to represent the low BCM sensitivity value); and the 90th percentile is 3,400 ug TEQ/kg dw (selected to represent the high BCM sensitivity value) (Table 3).

Dioxins/Furans

Available storm drain solids data for dioxins and furans were also used along with data for surface sediment samples collected for the LDW RI in the vicinity of storm drains throughout the Greater Seattle area to establish BCM lateral values for dioxins and furans. These two datasets were combined because the storm drain solids dataset was small compared to the other risk driver datasets. There are 11 dioxin and furan storm drain solids samples collected from on-site catch basins and in-line grab samples, as well as one street dirt sample. There are 12 surface sediment samples from the vicinity of storm drains throughout the Greater Seattle area that were analyzed for dioxins/furans that are included for this analysis; two of these 12 samples that had high concentrations of dioxins/furans were not included following an outlier analysis. Combining the two datasets results in the following: mean of 20 ng TEQ/kg dw (selected as the BCM input or base case value); median of 10 ng TEQ/kg dw (selected as the low BCM sensitivity value); and a 95% upper confidence limit on the mean (UCL) of 40 ng TEQ/kg dw (selected as the high BCM sensitivity value) (Table 3). The combined dioxin/furan dataset was not screened the same way other storm drain solids data were because of the limited data available. In addition, the UCL rather than the 90th percentile was used to establish the high BCM sensitivity value because it resulted in a more reasonable upper end estimate for the sensitivity analysis. The goal was to estimate, using best professional judgment, a reasonable range of BCM lateral input as sensitivity values.

King County CSO data

In addition to the storm drain solids dataset, King County data for PCBs, arsenic, and cPAHs in whole-water samples collected from CSOs were also considered when developing BCM lateral values. For both total PCBs and cPAHs, whole-water concentrations were divided by their sample-specific total suspended solids (TSS) concentrations (in mg/L) to calculate TSS-normalized concentrations. This gives a

[2] The cPAH input (or base case) and high BCM sensitivity values were rounded to two significant figures and the low BCM sensitivity value was rounded to one significant figure.

conservative estimate that is likely biased high because it is assumed that all of the PCBs and cPAHs are on the particulate fraction and none are in the dissolved or colloidal phases. For arsenic, paired total and dissolved concentrations were used to estimate the portions of the total arsenic concentrations associated with the particulate fraction, which were then divided by the sample-specific TSS concentrations to calculate a TSS-normalized concentration for arsenic. The summary statistics for these analytes are provided in Table 4. The median, mean, and 90th percentile values for these three chemicals generally fall within the ranges selected for the BCM lateral input values.

Table 4. Summary of TSS-normalized PCBs, cPAHs, and arsenic data for samples collected from King County Duwamish combined sewer basins.

	TSS-normalized Concentration		
	Total PCBs (µg/kg)	**Total cPAHs (µg TEQ/kg)**	**Arsenic (mg/kg)**
Count	28	26	21
Minimum	89	28.9	1.1
Maximum	1,627	4,136	15.8
Median	580	714	10.6
Mean	638	1,051	9.3
25th percentile	441	134	6.2
75th percentile	724	1,627	11.7
90th percentile	920	2,728	13.2

Table notes:

TSS = total suspended solids

Total PCBs based on sum of detected congeners

TSS-normalized calculation for PCBs and cPAHs based on sample-specific whole-water concentration divided by TSS concentration; this assumes all PCBs and cPAHs on particulate/solid fraction

TSS-normalized calculation for arsenic based on sample-specific total arsenic minus dissolved arsenic divided by TSS concentration

Table 3 - Revised BCM Lateral Input and Sensitivity Values for LDW Feasibility Study

Rationale

1. High – Conservative representation of current conditions assuming modest level of source control (e.g., management of high priority sources).
2. Input (Mid) – Pragmatic assessment of what might be achieved in the next decade with anticipated levels of source control.
3. Low – Best that might be attainable in 30 to 40 years with increased coverage and continued aggressive source control.

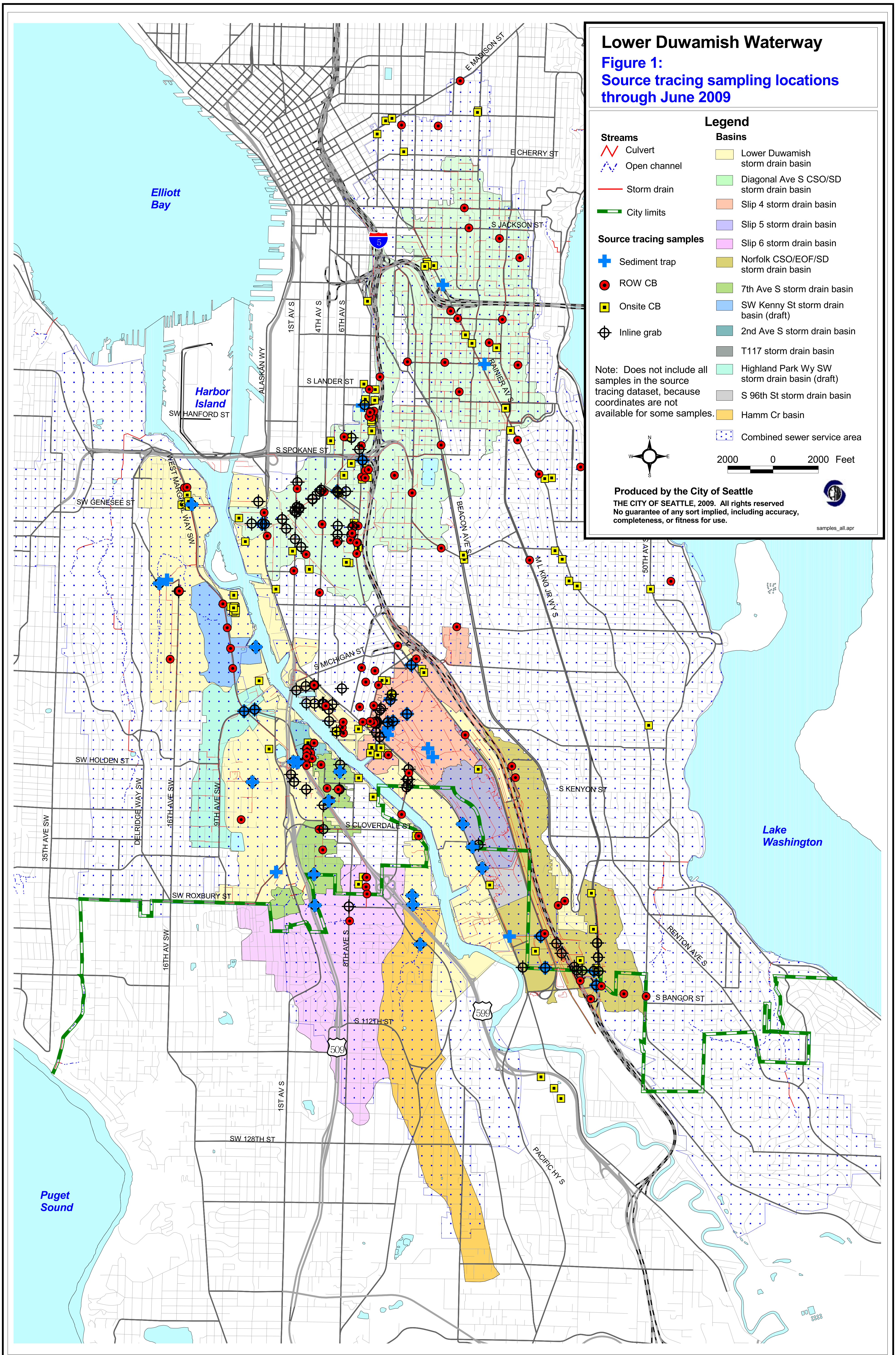
Chemical	Values Used in the Draft FS			Proposed Values for the Revised FS			Basis for Proposed BCM Input and Sensitivity Values
	Input	Low	High	Input	Low	High	
Arsenic[a] (mg/kg dw)	13	7	23	13	9	30	Screened the source tracing dataset to exclude concentrations above assumed SMS-based source control levels (93 and 57 mg/kg dw) **Input:** Mean excluding values >93 mg/kg (the CSL). **High:** 90th percentile excluding values >93 mg/kg (the CSL). **Low:** Median of all samples, excluding values >57 mg/kg (the SQS)[a].
Total PCBs[a] (µg /kg dw)	660	60	1,200	300	100	1,000	Used a range of screening concentrations to reflect potential levels of source control that could occur over time. **Input:** Mean of flow-weighted dataset excluding values >5,000 µg/kg dw. **High:** 90th percentile of flow-weighted source tracing dataset excluding values >10,000 µg/kg dw. **Low:** Median of flow-weighted source tracing dataset excluding values >2,000 µg/kg dw.[a]
cPAH[a] (µg TEQ/kg dw)	2,800	200	5,000	1,400	500	3,400	Screened the source tracing dataset to exclude concentrations above an assumed source control level. cPAHs are expected to be difficult to control due to the petroleum-based economy, intensity of urbanization in the LDW and myriad ongoing sources. **Input:** Mean of source tracing dataset excluding values >25,000 ug TEQ/kg dw. **High:** 90th percentile of source tracing dataset excluding values >25,000 ug TEQ/kg dw. **Low:** Median of source tracing dataset excluding values >25,000 ug TEQ/kg dw.[a].
Dioxins and Furans[b] (nq TEQ/kg dw)	20	10	100	20	10	40	Based on combined Greater Seattle sediment and SPU catch basin solids datasets. [b] **Input:** Mean. **Low:** Median (rounded to10). **High:** UCL95.

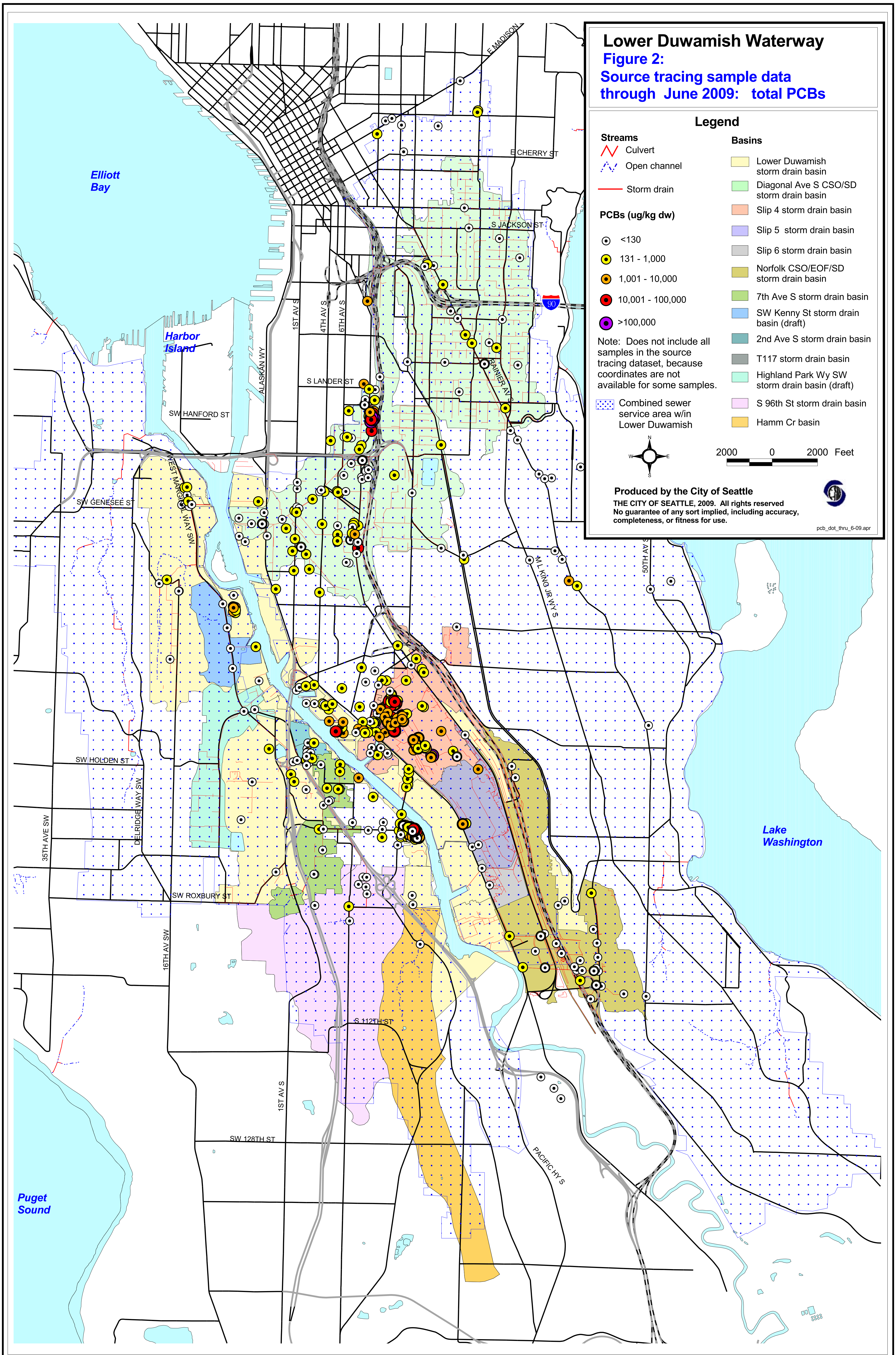
Notes:

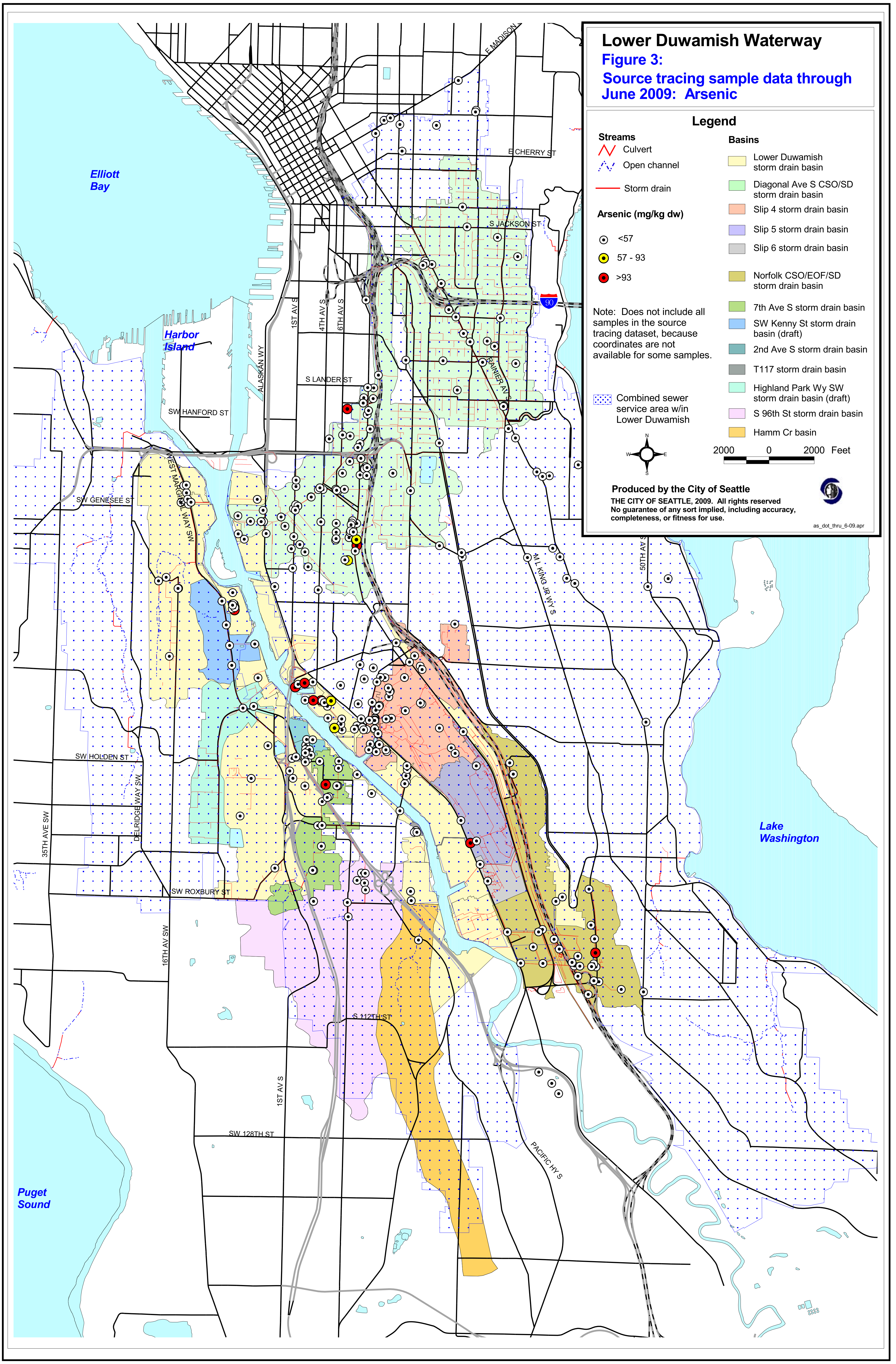
[a] Used Lower Duwamish Waterway source tracing dataset (compiled by SPU) through June, 2009 (SPU_StormDrainSolids_LDW_data_thru_6-30-09_.xls) as the primary basis for establishing lateral BCM parameter values for arsenic, total PCBs, and cPAH. The dataset was screened to remove concentrations using various source control practicability assumptions (best professional judgment). Total PCB data were flow-weighted before generating statistics because PCBs exhibit a distinct geographic distribution with hotspots identified in Terminal 117, NBF/GTSP, Rainer Commons, and Boeing Plant 2. These three areas have been extensively sampled and make up a significant portion of the overall source tracing dataset. Therefore, these source tracing data were flow-weighted to avoid skewing the summary statistics used in the BCM model. Arsenic and cPAH data were not flow-weighted prior to the statistical analysis because these chemicals lack a pronounced geographic dependency that would warrant flow-weighting.

[b] Parameter estimation for dioxins and furans was based on the Greater Seattle sediment and SPU catch basin solids datasets. The summary statistics used to estimate parameter values (see table entries) correspond to the combined datasets, as supported by statistical analysis. See source file (DioxinFuranBCMparameterMPC012-09-09.xls) for data and statistical analysis, including removal of outliers.

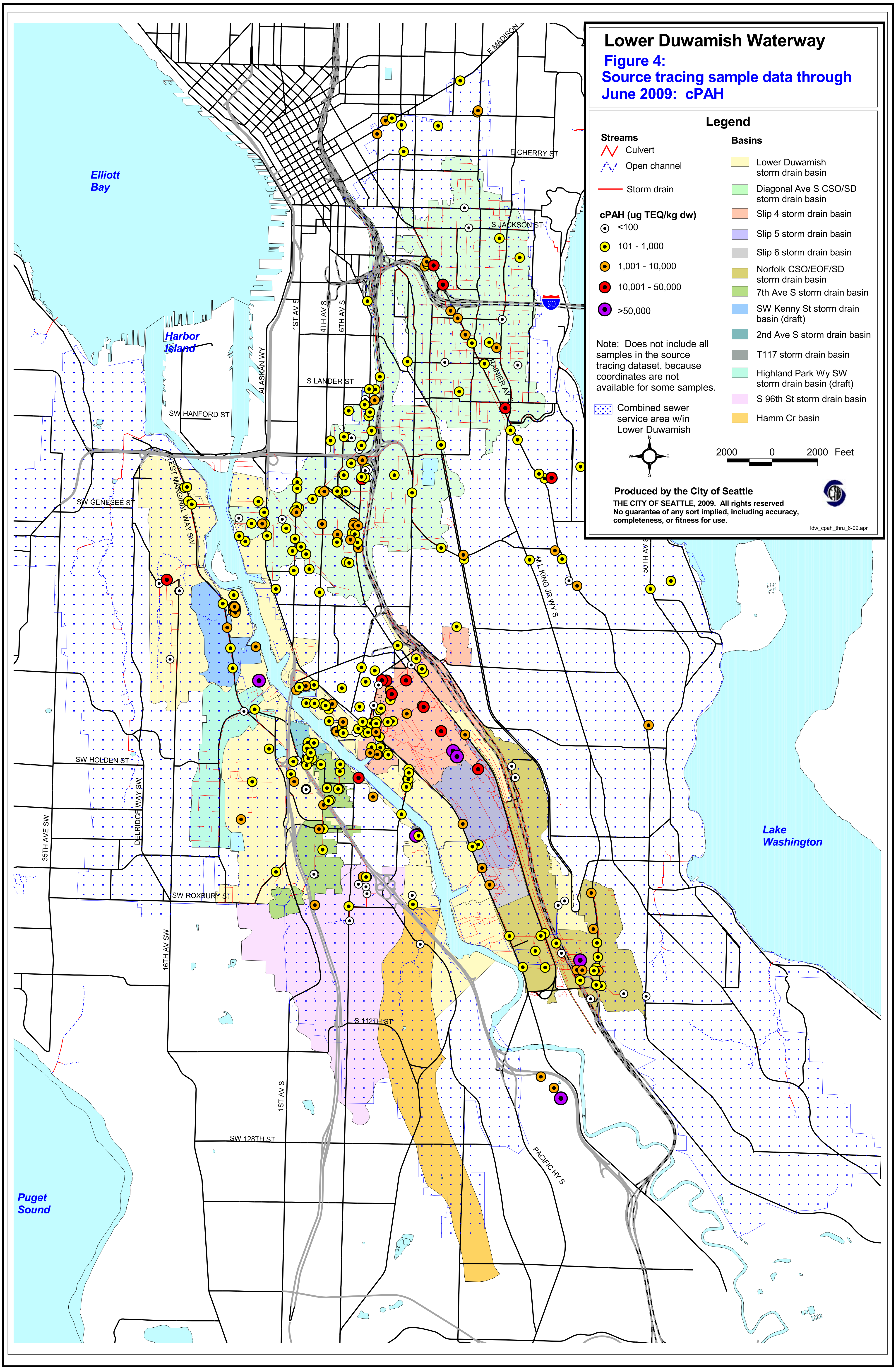
BCM = bed composition model; cPAH = carcinogenic polycyclic aromatic hydrocarbon; CSL = cleanup screening level; FS = feasibility study; GTSP = Georgetown Steam Plant; NBF = North Boeing Field; PCB = polychlorinated biphenyl; SPU = Seattle Public Utilities; TEQ = toxic equivalent; SQS = sediment quality standard; UCL95 = 95% upper confidence limit on the mean


Lower Duwamish Waterway
Figure 1:
Source tracing sampling locations through June 2009
Legend
Streams
Culvert
Open channel
Storm drain
City limits
Source tracing samples
Sediment trap
ROW CB
Onsite CB
Inline grab
Note: Does not include all samples in the source tracing dataset, because coordinates are not available for some samples.
Basins
Lower Duwamish storm drain basin
Diagonal Ave S CSO/SD storm drain basin
Slip 4 storm drain basin
Slip 5 storm drain basin
Slip 6 storm drain basin
Norfolk CSO/EOF/SD storm drain basin
7th Ave S storm drain basin
SW Kenny St storm drain basin (draft)
2nd Ave S storm drain basin
T117 storm drain basin
Highland Park Wy SW storm drain basin (draft)
S 96th St storm drain basin
Hamm Cr basin
Combined sewer service area
N
E
S
W
2000
0
2000
Feet
Produced by the City of Seattle
THE CITY OF SEATTLE, 2009. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
samples_all.apr
Elliott Bay
Harbor Island
Lake Washington
Puget Sound
E MADISON ST
E CHERRY ST
S JACKSON ST
5
1ST AV S
4TH AV S
6TH AV S
ALASKAN WY
S LANDER ST
SW HANFORD ST
S SPOKANE ST
SW GENESEE ST
WEST MARGINAL WAY SW
RAINIER AV S
BEACON AVE S
M L KING JR WY S
50TH AV S
S MICHIGAN ST
SW HOLDEN ST
DELRIDGE WAY SW
16TH AVE SW
9TH AVE SW
35TH AVE SW
S KENYON ST
S CLOVERDALE ST
SW ROXBURY ST
16TH AV SW
8TH AVE S
RENTON AVE S
S BANGOR ST
S 112TH ST
599
509
1ST AV S
SW 128TH ST
PACIFIC HY S


Lower Duwamish Waterway
Figure 2:
Source tracing sample data through June 2009: total PCBs
Legend
Streams
Culvert
Open channel
Storm drain
PCBs (ug/kg dw)
<130
131 - 1,000
1,001 - 10,000
10,001 - 100,000
>100,000
Note: Does not include all samples in the source tracing dataset, because coordinates are not available for some samples.
Combined sewer service area w/in Lower Duwamish
Basins
Lower Duwamish storm drain basin
Diagonal Ave S CSO/SD storm drain basin
Slip 4 storm drain basin
Slip 5 storm drain basin
Slip 6 storm drain basin
Norfolk CSO/EOF/SD storm drain basin
7th Ave S storm drain basin
SW Kenny St storm drain basin (draft)
2nd Ave S storm drain basin
T117 storm drain basin
Highland Park Wy SW storm drain basin (draft)
S 96th St storm drain basin
Hamm Cr basin
2000 0 2000 Feet
Produced by the City of Seattle
THE CITY OF SEATTLE, 2009. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
pcb_dot_thru_6-09.apr
Elliott Bay
Harbor Island
Lake Washington
Puget Sound
E MADISON
E CHERRY ST
S JACKSON ST
1ST AV S
4TH AV S
6TH AV S
ALASKAN WY
S LANDER ST
SW HANFORD ST
RAINIER AV S
SW GENESEE ST
WEST MARGINAL WAY SW
M L KING JR WY S
50TH AV S
SW HOLDEN ST
DELRIDGE WAY SW
35TH AVE SW
SW ROXBURY ST
16TH AV SW
S 112TH ST
1ST AV S
SW 128TH ST
PACIFIC HY S



Lower Duwamish Waterway
Figure 3:
Source tracing sample data through June 2009: Arsenic
Legend
Streams
Culvert
Open channel
Storm drain
Arsenic (mg/kg dw)
<57
57 - 93
>93
Note: Does not include all samples in the source tracing dataset, because coordinates are not available for some samples.
Combined sewer service area w/in Lower Duwamish
Basins
Lower Duwamish storm drain basin
Diagonal Ave S CSO/SD storm drain basin
Slip 4 storm drain basin
Slip 5 storm drain basin
Slip 6 storm drain basin
Norfolk CSO/EOF/SD storm drain basin
7th Ave S storm drain basin
SW Kenny St storm drain basin (draft)
2nd Ave S storm drain basin
T117 storm drain basin
Highland Park Wy SW storm drain basin (draft)
S 96th St storm drain basin
Hamm Cr basin
2000 0 2000 Feet
Produced by the City of Seattle
THE CITY OF SEATTLE, 2009. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
as_dot_thru_6-09.apr
Elliott Bay
Harbor Island
Lake Washington
Puget Sound
E MADISON
E CHERRY ST
S JACKSON ST
1ST AV S
4TH AV S
6TH AV S
ALASKAN WY
S LANDER ST
SW HANFORD ST
RAINIER AV S
SW GENESEE ST
WEST MARGINAL WAY SW
M L KING JR WY S
50TH AV S
SW HOLDEN ST
DELRIDGE WAY SW
35TH AVE SW
SW ROXBURY ST
16TH AV SW
S 112TH ST
1ST AV S
SW 128TH ST
PACIFIC HY S
90


Lower Duwamish Waterway
Figure 4:
Source tracing sample data through June 2009: cPAH
Legend
Streams
Culvert
Open channel
Storm drain
cPAH (ug TEQ/kg dw)
<100
101 - 1,000
1,001 - 10,000
10,001 - 50,000
>50,000
Note: Does not include all samples in the source tracing dataset, because coordinates are not available for some samples.
Combined sewer service area w/in Lower Duwamish
Basins
Lower Duwamish storm drain basin
Diagonal Ave S CSO/SD storm drain basin
Slip 4 storm drain basin
Slip 5 storm drain basin
Slip 6 storm drain basin
Norfolk CSO/EOF/SD storm drain basin
7th Ave S storm drain basin
SW Kenny St storm drain basin (draft)
2nd Ave S storm drain basin
T117 storm drain basin
Highland Park Wy SW storm drain basin (draft)
S 96th St storm drain basin
Hamm Cr basin
2000 0 2000 Feet
Produced by the City of Seattle
THE CITY OF SEATTLE, 2009. All rights reserved
No guarantee of any sort implied, including accuracy, completeness, or fitness for use.
ldw_cpah_thru_6-09.apr
Elliott Bay
Harbor Island
Lake Washington
Puget Sound
E MADISON
E CHERRY ST
S JACKSON ST
1ST AV S
4TH AV S
6TH AV S
ALASKAN WY
S LANDER ST
SW HANFORD ST
RAINIER AV S
WEST MARGINAL WAY SW
SW GENESEE ST
M L KING JR WY S
50TH AV S
SW HOLDEN ST
DELRIDGE WAY SW
35TH AVE SW
SW ROXBURY ST
16TH AV SW
S 112TH ST
1ST AV S
SW 128TH ST
PACIFIC HY S
90

Attachment A: Summary of LDW Storm Drain Solids Data, Including the Effects of Applying Various Screening Values

	n	Detect freq	SQS/LAET Exceed[c]	CSL/2LAET Exceed[c]	25th percentile	75th percentile	10th percentile	90th percentile	Min	Max	Median	Mean
Arsenic (mg/kg dw)												
All samples combined	576	52%	5%	3%	5	20	4	30	2	1,420	10	22
Minus samples > 93	563	51%	2%	1%	5	20	4	**30**	2	87	10	**13**
Minus samples > 57	553	50%	1%	1%	5	17	4	29	2	51	**9**	12
cPAHs (µg TEQ/kg dw)[c]												
All samples combined	543	93%	NA	NA	195	1,392	82	3,960	17	492,000	520	3,230
Minus Basin Oil	542	93%	NA	NA	195	1,385	82	3,926	17	83,540	517	2,328
Minus samples >50,000	537	93%	NA	NA	194	1,273	82	3,455	17	45,990	501	1,648
Minus samples >25,000	533	93%	NA	NA	194	1,267	81	**3,366**	17	22,390	**490**	**1,370**
Minus samples >10,000	521	93%	NA	NA	191	1,206	78	2,838	17	9,965	471	1,048
Total PCBs (µg/kg dw)												
All data												
All samples combined	953	84%	67%	41%	73	6,600	10	40,120	5	10,000,000	440	42,512
LDW minus RainCom/NBF/Plant2-Jorg	522	72%	44%	10%	25	302	10	936	5	92,000	101	1,200
Rainier Commons	15	100%	100%	87%	5,500	99,000	1,160	879,600	201	2,200,000	17,500	268,673
NBF[a]	350	99%	95%	80%	1,450	26,725	390	94,400	10	1,310,000	7,000	38,786
Plant 2-Jorgensen[b]	66	95%	92%	67%	523	76,500	201	620,000	19	10,000,000	7,250	337,600
Flow-weighted average	953	84%	NA	NA	63	2,489	21	16,554	5	334,650	387	9,409
Minus samples >20,000												
All samples combined	816	81%	62%	31%	50	1,705	10	7,900	5	19,800	253	2,149
LDW minus RainCom/NBF/Plant2-Jorg	514	71%	43%	8%	25	289	10	766	5	18,300	100	486
Rainier Commons	10	100%	100%	80%	2,375	17,400	380	18,000	201	19,800	12,700	10,310
NBF[a]	249	98%	94%	72%	860	8,020	250	13,720	10	19,700	2,880	5,077
Plant 2-Jorgensen[b]	43	93%	88%	49%	293	6,000	131	9,040	19	14,200	970	3,177
Flow-weighted average	816	81%	NA	NA	46	558	17	1,186	5	18,263	171	631
Minus samples >10,000												
All samples combined	755	80%	59%	25%	47	1,021	10	4,050	5	9,300	206	1,166
LDW minus RainCom/NBF/Plant2-Jorg	512	71%	43%	8%	25	288	10	729	5	8,300	99	418
Rainier Commons	5	100%	100%	60%	400	2,600	281	6,080	201	8,400	2,300	2,780
NBF[a]	198	97%	92%	65%	580	4,297	184	7,200	10	9,300	1,735	2,785
Plant 2-Jorgensen[b]	40	95%	88%	45%	283	3,998	129	8,020	19	9,300	895	2,523
Flow-weighted average	755	80%	NA	NA	40	443	16	**1,009**	5	8,353	146	508
Minus samples >5,000												
All samples combined	692	78%	55%	18%	38	580	10	1,898	5	4,900	161	613
LDW minus RainCom/NBF/Plant2-Jorg	500	71%	42%	6%	22	264	10	602	5	3,950	94	272

Attachment A: Summary of LDW Storm Drain Solids Data, Including the Effects of Applying Various Screening Values

	n	Detect freq	SQS/LAET Exceed[c]	CSL/2LAET Exceed[c]	25th percentile	75th percentile	10th percentile	90th percentile	Min	Max	Median	Mean
Rainier Commons	4	100%	100%	50%	350	2,375	261	2,510	201	2,600	1,350	1,375
NBF[a]	156	97%	90%	56%	473	2,578	131	3,700	10	4,900	1,300	1,589
Plant 2-Jorgensen[b]	32	94%	84%	31%	236	1,428	117	3,280	19	4,800	505	1,098
Flow-weighted average	692	78%	NA	NA	35	332	15	718	5	3,992	125	**315**
Minus samples >2,000												
All samples combined	625	76%	50%	10%	30	405	10	992	5	1,980	133	321
LDW minus RainCom/NBF/Plant2-Jorg	489	70%	40%	3%	22	250	10	496	5	1,980	86	205
Rainier Commons	2	100%	100%	0%	251	350	221	380	201	400	301	301
NBF[a]	108	96%	85%	36%	273	1,313	97	1,647	10	1,900	680	796
Plant 2-Jorgensen[b]	26	92%	81%	15%	192	828	98	1,240	19	1,620	330	531
Flow-weighted average	625	76%	NA	NA	30	282	14	534	5	1,973	**102**	223
Minus samples >1,000												
All samples combined	562	73%	44%	0%	26	280	10	520	5	980	99	187
LDW minus RainCom/NBF/Plant2-Jorg	471	69%	38%	0%	20	220	10	442	5	940	79	156
Rainier Commons	2	100%	100%	0%	251	350	221	380	201	400	301	301
NBF[a]	67	97%	76%	0%	139	580	42	796	10	980	390	396
Plant 2-Jorgensen[b]	22	91%	77%	0%	148	508	84	841	19	970	293	372
Flow-weighted average	562	73%	NA	NA	25	233	12	458	5	943	89	166

BCM inputs:

Low = median concentration with concentrations above a certain screening level removed

Med = mean concentration with concentrations above a certain screening level removed

High = 90th percentile concentration with concentrations above a certain screening level removed

Includes all source samples (sediment) collected through June 2009. Includes samples collected by SPU, King County, and Boeing.

a. Catch Basin samples from North Boeing Field area (all areas downstream of the runway, Cargill 2007).

b. Plant 2-Jorgensen source control area delineated by Ecology. Catch basin and in-line samples collected from Plant 2 storm drains and from the storm drain between Plant 2 and Jorgensen Forge (Floyd Snider 2005, Cargill 2005, Flint 2005).

c. LAET and 2LAET used for total PCBs; SQS/CSL used for arsenic.

Notes:

NA = not applicable

Total PCBs = sum of the detected Aroclors

cPAH = sum of toxic equivalents calculated using toxic equivalency factors for the individual cPAHs, the concentrations of detected cPAHs, and half the detection limits for undetected cPAHs

For summary statistics, half the detection limit used for non-detects.

AECOM Environment
710 Second Avenue, Suite 1000, Seattle, WA 98104
T 206.624.9349 F 206.623.3793 www.aecom.com

AECOM

Memorandum

Date: August 5, 2010[5]

To: Lower Duwamish Waterway Group

From: AECOM

Subject: Datasets Used in the Development of Upstream BCM Model Input Parameters

The majority of solids deposited within the Lower Duwamish Waterway (LDW) originates as bed load and suspended solids transported into the LDW from the Green/Duwamish River. Therefore, the risk-driver concentrations associated with sediments and suspended solids in the Green/Duwamish River upstream of the LDW substantially influence the resulting LDW sediment concentrations and are an important determinant for the bed composition model (BCM).This memorandum presents the datasets used to estimate the risk-driver concentrations in sediment particles from upstream sources that enter and deposit within the LDW. The datasets include concentrations of total polychlorinated biphenyls (PCBs), arsenic, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), and dioxins/furans associated with the upstream sources of sediments over a period of years. From these datasets, concentrations representing the potential range of upstream concentrations of each constituent were determined. These representative values are important in the evaluation of the LDW because each dataset is influenced by various sediment transport phenomena, spatially varying physical properties, and localized geographical, meteorological, and chemical loading factors; therefore, no one dataset adequately represents the actual risk-driver concentrations on sediment depositing in the LDW. Having a range of upstream values was essential in defining the upstream input parameters for the BCM described in Section 5.

Upstream Datasets

Four sources of data are presented and discussed below to characterize upstream concentrations for use as upstream input parameters to the BCM:

- Estimated risk-driver concentrations associated with suspended solids in the Green/Duwamish River inflow, based on upstream water quality monitoring data collected by King County from 2001 through 2008 (data received from King County by Windward)
- Data from centrifuged solids samples collected in the Duwamish River upstream of the LDW by the Washington State Department of Ecology (Ecology) in 2008 and 2009 (Ecology 2009)
- Upstream surface sediment data collected from 1994 through 2006 between river mile (RM) 5.0 and 7.0 by multiple parties (data from LDW Remedial Investigation), and surface sediment samples collected in 2008 between RM 4.9 and RM 6.5 by Ecology (data received from Ecology by Windward)
- U.S. Army Corps of Engineers (USACE) dredged material characterization core data collected from the upper reach of the LDW between RM 4.3 and RM 4.75 from 1990 through 2009 (USACE 2009a, 2009b).

[5] Revisions shown are for consistency with the FS; no new analysis was performed.

All of these data have been incorporated into the feasibility study (FS) project database maintained by Windward Environmental on behalf of the Lower Duwamish Waterway Group.

King County's Green/Duwamish River Whole-Water Data

King County whole-water samples were collected from two sampling locations in the Green/Duwamish River (Figure 1). These sampling locations are located approximately 1.3 miles (Duwamish River at Marginal Way; RM 6.3) and 5.9 miles (Green River at Fort Dent; RM 10.9) upstream of the LDW. These samples were collected as part of the county's routine monthly stream sampling and as part of targeted wet weather event sampling.

Table 1 summarizes the available total PCB, arsenic, and cPAH surface water data from King County, and Table 2 provides a summary of the overall data quality. Chemistry data for the whole-water samples were referenced or normalized to the total suspended solids (TSS) concentrations of the samples as an estimate of the equivalent concentration in settleable material (Table 1). In the case of arsenic, the calculation was made using the concentration of arsenic associated only with particulate matter (total minus dissolved fraction). In the case of the hydrophobic organics (total PCBs and cPAHs), the calculation used the whole-water sample concentration (filtered samples were not collected for analysis of organic compounds). This conservatively assumes that all of the organic compound mass in any given sample is adsorbed to the suspended solids.[6]

The Green/Duwamish River whole-water data collected by King County are considered to be of good quality and of sufficient quantity to enable statistical calculations. Table 2 notes aspects of this dataset that could lead to bias and the expected direction of that bias. The most noteworthy aspects of the whole-water sample data that could lead to bias are:

- The sample collection technique may not capture the full particle size distribution (especially sands, which are transported primarily in the bed load), and thus samples may contain a higher percentage of fines than the material that settles in the LDW.
- The samples are temporal "snapshots" of water quality conditions that can vary significantly in response to river flow, rainfall, and other factors.[7] In the aggregate, the water quality data can be analyzed to identify central-tendency estimates of upstream inflows.
- Changes in geochemical conditions between the aerobic freshwater riverine environment and the reduced anoxic conditions of the saline bed sediment environment can profoundly influence arsenic chemistry and partitioning (Peterson and Carpenter 1986). The particulate load of arsenic in the water column represents an upper limit on the potential arsenic loading to sediments. In the water column, arsenic is most likely present in its oxidized form (arsenate), which is strongly adsorbed by particulate iron and manganese oxides and to a lesser degree, clays. As these arsenic-bearing particles settle to the sediment-water interface and are buried over time, reducing conditions are established (below the top few centimeters of the sediment) as a result of the depletion of dissolved oxygen by the decay of organic matter. Under these anoxic conditions, further decay of organic matter is coupled to the reductive dissolution of the iron and manganese oxides and to the reduction of arsenate to arsenite through microbial metabolic processes. The reduced sorption capacity of the sediment and transformation of arsenic to a less strongly adsorbing form (arsenite) results in repartitioning of a significant part of the accumulated arsenic to the porewater, which may be released to the overlying water column.

---

6 This is a conservative assumption because the fraction of the contaminant mass that is either dissolved or may be associated with colloidal particles is assumed to be included within the TSS fraction.

7 Because variability of a dataset can range naturally by differing site conditions over time during sampling, it is difficult to conduct an "outlier analysis." An apparent "outlier" may truly represent observed variability of the site during some river flow or wet weather conditions.

- Differential settling (by particle size and density) of Green/Duwamish River TSS, induced by variable hydrodynamic conditions within the LDW, may lead to systematic spatial variations in bed-sediment chemistry.

However, even with these biases, the Green/Duwamish River whole-water data collected by King County are considered to be of good quality and of sufficient quantity to enable statistical calculations for use in determining the range of upstream input parameters for the BCM.

Ecology's Green River Centrifuged Solids Data

Centrifuged solids data were collected by Ecology in late 2008 and early 2009 (Ecology 2009), at the 119th Street footbridge location near Tukwila (RM 6.7) (see Figure 1). Samples of suspended material were collected on seven occasions at this location during varying flow and rainfall conditions (see Figure 2). Sampling was conducted by pumping river water into continuous-flow centrifuges and through stainless steel sieves to collect enough mass of suspended sediment from the water column to analyze risk-driver concentrations that are associated with different size ranges of suspended sediments (particles collected in a 250 µm mesh sieve [medium-coarse sands], particles collected in a 63 µm mesh sieve [fine-medium sands], and other fine particles). Several discrete samples were collected from the water column every 3 hours (to coincide with tidal phases) over 1 to 2 full tidal cycles (24-48 hours) and then composited. Water quality parameters such as TSS, total organic carbon (TOC), and dissolved organic carbon (DOC) were analyzed, as well as PCB Aroclors, arsenic, PAHs, and dioxins/furans. These data are summarized in Table 1, and a summary of the overall data quality is provided in Table 2. Table 3 provides the risk-driver concentrations for each sample since these data were not presented in the remedial investigation (RI; Windward 2010).

The Ecology samples are generally representative of sediments suspended mid-channel in the Green River that would have entered the LDW. This is based on elements of the study design, choice of field methods, field measurements, and validated analytical results. Samples were collected:

- During a reasonable range of flow (391-4,800 cfs) and TSS conditions (5-76 mg/L), capturing some seasonal variability
- From a location in the Green River not influenced by downstream/local contaminant sources
- During full tidal cycles (24 or 48 hours) for each sampling event, tempering short-term temporal variability in suspended sediment concentrations
- From one or more depths in the water column at RM 6.7 (the pump intake depth was monitored and periodically adjusted to a target of 0.6 times the mid-channel maximum depth; depth adjustments were based on stage height, tidal phase, and the maximum water depth)
- Over time to integrate environmental variability (composite and continuous sampling).

It is noted that only seven sampling events, with only one being during a wet weather event, occurred during this study, which is considered to be insufficient to represent actual seasonal variability. In addition, some sampling events did not include any sampling during spring seasonal flows or during the rising stage of high-flow events. Thus, in these events, a portion of the load entering the LDW may have been missed. Further, samples were not truly depth-integrated, because water was pumped from a single target depth, which may underestimate the concentration on suspended sediments and not be representative of the average distribution of suspended sediment.

However, even with these biases, the Green River centrifuged solids data collected by Ecology are considered to be of good quality (although limited quantity) for use in determining the range of upstream input parameters for the BCM.

Upstream Surface Sediment Data

Sediment data have been collected by multiple parties from locations upstream of the LDW (RM 5.0 to RM 7.0) (see Figure 3); these data were collected between 1994 and 2006 and were compiled in the RI (Windward 2010). Further, Ecology collected surface sediment data upstream of the LDW (RM 4.9 to RM 6.5) in 2008 and are presented in Table 4 since these data were not presented in the RI (Windward 2010). These datasets were compiled to evaluate the quality of sediment potentially being transported into the LDW from the Green/Duwamish River. Bed sediments just upstream of the LDW can be resuspended under high-flow conditions, and then transported to, and redeposited in the LDW, thereby contributing to the chemical composition of LDW sediment. Table 5 summarizes the upstream surface sediment data included in the analysis, and Table 6 summarizes the overall quality of the data collected upstream of the LDW.

As a result of the diverse sediment transport processes in the LDW, sediments sampled in various locations tend to have differing physical properties. Table 7a summarizes the TOC content and percent fines (sum of silt and clay fractions) of the upstream sediment data (i.e., surface sediment data from RM 5.0 to RM 7.0) and surface sediment data from RM 0.0 up to RM 4.0 in the LDW.

The TOC and percent fines values for available surface sediment samples upstream of RM 5.0 were much lower than those values for surface sediments below RM 4.0. These results are consistent with the observation that suspended solids, which primarily consist of fine particles with relatively higher TOC content (compared to sand), are transported from upstream regions (above RM 5.0) throughout the LDW. The subsurface sediment data from RM 4.0 to RM 4.3 were similar in grain size and TOC to the data from surface sediment in RM 0.0 to RM 4.0 (Table 7a). In contrast, the RM 4.3 to RM 4.75 data close to the Upper Turning Basin more closely resemble the surface sediment data from upstream of RM 5.0 (sand sized particles). These results are consistent with the observation that coarser bed load fractions from upstream regions are preferentially deposited within and near the Upper Turning Basin compared to more downstream locations. Fine-grained particles will stay suspended longer and travel farther downstream than will sand-sized particles.

Table 7a shows that samples from the upstream sediment dataset, in the aggregate, contain significantly lower TOC and fines than those found in sediment within the LDW. The median TOC of the upstream dataset is less than one-half the median TOC of the entire LDW (RM 0.0 to RM 5.0) dataset (Table 7b). The importance of this difference stems from the often observed correlation between contaminant concentrations, TOC, and fines in soil and sediment (Hedges and Keil 1995), which holds true for LDW sediment. Total PCBs, arsenic, and cPAHs in LDW sediment (RM 0.0 to RM 5.0) are all positively correlated with TOC, and arsenic and cPAHs are positively correlated with percent fines (Table 8). This suggests that differential settling of particles between upstream and downstream locations of the waterway and resulting variations in the percentage of fines and TOC influence the concentrations of contaminants in deposited sediment. This observation, coupled with the previous observation that TOC and fines are lower in the upstream surface sediment dataset compared to surface sediment in the Upper Turning Basin (see Figure 4), suggests that the upstream surface sediment data may be biased low with respect to the concentrations on the upstream particles that settle in the LDW. Thus, the upstream surface sediment dataset may have a low bias and should be used in consideration with other datasets for determining upstream BCM input parameters. To account for the grain size bias, only samples with >30% fines will be considered in the statistical analysis and in setting the range of upstream input values for the BCM.

The 2008 Ecology study was conducted to provide a better characterization of the contaminants in upstream surface sediments. This study assessed the potential point sources located in these upstream areas and provides an unbiased representation of risk-driver concentrations. The dataset is a newer source compared to the 1994-2006 upstream surface sediment data collected during the RI; moreover, it has a larger number of samples (N=74) with very low reporting limits. Therefore, it is the preferred surface sediment dataset for developing upstream BCM input parameters. Table 5 summarizes the Ecology upstream surface sediment data included in the analysis, and Table 6 summarizes the overall data quality. However, as discussed above, upstream sediment datasets may also have low bias and should be used in consideration with other datasets for determining upstream input parameters for the BCM.

Core Data from the Upper Turning Basin and Navigation Channel

The entire upper reach of the LDW (RM 4.0 to RM 4.75) functions as a trap for approximately one-third of the sediment entering the waterway from the Green/Duwamish River, and the navigation channel portion of this river segment is frequently dredged to maintain adequate channel depths. RM 4.75 coincides with the upstream end of the Upper Turning Basin, which is part of the navigation channel. RM 4.0 is the approximate downstream boundary of the area the USACE dredges frequently to maintain the navigation channel.

Chemical and physical data for subsurface sediment samples collected between RM 4.0 and RM 4.75 from 1990 through 2003 were obtained from a query of the Dredged Analysis Information System [DAIS]), and the USACE provided more recent subsurface sediment data from 2008 and 2009. For the purposes of dredged sediment characterization, the USACE has been compositing sediment cores for characterization vertically (generally 0- to 4-foot [ft] intervals, but occasionally over deeper intervals, up to 10 ft), and in some cases, horizontally (compositing two or more cores collected within a dredged material management unit; DMMU).

Figures 5a and 5b show the sampling locations and associated dredging footprints for 10 dredging events conducted between 1990 and 2010. The data presented are spatially limited to the portion of the LDW between RM 4.3 and RM 4.75. Table 9 summarizes the data[8] and Table 10 describes the overall data quality, including potential bias. The most noteworthy aspect of the frequently dredged area that could lead to bias is the contribution from lateral sources.

It is noted that only data from RM 4.3 and RM 4.75 (including subsurface sediment samples collected in this area in 2008 and 2009) are used in the FS, because: 1) contaminant concentrations in this section are lower than those collected farther downstream; 2) contaminant concentrations are not likely to be influenced by lateral sources (e.g., Hamm Creek, which discharges at approximately RM 4.3; a major storm drain at the head of Slip 6, at approximately RM 4.2); 3) contaminant concentrations represent relatively recent material deposited from upstream sources, and 4) the USACE conducts routine dredging in this part of the LDW.

The navigation channel in the upper reach of the LDW collects most of the bed load and a portion of the suspended solids that enter the LDW from the Green/Duwamish River. The net sedimentation rates in this area are as high as 4 ft per year near RM 4.75. These high sedimentation rates necessitate frequent dredging of the Upper Turning Basin by the USACE (USACE 2009a). The section between RM 4.3 and RM 4.75 is dredged approximately every 2 years. Almost all of the dredged material from this area over the past 15 years was deemed suitable for open-water disposal by the Dredged Material Management Program (DMMP) agencies, with the exception of dredged sediments adjacent to and immediately south of Slip 6 that failed testing in 1995 and 1996 (USACE 2009b). Additionally, some of this dredged material has been beneficially used for capping at a number of sediment remediation projects in the area. Data from this portion of the navigation channel provides another line of evidence for characterizing the potential contribution of upstream sediment to the LDW because they represent relatively recent material deposited from upstream sources.

The vertical compositing of these cores decreases the influence of potential outliers and “averages” the incoming sediment contaminant concentrations toward a central tendency. Since cores represent a longer period of deposition, this data may also represent a longer term average of input to the LDW

---

8 Data results for PCB Aroclors analyzed by TestAmerica for Rounds 1 and 2 met quality assurance level 1 (QA1) data evaluation requirements but were rejected by a more rigorous independent data validation by USACE. Core data presented and used in these analyses were analyzed from archived sediment by ARI Laboratory and independently validated by EcoChem Inc. in 2009 (USACE 2009b).

than surface data. Figure 6 illustrates an example of the typical depth of the DAIS sediment cores relative to the typical dredging depths in the navigation channel associated with maintenance dredging that occurred in 2004 and 2007. This figure shows that the DAIS samples are fairly large vertical composites of material that has settled since the previous dredging event.

Even with potential bias, the data collected by USACE over a period of years is representative of material settling in the LDW. The data are considered to be of good quality and of sufficient quantity to enable statistical calculations for use in determining the range of upstream input parameters for the BCM.

Summary Statistics for the Upstream Datasets

The datasets identified above were used to establish a range of upstream BCM input parameters for total PCBs, arsenic, cPAHs, and dioxins/furans. The datasets were evaluated using methods prescribed in Ecology's *Statistical Guidance for Site Managers* (1992) and U.S. Environmental Protection Agency's (EPA) *ProUCL v.4.00.04 Technical and User's Guide* (2009). Each dataset was conditioned in accordance with procedures recommended in the guidance (e.g., goodness-of-fit, identification of outliers, handling of non-detect values) before analysis using the ProUCL software. The goodness-of-fit tested for the type of distribution (normal, lognormal, gamma, or non-parametric) of the population at 95% confidence level, based on its skewness, sample size and number of non-detects. In addition to this formal test, the informal histogram and quantile-quantile (Q-Q) plot were also conducted to visually test data distributions. Potential extreme values were also identified as statistical outliers (with the exception of the water quality data) that do not fit with the distribution of the remainder of the data. With regard to non-detect values for total PCBs, the sum of the detected concentrations of the individual PCB Aroclors or PCB congeners was used. In cases where no PCB Aroclors were detected, the highest reporting limit for an individual PCB Aroclor was used as the value of total PCBs. Other individual PCB Aroclors or PCB congeners may have been present at concentrations below the laboratory reporting limit, but those PCB Aroclors or PCB congeners are not included in the sums. Both cPAHs and dioxins/furans used one-half the reporting limit in the toxic equivalents (TEQs) calculations, where individual PAH compounds or dioxin/furan congeners were not detected. For arsenic in water, only total and dissolved detected value pairs were used; and in sediment, one-half the reporting limit was used for non-detect values.

A summary of these statistical analyses is provided in Tables 11 through 14 for total PCBs, arsenic, cPAHs, and dioxins/furans, respectively.

Total PCBs

Table 11 presents the total PCB summary statistics for the upstream datasets. As discussed previously, the data sources evaluated are the King County whole-water data, the Ecology centrifuged solids data, the RI and the Ecology upstream surface sediment data, and the USACE Upper Turning Basin core data (RM 4.3 and RM 4.75). In all datasets, the concentration of total PCBs represents the sum of the detected concentrations of the individual PCB Aroclors or of the detected PCB congeners.

The statistical analysis of the USACE Upper Turning Basin core data (RM 4.3 to RM 4.75) and King County whole-water data generated similar results. The mean total PCB concentrations in these two datasets were 36 and 50 µg/kg dw, and the 95% upper confidence limit on the mean (UCL) values were 42 and 82 µg/kg dw, respectively. By comparison, the upstream surface sediment samples (RM 5.0 to RM 7.0) and the Ecology centrifuged solids contained much lower mean concentrations of total PCBs
(3 to 23 µg/kg dw). 95% UCL values for these datasets ranged from 3 to 36 µg/kg dw. This disparity may be attributable to the relatively low fines content in the upstream surface sediment samples, the majority of which were less than 50%. The low fines content is consistent with the observation that this section of the river is mostly non-depositional with a sandy or "hard bottom" surface.

Figure 7 shows the concentration of total PCBs in Upper Turning Basin core samples (RM 4.3 – 4.75) as a function of time. These data suggest that following the 1990 dredging, total PCB concentrations in navigation channel sediment in the upper portion of the river remained comparatively constant and in the approximate range of 2 to 94 µg/kg dw, with a mean of 36 µg/kg dw.

Figure 8 summarizes statistics for the multiple datasets presented above. The overall weight of evidence suggests a range of 5 µg/kg dw (mean of Ecology upstream surface sediment data with fines >30%) to 107 µg/kg dw (90th percentile of King County whole-water data).

Arsenic

Table 12 presents the arsenic summary statistics, which yield mean concentrations on the order of 8 mg/kg dw and 95% UCL values on the order of 10 mg/kg dw. The range is fairly small, with a 90th percentile value of 11 mg/kg dw. The exception is the King County whole-water data, in which the mean and the 95% UCL for arsenic are 37 and 47 mg/kg dw, respectively.

The King County whole-water sample concentrations for arsenic are much higher than concentrations in either the upstream surface sediment or USACE Upper Turning Basin cores. Possible explanations for this disparity are differential particle settling and arsenic geochemistry:

- The full distribution of suspended solids in the water column includes fines that do not fully settle in the upstream areas or in the LDW. If arsenic concentrations are higher on smaller particles, the TSS-normalized water data for arsenic may be biased high relative to the comparatively coarser grain size distribution of sediments that actually deposit in the LDW.
- Equilibrium arsenic concentrations in sediment are sensitive to reduction/oxidation (redox), pH, and sediment mineralogy. Therefore, TSS-associated arsenic may not be conserved between the two environments (i.e., water column and settled sediment), an otherwise reasonable assumption when applied to persistent hydrophobic organic compounds.

Therefore, these King County data were not used as a line of evidence for developing the upstream BCM input parameter for arsenic.

Figure 9 shows the concentration of arsenic in the USACE Upper Turning Basin core samples as a function of time relative to the USACE dredging events. The data from RM 4.3 to RM 4.75 are consistent and range between approximately 3 and 13 mg/kg dw, with a mean of 7 mg/kg dw; a steady trend is observed with time (last 20 years).

Figure 10 summarizes statistics for the multiple datasets presented above. If the King County whole-water dataset is discounted as unrepresentative of settled sediment conditions for reasons discussed above, then the overall weight of evidence suggests a range of 7 mg/kg dw (mean of RI surface sediment data) to 24 mg/kg dw (90th percentile of Ecology centrifuged solids data).

cPAHs

Table 13 presents the cPAH summary statistics. For cPAHs, TEQs were calculated using one-half the reporting limit in cases where individual cPAH compounds were not detected. The King County whole-water data and the Ecology centrifuged solids data have similar mean concentrations (138 and 151 µg TEQ/kg dw). Much lower cPAH concentrations are observed in upstream surface sediment and USACE core datasets. Again, the low percentage of fines and TOC in the upstream surface sediment samples suggests that those samples may under-represent concentrations for chemicals typically associated with finer particle size solids.

Figure 11 shows the concentration of cPAHs in USACE core samples as a function of time relative to the USACE dredging events. The data are variable and do not suggest a temporal trend.

Figure 12 summarizes statistics for the multiple datasets presented above. Considering both the King County whole-water data and the Ecology centrifuged solids data, the overall weight of evidence suggests a range of 37 μg TEQ/kg dw (mean of Ecology upstream surface sediment data with fines >30%) to 432 μg TEQ/kg dw (95% UCL of Ecology centrifuged solids data9).

Dioxins / Furans

The analysis for dioxins/furans differs from the analysis for total PCBs, arsenic, and cPAHs, primarily because of the limited data available. For example, the USACE cores between RM 4.3 and RM 4.75 contain only two samples analyzed for dioxins/furans and King County did not analyze water samples for dioxins/furans. Therefore, the statistical analysis makes use of the Ecology centrifuged solids and surface sediment datasets, and the RI surface sediment data collected upstream of the LDW. For dioxins/furans, toxic equivalents (TEQs) were calculated using one-half the reporting limit in cases where individual dioxin/furan congeners were not detected.

Table 14 identifies the dioxin/furan datasets and provides statistics used in developing the upstream BCM input parameters. The population of each dataset is low (less than 6), except for the 2008 Ecology surface sediment dataset (N=74). The mean concentrations of the three datasets ranged between 1 and 6 ng TEQ/kg dw, and the 95% UCL values ranged between 2 and 10 ng TEQ/kg dw.

Figure 13 summarizes statistics for the multiple datasets presented above. Considering all of the data, the overall weight of evidence suggests a range of 2 ng TEQ/kg dw (mean of Ecology upstream surface sediment data with fines >30%) to 13 μg TEQ/kg dw (90th percentile of Ecology centrifuged solids data).[10]

Conceptual Site Model and Support for Use of Upstream Datasets

The use of data collected from the upper reach of the LDW is supported by the conceptual site model (CSM). Approximately 99% of the total sediment load to the LDW from external sources comes from the Green/ Duwamish River upstream of the LDW, and over 24% of the total sediment load (as both bed load and suspended solids) entering the LDW settles in the Upper Turning Basin (RM 4.5 to RM 4.75) (QEA 2008).

The remainder of the total sediment load entering the STM study area (76%) is suspended material. This material generally consists of finer fractions (i.e., clay, silt, and fine sand) with lower settling velocities compared to bed load sand, and therefore, is generally transported greater distances in the LDW. Approximately 50% of this material is the very fine fraction that does not settle in the LDW (QEA 2008), The finer fractions may have higher contaminant concentrations than the coarser bed load sand (i.e., medium and coarse sand) because of the affinity of chemicals (such as hydrophobic PCBs, cPAHs, and dioxins/ furans) to sorb to these finer sediments, which have high surface area-to-volume ratios and TOC (Hedges and Keil 1995). Potential differences in contaminant concentrations between larger-size-fraction bed load and smaller-size-fraction suspended materials may also be mirrored by differences in contaminant concentrations among the various size fractions of the suspended materials themselves. Much of the finest particulate matter from upstream may be carried through the LDW without depositing, and contaminant concentrations in the depositing sediments may increase as particle size decreases.

---

9 The 95% UCL of the Ecology centrifuged solids data overestimates cPAH current concentrations in the LDW, and therefore, it does not represent average upstream conditions. Only upstream surface sediment with >30% fines is considered.

10 The 95% UCL and 90th percentile of the Ecology centrifuged solids data overestimate dioxin/furan current concentrations in the LDW, and therefore, they do not represent average upstream conditions. Only upstream surface sediment with >30% fines is considered.

The use of the datasets described previously is consistent with the CSM for the LDW and the STM findings that most of the sediment in the LDW is derived from upstream sources.

Attachments

Table 1	Summary of King County Whole-Water Samples and Ecology Centrifuged Solids Samples
Table 2	Data Quality Summary for King County Whole-Water Samples and Ecology Centrifuged Solids Samples
Table 3	Human Health Risk Driver Concentrations from Ecology Centrifuged Solids (NEW)
Table 4	Human Health Risk Driver Concentrations from Ecology Upstream Surface Sediment Event (NEW)
Table 5	Surface Sediment Sampling Events Conducted Upstream of the Lower Duwamish Waterway (RI Data)
Table 6	Data Quality Summary for Upstream Surface Sediment Data (RM 5 to RM 7) Collected During the RI
Table 7a	Summary of Total Organic Carbon (TOC) and Percent Fines Data for Upstream Surface Sediment Datasets Compared to LDW Surface and Subsurface Sediment from RM 0.0 to RM 4.0
Table 7b	Percent Fines and TOC Property Differences of LDW and Upstream (RM 5.0 to RM 7.0) Surface Sediment
Table 8	Correlation of Lower Duwamish Waterway (RM 0 – 5) Surface Sediment Chemistry to TOC and Fines
Table 9	Summary of USACE DMMP Core Data (RM 4.3 to RM 4.75)
Table 10	Data Quality Summary for USACE DMMP Core Data in the Frequently Dredged Area (RM 4.3 to 4.75)
Table 11	Summary Statistics of Total PCBs for the Development of Upstream BCM Input Parameters
Table 12	Summary Statistics of Arsenic for the Development of Upstream BCM Input Parameters
Table 13	Summary Statistics of cPAHs for the Development of Upstream BCM Input Parameters
Table 14	Summary Statistics of Dioxins and Furans for the Development of Upstream BCM Input Parameters
Figure 1	Upstream Surface Water Sampling Locations
Figure 2	Green River Discharge and Rainfall during Ecology Centrifuged Solids Sampling Project
Figure 3	Surface Sediment Sampling Stations Used to Characterize Sediments from Upstream
Figure 4	Comparisons of Surface Sediment Percent Fines and TOC in the Upper Turning Basin (RM 4.5 - 4.8) and Upstream of the LDW (RM ≥ 5.0)
Figure 5a	1990-2003 Pre-Dredging Event Sampling Locations from Upper Reach
Figure 5b	2008 & 2009 Pre-Dredging Event Sampling Locations from Upper Reach
Figure 6	Conceptual Diagram of USACE Core Sample Depths to Mudline

References

Ecology 1992. *Statistical Guidance for Site Managers*. Publication 92-54. August 1992.

Ecology 2009. *Contaminant Loading to the Lower Duwamish Waterway from Suspended Sediment in the Green River*. Publication No. 09-03-028. November 2009.

EPA 2009. *ProUCL v.4.00.04 Technical Guide*. Office of Research and Development, Washington, DC 20460. Publication EPA/600/R-07/041. February 2009.

EPA 2009. *ProUCL v.4.00.04 User's Guide*. Office of Research and Development, Washington, DC 20460. Publication EPA/600/R-07/038. February 2009.

Hedges, J.I. and Keil R.G. 1995. Sedimentary organic matter preservation: an assessment and speculative synthesis. In *Mar Chem*, 49:81-115. 1995.

Peterson, M.L. and Carpenter, R. 1986. Arsenic distributions in pore waters and sediments of Puget Sound, Lake Washington, the Washington coast and Saanich Inlet, B.C. School of Oceanography, WB-10, University of Washington, Seattle, WA. In *Geochemical et Cosmochimica Acta*, Vol.54, pp. 353-369. 1986.

QEA 2008. *Sediment Transport Modeling Report.* Final. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, Washington and Washington Department of Ecology, Bellevue, Washington. Prepared by Quantitative Environmental Analysis, LLC, Montvale, NJ. October 29, 2008.

USACE 2009a. *Duwamish River Federal Navigation Channel Dredged Material Characterization (Seattle, WA), Data Report Final*. October 7, 2009.

USACE 2009b. *Duwamish River Federal Navigation Channel Dredged Material Characterization (Seattle, WA), Data Report Addendum Final*. November 20, 2009.Windward Environmental, LLC 2010. *Final Remedial Investigation Report, Lower Duwamish Waterway*. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, Washington and Washington Department of Ecology, Bellevue, Washington. July 2010.

Windward Environmental, LLC 2010. *Lower Duwamish Waterway Remedial Investigation, Remedial Investigation Report. Final.* Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. July 2010.

Table 1 Summary of King County Whole-Water Samples and Ecology Centrifuged Solids Samples

Sample Type	Number of Samples (number of detections)	Sample Period	Total Water Concentration	Dissolved Concentration (µg/L)	Particulate Value (µg/L)	TSS (mg/L)	Total Value Normalized to TSS or Centrifuged Particulate Value	Data Source
Total PCBs								
King County Whole-Water Samples[a]	22 (22)	2005 – 2008	24 – 2,400 (pg/L)	n/a	n/a	1.3 – 77.8	2.8 – 162 (µg/kg dw)	Data provided by King County 2008, 2009
Ecology Centrifuged Solids Samples[b]	7 (4)	2008, 2009	n/a	n/a	n/a	6.1 – 55.6	1.2U – 64 (µg/kg dw)	Data from Ecology EIM query 2009 (Ecology 2009)
Arsenic								
King County Whole-Water Samples[a]	100 (100)[c]	2001 – 2008	0.83 – 4.16 (µg/L)	0.44 – 0.84	0.01 – 3.91	1 – 312	0.5 – 133 (mg/kg dw)	Data from King County LIMS query 2007
Ecology Centrifuged Solids Samples[b]	7 (7)	2008, 2009	n/a	n/a	n/a	6.1 – 55.6	9.2 – 24 (mg/kg dw)	Data from Ecology EIM query 2009 (Ecology 2009)
cPAHs								
King County Whole-Water Samples[a]	18 (13)	2008	0.5U – 4.0 (ng TEQ/L)	n/a	n/a	1.4 – 22	22U – 408 (µg TEQ/kg dw)	Data provided by King County 2008, 2009
Ecology Centrifuged Solids Samples[b]	7 (7)	2008, 2009	n/a	n/a	n/a	6.1 – 55.6	14.9 – 621 (µg TEQ/kg dw)	Data from Ecology EIM query 2009 (Ecology 2009)
Dioxins/Furans[d]								
Ecology Centrifuged Solids Samples[b]	6 (6)	2008, 2009	n/a	n/a	n/a	6.1 – 55.6	0.83 – 16 (ng TEQ/kg dw)	Data from Ecology EIM query 2009 (Ecology 2009)

Note:

a. Surface water samples were collected at Ft. Dent (RM 10.9) on the Green River and at Marginal Way (RM 6.3) on the Duwamish River (see Figure 1).

b. Suspended solids samples were collected at the Tukwila footbridge (RM 6.7) on the Green River (see Figure 1).

c. Number of detected samples based on total arsenic data used to calculate TSS-normalized particulate arsenic. Total arsenic method reporting limit is 0.5 µg/L.

d. Surface water samples collected by King County were not analyzed for dioxins/furans.

dw = dry weight; EIM = Environmental Information Management; kg = kilograms; L = liter; LIMS = Laboratory Information Management System; µg = micrograms; mg = milligrams; n/a = not available; ng = nanogram; pg = picogram; TEQ = toxic equivalent; TSS = total suspended solids; U = undetected at the reporting limit shown

Table 2 Data Quality Summary for King County Whole-Water Samples and Ecology Centrifuged Solids Samples

Risk Driver (Sample Period)	Number of Samples	Data Selection	Overall Strengths of Line of Evidence	Data Quality Considerations for Developing BCM Parameters of Upstream Sediment Settling in the LDW: Level of Data Validation	Precision	Representativeness	Accuracy/Potential Bias Effects	Completeness	Comparability
King County Whole-Water Data									
Total PCBs (2005, 2008)	22	All available low-level whole-water data used (there are no dissolved data). Sample count is averaged to the station; count would be 28 if field replicates are considered.	Data are recent and of high quality. Data characterize contaminant concentrations on suspended solids that flow into the LDW. Sampling covers a range of flow conditions.	2008 PCB data validated by LDC. 2005 PCB data validated by King County.	Acceptable	Samples collected may exclude sands in bed load and thus contain a higher percentage of fines than material that settles in the LDW.	High bias	Acceptable. Sample numbers allow statistical interpretation.	Water samples have inherent representativeness limitations for comparison to sediment data. Water samples generally have greater temporal variability in concentrations than sediment samples. A large dataset reduces this effect.
						Ft. Dent station may exclude some anthropogenic inputs farther downstream.	Low bias		
						TSS normalization of whole-water sample assumes dissolved and colloidal fractions of contaminant are present on the settling solids	High or Low bias		
Arsenic (2001 - 2008)	100	Only samples with corresponding total arsenic, dissolved arsenic, and TSS used. Samples where total arsenic concentration was less than dissolved arsenic were not used.	Data are numerous, recent and of high quality. Data characterize contaminant concentrations on suspended solids that flow into the LDW. Sampling covers a range of flow conditions.	Data validated by Herrera for King County.		Samples collected may exclude sands in bed load and thus contain a higher percentage of fines than material that settles in the LDW.	High bias		
						Ft. Dent station may exclude some anthropogenic inputs farther downstream.	Low bias		
						TSS normalization of arsenic assumes all particulate arsenic associated with solids and expected to settle in LDW, TSS normalization does not account for geochemical properties of arsenic in LDW.	High bias		
cPAHs (2008)	18	All available low-level whole-water data used (there are no dissolved data). Sample count includes field replicates.	Data are recent and of high quality. Data characterize contaminant concentrations on suspended solids that flow into the LDW. Sampling covers a range of flow conditions.	Data validated by King County.		Samples collected may exclude sands in bed load and thus contain a higher percentage of fines than material that settles in the LDW.	High bias		
						Ft. Dent station may exclude some anthropogenic inputs farther downstream.	Low bias		
						TSS normalization of whole-water samples assumes dissolved and colloidal fractions of contaminant are present on the settling solids.	High or Low bias		
Ecology Centrifuged Solids Data									
Total PCBs (2008, 2009)	7	All available centrifuged solids data used. Sample count is low.	Data are recent and of high quality. Data characterize contaminant concentrations on suspended solids that flow into the LDW. Sampling covers a range of flow conditions.	Data validated by EPA.	Acceptable	Samples are representative of sediments suspended mid-channel in the Green River that would have entered the LDW.	High bias	Sample counts are low for statistical analysis and interpretation.	The analytical method used to measure TSS may underestimate true concentrations of suspended solids. This happened for samples containing appreciable sand-sized particles. Centrifuged samples may be representative but limited for comparison to sediment data.
Arsenic (2008, 2009)	7					Short-term temporal variability was captured by centrifuging suspended sediment throughout full tidal cycles.			
cPAHs (2008, 2009)	7								
Dioxins / Furans (2008, 2009)	6					Some variability was captured by the seven sampling events covering a range of flow conditions (spring seasonal flows were not included and only one wet weather event was included).			

Notes:

No surface water data available from King County for dioxins/furans.

BCM = Bed Composition Model; cPAH = carcinogenic polycyclic aromatic hydrocarbons; dw = dry weight; Ecology = Washington State Department of Ecology; EPA = U.S. Environmental Protection Agency; kg = kilograms; L = liter; LDC = Laboratory Data Consultants; LDW = Lower Duwamish Waterway; LIMS = laboratory information management system; µg = micrograms; mg = milligrams; n/a = not available; ng = nanogram; PCBs = polychlorinated biphenyls; pg = picogram; TEQ = toxic equivalent; TSS = total suspended solids; U = undetected at the reporting limit shown

Table 3 Human Health Risk Driver Concentrations from Ecology Centrifuged Solids

Sample Date	Total PCBs (µg/kg dw)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxin/furan (ng TEQ/kg dw)
7/15/2008	7.5	13.5	58.44	NA
8/25/2008	63.5	22.4	620.55	16.2
9/29/2008	10.8	24.3	40.85	8.35
10/15/2008	15.8	23.6	158.45	4.97
11/17/2008	2.5 U	9.2	14.87	1.51
12/15/2008	2.7 U	14	53.31	1.38
1/20/2009	1.2 U	9.39	17.55	0.83

Notes:

1. Significant figures for the data are shown as reported in *Contaminant Loading to the Lower Duwamish Waterway from Suspended Sediment in the Green River* (Ecology 2009).

cPAH = carcinogenic polycyclic aromatic hydrocarbons; dw = dry weight; Ecology = Washington State Department of Ecology; kg = kilograms; µg = micrograms; mg = milligrams; ng = nanograms; NA = not analyzed; PCBs = polychlorinated biphenyls; TEQ = toxic equivalent; U = undetected at the reporting limit shown.

Table 4 Human Health Risk Driver Concentrations from Ecology Upstream Surface Sediment Event

Sample Date	Location ID	Sample ID	Total PCBs (µg/kg dw)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxins/furans (ng TEQ/kg dw)
4/28/2008	DR-01	DR-01-VV-11	3.6	6.1	16	0.287
4/28/2008	DR-02	DR-02VV12	7.2 U	5.3	0.84 U	0.107 U
4/28/2008	DR-03	DR-03VV15	3.4	5.1	2	0.109 U
4/28/2008	DR-04	DR-04VV15	2.9	4.9	0.88	0.108 U
4/28/2008	DR-05	DR-05VV15	2.6	8.6	2.1	0.132 U
4/28/2008	DR-06	DR-06VV16	3	4.7	0.76 U	0.091 U
4/28/2008	DR-07	DR-07VV15	2.3	5.6	9.7	0.095 U
4/28/2008	DR-08	DR-08VV16	2.6	4.5	0.82	0.084
4/28/2008	DR-09	DR-09VV15	2.7	4.8	0.84 U	0.135
4/28/2008	DR-10	DR-10VV16	2.5	5.7	0.8	0.1569
4/28/2008	DR-11	DR-11VV13	7.7 U	4.7	2.1	0.114
4/28/2008	DR-12	DR-12VV14	2.7	3.7	2.1	0.262
4/29/2008	DR-14	DR-14VV16	6.7 U	4.5	5.6	0.137
4/29/2008	DR-15	DR-15VV15	7 U	4.5	0.76 U	0.102
4/29/2008	DR-16	DR-16VV15	3.5	5.4	2.1	0.088 U
4/29/2008	DR-17	DR-17VV16	3.1	4.4	1.7	0.144
4/29/2008	DR-18	DR-18VV14	6.7 U	5.2	0.77 U	0.087 U
4/30/2008	DR-19	DR-19VV15	6.8 U	5.4	0.76 U	0.232
4/30/2008	DR-20	DR-20VV15	5.9 U	5.4	0.75	0.237 U

Table 4 Human Health Risk Driver Concentrations from Ecology Upstream Surface Sediment Event (continued)

Sample Date	Location ID	Sample ID	Total PCBs (µg/kg dw)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxins/furans (ng TEQ/kg dw)
4/30/2008	DR-21	DR-21VV15	7.2 U	4.5	29	0.126
4/30/2008	DR-22	DR-22VV14	7.1 U	4.9	3.3	0.518
4/30/2008	DR-23	DR-23VV14	7.1 U	5.6	0.82 U	0.384
4/30/2008	DR-24	DR-24VV15	6.7 U	4.8	0.76 U	0.137
4/30/2008	DR-25	DR-25VV15	6.4 U	5.8	0.76 U	0.129 U
4/29/2008	DR-26	DR-26VV15	5.9 U	4	0.74	0.188 U
4/29/2008	DR-27	DR-27VV17	6.3 U	4.6	0.71 U	0.073 U
4/29/2008	DR-28	DR-28VV15	3	4.2	0.7 U	0.094 U
4/29/2008	DR-36	DR-36VV15	6.1 U	4.2	0.78	0.112
5/8/2008	DRB-100W	DRB-100W	8.4	7.3	55	1.58
5/8/2008	DRB-101	DRB-101W	2	5.3	18	0.870
5/8/2008	DRB-103	DRB-103E	1.2	7.6	17	1.240
5/8/2008	DRB-104	DRB-104W	0.99	7.8	8.4	1.070
5/9/2008	DRB-105	DRB-105	1	7.7	6.2	0.850
5/9/2008	DRB-106	DRB-106W	1.5	9.1	9.1	0.950
5/9/2008	DRB-107	DRB-107W	0.73	4.5	6.2	0.341
5/9/2008	DRB-108	DRB-108W	10 U	8.3	48	1.45
5/9/2008	DRB-108	DRB-50W	20 U	7.9	54	1.46
5/9/2008	DRB-109	DRB-109W	10 U	8.4	40	1.84
5/9/2008	DRB-110	DRB-110E	1.6	6.8	10.6	0.790

Table 4 Human Health Risk Driver Concentrations from Ecology Upstream Surface Sediment Event (continued)

Sample Date	Location ID	Sample ID	Total PCBs (µg/kg dw)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxins/furans (ng TEQ/kg dw)
5/9/2008	DRB-111	DRB-111E	22 U	9.4	54	1.44
5/9/2008	DRB-112	DRB-112W	1.9	10	13.8	1.24
5/9/2008	DRB-113	DRB-113W	2.7 U	9.5	70	1.78
5/9/2008	DRB-114	DRB-114W	11 U	9.7	90	2.25
5/9/2008	DRB-115	DRB-115W	2.1	6.8	16	1.09
5/9/2008	DRB-116	DRB-116W	1.7	6.9	10.9	1.00
5/9/2008	DRB-117	DRB-117W	0.86	5.5	10	1.32
5/1/2008	NFK501	NFK-501VV16	7	15	230	2.21
4/30/2008	NFK502	NFK502VV12	7.2 U	6	40	0.339
5/1/2008	OF-28	OF-28HS10	2.4	9.2	9.9	3.00
5/1/2008	OF-33	OF-33VV10	7.1 U	4.3	0.83 U	0.111 U
5/1/2008	OF-36	OF-36VV13	7 U	4.6	12	0.119
5/1/2008	OF-41	OF-41VV16	7.2 U	4.9	0.82 U	0.072 U
5/1/2008	OR-01	OR-01VV16	2.2	9.4	23	2.50
5/2/2008	OR-02	OR-02VV9	1.9	8.3	9.9	1.55
5/5/2008	OR-04	OR-04VV09	6.3 U	6.5	0.97	0.146 U
5/5/2008	OR-05	OR-05VV10	6.3 U	5.9	0.88	0.161 U
5/5/2008	OR-06	OR-06VV13	6.5 U	9.1	1	0.155 U
5/5/2008	OR-07	OR-07VV13	5.8 U	5	0.71	0.530

Table 4 Human Health Risk Driver Concentrations from Ecology Upstream Surface Sediment Event (continued)

Sample Date	Location ID	Sample ID	Total PCBs (µg/kg dw)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxins/furans (ng TEQ/kg dw)
5/5/2008	OR-08	OR-08VV14	6.1 U	4.7	0.74	0.082 U
5/5/2008	OR-09	OR-09VV14	6.3 U	4.2	0.71 U	0.104 U
5/5/2008	OR-10	OR-10VV14	12	9.2	43	1.59
5/5/2008	OR-11	OR-11VV12	17 U	6.3	29	0.611
5/5/2008	OR-12	OR-12VV05	6.9 U	4.9	0.87	0.180
5/5/2008	OS-03	OS-03VV08	7.2 U	5.1	9.9	0.155
5/2/2008	OS-05	OS-05VV16	3.2	13	16	3.34
5/2/2008	OS-06	OS-06HS10	770	11	92	8.40
5/5/2008	OS-10	OS-10HS10	20 U	7.7	77	1.42
5/6/2008	OS-14	OS-14HS10	2.6	8.6	18	1.27
5/6/2008	OS-15	OS-15HS10	4.6	9	13	2.10
5/6/2008	OS-18	OS-18HS10	2	10	55	1.35
5/6/2008	OS-21	OS-21HS10	1.5	9.4	16.1	1.93
5/6/2008	OS-22	OS-22HS10	2.8	8.9	16	1.57
5/6/2008	OS-23	OS-23HS10	1.1	9.2	11.4	1.59
5/6/2008	OS-24a	OS-24AHS10	1.4	16	9.8	3.00

Notes:
1. Significant figures for the data are shown as reported by the Washington State Department of Ecology to Windward.

cPAH = carcinogenic polycyclic aromatic hydrocarbons; dw = dry weight; Ecology = Washington State Department of Ecology; ID = identification number; kg = kilograms; µg = micrograms; mg = milligrams; ng = nanograms; PCBs = polychlorinated biphenyls; TEQ = toxic equivalent; U = undetected at the reporting limit shown

Table 5 Surface Sediment Sampling Events Conducted Upstream of the Lower Duwamish Waterway (RI Data)

Sampling Event (Event Code)	Sampling Year	River Mile	Number of Samples (Number of Detections)				Range of Concentrations			
			Total PCBs	Arsenic	cPAHs	Dioxins/ Furans	Total PCBs (µg/kg dw)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxin/Furans (ng TEQ/kg dw)
LDW Upstream Surface Sediment Samples During RI										
LDW RI: surface sediment sampling for chemical analyses and toxicity testing (LDW RI – Surface Sediment Round 2)	2005	5.1 – 5.8	6 (0)	6 (6)	6 (4)	0	19 U – 20 U	3.3 – 7.3	9 U – 56	—
LDW RI: surface sediment sampling for chemical analyses and toxicity testing (LDW RI – Surface Sediment Background)	2005	5.3 (PCBs) 6.1 – 7.0 (arsenic) 5.3 and 10.2 [a] (dioxins/furans)	1 (0)	8 (8)	0	2 (2)	20 U	4.6 – 10.9	—	1.7 – 2.9
EPA Site Inspection: Lower Duwamish River (EPA SI)	1998	5.3 – 5.5	5 (0)	5 (5)	5 (0)	2 (2)	40 U	4.0 – 5.1	18 U	1.1 – 1.2
Duwamish Waterway Phase 1 site characterization (Boeing Site Char; upstream reference samples)	1997	6.1	3 (0)	3 (3)	3 (2)	0	38 U – 40 U	4.5 – 7.2	17 U – 260	—
Duwamish Waterway sediment characterization study (NOAA Site Char)	1997	5.2 – 6.0	20 (18)	0	0	0	0.6 U – 140	—	—	—
Norfolk CSO sediment cleanup study – Phase 1 (Norfolk cleanup 1)	1994	5.4 – 5.5	2 (0)	2(2)	2 (1)	0	15 U – 26 U	11 – 22	18 U – 64	—
Total No. of Samples Used in Statistics			**37 (18)**	**24 (24)**	**16 (7)**	**4 (4)**	**0.6 U – 140**	**3.3 – 22**	**9 U – 260**	**1.1 – 2.9**
Other Upstream Surface Sediment Samples										
Ecology Study	2008	4.9 – 6.5	73[b] (38)	74 (74)	74 (60)	74 (54)	2.7 U – 22	3.7 - 16	0.7U - 230	0.07U - 8.4

Notes:

a. This sample was collected in Springbrook Creek, which enters the Green/Duwamish River at approximately RM 10.2.

b. Outlier of 770 µg/kg dw for total PCBs was excluded from the dataset statistics, because it appeared to be related to an outfall.

cPAH = carcinogenic polycyclic aromatic hydrocarbons; CSO = combined sewer overflow; Ecology = Washington State Department of Ecology; EPA = U.S. Environmental Protection Agency; LDW = Lower Duwamish Waterway; µg = micrograms; mg = milligrams; NOAA = National Oceanic and Atmospheric Administration; ng = nanograms; PCBs = polychlorinated biphenyls; RI = remedial investigation; SI = site investigation; TEQ = toxic equivalent; U = undetected at the reporting limit shown

Table 6 Data Quality Summary for Upstream Surface Sediment Data (RM 5 to RM 7) Collected During the RI

<table>
<tr><th rowspan="2">Study Event [a]</th><th rowspan="2">Risk Driver</th><th rowspan="2">Number of Samples</th><th rowspan="2">Data Selection</th><th rowspan="2">Overall Strength of Line of Evidence</th><th colspan="7">Data Quality Considerations for Developing BCM Parameters of Upstream Sediment Settling in the LDW</th></tr>
<tr><th>Level of Data Validation</th><th>Precision</th><th>Representativeness</th><th>Accuracy / Potential Bias Effects</th><th>Completeness</th><th>Comparability</th></tr>
<tr><td rowspan="4">Multiple (1994-2006)</td><td>Total PCBs</td><td>37 / 20</td><td>37 samples considered.[a] Data evaluated in two ways: all data and only detected data. In the latter, only 20 samples from NOAA 1997 event (non-standard method[b]) were evaluated because all other events did not yield detectable concentrations.</td><td rowspan="4">Data characterize contaminant concentrations of surface sediments immediately upstream of the LDW.</td><td rowspan="4">Data quality reviewed for inclusion in RI database. Only acceptable data included in database.</td><td rowspan="4">Acceptable</td><td rowspan="4">Upstream samples are more coarse-grained and contain lower TOC than LDW sediments.

Some datasets are over 10 years old and have small numbers of samples</td><td>PCBs: High bias with N=37 (many values based on reporting limits).
Low bias with N=20 (NOAA values may be underestimated). [a]</td><td>Acceptable:
Numbers allow for statistical interpretation.</td><td rowspan="4">Upstream surface sediment generally not directly comparable to LDW surface sediment because of different grain size distributions and TOC contents. The finer fractions settling in the LDW are under-represented in upstream surface sediment samples.</td></tr>
<tr><td>Arsenic</td><td>24</td><td>All available data used.</td><td>As: Low bias</td><td>Acceptable: Numbers allow for statistical interpretation</td></tr>
<tr><td>cPAHs</td><td>16</td><td>All available data used.</td><td>cPAHs: Low bias</td><td>Less than 20 samples.
Most based on undetected data.</td></tr>
<tr><td>Dioxins/Furans</td><td>4</td><td>All available data used.</td><td>D/F: Low bias</td><td>Only 4 samples</td></tr>
<tr><td rowspan="4">Ecology (2008)</td><td>Total PCBs</td><td>74/73</td><td>73 samples considered (one outlier was excluded because it appeared to be related to an outfall).</td><td rowspan="4">Data characterize contaminant concentrations of surface sediments immediately upstream of the LDW.</td><td rowspan="4">Data quality reviewed and acceptable.</td><td rowspan="4">Acceptable</td><td rowspan="4">Data more representative because they are more recent, with larger datasets and lower reporting limits.</td><td rowspan="4">Low bias, most data were detected.</td><td rowspan="4">Acceptable:
Numbers allow for statistical interpretation.</td><td rowspan="4">Upstream surface sediment generally not directly comparable to LDW surface sediment because of different grain size distributions and TOC contents. The finer fractions settling in the LDW are under-represented in upstream surface sediment samples.</td></tr>
<tr><td>Arsenic</td><td>74</td><td>All available data used.</td></tr>
<tr><td>cPAHs</td><td>74</td><td>All available data used.</td></tr>
<tr><td>Dioxins/Furans</td><td>74</td><td>All available data used.</td></tr>
</table>

Notes:

a. Ecology data from 2008 were the only data used in the BCM input parameter selection, because they are from a newer, larger dataset, with low reporting limits.

b. A non-standard PCB method was used for the NOAA event. Total PCBs were quantified as the difference between total polychlorinated terphenyls (PCTs) (using GC/ECD) and PCBs+PCTs (using HPLC/PDA). Data results from 100 to 600 µg/kg dw are not biased. Data below 100 µg/kg dw are JL qualified because they may have a large potential negative bias (i.e., total PCB concentrations may be underestimated).

BCM = bed composition model; cPAH = carcinogenic polycyclic aromatic hydrocarbons; CSO = combined sewer overflow; EPA = U.S. Environmental Protection Agency; LDW = Lower Duwamish Waterway; NOAA = National Oceanic and Atmospheric Administration; PCBs = polychlorinated biphenyls; RI = remedial investigation; SI = site investigation; TEQ = toxic equivalent; TOC = total organic carbon; U = undetected at the reporting limit shown

Table 7a Summary of Total Organic Carbon (TOC) and Percent Fines Data for Upstream Surface Sediment Datasets Compared to LDW Surface and Subsurface Sediment from RM 0.0 to RM 4.0

Statistical Parameter	LDW Surface Sediment (RM 0.0 to RM 4.0)	LDW Subsurface Sediment (RM 4.0 to RM 4.3)	LDW Subsurface Sediment (RM 4.3 to RM 4.75)	Upstream Surface Sediment (RM 5.0 to RM 7.0)
Total Organic Carbon (%)				
Minimum	0.1	0.6	0.03	0.07
10th percentile	0.9	1.4	0.4	0.08
Mean	2.0	1.9	1.3	0.8
90th percentile	2.9	2.6	2.7	1.9
Maximum	12	2.8	3.1	2.3
Percent Fines				
Minimum	1.6	23	2.6	0.01
10th percentile	14	49	6.0	0.01
Mean	53	58	17	24
90th percentile	86	69	34	57
Maximum	100	78	37	65

Table 7b Percent Fines and TOC Property Differences of LDW and Upstream (RM 5.0 to RM 7.0) Surface Sediment

Parameter	LDW Surface Sediment (RM 0.0 to RM 5.0)		Upstream Surface Sediment (RM 5.0 to RM 7.0)		Result of Mann-Whitney 2-tailed test	
	Number of Samples	Median	Number of Samples	Median	p value	Are the Datasets Statistically Different?
TOC (% dw)	1,146	1.8	37	0.7	0.000	Yes
Fines (% dw)	1,085	57.4	44	37.8	0.000	Yes

Notes:
ProUCL v.4.0 determined all data distributions to be non-parametric, and was used to identify outliers.
Mann-Whitney, the non-parametric equivalent of the t-test, was used on the untransformed data.

dw = dry weight; fines = sum of silt and clay grain-size fractions; LDW = Lower Duwamish Waterway; RM = river mile;
TOC = total organic carbon

Table 8 Correlation of Lower Duwamish Waterway (RM 0 – 5) Surface Sediment Chemistry to TOC and Fines

Parameter	Metric	TOC (%)	Fines (%)
Total PCBs	Correlation Coefficient	**0.397***	0.218*
	Significance (2-tailed)	**0.000**	0.000
	N	**833**	823
Arsenic	Correlation Coefficient	**0.526***	**0.505***
	Significance (2-tailed)	**0.000**	**0.000**
	N	**546**	**549**
cPAHs	Correlation Coefficient	**0.433**	**0.382***
	Significance (2-tailed)	**0.000**	**0.000**
	N	**557**	**558**
TOC	Correlation Coefficient	**n/a**	**0.602***
	Significance (2-tailed)		**0.000**
	N		**828**

Notes:
1. Correlation tests were performed with SPSS 13.0 statistical software; asterisk (*) indicates correlation significant at the 0.01 level (2-tailed).
2. ProUCL 4.0 was used to identify outliers.
3. Sample size is less than Table 5b because only data with complimentary chemistry, grain size, and TOC data were used in this analysis.

Bold values indicate statistically significant relationship.

Shading indicates significant relationship between risk-driver parameter and conventional parameter.

cPAHs = carcinogenic polycyclic aromatic hydrocarbons; fines = sum of silt and clay grain-size fractions; N = number of samples; n/a = not applicable; PCBs = polychlorinated biphenyls; RM = river mile; TOC = total organic carbon

Table 9 Summary of USACE DMMP Core Data (RM 4.3 to RM 4.75)

USACE Sampling Event	Sampling Year	Number of Samples[a] (Number of Detections): Total PCBs	Arsenic	cPAHs	Dioxins/ Furans	Range of Concentrations: Total PCBs (µg/kg dw)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxin/Furan (ng TEQ/kg dw)	Dredging Event[b]: Year	Footprint (RM)
DR09-Round 2	2009	2 (1) [c]	2 (2)	2 (2)	—	2U - 27	4 - 6	8 - 26	—	2010	4.18 – 4.49, 4.55 – 4.65
DR08-Round 1	2008	2 (2) [c]	2 (2)	2 (2)	2 (2)	25 - 53	10 - 14	41 - 108	2 - 3		
DUWO41AF189	2003	5 (5)	5 (5)	5 (5)	—	11 – 42	4 – 7	29 – 64	—	2004 2007	4.35 – 4.65 4.25 – 4.65
DUWA81BF128	1998	3 (1)	3 (3)	3 (3) 2 (2)	—	38U - 82	5 - 11	57 – 1,052 57 - 89[d]	—	1999 2002	3.45 – 4.65 4.25 – 4.65
DUWA71BF107	1996	1 (1)	1 (1)	1 (1)		94	7	185		1997	4.25 – 4.65
DUWA61BF132	1995	1 (1)	1 (1)	1 (1)	—	28	13	226	—	1996	4.0 – 4.5
DUWA21BF038	1991	4 (2)	4 (4)	4 (4)	—	32U – 34	3 – 9	14 – 181	—	1992 1994	3.35 – 4.65 4.35 – 4.65
DUWA01BF014	1990	2 (0)	0	2 (2)	—	20U	—	19 – 67	—	Data were post-dredging results for 1990 event.	
All Events		**20 (13)**	**18 (18)**	**20 (20) 19 (19)[d]**	**2 (2)**	**2U – 94**	**3 – 14**	**8 – 226[d]**	**2 – 3**	—	

Notes:
1. Stations downstream of RM 4.3 not used in any statistical analysis.
2. Core data queried from DAIS.

a. Subsurface sediment samples are either discrete vertically-composited samples or horizontally-composited samples from multiple cores.
b. Dredging event for which samples characterized the dredged material.
c. Data results for PCB Aroclors analyzed by TestAmerica for Rounds 1 and 2 met quality assurance level 1 (QA1) data evaluation requirements but were rejected by a more rigorous independent data validation by USACE. Core data presented and used in these analyses were analyzed from archived sediment by ARI Laboratory and independently validated by EcoChem Inc. in 2009 (USACE, 2009b).
d. Range of concentrations for cPAHs without an outlier of 1,052 µg TEQ/kg dw.

— = no data collected; cPAHs = carcinogenic polycyclic aromatic hydrocarbons; DAIS = Dredged Analysis Information System; DMMP = Dredged Material Management Program; dw= dry weight; µ = microgram; PCBs = polychlorinated biphenyls; RM = river mile; TEQ = toxic equivalent; U = undetected at the reporting limit shown; USACE = U.S. Army Corps of Engineers

Table 10 Data Quality Summary for USACE DMMP Core Data in the Frequently Dredged Area (RM 4.3 to 4.75)

Study Event	Risk Driver	Number of Samples	Data Selection	Overall Strength of Line of Evidence	Data Quality Considerations for Developing BCM Parameters of Upstream Sediment Settling in the LDW					
					Level of Data Validation	Precision	Representativeness	Accuracy / Potential Biasing Effects	Completeness	Comparability
Multiple (1990 – 2009)	Total PCBs	20	20 samples considered. Only data from 1990 - 2009 used.	Data characterize material that actually settles in the LDW.	Data are validated at QA-1 level for DMMP program.	Acceptable.	DAIS cores are generally similar to material that settles in the remainder of the LDW. Coarser material present above RM 4.5, consistent with bed load materials. Modeling indicates negligible contribution of lateral source material or downstream material to bed sediment composition in this reach.	Minor potential biases associated with sediment composition (low percent fines and TOC above RM 4.5). Low to medium bias associated with potential contributions from lateral sources. Modeling calculations demonstrate that lateral sources have minimal influence on sediment chemistry in this reach.	Acceptable. Sample numbers allow statistical interpretation.	The sample matrix is comparable to LDW sediment samples. Sample search is extended downstream to RM 4.3 to include samples with higher percent fines (than Upper Turning Basin) to match physical conditions in LDW.
	Arsenic	18	18 samples considered. Only data from 1991 - 2009 used. No arsenic data for 1990 event.							
	cPAHs	19	19 samples considered. Only data from 1990 - 2009 used one outlier was excluded).							
	Dioxins/Furans	2	2 samples considered. Data available only for 2009 event.							

Notes:
BCM = bed composition model; cPAHs = carcinogenic polyaromatic hydrocarbons; DAIS = Dredged Analysis Information System; DMMP = Dredged Material Management Program; LDW = Lower Duwamish Waterway; PCBs = polychlorinated biphenyls; RM = river mile; TOC = total organic carbon; USACE = U.S. Army Corps of Engineers.

Table 11 Summary Statistics of Total PCBs for the Development of Upstream BCM Input Parameters

Data Sources	Number of Observations	Data Distribution	Total PCB Concentration (µg/kg dw)			
			Mean	Median	90th Percentile	95% UCL[a]
Green/Duwamish River Water Quality						
King County Whole-Water Data (2001-2008)	*22*	Lognormal	50	21	107	82
Ecology Centrifuged Solids Data (2008, 2009)	*7*	Lognormal	14	8	54	36
King County Whole Water and Ecology Centrifuged Solids Combined	*29*	Lognormal	42	11	120	127
Upstream Surface Sediment (RM 5.0 to 7.0)						
LDW RI Upstream Sediment Data (1994-2006)[b]	*37*	Non-parametric	23	19	40	21[e]
Ecology Upstream Surface Sediment Data (2008)[c]						
Fines > 30 %	*30*	Non-parametric	5	2	13	8
All	*73*	Non-parametric	3	3	6	3
LDW RI and Ecology Surface Sediment Combined [c]	*110*	Non-parametric	8	3	23	13
Upper Turning Basin and Navigation Channel						
USACE DMMP Core Data (1990-2009)[d] RM 4.3 - RM 4.75	*20*	Lognormal	36	33	56	42

Notes:
a. Reported value is the 95% UCL recommended by ProUCL 4.00.04.
b. Surface sediment samples between RM 5 and 7 that are included in the RI baseline dataset.
c. Outlier excluded for total PCBs: 770 µg/kg dw.
d. Dredged Analysis Information System (DAIS) data obtained from USACE.
e. The 95%UCL is lower than the mean because this is a non-parametric distribution, left-censored dataset with 51% non-detects. Therefore, the 95%UCL is based on a bias-corrected accelerated (BCA) bootstrap method. UCL95 is the one recommended by ProUCL software.

BCM = bed composition model; DMMP = Dredged Material Management Program; LDW = Lower Duwamish Waterway; µg/kg dw = micrograms per liter dry weight; mg/L = milligram per liter; PCB = polychlorinated biphenyl; RI = remedial investigation; RM = river mile; TSS = total suspended sediments; UCL = upper confidence limit on the mean; USACE = U.S. Army Corps of Engineers

Table 12 Summary Statistics of Arsenic for the Development of Upstream BCM Input Parameters

Data Sources	Number of Observations	Data Distribution	Arsenic Concentration (mg/kg dw)			
			Mean	Median	90^{th} Percentile	95% UCL[a]
Green/Duwamish River Water Quality						
King County Whole-Water Data (2001-2008)	*100*	Non-parametric	37	29	73	47
Ecology Centrifuged Solids Data (2008, 2009)	*7*	Lognormal	17	14	24	22
Upstream Surface Sediment (RM 5.0 to 7.0)						
LDW RI Upstream Sediment Data (1994-2006)[b]	*24*	Lognormal	7	5	11	8
Ecology Upstream Surface Sediment Data (2008)						
Fines > 30 %	*31*	Non-parametric	9	9	11	10
All	*74*	Non-parametric	7	6	10	7
LDW RI and Ecology Surface Sediment Combined	*98*	Non-parametric	7	6	10	7
Upper Turning Basin and Navigation Channel						
USACE DMMP Core Data (1990-2009)[c] RM 4.3 - RM 4.75	*18*	Lognormal	7	6	12	8

Notes:

a. Reported value is the 95% UCL recommended by ProUCL 4.00.04.
b. Surface sediment samples between RM 5 and 7 that are included in the RI baseline dataset.
c. Dredged Analysis Information System (DAIS) data obtained from USACE.

BCM = bed composition model; DMMP = Dredged Material Management Program; LDW = Lower Duwamish Waterway; mg/kg dw = milligrams per kilogram dry weight; RI = remedial investigation; RM = river mile; UCL = upper confidence limit on the mean; USACE = U.S. Army Corps of Engineers.

Table 13 Summary Statistics of cPAHs for the Development of Upstream BCM Input Parameters

Data Sources	Number of Observations	Data Distribution	cPAH Concentration (µg TEQ/kg dw)			
			Mean	Median	90th Percentile	95% UCL[a]
Green/Duwamish River Water Quality						
King County Whole Water Data (2001-2008)	*18*	Lognormal	151	74	354	269
Ecology Centrifuged Solids Data (2008, 2009)	*7*	Lognormal	138	53	400	432
King County Whole Water and Ecology Centrifuged Solids Combined	*25*	Lognormal	135	58	330	266
Upstream Surface Sediment (RM 5.0 to 7.0)						
LDW RI Upstream Sediment Data (1994-2006)[b]	*16*	Non-parametric	55	18	135	100
Ecology Upstream Surface Sediment Data (2008)						
Fines > 30 %	*31*	Non-parametric	37	16	77	72
All	*74*	Non-parametric	18	9	57	43
LDW RI and Ecology Sediment Combined	*90*	Non-parametric	25	10	73	55
Upper Turning Basin and Navigation Channel						
USACE DMMP Core Data (1990-2009)[c] RM 4.3 - RM 4.75	*19*	Lognormal	73	57	180	134

Notes:

a. Reported value is the 95% UCL recommended by ProUCL 4.00.04.
b. Surface sediment samples between RM 5 and 7 that are included in the RI baseline dataset.
c. Dredged Analysis Information System (DAIS) data obtained from USACE. Outlier excluded for cPAHs: 1,052 µg TEQ/kg dw.

BCM = bed composition model; cPAH = carcinogenic polycyclic aromatic hydrocarbon; DMMP = Dredged Material Management Program; LDW = Lower Duwamish Waterway; µg TEQ/kg dw = micrograms toxic equivalent per kilogram dry weight; RI = remedial investigation; RM = river mile; TEQ = toxic equivalent; UCL = upper confidence limit on the mean; USACE = U.S. Army Corps of Engineers.

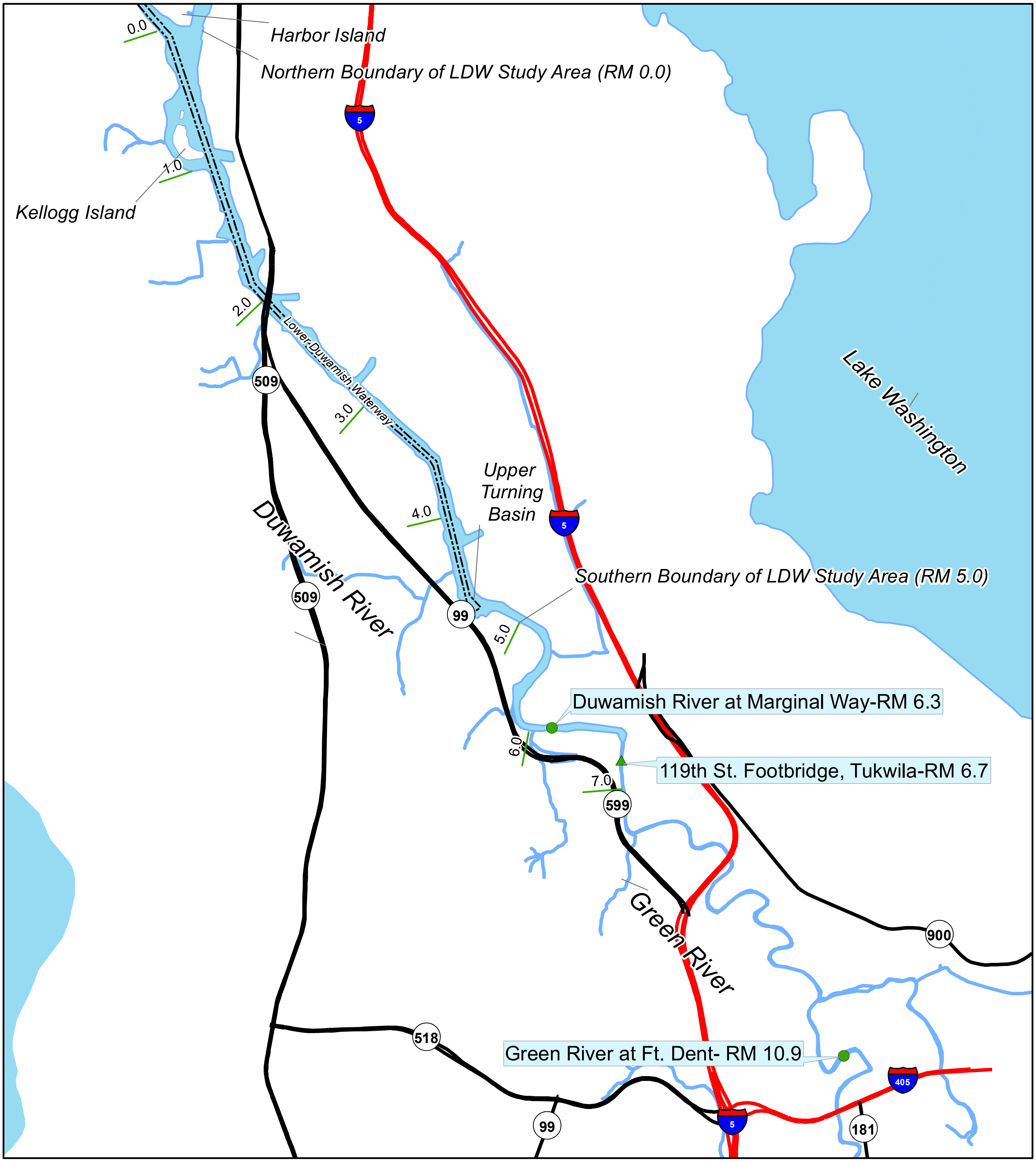
Table 14 Summary Statistics of Dioxins and Furans for the Development of Upstream BCM Input Parameters

Data Sources	Number of Observations	Data Distribution	Dioxin/Furan Concentration (ng TEQ/kg dw)			
			Mean	Median	90th Percentile	95% UCL[a]
Duwamish River Water Quality						
Ecology Centrifuged Solids Data (2008, 2009)	6	Lognormal	6	3	13	10
Upstream Surface Sediment (RM 5.0 to 7.0)						
LDW RI Upstream Sediment Data (1994-2006)[b]	4	—	Range of Values (Median): 1.1 - 2.6 (1.7)			
Ecology Upstream Surface Sediment Data (2008)						
Fines > 30 %	31	Non-parametric	2	2	3	2
All	74	Non-parametric	1	0.3	3	2
Upper Turning Basin and Navigation Channel						
USACE DMMP Core Data (1990-2009)[c] RM 4.3 - RM 4.75	2	—	2 and 2.8 ng TEQ/kg dw			

Notes:

a. Reported value is the 95% UCL recommended by ProUCL 4.00.04.
b. Surface sediment samples between RM 5 and 7 that are included in the RI baseline dataset.
c. Dredged Analysis Information System (DAIS) data obtained from USACE.

LDW = Lower Duwamish Waterway; ng TEQ/kg dw = nanograms toxic equivalent per kilogram dry weight; RI = remedial investigation; RM = river mile; TEQ = toxic equivalent; UCL = upper confidence limit on the mean; USACE = U.S. Army Corps of Engineers.



Notes:
1. Stations sampled by King County are located in the Duwamish River at the Marginal Way station (identified by locator 0309) and in the Green River at the Ft. Dent station (identified by locators A310, 3106, and TGS/1).
2. The station sampled by Ecology is at the 119th Street Footbridge near Tukwila (RM 6.7).

Legend
- King County whole-water sample location
- Ecology centrifuged solids sample location
- Navigation Channel
- River Mile Marker
- Interstate Highway
- State Highway

0 0.25 0.5 1 Miles

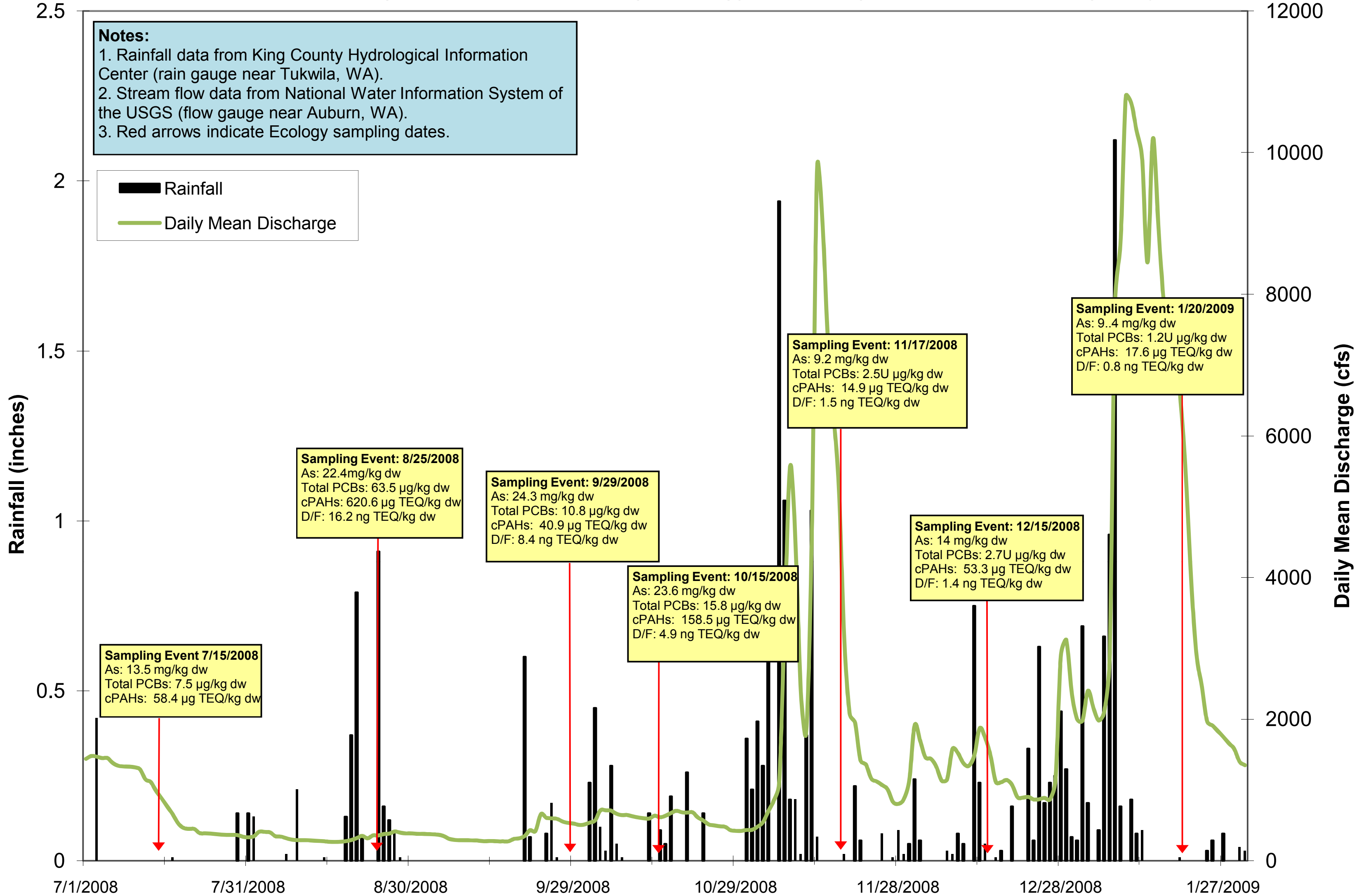
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

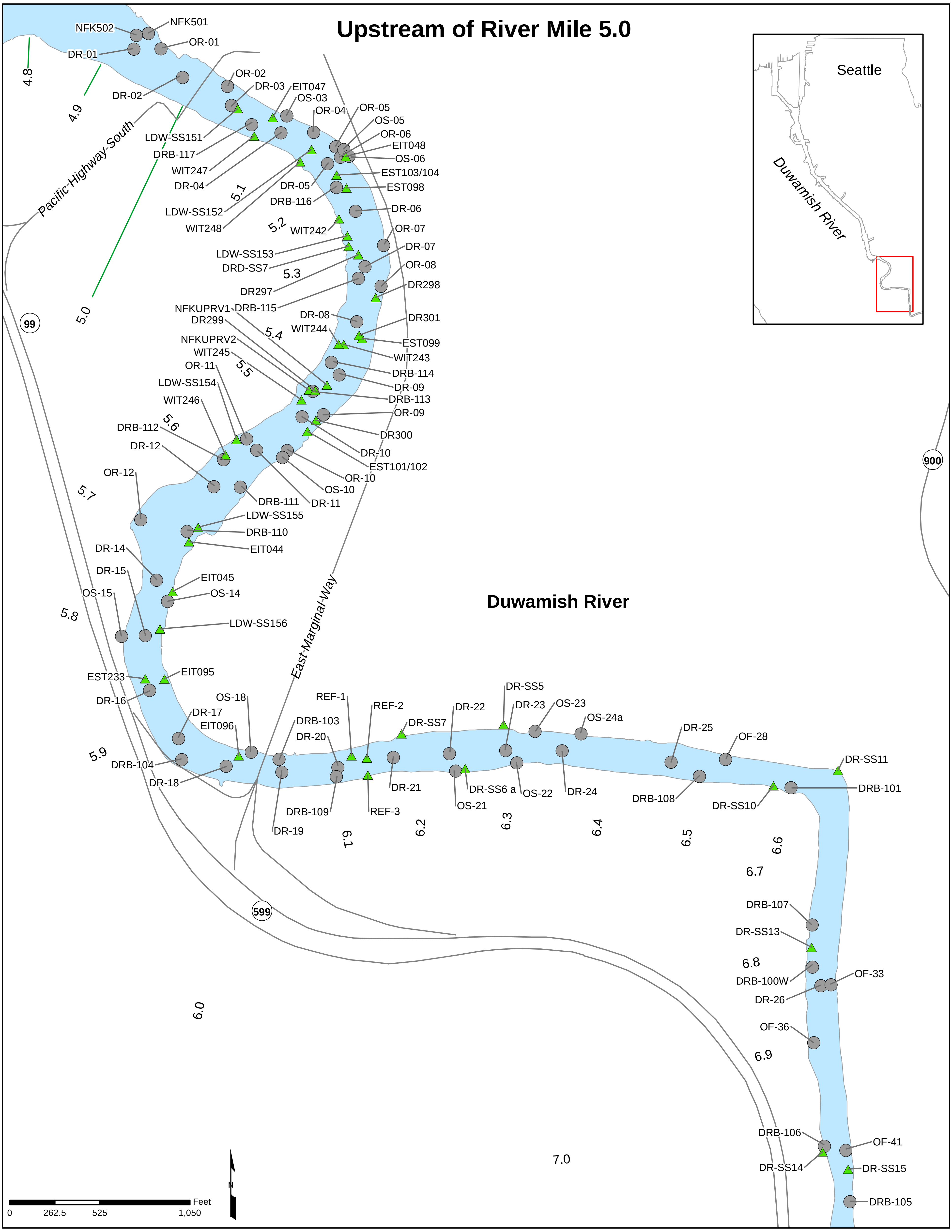
Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	**Upstream Surface Water Sampling Locations**
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE 1

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-3_1_Upstreamsurfacewatersamplocs.mxd

Figure 2
Green River Discharge and Rainfall During Ecology Centrifuged Solids Sampling Project



Notes:
As = arsenic; cfs = cubic feet per second; cPAH = carcinogenic polycyclic aromatic hydrocarbon; D/F = dioxins and furans; dw = dry weight; PCB = polychlorinated biphenyl; TEQ = toxic equivalent



Notes:
1. Surface sediment samples from RM 5.0 to 7.0 are from RI baseline dataset (1994 - 2006).
2. Surface sediment samples from RM 4.9 to 6.5 are from 2008 Ecology study. DR = center channel samples,
OS = samples near the discharge points of outfalls, OR = samples within the Duwamish River approximately 15 meters downstream of outfall discharge points, DRB = bank samples that appear to be depositional environments,
OF = bank samples at discharge points of selected newly identified outfalls upstream of RM 6.5,
NFK = samples near the Norfolk combined sewer overflow.
3. Surface sediment samples collected at depths between 0 and 10 cm.

Legend

Upstream Surface Sediment Sample Location

- LDW Remedial Investigation Dataset
- Ecology 2008 Study
- River Mile Marker
- State Highway

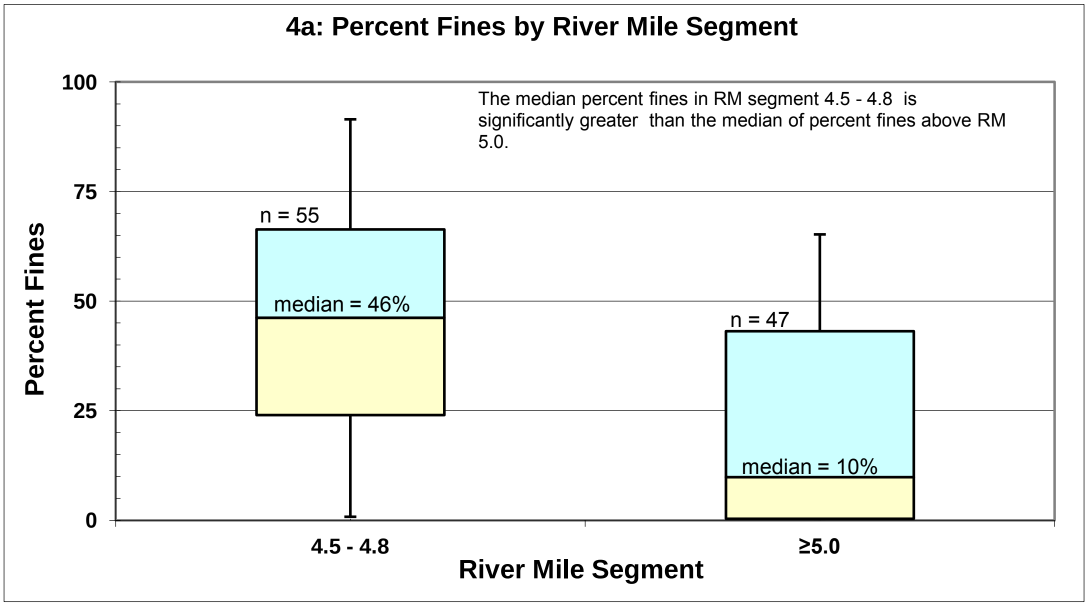
AECOM

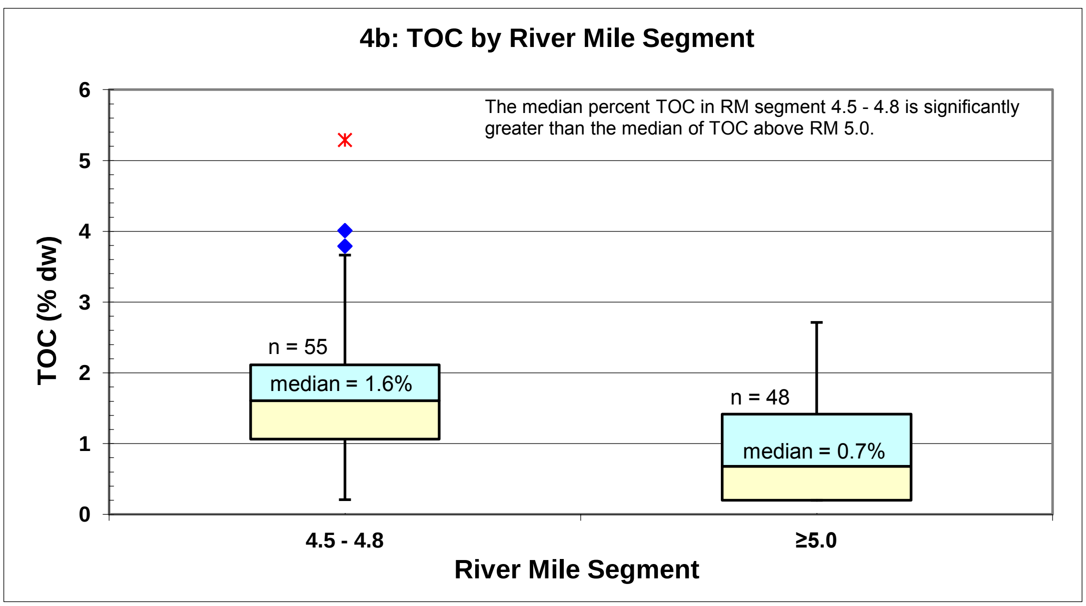
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			**Surface Sediment Sampling Stations Used to Characterize Sediments from Upstream**
DATE: 10/31/12	DWRN: MVI/sea	Revision: 0	**FIGURE 3**

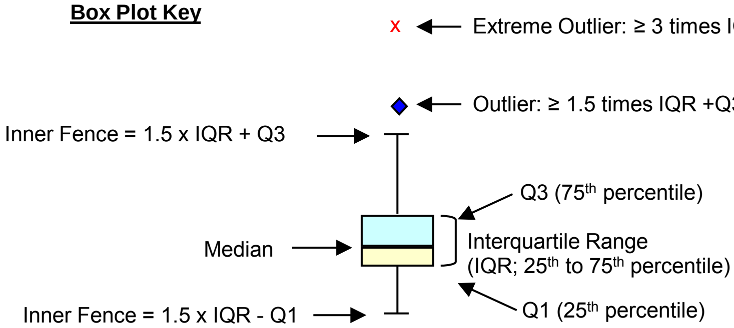
L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-3_3_Sample locationsupstreamofRM4.0.mxd

Figure 4
Comparisons of Surface Sediment Percent Fines and TOC in the Upper Turning Basin (RM 4.5 - 4.8) and Upstream of the LDW (RM ≥ 5.0)

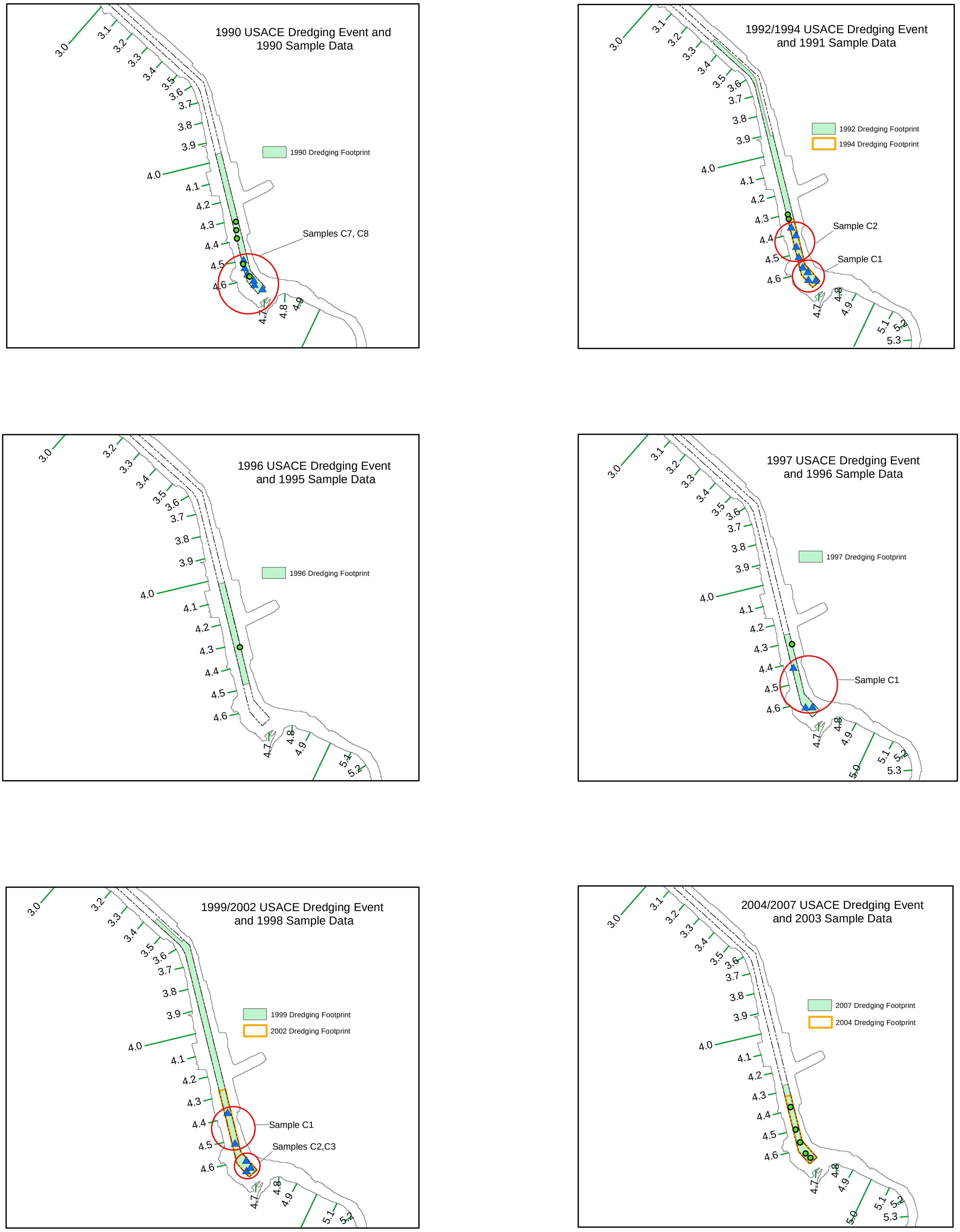




Box Plot Key



Notes
IQR = interquartile range
Figures generated in Excel



Notes:
1. Sample data provided by David Fox, USACE, in March 2007.
2. Dredging footprints from USACE Dredge Summary and Analysis Reports.
3. Single sample locations represent stations where sediment data were collected and analyzed without horizontal compositing. Composite sample locations represent stations where sediment was collected and then composited with sediment from other stations before analysis.
4. Stations downstream of RM 4.3 not shown.
5. Most 1990-2003 sediment samples collected from 0 to 4 ft below mudline.
6. USACE= US Army Corps of Engineers

Legend

- Single Sample Core Location
- Composite Sample Core Location
- Navigation Channel
- River Mile Marker

Feet
0 800 1,600 3,200

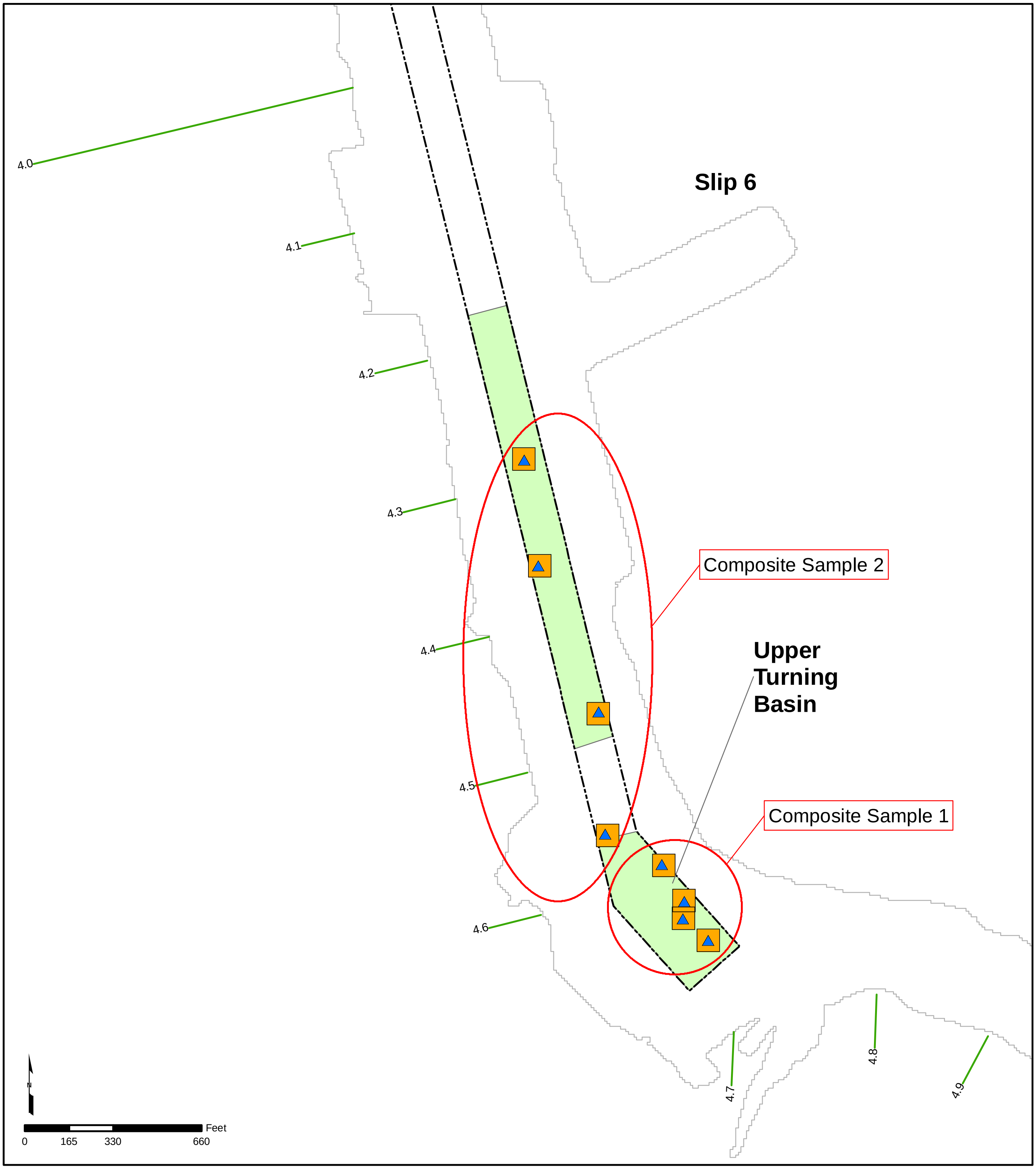
N

L:\Lower Duwamish FS\FS_Final_GIS\GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-3_5a_DAIS_USACEdredge.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			**1990-2003 Pre-Dredging Event Sampling Locations from Upper Reach**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE 5a**



Notes:
1. Sample data provided by SAIC and USACE in September 2009. Final data reports published in October and November 2009.
2. Stations downstream of RM 4.3 not shown.

Legend

- River Mile Marker
- Navigation Channel
- 2008 Surface Sample Location
- 2009 Core Sample Location
- 2010 Dredging Footprint

AECOM Lower Duwamish Waterway Group Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			**2008 & 2009 Pre-Dredging Event Sampling Locations from Upper Reach**
DATE: 10/31/12	DRWN:MVI/sea	Revision: 0	**FIGURE 5b**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-3_5b_DAIS_USACEdredge.mxd

Figure 6
Conceptual Diagram of USACE Core Sample Depths to Mudline

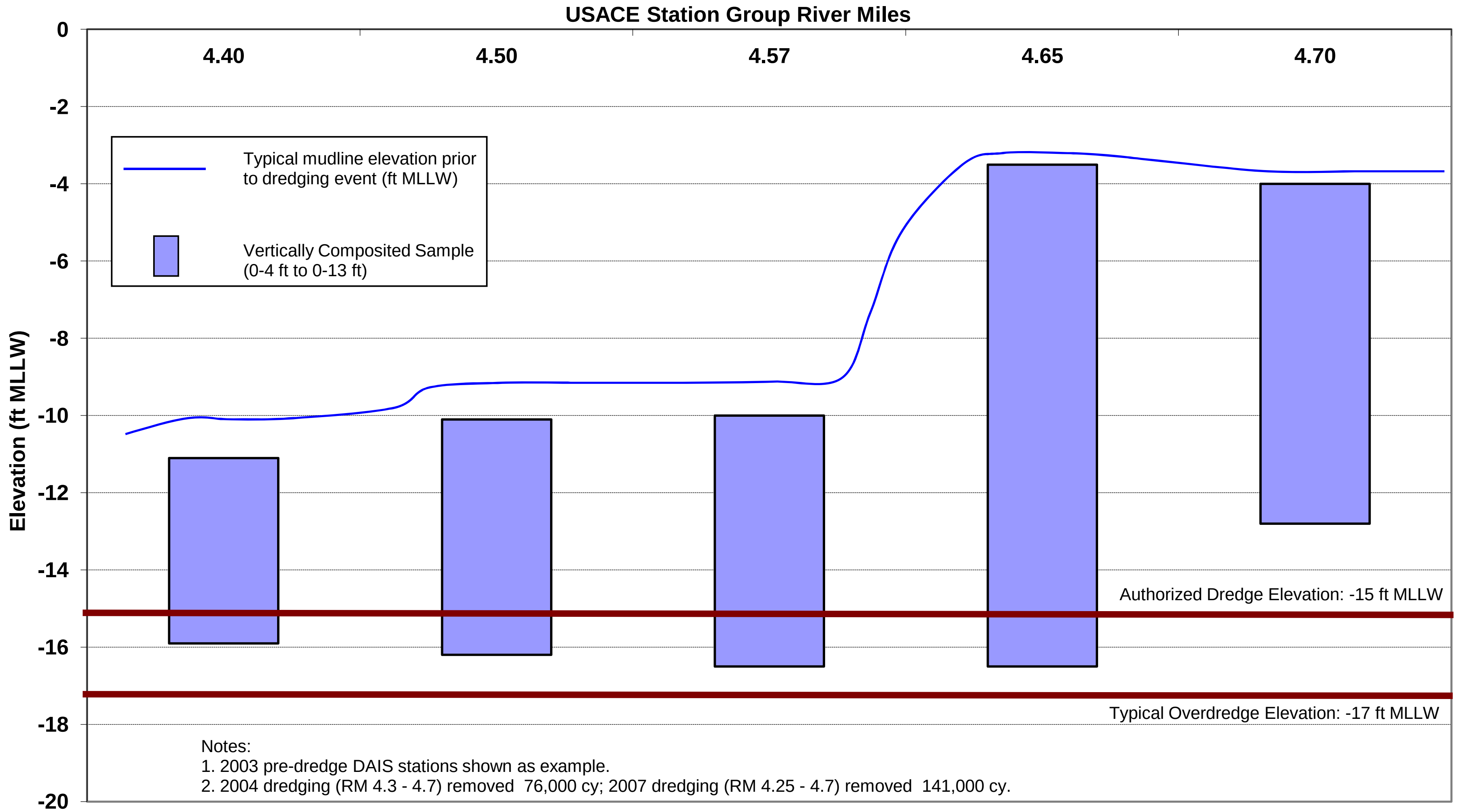


Figure 7
Temporal Representation of USACE Core Data - Total PCBs by Location and Year

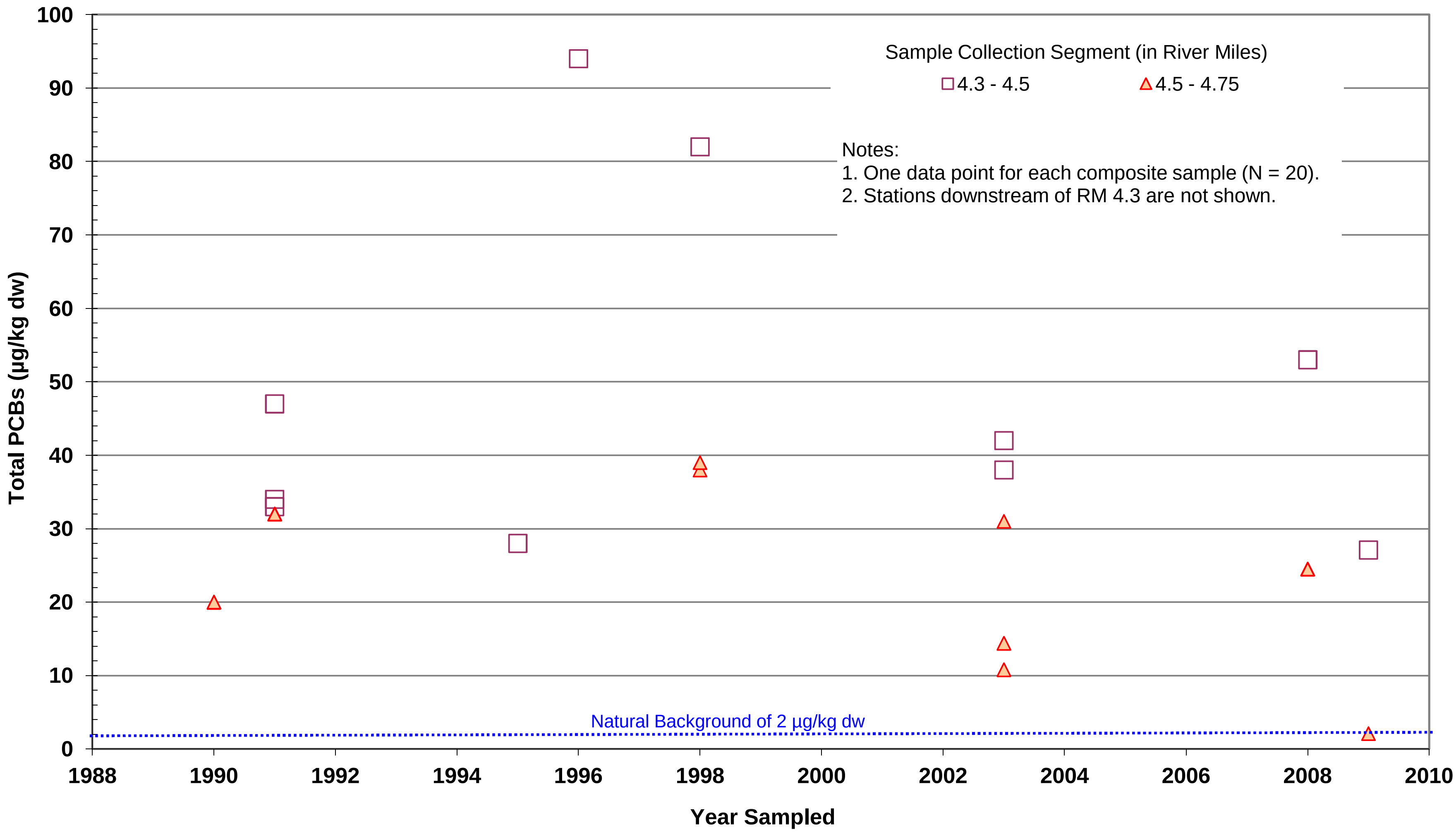


Figure 8
Summary of Lines of Evidence for Upstream BCM Input Parameter Development - Total PCBs

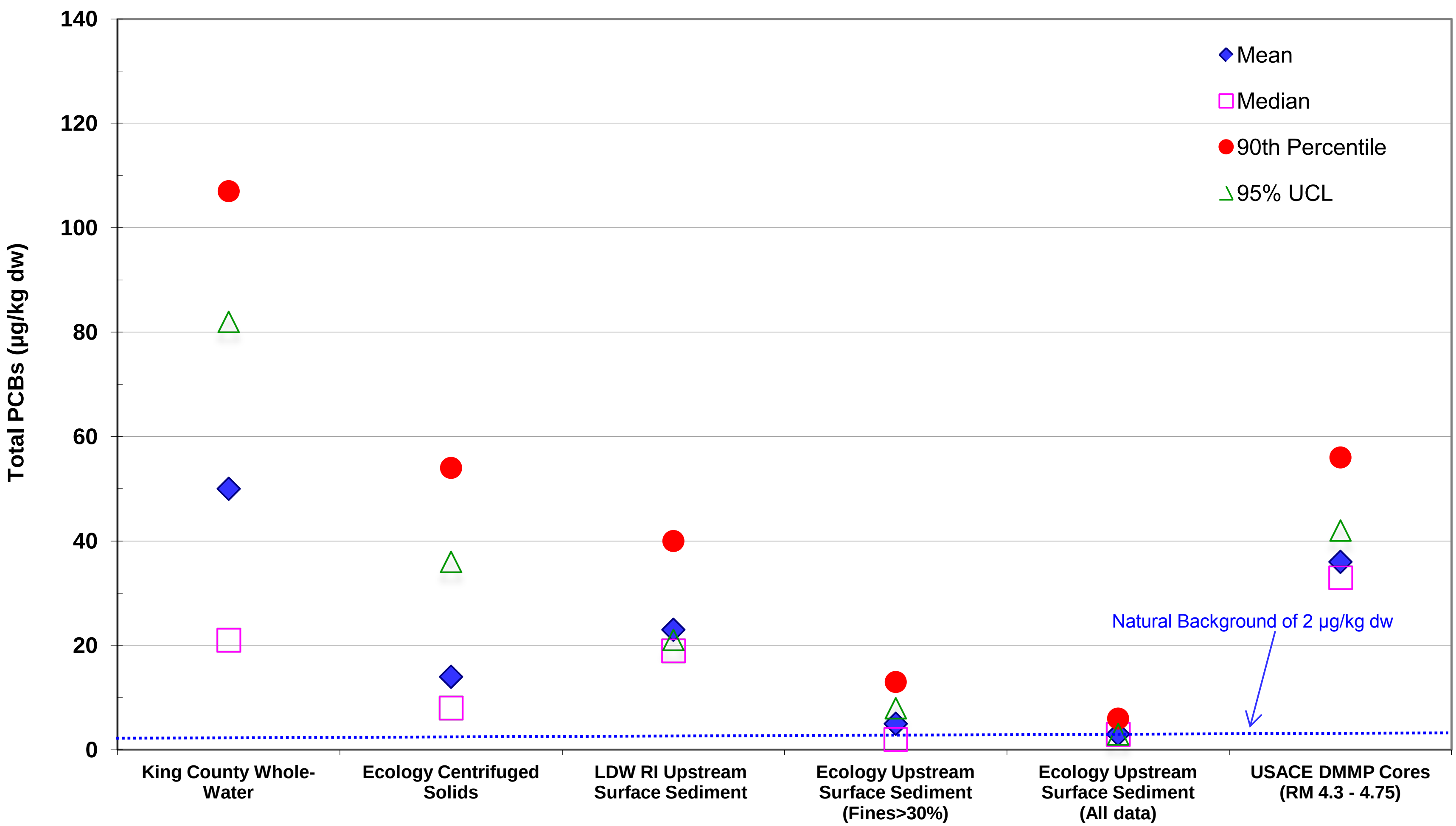


Figure 9
Temporal Representation of USACE Core Data - Arsenic by Location and Year

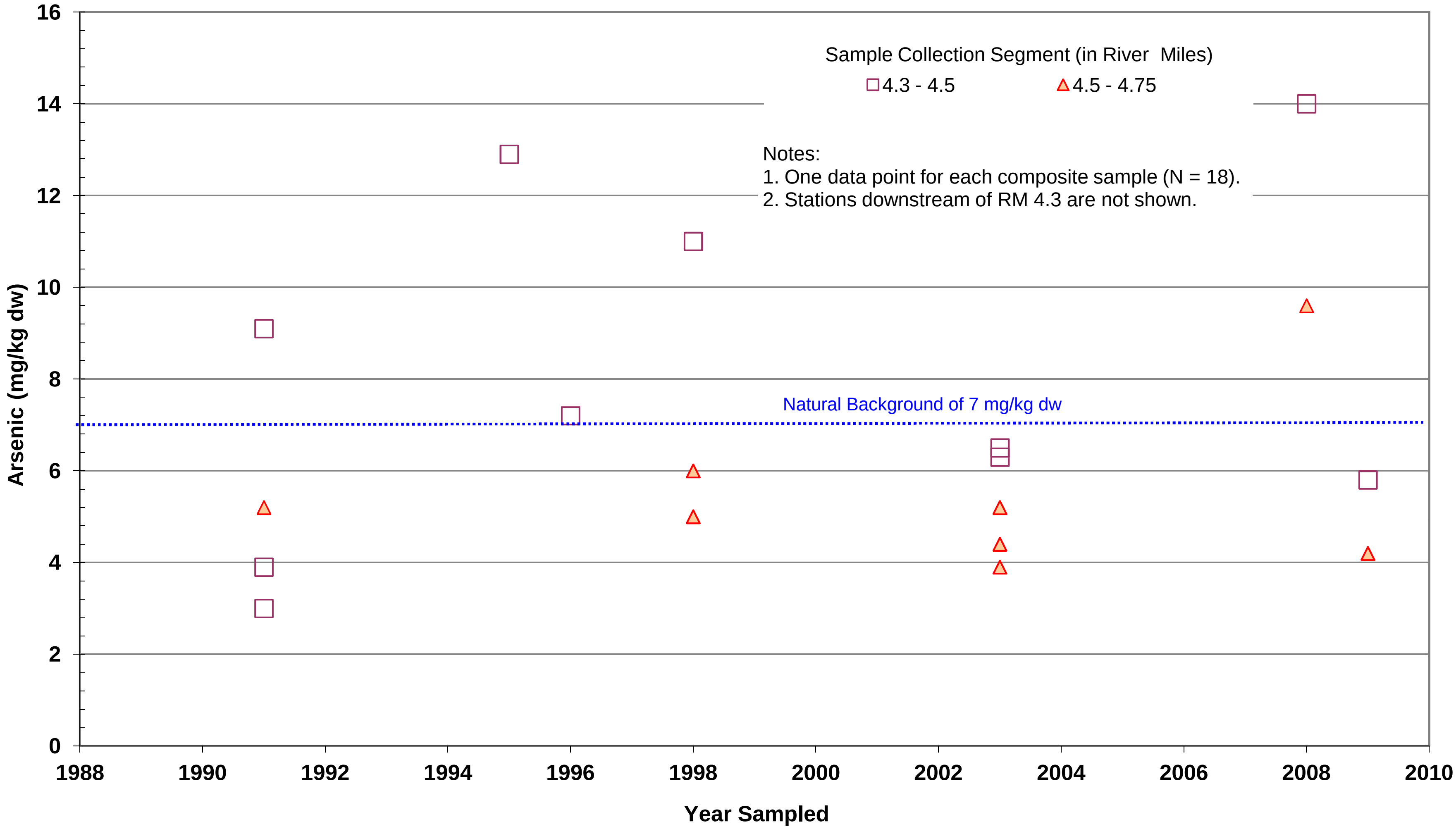


Figure 10
Summary of Lines of Evidence for Upstream BCM Input Parameter Development - Arsenic

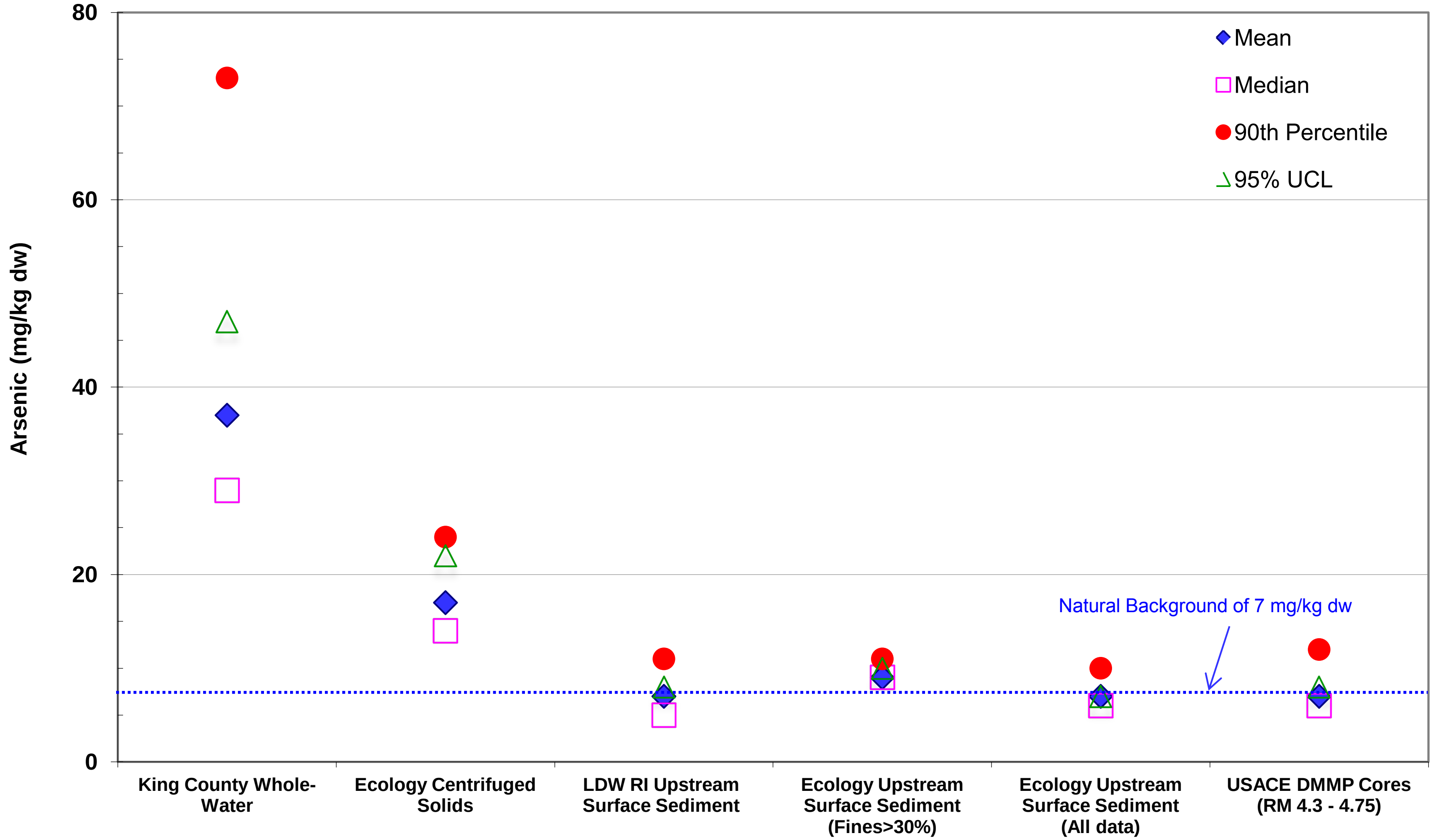


Figure 11
Temporal Representation of USACE Core Data - cPAHs by Location and Year

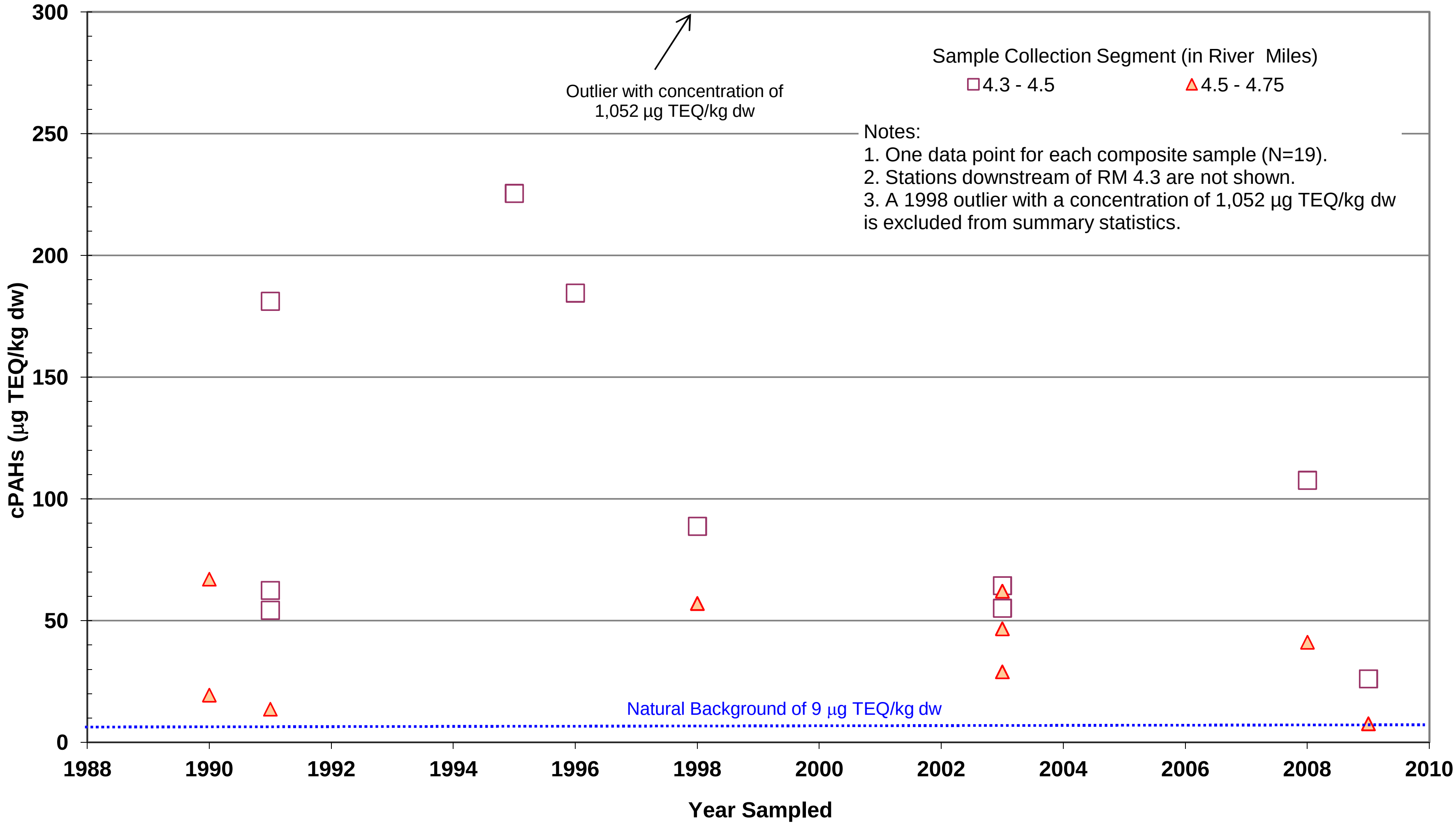


Figure 12
Summary of Lines of Evidence for Upstream BCM Input Parameter Development - cPAHs

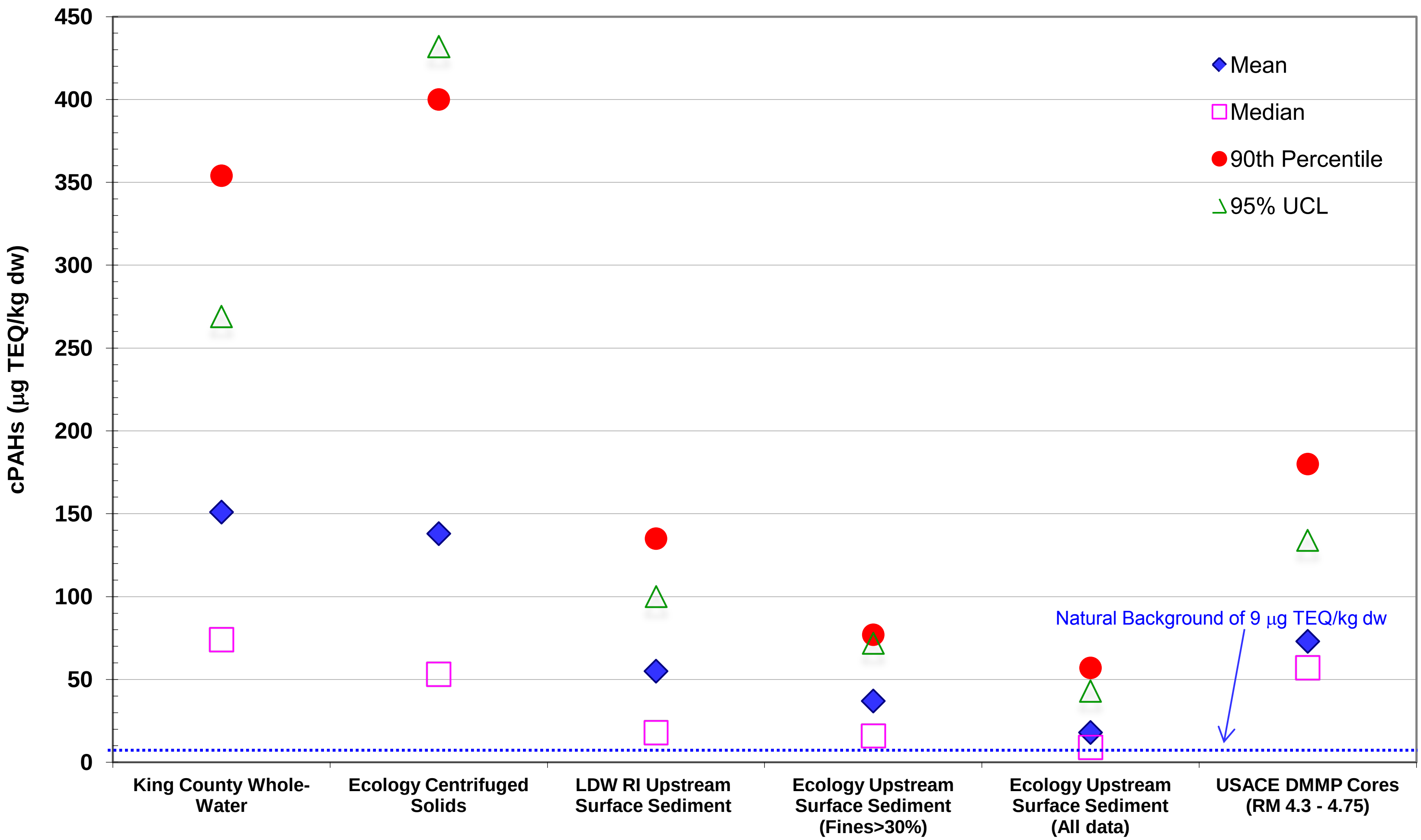
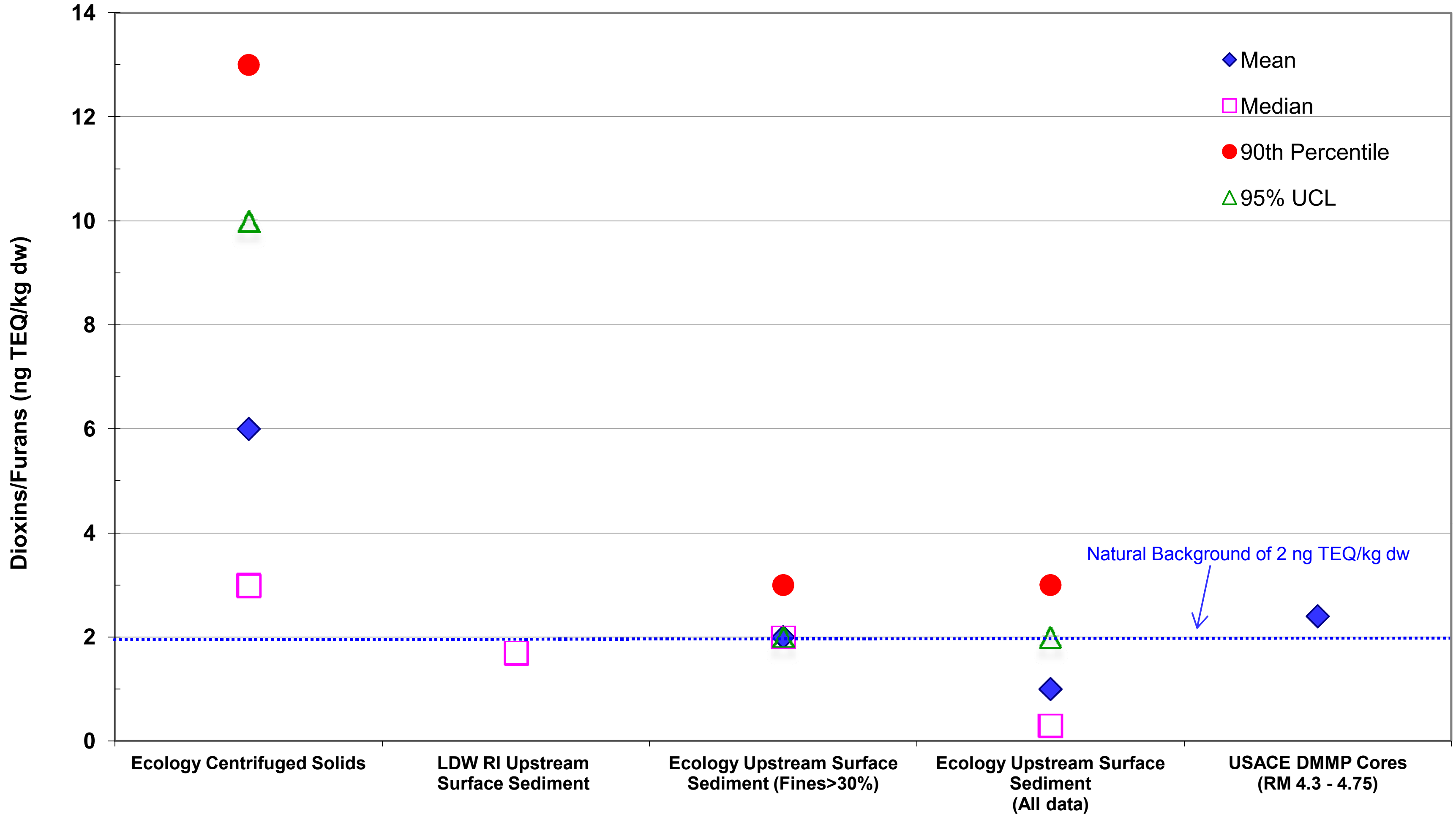


Figure 13
Summary of Lines of Evidence for BCM Upstream Input Parameter Development - Dioxins/Furans



Part 4: LDW Sediment Transport Model: Results of Five Scenario Simulations

Scenario 1: **Potential Recontamination of Early Action Areas**

Scenario 2: **Distributed Discharges from Lateral Sources**

Scenario 3: **Movement of LDW Bed Sediment into the Upper Turning Basin**

Scenario 4: **Movement of Bed Sediments between Reaches**

Scenario 5: **Sediment Scoured from Greater than 10-cm Depth**

AECOM

ANCHOR QEA

305 West Grand Avenue, Suite 300
Montvale, New Jersey 07645
Phone 201.930.9890
Fax 201.930.9805
www.anchorqea.com

MEMORANDUM

To:	Lower Duwamish Waterway Group	**Date:**	April 20, 2009[1]
From:	C. Kirk Ziegler, Anchor QEA	**Project:**	RETldw:230
Cc:	Files		
Re:	LDW Sediment Transport Model: Results of Five Scenario Simulations		

INTRODUCTION

A Sediment Transport Model (STM) for the Lower Duwamish Waterway (LDW) has been developed, calibrated, and validated (QEA 2008). Extensive evaluation of the STM indicated that the model adequately simulates sediment transport processes in the LDW for the purposes and applications specified in the final STM Report (QEA 2008) approved by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) on October 31, 2008. Based on these results, the following conclusions concerning model reliability were developed:

- The STM may be used to refine, confirm, and validate the conceptual site model (CSM).
- The analysis provides quantitative uncertainty estimates for STM predictions and CSM components.
- The STM provides a framework to support evaluation of physical processes and the effects of potential actions in the LDW.
- Over small spatial scales (i.e., areas corresponding to approximately one or two grid-cells in size), the STM will typically demonstrate trends that may be used as one line-of-evidence, along with other information and data, to guide decision-making.
- The STM is a reliable framework for supporting extrapolation to conditions where no erosion and/or empirical net sedimentation rate (NSR) data are available.

[1] Revised October 15, 2010 to be consistent with revisions to the FS requested by the agencies.

The STM has been used as a diagnostic tool to quantitatively evaluate five scenarios in the LDW. This technical memorandum describes the five scenarios and presents the results of the scenario simulations. The five scenario simulations are summarized in Table 1.

Table 1
Summary of Five Scenario Simulations

Scenario	Primary Objective	General Description of Simulation
1. Potential Recontamination of Early Action Areas (EAAs)	Evaluate changes in bed sediment within EAAs after removal actions are simulated in EAAs.	10-year simulation that tracked sediment from four sources: 1) EAA bed sediment; 2) bed sediment from areas outside the EAAs; 3) lateral source; and 4) upstream (Green River) source.
2. Distributed Discharges from Lateral Sources	Evaluate the effects of spatially distributed lateral-source discharge locations.	10-year simulation that is modified to have the lateral load distributed among the near-shore cells adjacent to shoreline outfalls. The model is run for a 10-year period to compare the STM base case (the lateral load distributed via 21 outfalls) with the redistributed lateral loads via x point sources.
3. Movement of LDW Bed Sediment into the Upper Turning Basin	Determine the amount of bed sediment originating from downstream of RM 4.0 that is eroded and redeposited in the region upstream of RM 4.0.	10-year simulation that tracked bed sediment from four sources: 1) Upper Turning Basin, RM 4.3 to 4.75; 2) navigation channel, RM 4.0 to 4.3; 3) bench areas upstream of RM 4.0; and 4) all sediment downstream of RM 4.0. The model run predicts whether downstream LDW sediments resuspend and settle upstream in the turning basin.
4. Movement of Bed Sediment Between Reaches	Determine the fate of bed sediment from Reaches 1, 2, and 3.	30-year simulation resulting in a mass balance of sediment movement between reaches and out of the LDW for each reach.
5. Sediment Scoured From Greater Than 10-cm Depth	Determine fate of bed sediment from 0-to-10-cm and deeper-than-10-cm layers, following scour by a 100-year high-flow event.	Areas that are predicted to scour greater than 10 cm depth are assigned a new variable to represent a new sediment class. The 100-year high-flow simulation is used to predict where these >10 cm scoured sediments resettle.

EAA=Early Action Area; RM=river mile

The 10-year period used for Scenarios 1 through 4 corresponds to the first 10 years of the 30-year simulation presented in the final STM (QEA 2008). Comparison of the STM results for this 10-year period to the results for the entire 30-year period indicated that the 10-year period is representative of multi-year periods; the 10-year period results are similar to the 30-year period results. The initial conditions for the spatial distribution of bed composition were the same as those used for the diagnostic simulations presented in the final STM.

SCENARIO 1: POTENTIAL RECONTAMINATION AT EARLY ACTION AREAS

The objective of the Scenario 1 simulation was to evaluate temporal changes in the composition of surface (0 – 10 cm) sediment within early action areas (EAAs). The locations of the EAAs are shown in Figure 1-1. The Norfolk EAA is outside the area represented in the STM. To accomplish this objective, a 10-year simulation was conducted and the fate of sediment originating from the following four sources was tracked: 1) EAA bed sediment; 2) non-EAA bed sediment; 3) lateral sources; and 4) upstream (Green River) source. The bed properties within the EAA bed source areas were not modified for this scenario simulation (i.e., the EAA bed properties were assumed to represent current conditions). No adjustment of bed properties in the EAA bed source areas was made to represent post-remediation conditions.

The predicted spatial distributions of the relative amounts of sediment from the four sources in the surface sediment at the end of the 10-year period are presented in Figures 1-2 through 1-5. Some sediment from outside the EAAs has been resuspended and redeposited within the EAAs, with the non-EAA sediment contributing 5% or less to the surface sediment within the EAAs (Figure 1-3). Generally, the composition of surface sediment in the EAAs at the end of the 10-year period is dominated by sediment from the upstream source (Figure 1-5).

Quantitative comparisons of the relative amounts of sediment from the four sources in surface sediment at the end of the 10-year period in each of the six EAAs are shown in Figure 1-6. Upstream-source sediment comprises about 55% to 75% of the surface-layer composition in the EAAs. The relative amount of the original sediment in the EAAs, which was 100% at the beginning of the simulation, decreased to about 15% to 35% after 10 years. Sediment resuspended from outside the EAAs and redeposited within the EAAs comprises

3% or less of the surface sediment within the EAAs at the end of the 10-year period. The contribution of lateral-source sediments to the EAA surface sediments is variable, with this content ranging between about 1% and 15% for the EAAs.

The Scenario 1 simulation tracks the movement of bed sediment inside and outside of the EAAs for 10 years, following cleanup of the EAAs. Cleanup was simulated by setting feasibility study (FS) baseline total PCB concentrations in the EAAs to the recommended post-remedy bed sediment replacement value (RV) of 60 μg/kg dw. The bed composition model (BCM) equation used to calculate the 10-year period was modified by including two bed sediment sources. For sediments in EAAs, the bed concentration was equal to the RV. The bed concentration of sediment sourced from outside of the EAAs was set to the site-wide spatially-weighted average concentration (SWAC) for the grid cells not located in the EAAs, which are equal to 271 μg/kg dw in Reach 1 and 435 μg/kg dw in Reach 2. There are no EAAs in the STM domain in Reach 3, therefore, the Reach 3 site-wide SWAC was not changed. The upstream and lateral chemical input parameters were set to the recommended mid range values used in the base case, which are 35 and 300 μg/kg dw, respectively.

This simulation demonstrates that very little bed sediment is suspended from outside of the EAAs and redeposited within the EAAs with averages of 1.9% and 4.0% in Reaches 1 and 2, respectively. The EAA SWACs at the end of 10 years in Reaches 1 and 2 are 86 and 66 μg/kg dw, respectively. The predicted total PCB concentrations at the end of 10 years in the EAAs are displayed in Figure 1-7. The EAA SWAC in Reach 1 exceeds that in Reach 2 because the STM grid cells in the Reach 1 EAA (Duwamish/Diagonal) have, on average, a higher percentage of sediment originating from the lateral sources than those in Reach 2 (15% vs. 2.8%).

SCENARIO 2: DISTRIBUTED DISCHARGES FROM LATERAL SOURCES

Storm drains, combined sewer overflows (CSOs), and streams discharge into the LDW at over 200 locations; in the STM report (base-case runs), these lateral sources were aggregated and represented by 21 point sources (9 CSOs and 12 storm drains) that discharged into the LDW at 16 locations (i.e., 16 individual grid cells). Sediment loads specified as "storm drains" in the base-case simulation included aggregated flow due to runoff from waterfront areas and streams. Aggregating the lateral sources introduces uncertainty into the model predictions of surface (0 - 10 cm) sediment composition (i.e., relative amounts of sediment originating from the original bed, lateral, and upstream sources). Therefore, the objective of Scenario 2 was to evaluate the effects of the spatial distribution of lateral-source discharge locations on surface sediment composition. The base-case version of the Scenario 2 simulation is used throughout the FS. Therefore, BCM methods and findings using this simulation are not discussed in this appendix, but can be found throughout the FS, primarily in Sections 5 and 9.

A 10-year simulation was conducted with the spatial distribution of lateral sources being increased, relative to the simulation presented in Section 4 of the final STM. For the Scenario 2 simulation, lateral loads were separated into three broad categories: 1) CSOs; 2) storm drains (including streams); and 3) waterfront areas. Total sediment loads from these three sources for the base-case and Scenario 2 simulations are compared in Table 2, which shows that: 1) total CSO load did not increase; 2) total storm drain load decreased by 9.5%, due to transfer of a portion of the aggregated load in the base-case simulation to waterfront areas and reassessment of storm drain loads at some locations; and 3) distributed runoff from waterfront areas was incorporated into the model. As a result of more recent refinements in the overall loading estimates, the total sediment load from lateral sources increased by 4.3% (i.e., 52 MT/yr) for the Scenario 2 simulation, relative to the base-case simulation. The CSO sediment loads at nine locations, which were unchanged between the base-case and Scenario 2 simulations, are presented in Table 3.

Table 2
Total Sediment Loads for Base-Case and Scenario 2 Simulations

Type of Lateral Load	Base-Case Sediment Load (MT/yr)	Scenario 2 Sediment Load (MT/yr)	Relative Change in Sediment Load (%)
CSOs	35.1	35.1	0.0
Storm Drains	1,170	1,059	-9.1
Waterfront Areas	0	163	+100
Total	**1,205.1**	**1,257.1**	**+4.3**

CSO = combined sewer overflow

Table 3
Base-Case and Scenario 2 Sediment Loads at 9 CSO Locations

Location Name	River Mile Location	Sediment Load (MT/yr)
Duwamish P.S. W.	0.44 W	0.1
Hanford #1 (Hanford @ Rainier)	0.49 E	4.9
CSO 111	0.49 E	3.4
Duwamish P.S. E.	0.49 E	1.0
Brandon St.	1.11 E	14.6
Terminal 115	1.53 W	1.5
Michigan St.	1.96 E	9.0
Michigan W.	2.06 W	0.5
Norfolk St.	4.93 E	0.1
Total		**35.1**

E = east bank; W = west bank; MT = metric tons
CSOs located at 8th Ave. and E. Marginal PS have zero sediment loads, so were not included in this analysis.

The revised storm drain loads for Scenario 2 are compared to the base-case loads in Table 4. Note that discharges from Hamm and Puget Creeks are included with the storm drain discharges. The base-case load at the east bank #11 location (RM 1.24 E) was removed from the Scenario 2 simulation. This sediment load was incorporated into the waterfront area loads discussed below. Storm drain loads were added at two locations for Scenario 2: 1st Ave S (RM 2.10 W) and S 96th St (RM 4.17 W). Thus, storm drain loads were specified at 13 locations for Scenario 2, whereas 12 storm drain locations were used in the base-case simulation. For the 11 storm drain locations with unchanged locations, the load was decreased at six locations and increased at five locations for Scenario 2. Overall, the total storm drain load decreased by 9.5% (111 MT/yr) for the Scenario 2 simulation.

Table 4
Base-Case and Scenario 2 Sediment Loads at 14 Storm Drain Locations

Scenario 2 Name (Base-Case Name)	River Mile Location	Base-Case Sediment Load (MT/yr)	Scenario 2 Sediment Load (MT/yr)	Relative Change in Sediment Load (%)	Description of Change
SW Idaho SD (West bank #5)	0.28 W	72	62	-14	Original Location; Load Decreased
Diagonal Ave SD (Diagonal)	0.49 E	284	316	+11	Original Location; Load Increased
N/A (East bank #11)	1.24 E	29	0	-100	Storm Drain Source Removed
SW Kenny SD (West bank #6)	1.53 W	72	15	-79	Original Location; Load Decreased
SW Highland Park Wy SD (West bank #7)	1.87 W	72	62	-14	Original Location; Load Decreased
1st Ave S (N/A)	2.10 W	0	31	+100	Storm Drain Source Added
Near S Brighton St SD (East Bank #12)	2.17 E	19	44	+132	Original Location; Load Increased
7 Ave S SD (7 Ave S SD)	2.73 W	28	33	+18	Original Location; Load Increased
Slip 4 SDs (Slip 4 SDs)	2.83 E	93	97	+4	Original Location; Load Increased
KC Airport SD #2 (East bank #9)	3.80 E	65	48	-26	Original Location; Load Decreased
KC Airport SD #1 (East bank #10)	4.16 E	65	13	-80	Original Location; Load Decreased
S 96th St SD (N/A)	4.17 W	0	128	+100	Storm Drain Source Added
Hamm Creek (West bank #8)	4.33 W	250	86	-66	Original Location; Load Decreased
Norfolk SD (Norfolk SD)	4.93 E	121	124	+2	Original Location; Load Increased
Total		**1,170**	**1,059**	**-9.5**	**Total SD Load Decreased**

KC = King County; SD = storm drain; E = east bank; W = west bank; N/A = not applicable; MT = metric tons

Runoff sediment loads from waterfront areas adjacent to the LDW were estimated and distributed along the east and west banks of the LDW for the Scenario 2 simulation. The waterfront loads, which had been aggregated into the storm drain loads for the base-case simulation, were separated into 11 waterfront areas, with the total sediment load from the waterfront areas being 163 MT/yr, see Table 5. The 11 waterfront areas represent discharges from about 161 individual outfalls along the LDW. Within a specific waterfront area, the sediment load for that area, as input to the STM, was distributed over a distinct section of the LDW shoreline; see below for more discussion about specification of model inputs.

Table 5
Sediment Loads for 11 Waterfront Areas for Scenario 2

Waterfront Area	River Mile Location	Sediment Load (MT/yr)
WF-1	0.44 – 1.0 E	9
WF-2	0.98 – 1.96 E	14
WF-3	2.0 – 2.8 E	9
WF-4	2.94 – 4.4 E	43
WF-5	4.28 – 5.2 E	20
WF-6	3.1 – 4.28 W	11
WF-7	1.96 – 3.12 W	7
WF-8	1.53 – 1.96 W	12
WF-9	0.84 – 1.53 W	9
WF-10	-0.15 – 0.86 W	11
WF-11	4.28 – 5.98 W	18
Total		**163**

WF = waterfront area; E = east bank; W = west bank; MT = metric tons

Sediment loads from CSOs, storm drains, and waterfront areas were input at 87 individual locations (i.e., grid cells) in the STM for Scenario 2. Table 6 presents a summary of model inputs for lateral loads for Scenario 2. Multiple CSO and storm drain loads are input to a single grid cell at three locations: 1) RM 0.49 east bank (Diagonal Ave SD; Duwamish P.S. E; Hanford #1; CSO 111; total load of 325.3 MT/yr); 2) RM 1.53 west bank (SW Kenny SD; Terminal 115; total load of 16.5 MT/yr); and 3) RM 4.93 east bank (Norfolk SD; Norfolk CSO; total load of 128.1 MT/yr).

Table 6
Specification of Lateral-Load Model Inputs for Scenario 2

Lateral Load	Number of Grid Cells Used for Model Input	River Mile Location	Average Sediment Load Per Grid Cell (MT/yr)	Sediment Load (MT/yr)
WF-1	6	0.44 – 1.0 E	1.5	9.0
WF-2	8	0.98 – 1.96 E	1.5	11.6
WF-3	6	2.0 – 2.8 E	1.5	9.0
WF-4	13	2.94 – 4.4 E	3.1	40.2
WF-5	6	4.28 – 5.2 E	2.7	16.0
WF-6	7	3.1 – 4.28 W	1.3	9.0
WF-7	8	1.96 – 3.12 W	0.6	5.1
WF-8	2	1.53 – 1.96 W	3.0	6.0
WF-9	6	0.84 – 1.53 W	1.5	9.0
WF-10	4	-0.15 – 0.86 W	2.8	11.0
WF-11	4	4.28 – 5.98 W	4.5	18.0
SW Idaho SD	1	0.28 W	62.0	62.0
Duwamish P.S. W.	1	0.44 W	0.1	0.1
- Diagonal Ave SD - Duwamish P.S. E - Hanford #1 - CSO 111	1	0.49 E	325.3	325.3
Brandon St.	1	1.11 E	16.2	16.2
- SW Kenny SD - Terminal 115	1	1.53 W	16.5	16.5
SW Highland Park Wy SD	1	1.87 W	68.0	68.0
Michigan St.	1	1.96 E	9.8	9.8
Michigan W.	1	2.06 W	0.9	0.9
1st Ave S.	1	2.1 W	32.1	32.1
Near S Brighton St SD	1	2.17 E	44.0	44.0
7th Ave S SD	1	2.73 W	33.4	33.4
Slip 4 SDs	1	2.83 E	97.0	97.0
KC Airport SD #2	1	3.8 E	48.9	48.9
S 96th St SD	1	4.17 W	130.0	130.0
KC Airport SD #1	1	4.16 E	14.9	14.9
Hamm Cr.	1	4.33 W	86.0	86.0
- Norfolk SD - Norfolk CSO	1	4.93 E	128.1	128.1
Total	**87**	**---**	**---**	**1257.1**

KC = King County; SD = storm drain; CSO = combined sewer overflow; WF = waterfront area; E = east bank; W = west bank; MT = metric tons

The percentages of surface sediment originating from lateral sources at the end of the 10-year simulations for the base-case and Scenario 2 input distributions are shown in Figures 2-1 through 2-3. Generally, the spatial distributions of lateral-source content are similar, with no large-scale differences between the two simulations. Noticeable changes between the base-case and Scenario 2 input distributions typically occur over relatively small areas that are in the vicinity of storm drains where changes occurred between the two simulations (i.e., change in input location and/or magnitude of sediment load).

A one-to-one comparison of predicted lateral-source percentages for each grid-cell in the LDW at the end of the 10-year simulation is presented in Figure 2-4. This figure indicates that no apparent bias exists between the base-case and Scenario 2 results. The cumulative frequency distribution of the absolute difference (i.e., difference between Scenario 2 and base-case predictions) between lateral-source percentages at the end of the 10-year simulation is shown in Figure 2-5. These results show that the absolute difference in lateral-source content is less than +1% at about 94% of the grid-cells in the LDW.

SCENARIO 3: MOVEMENT OF LDW BED SEDIMENT INTO THE UPPER TURNING BASIN

The Scenario 3 simulation was conducted to analyze the fate of bed-source sediment originating from areas located upstream and downstream of RM 4.0. A specific focus of this simulation was determining the amount of bed-source sediment from the region downstream of RM 4.0 that is resuspended and redeposited in the region upstream of RM 4.0. This type of upstream transport is possible due to the estuarine circulation caused by the saltwater wedge in the LDW. For Scenario 3, a 10-year simulation was conducted, and the fate of bed sediment originating from the following four areas in the LDW was tracked: 1) Upper Turning Basin (Area 1); 2) navigation channel, RM 4.0 to 4.3 (Area 2); 3) bench areas upstream of RM 4.0 (Area 3); and 4) area downstream of RM 4.0 (Area 4).

The predicted spatial distributions of the relative amounts of bed sediment originating from the four areas in surface (0 - 10 cm) sediment at the end of the 10-year simulation are presented in Figures 3-1 through 3-4. Some sediment from Area 1 (Upper Turning Basin), which is primarily composed of sand, was resuspended and redeposited downstream of RM 4.0, but relatively small amounts of sediment from Area 1 were redeposited downstream of approximately RM 1.7 (Figure 3-1). Sediment from Area 2 (navigation channel, RM 4.0 to

4.3) represented 1% or less of surface sediments throughout the LDW at the end of the 10-year period, with sediment resuspended in this area being redeposited primarily between RM 1.6 and RM 4.0 (Figure 3-2). Similarly, sediment from Area 3 (bench areas upstream of RM 4.0) typically represented 1% or less of surface sediments throughout most of the LDW at the end of the 10-year period (Figure 3-3). The results shown on Figure 3-4 indicate that a relatively small amount of sediment from Area 4 (downstream of RM 4.0) was resuspended and redeposited upstream of RM 4.0, with Area 4 sediment representing 0.05% or less of the surface sediments upstream of RM 4.0 at the end of the 10-year period.

The total sediment mass balance for the 10-year period is shown in Figure 3-5. Additional quantification of the transport and fate of bed sediment originating from downstream of RM 4.0 is provided in Figure 3-6. The mass balance on Figure 3-6 shows that 240 MT of bed sediment originating from Area 4 was transported upstream and redeposited in the region upstream of RM 4.0 (i.e., Areas 1, 2, and 3). This amount of sediment deposition (240 MT) is compared to the total net deposition of 699,500 MT in the region upstream of RM 4.0 (see Figure 3-5). These results demonstrate that only about 0.03% of the net deposition in the region upstream of RM 4.0 (i.e., Areas 1, 2, and 3) consists of bed sediment originating from the region downstream of RM 4.0 (i.e., Area 4).

For the Scenario 3 simulation, total PCB concentrations for the 10-year period were predicted using the BCM equation. For the area being modeled, the bed sediment concentration was set equal to the FS baseline interpolated value. For bed sediment from other areas, the bed concentration was set equal to the SWAC of the grid cells located within the area from which the bed sediment originated. Using the FS baseline dataset, these SWACs, and the predicted SWACs for the 10-year period are listed in Table 7. The upstream and lateral chemical input parameters were set to the recommended mid range values used in the base case, which are 35 and 300 µg/kg dw, respectively. The predicted total PCB concentrations for the 10-year period are displayed in Figure 3-7.

Table 7
Predicted SWACs for Year 10 in Different Areas of the LDW

	Upper Turning Basin	Navigation Channel RM 4.0 to 4.3	Bench Areas Upstream of RM 4.0	Downstream of RM 4.0
Year 0 SWAC	77	48	54	470
Year 10 SWAC	40	44	42	N/A

Based on this analysis and the contribution from lateral loads, the sediment in the Upper Turning Basin and the navigation channel above RM 4.0 should not be adversely affected by surrounding sediment within the study area.

SCENARIO 4: MOVEMENT OF BED SEDIMENTS BETWEEN REACHES

The Scenario 4 simulation is similar to Scenario 3, with the difference being that Scenario 4 tracked the fate of bed sediment originating from three reaches in the LDW: 1) Reach 1 (RM 0.0 to 2.2); 2) Reach 2 (RM 2.2 to 4.0); and 3) Reach 3 (RM 4.0 to 4.75). These three reaches, as shown in Figure 4-1, were defined in the final STM (QEA 2008) based on differences in the hydrodynamic and sediment transport characteristics of each reach. The predicted spatial distributions of the relative amounts of bed sediment originating from the three reaches in surface (0 – 10 cm) sediment at the end of the 10-year simulation are presented in Figures 4-2 through 4-4. BCM simulations were not performed on the results of the Scenario 4 simulation.

The mass balances for bed sediment originating from each of the three reaches are of particular interest for Scenario 4; see Figures 4-5 through 4-7. The mass balance for bed sediment from Reach 1 shows that 20 MT was transported upstream and redeposited in Reach 2, with this mass of sediment corresponding to 6% of the net erosion from Reach 1 (Figure 4-5). A negligible amount of the sediment originating from Reach 1 was redeposited in Reach 3 (i.e., less than 3 MT, which corresponds to less than 0.001% of total net deposition in Reach 3). About 2% (240 MT) of the bed sediment resuspended within Reach 2 was transported upstream and redeposited in Reach 3 (Figure 4-6). Of the remaining 98% of sediment originating from Reach 2, 41% was redeposited in Reach 1 and 57% was transported downstream past RM 0.0. Nearly all of the bed sediment (greater than 99%) resuspended within Reach 3 was redeposited in the LDW (Figure 4-7).

SCENARIO 5: SEDIMENT SCOURED FROM GREATER THAN 10-CM DEPTH

An analysis of the effects of high-flow events on bed stability in the LDW was presented in the final STM (QEA 2008). Additional analysis of the 100-year high-flow event was conducted to determine the fate of bed sediment originating from two bed layers: 1) the 0- to 10-cm layer; and 2) the layer deeper than 10 cm. Areas in the LDW with predicted bed scour depths of 0 to 10 cm and deeper than 10 cm during the 100-year high-flow event are shown in Figure 5-1. Net erosion occurs over approximately 18% (70 acres) of the LDW sediment bed, on an area basis, during a 100-year high-flow event. Bed-scour depths of 0 to 10 cm and deeper than 10 cm occur over about 12% and 6% (i.e., 48 acres and 22 acres) of the LDW bed area, respectively. BCM simulations were not performed on the results of the Scenario 5 simulation.

The total sediment mass balance for the 100-year high-flow event simulation is shown in Figure 5-2. This mass balance figure is also presented in the final STM (QEA 2008) as Figure E-15. Mass balances for bed sediment originating from the 0-to-10-cm and deeper-than-10-cm layers are presented in Figures 5-3 and 5-4, respectively. Of the total suspended sediment load transported downstream past RM 0.0 during the 100-year high-flow event (i.e., 211,600 MT, as shown in Figure 5-2), only about 4% and 2% of the total load was composed of bed sediment originating from the 0-to-10-cm and deeper-than-10-cm layers (i.e., 7,800 MT and 3,500 MT, as shown in Figures 5-3 and 5-4), respectively. The total mass of sediment eroded from the bed during the 100-year high-flow event was predicted to be about 52,200 MT, with approximately 80% and 20% of the total eroded mass originating from the 0-to-10-cm (42,100 MT) and deeper-than-10-cm layers (10,100 MT), respectively. About 78% of the sediment resuspended from the original bed (i.e., 40,900 MT) was predicted to be redeposited in the LDW during the 100-year high-flow event.

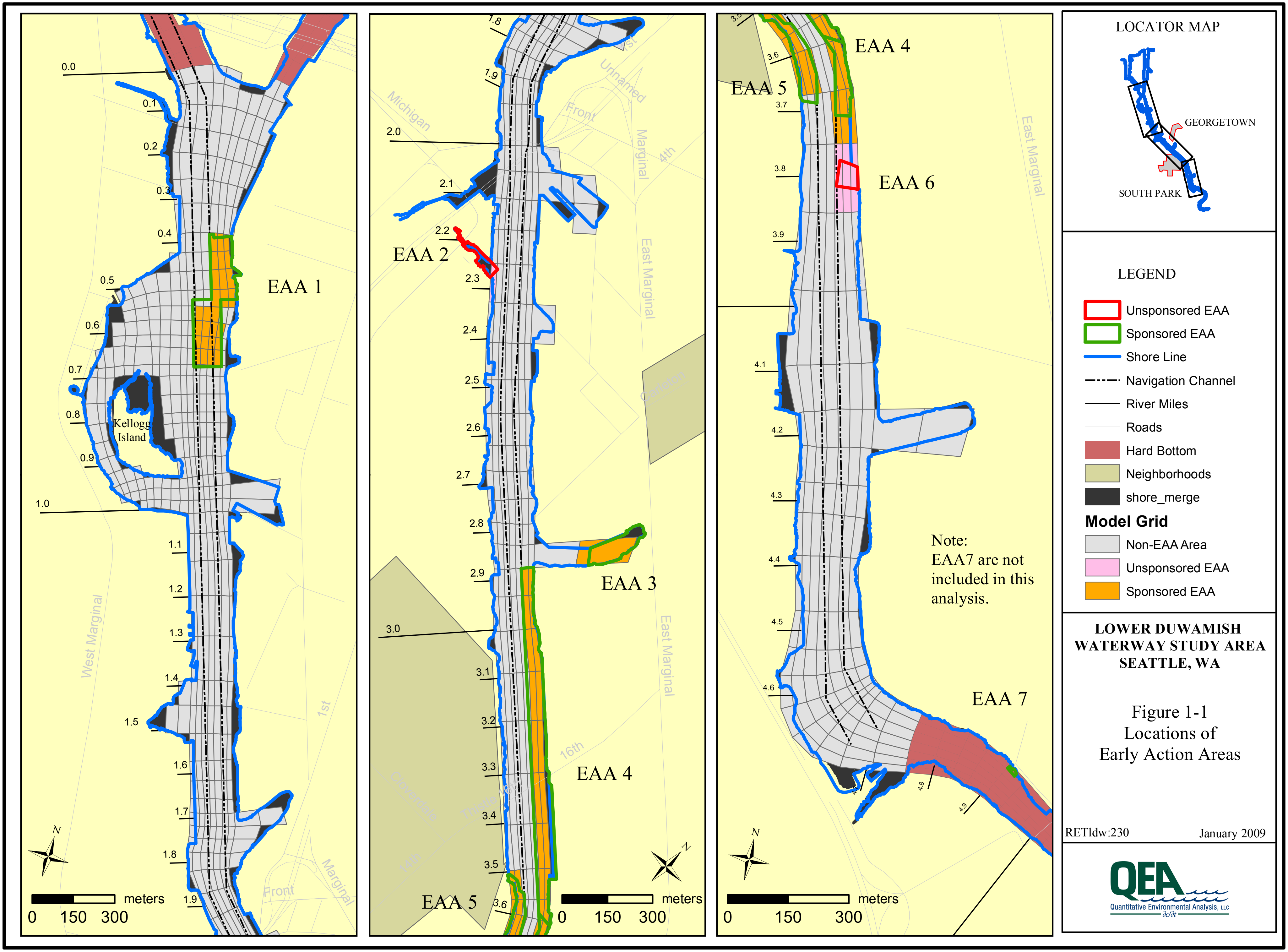
Many areas where scour in excess of 10 cm is predicted to occur have subsurface sediments that are below the Washington State sediment quality standards (SQS) or cleanup screening level (CSL). Figure 5-5 shows the areas where scour in excess of 10 cm is predicted to occur and 0- to 2-ft core data that exceeds the SQS or CSL. The 0- to 2-ft core data are shown because the maximum predicted depth of scour even using upper-bound erosion rate parameters is less than 2 feet.

The mass balance analysis shows that only a relatively small mass of the sediment load transported during a 100-year high-flow event is scoured from below 10 cm. Figure 5-5 indicates that of this small mass of sediment scoured from areas below 10 cm, only a few of these areas are above the SQS or CSL.

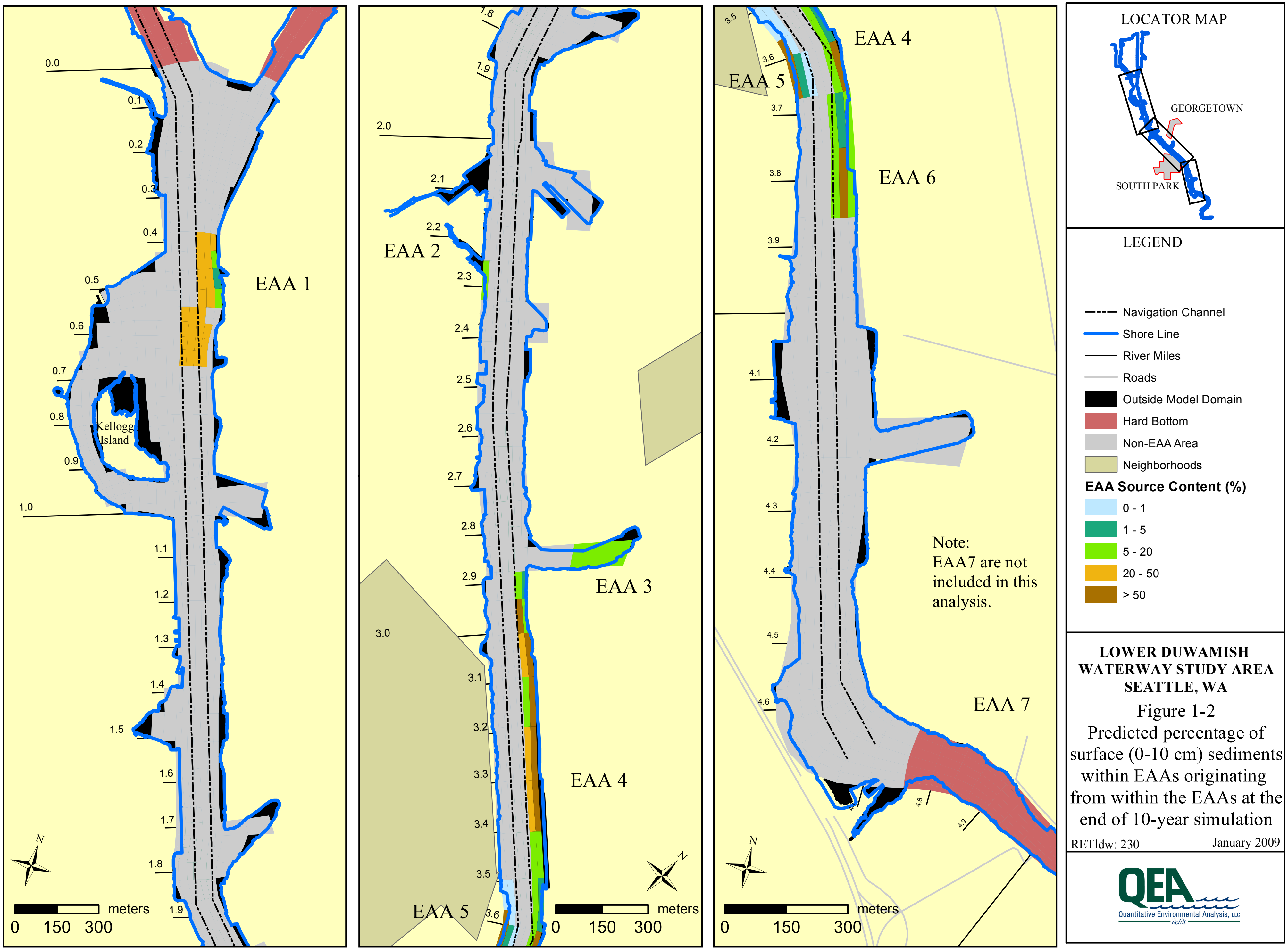
ATTACHMENTS

REFERENCE

Quantitative Environmental Analysis, LLC. 2008. *Lower Duwamish Waterway Sediment Transport Modeling Report. Final.* Prepared for the Lower Duwamish Waterway Group for submittal to the U.S. Environmental Protection Agency, Region 10, and Washington State Department of Ecology. Quantitative Environmental Analysis, LLC, Montvale, NJ. October 2008.



fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_1-1_20121107.mxd inmanm 11/14/2012 1:58:40 PM



LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 1-2
Predicted percentage of surface (0-10 cm) sediments within EAAs originating from within the EAAs at the end of 10-year simulation

RETldw: 230 January 2009

QEA Quantitative Environmental Analysis, LLC

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_1-2_20121107.mxd inmanm 11/14/2012 2:04:53 PM

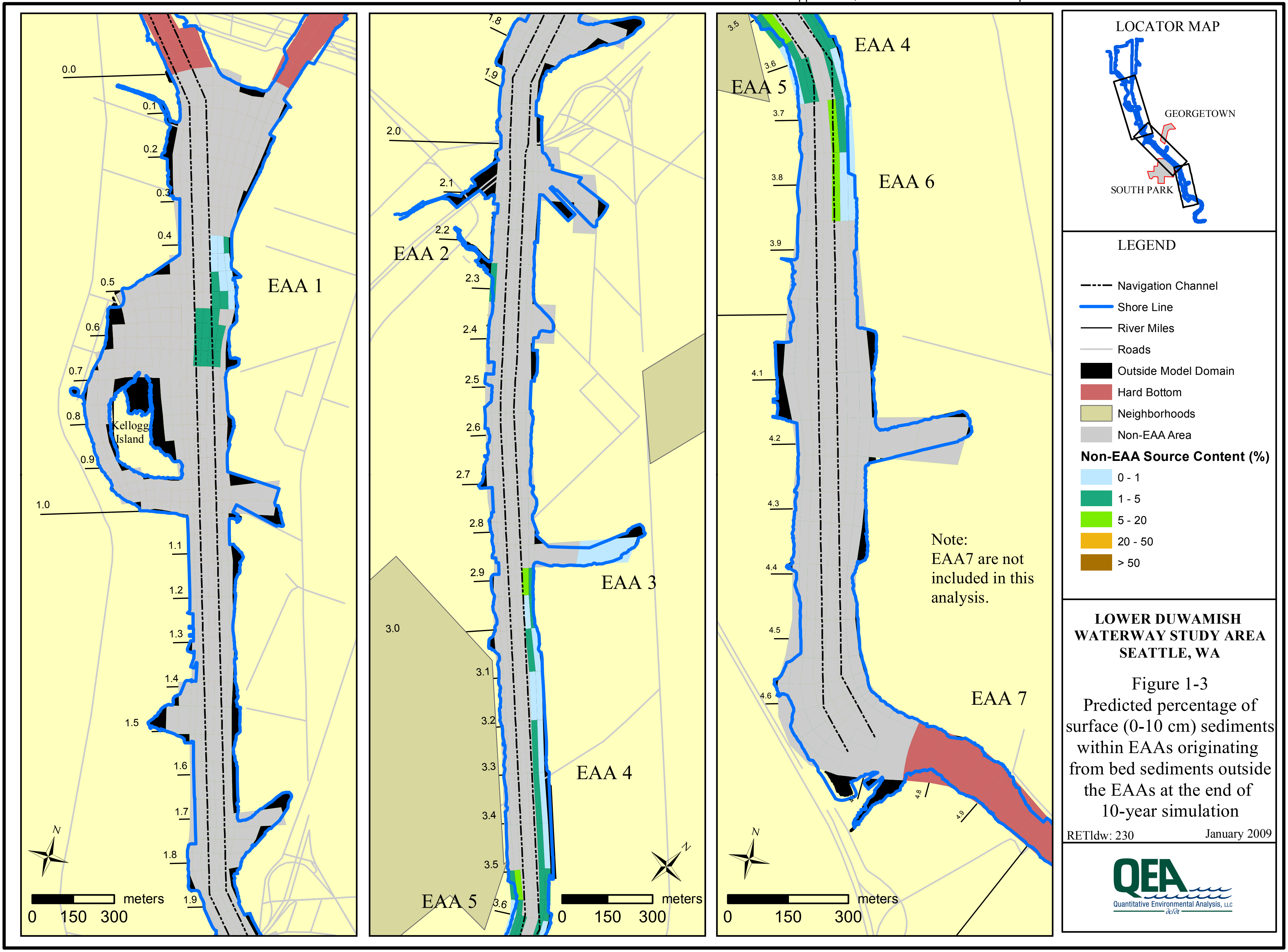
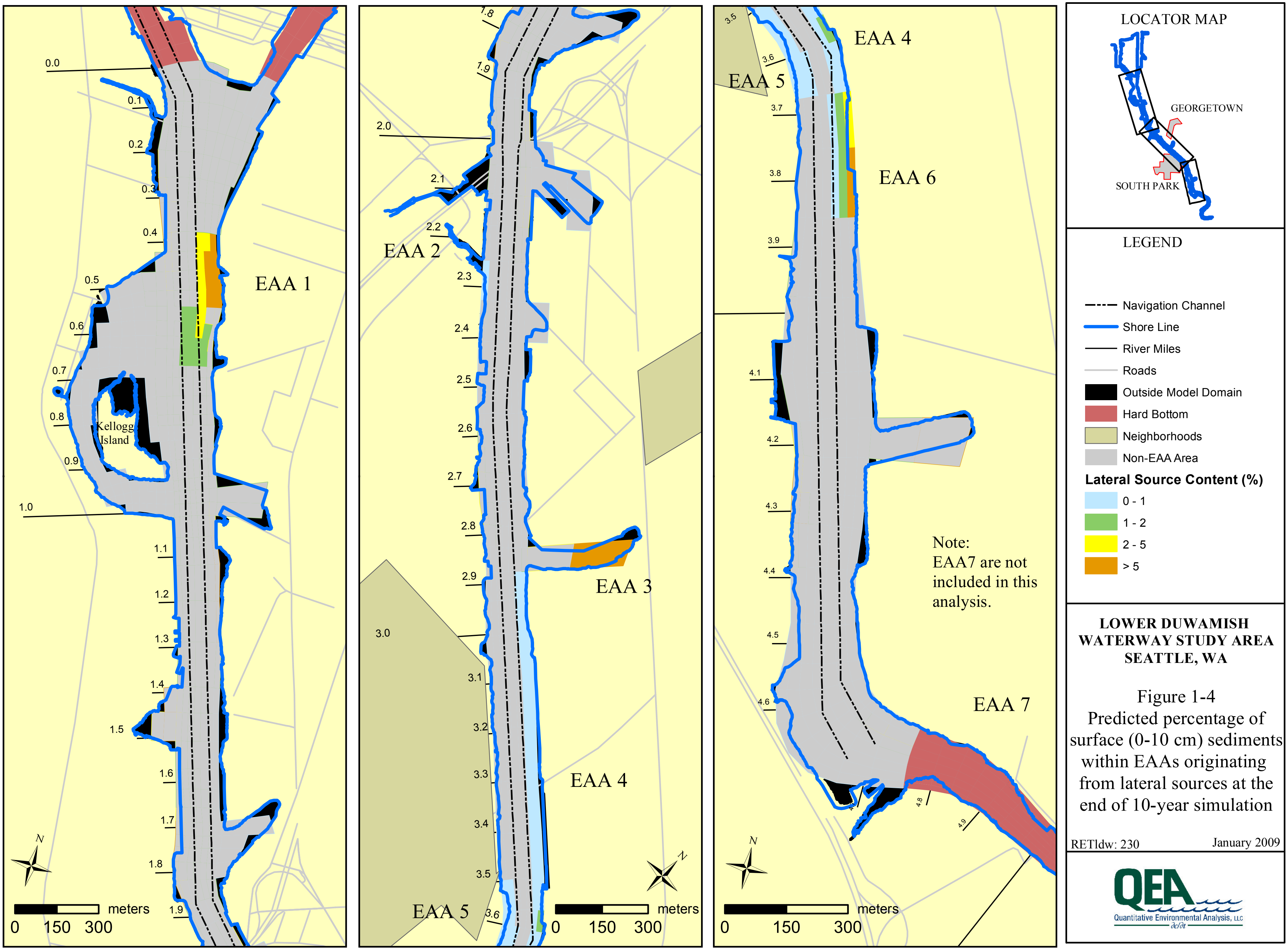


Figure 1-3
Predicted percentage of surface (0-10 cm) sediments within EAAs originating from bed sediments outside the EAAs at the end of 10-year simulation

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_1-3_20121107.mxd inmanm 11/14/2012 2:06:26 PM



LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 1-4
Predicted percentage of surface (0-10 cm) sediments within EAAs originating from lateral sources at the end of 10-year simulation

RETldw: 230 January 2009

QEA Quantitative Environmental Analysis, LLC

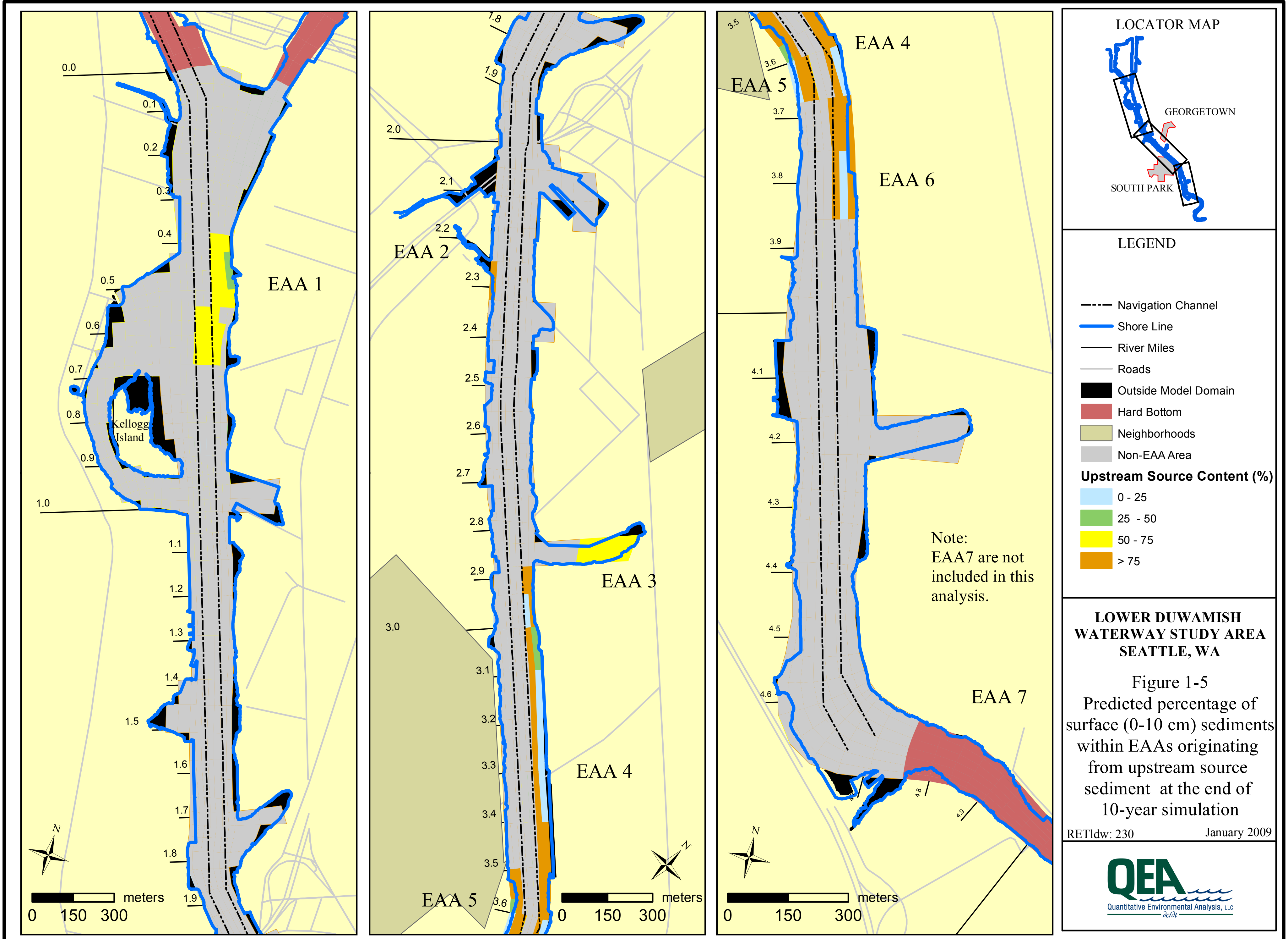
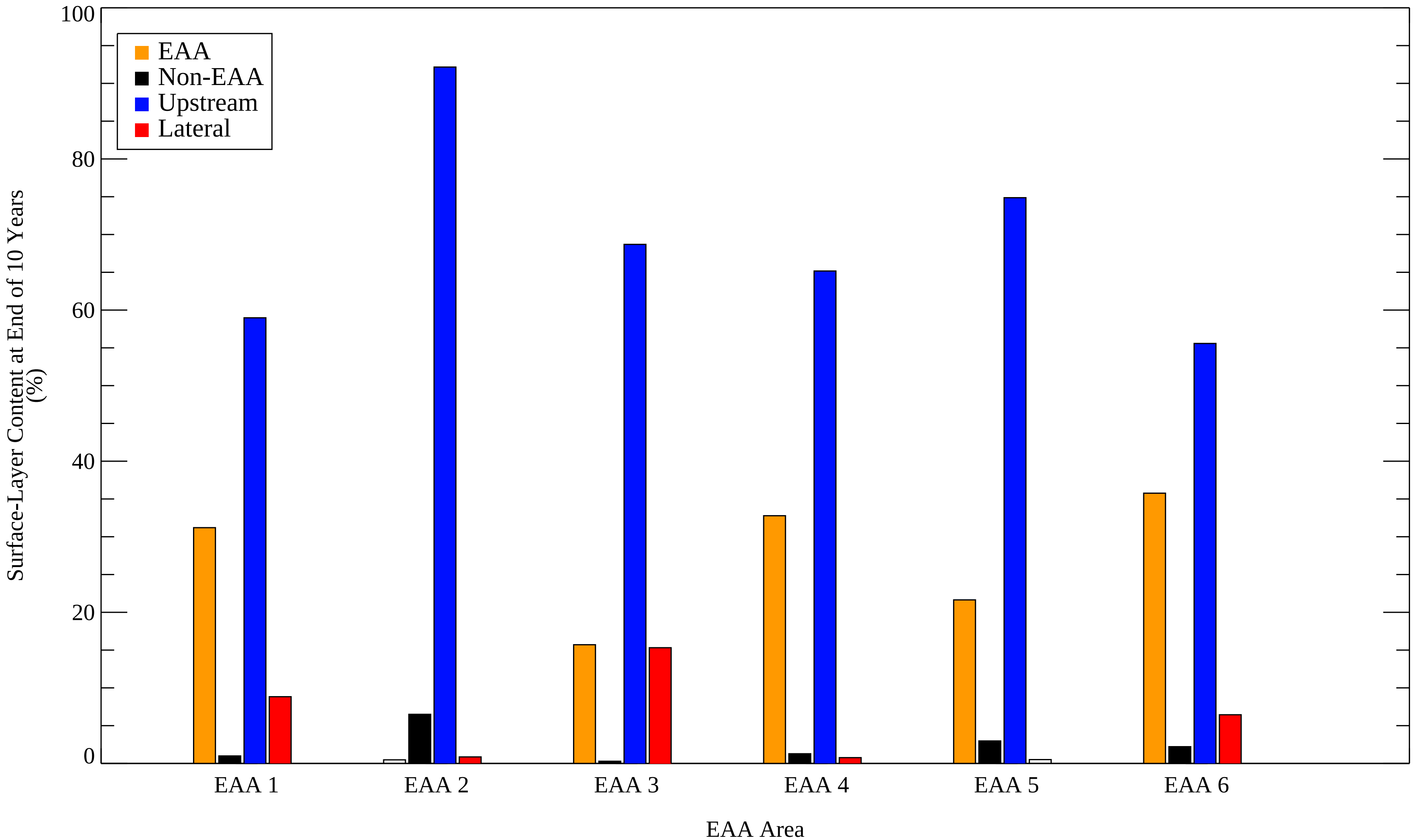
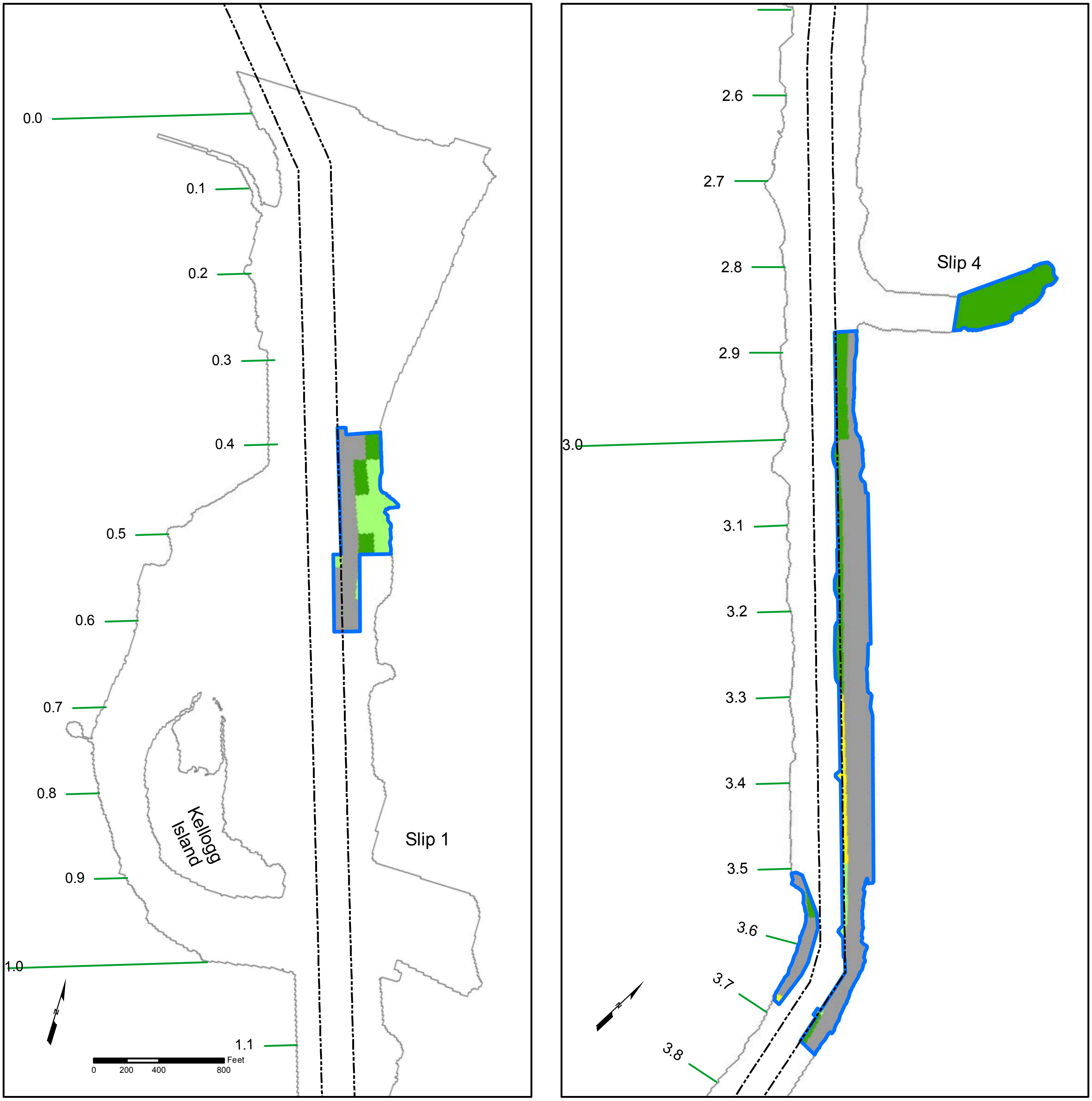


Figure 1-5
Predicted percentage of surface (0-10 cm) sediments within EAAs originating from upstream source sediment at the end of 10-year simulation

Figure 1-6. Comparison of surface-layer composition within different EAAs at end of 10-year simulation.



EAA 7 was not included in this analysis.



Notes:
1. Remediation was simulated in EAAs by changing the original baseline surface sediment concentration to the recommended post-remedy bed sediment replacement value (RV): 60 µg/kg dw.
2. 10 year model simulation for total PCBs were calculated using the recommended upstream input (35 µg/kg dw), the recommended lateral input (300 µg/kg dw), the RV for the bed sourced from the EAAs, and the reach-wide SWAC from sediment outside of the EAAs for the bed sourced from outside the EAAs. Those SWACs are as follows: Reach 1=271 µg/kg dw, Reach 2=435 µg/kg dw, and Reach 3=n/a (there are no EAAs in the STM footprint in Reach 3).

Legend

River Mile Marker
Navigation Channel
Early Action Area

Interpolated 10 Year Total PCB Concentration (µg/kg dw) in EAAs

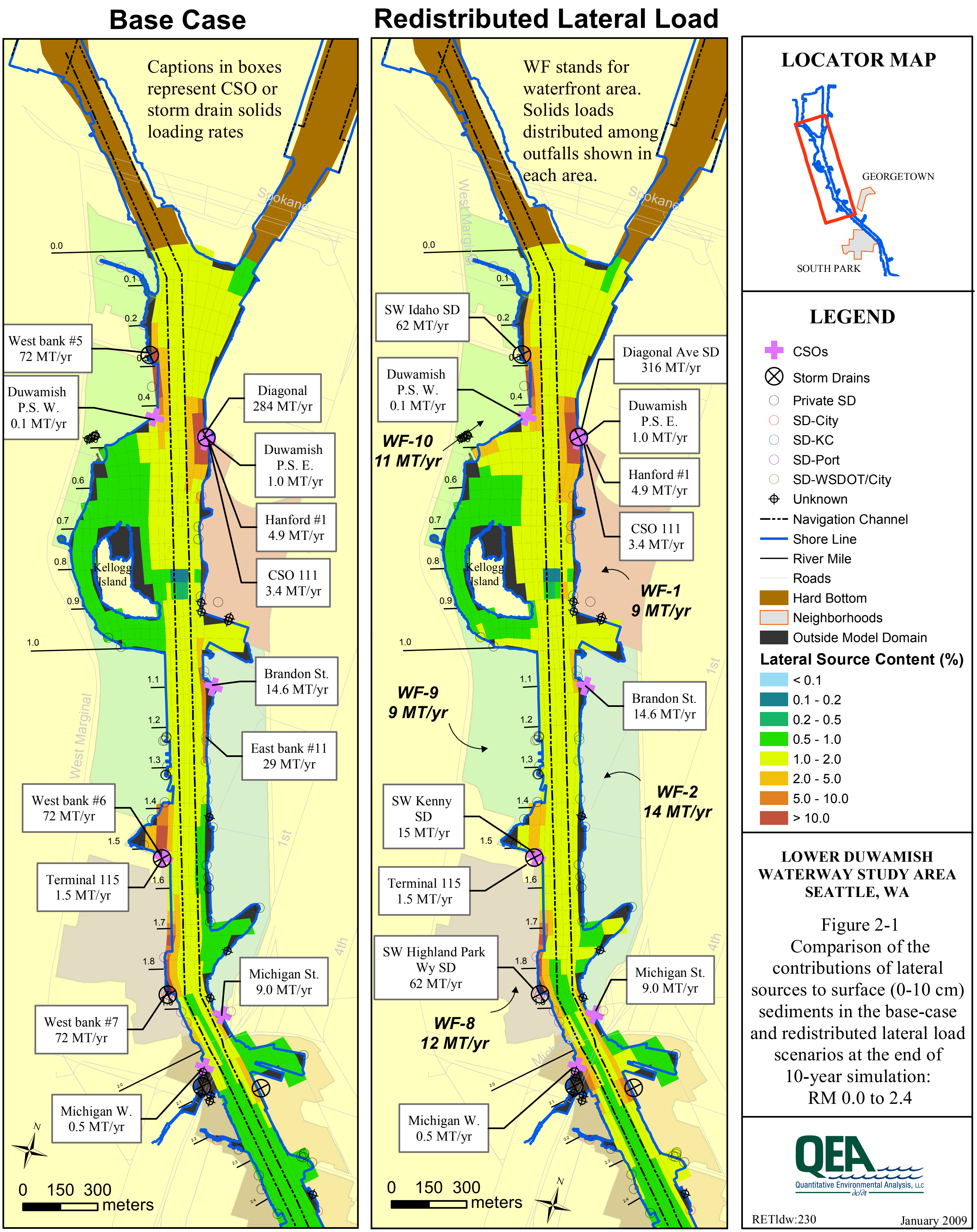
≤ 60
60 - 100
100 - 240
240 - 480 (>SQS)
480 - 720
720 - 1,300
> 1,300 (>CSL)

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-4_1_7_Special Scenario 1.mxd

AECOM

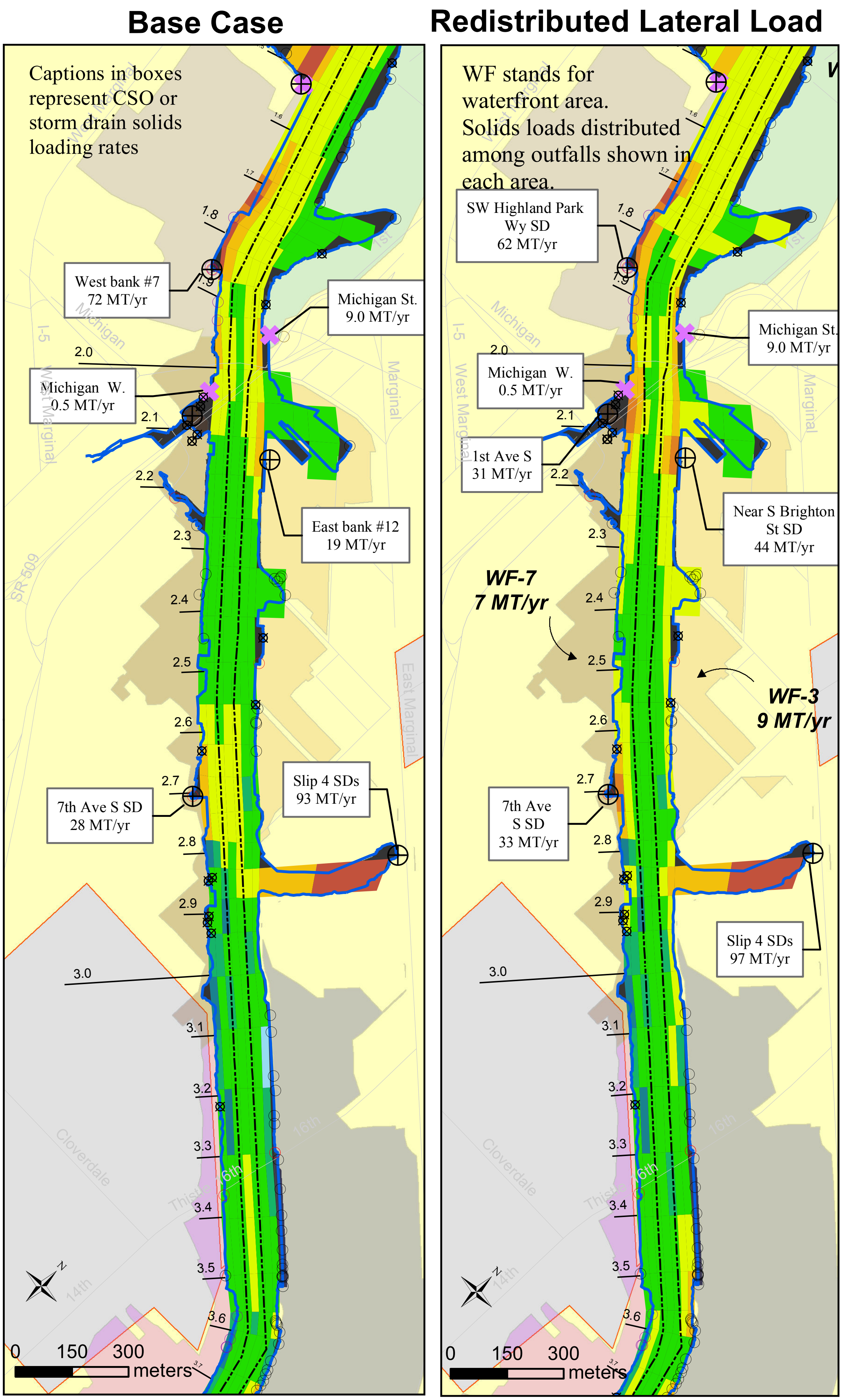
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

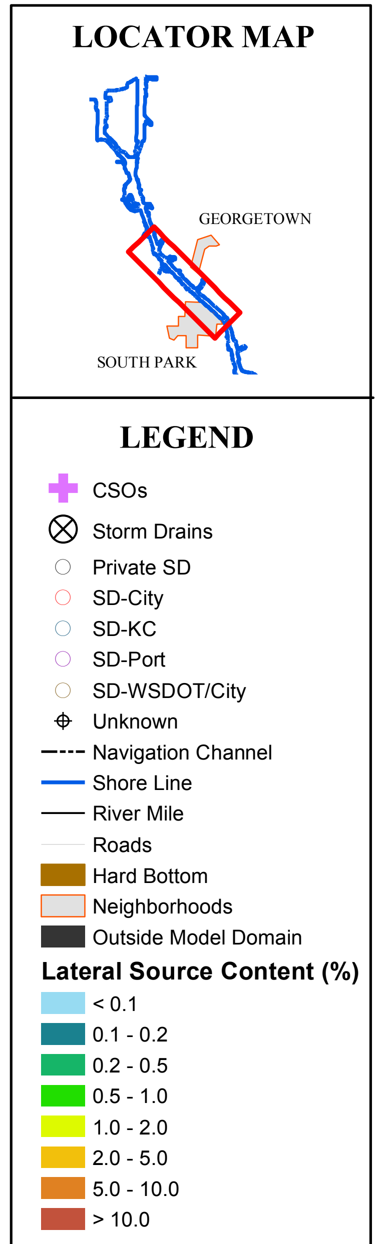
Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			**Recontamination of EAAs: 10 Year Total PCB Surface Sediment Concentrations**
DATE: 10/31/12	DWRN:mvi/SEA	Revision: 0	**FIGURE 1-7**



LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 2-1 Comparison of the contributions of lateral sources to surface (0-10 cm) sediments in the base-case and redistributed lateral load scenarios at the end of 10-year simulation: RM 0.0 to 2.4



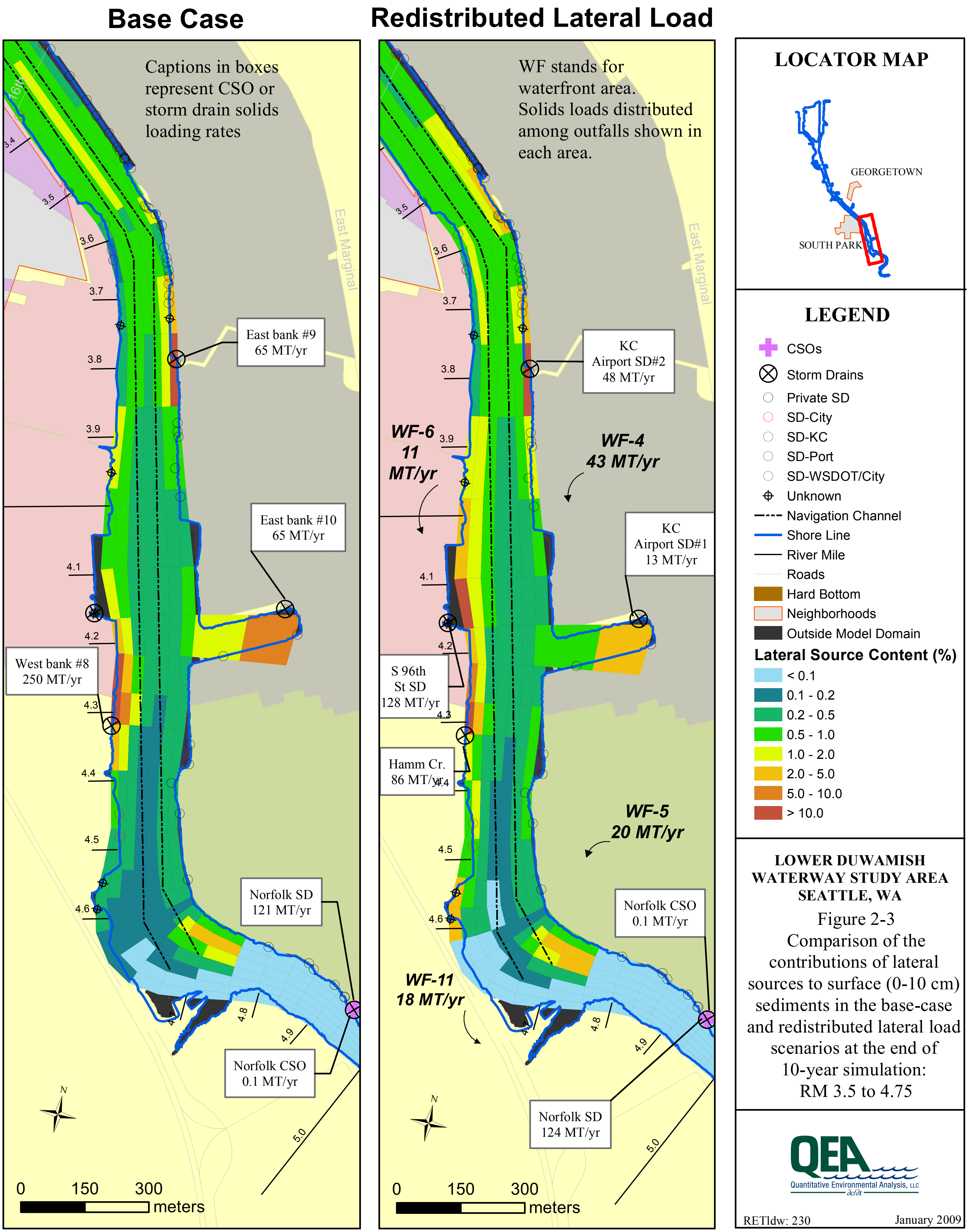


LOWER DUMAMISH WATERWAY STUDY AREA
SEATTLE, WA

Figure 2-2
Comparison of the contributions of lateral sources to surface (0-10 cm) sediments in the base-case and redistributed lateral load scenarios at the end of 10-year simulation: RM 1.6 to 3.6

QEA Quantitative Environmental Analysis, LLC

RETldw: 230 January 2009



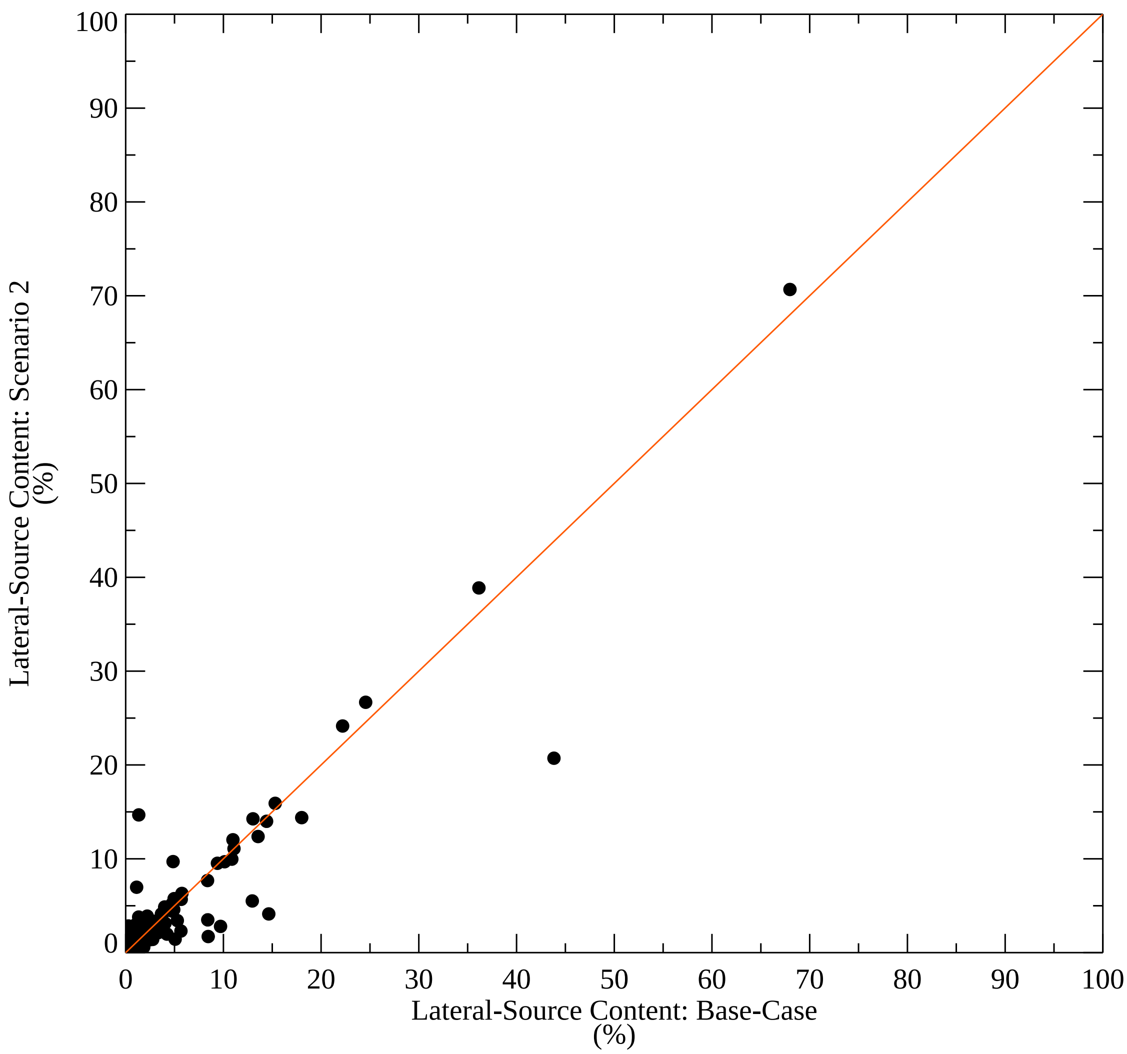
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 2-3
Comparison of the contributions of lateral sources to surface (0-10 cm) sediments in the base-case and redistributed lateral load scenarios at the end of 10-year simulation: RM 3.5 to 4.75

RETIdw: 230

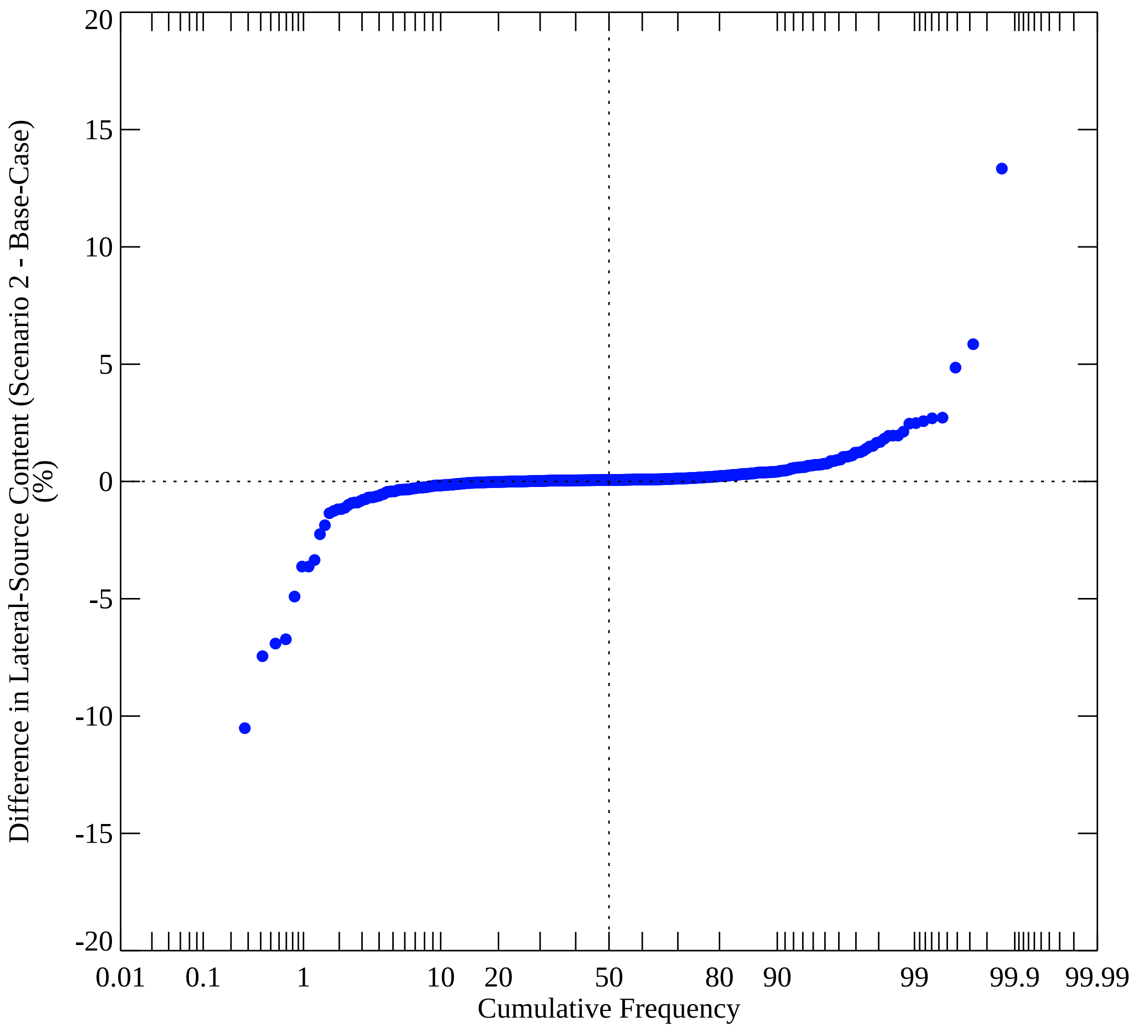
January 2009

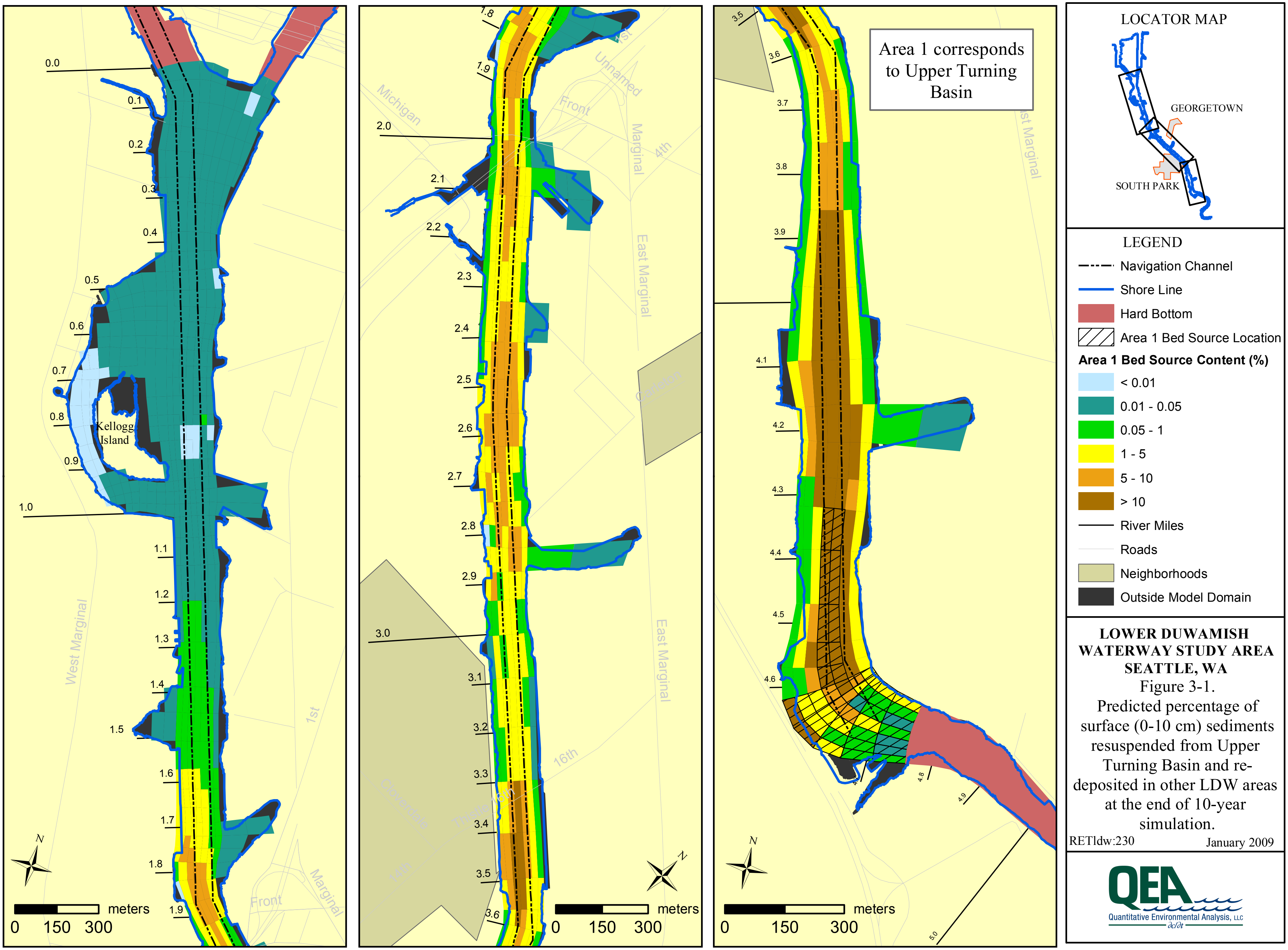
Figure 2-4 Cell-by-cell comparison of base-case and redistributed lateral load contributions to surface (0-10 cm) sediments at the end of 10-year simulation.



Total number of cells compared is 720.

Figure 2-5 Cumulative frequency distribution of absolute difference between base-case and redistributed lateral load contributions to surface (0-10 cm) sediments at the end of 10-year simulation.





LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

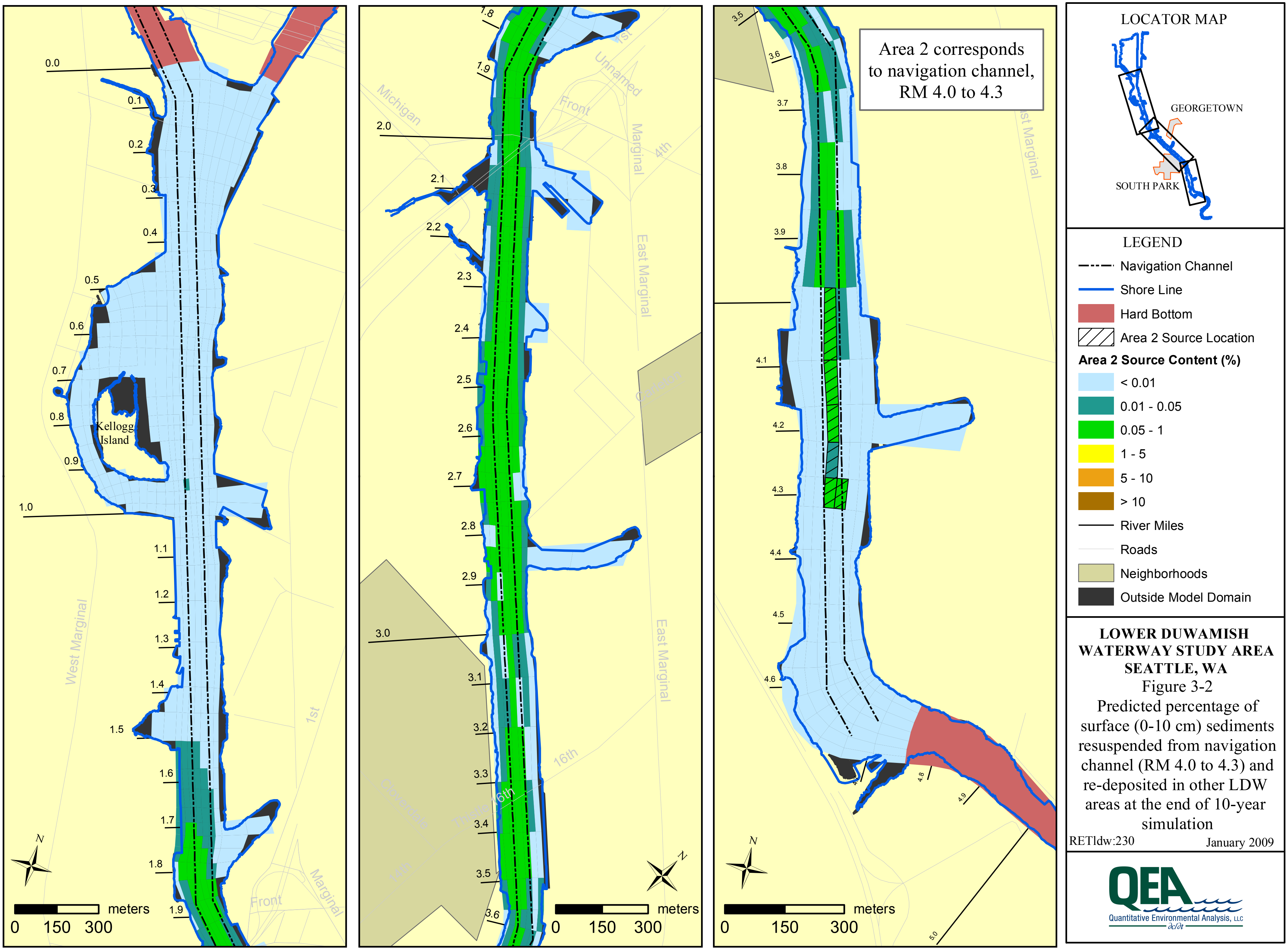
Figure 3-1.
Predicted percentage of surface (0-10 cm) sediments resuspended from Upper Turning Basin and re-deposited in other LDW areas at the end of 10-year simulation.

RETldw:230

January 2009

QEA Quantitative Environmental Analysis, LLC

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_3-1_20121107.mxd inmanm 11/14/2012 2:14:55 PM



LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

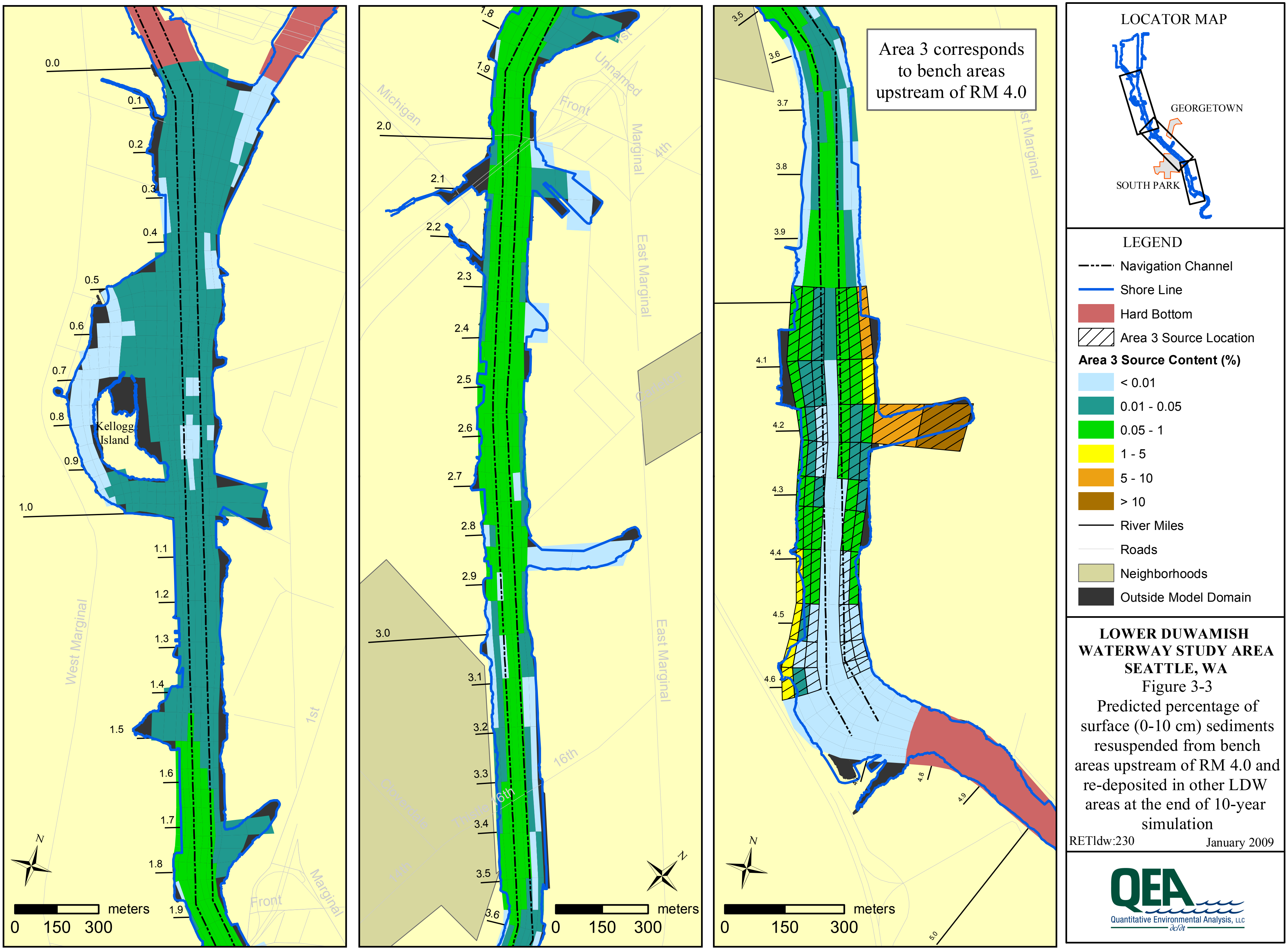
Figure 3-2

Predicted percentage of surface (0-10 cm) sediments resuspended from navigation channel (RM 4.0 to 4.3) and re-deposited in other LDW areas at the end of 10-year simulation

RETldw:230 January 2009

QEA Quantitative Environmental Analysis, LLC

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_3-2_20121107.mxd inmanm 11/14/2012 2:15:36 PM



LEGEND

- Navigation Channel
- Shore Line
- Hard Bottom
- Area 3 Source Location

Area 3 Source Content (%)

- < 0.01
- 0.01 - 0.05
- 0.05 - 1
- 1 - 5
- 5 - 10
- > 10
- River Miles
- Roads
- Neighborhoods
- Outside Model Domain

LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

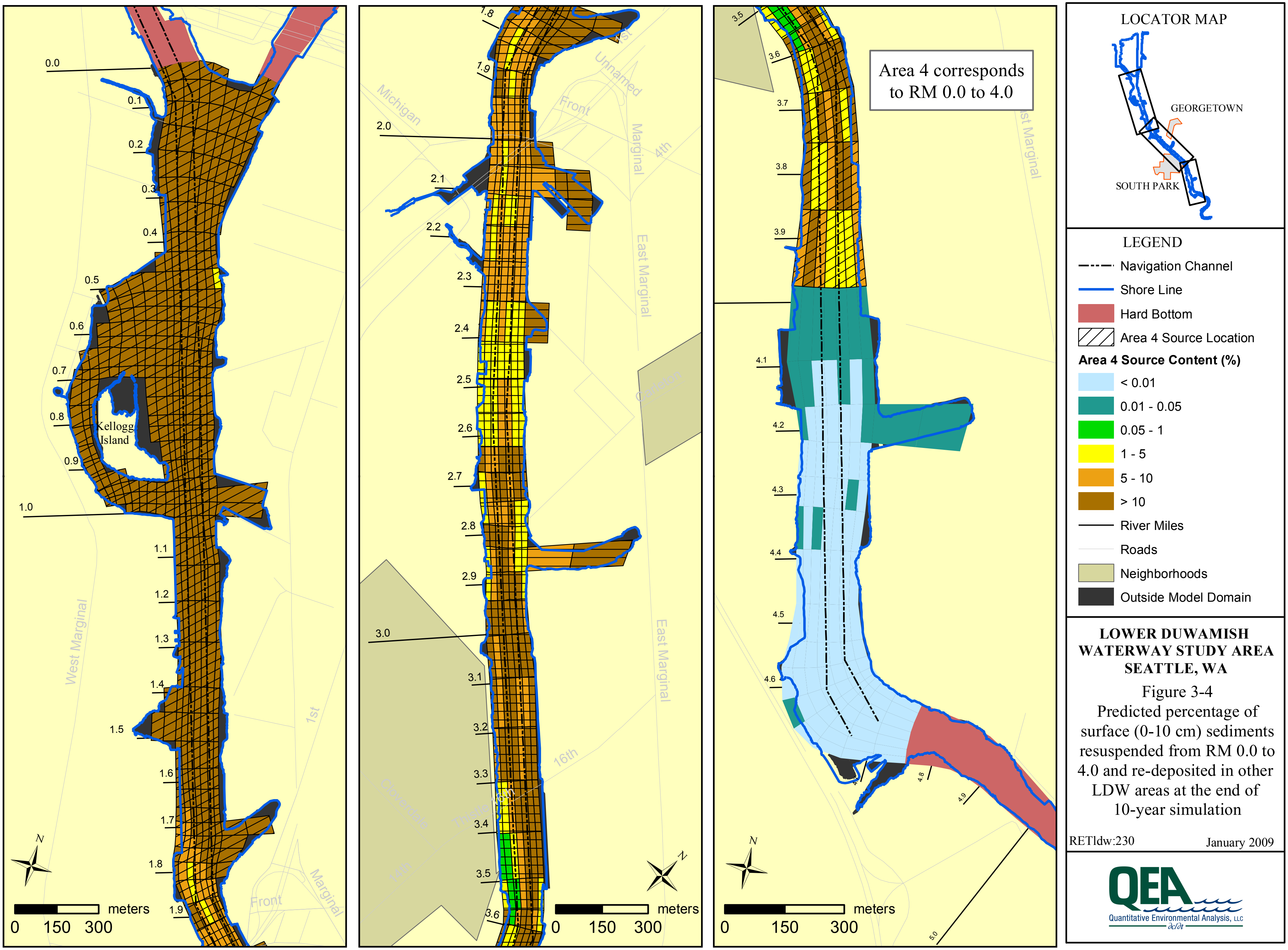
Figure 3-3

Predicted percentage of surface (0-10 cm) sediments resuspended from bench areas upstream of RM 4.0 and re-deposited in other LDW areas at the end of 10-year simulation

RETldw:230 January 2009

QEA Quantitative Environmental Analysis, LLC

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_3-3_20121107.mxd inmanm 11/14/2012 2:16:36 PM



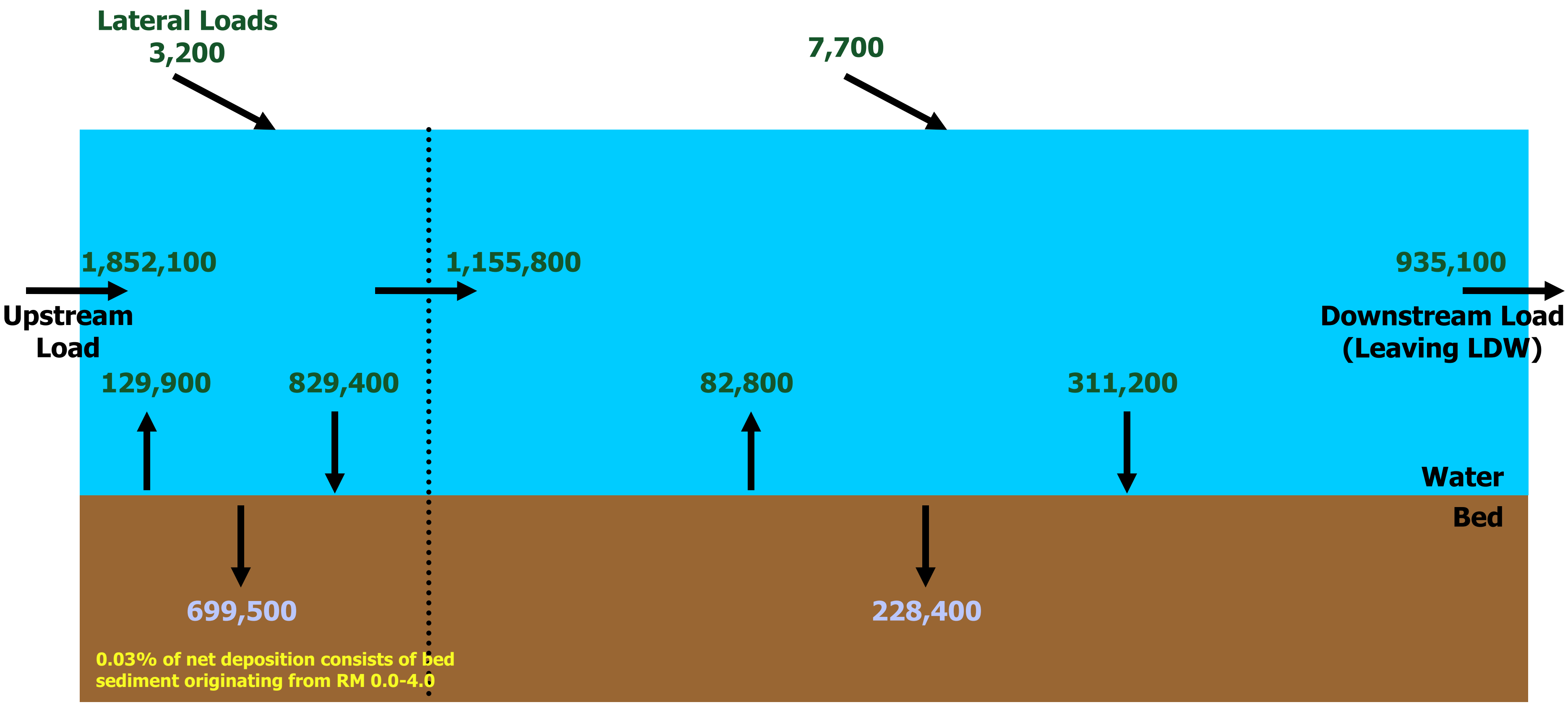
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 3-4
Predicted percentage of surface (0-10 cm) sediments resuspended from RM 0.0 to 4.0 and re-deposited in other LDW areas at the end of 10-year simulation

RETldw:230 January 2009

QEA Quantitative Environmental Analysis, LLC

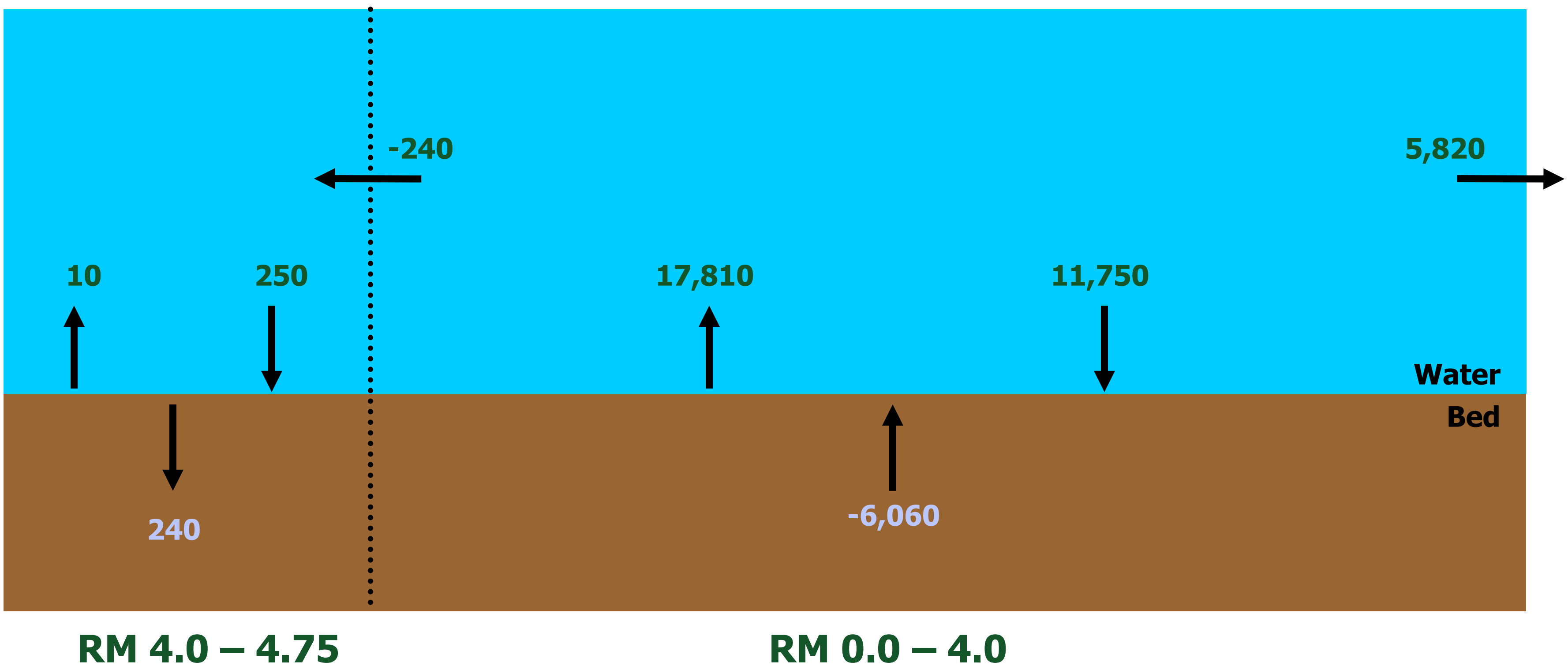
Figure 3-5 Total sediment mass balance for Scenario 3 simulation for 10-year period



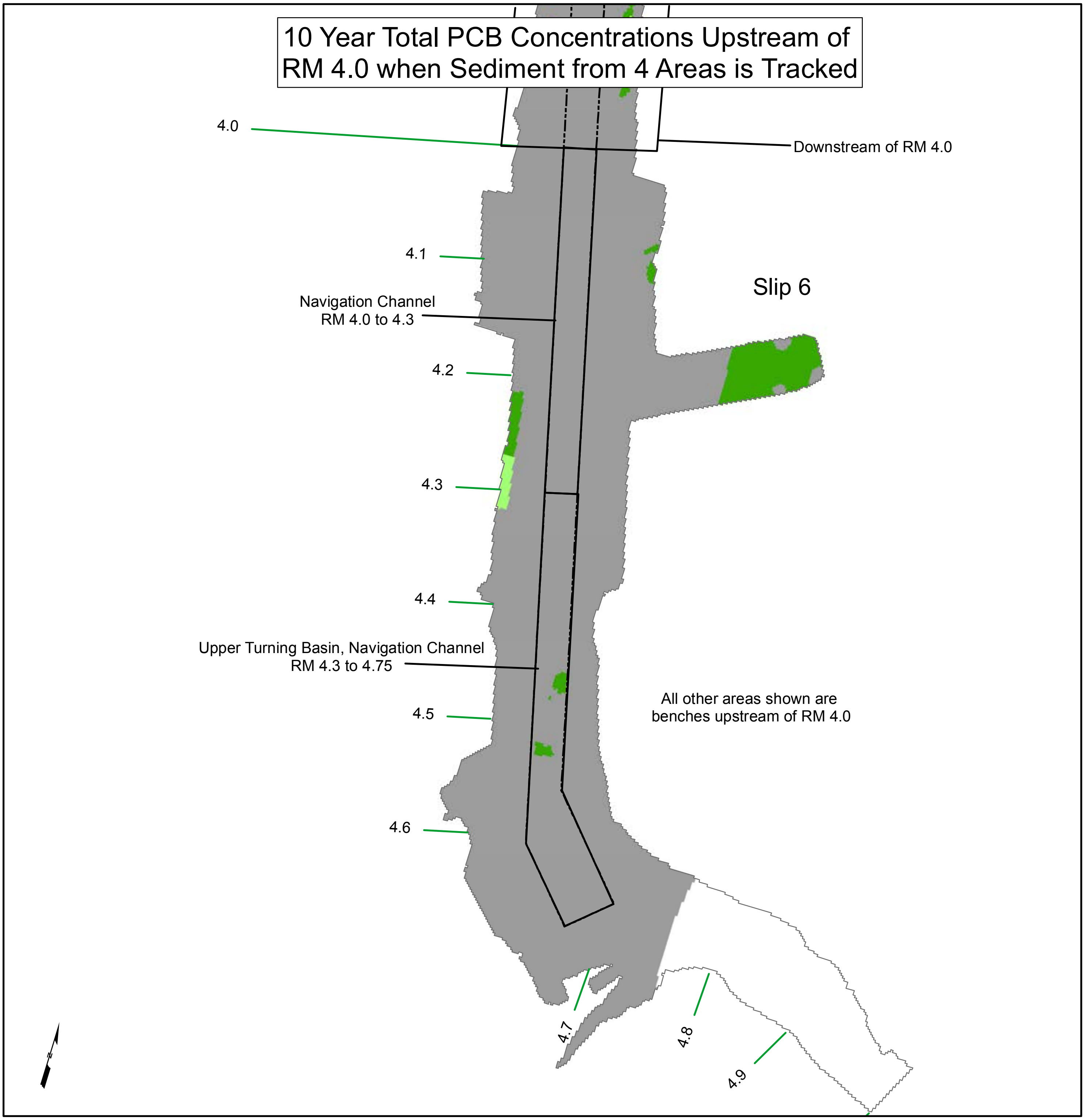
RM 4.0 – 4.75 **RM 0.0 – 4.0**

Notes:
Sediment mass units are in metric tons.
Mass balance results are rounded to the nearest 100 metric tons.

Figure 3-6 Mass balance for bed sediment originating from RM 0.0 to 4.0 for 10-year period



Notes:
Sediment mass units are in metric tons.
Mass balance results are rounded to the nearest 10 metric tons.



Notes:
1. Special Scenario 3 tracks movement of surface sediment from 4 areas into the Upper Turning Basin, downstream of RM 4.0, benches upstream of RM 4.0, navigation channel from RM 4.0 to 4.3, and navigation channel from 4.3 to 4.75 (Upper Turning Basin).
2. The recommended BCM input parameters were used: upstream = 300 µg/kg dw, lateral = 35 µg/kg dw.
3. Bed sediment input parameters for sediment originating from outside of the area being modeled were set to the FS baseline SWAC for those external areas. For example, in the Upper Turning Basin sediment migrating from the following areas was assigned the following input parameters: navigation channel RM 4.0 to 4.3 = 48 µg/kg dw; Upper Turning Basin = baseline value of interpolated cell; benches upstream of RM 4.0 = 54 µg/kg dw; and downstream of RM 4.0 = 474 µg/kg dw.

Legend

Interpolated Total PCB Concentration (µg/kg dw)

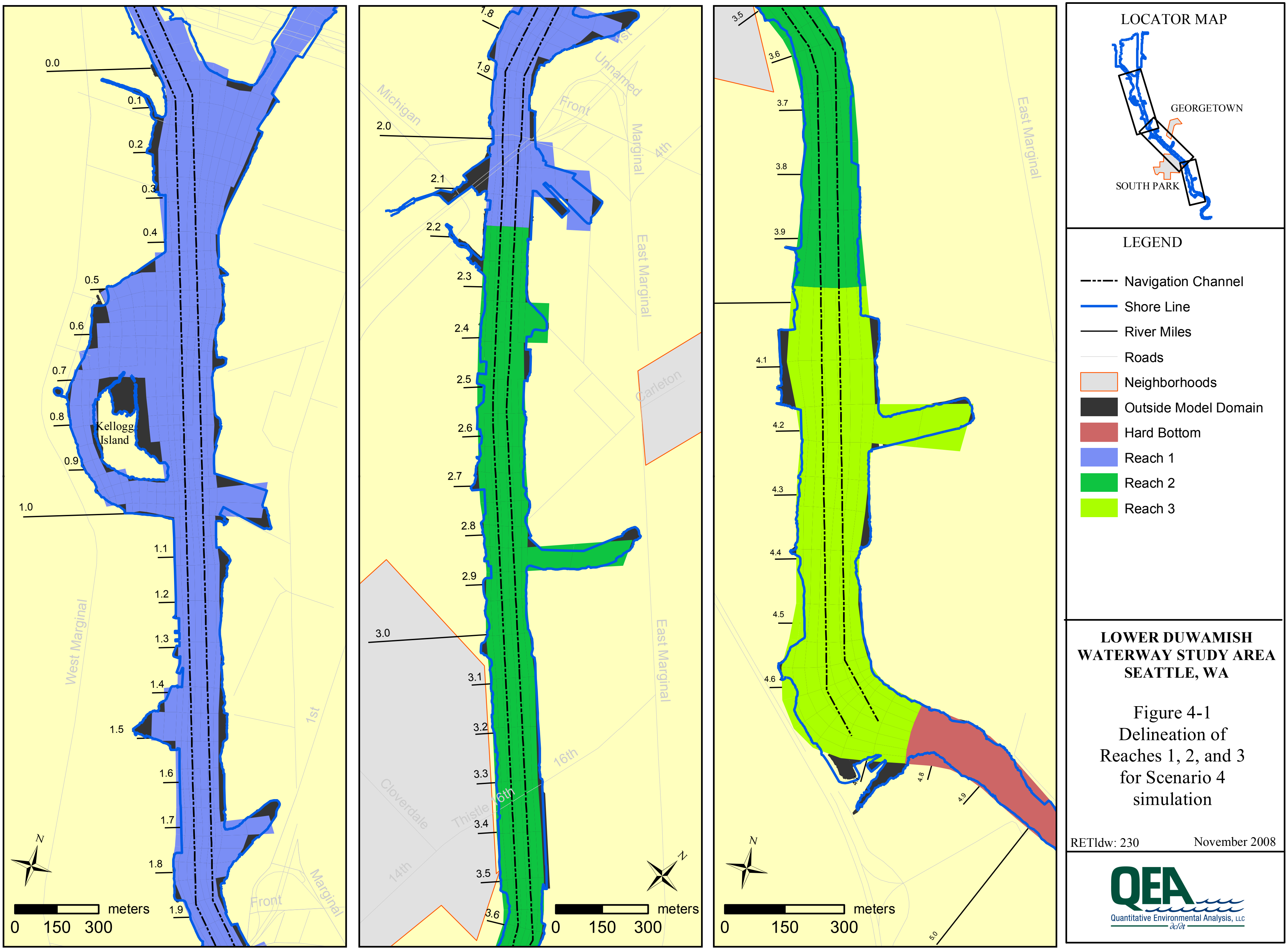
- ≤ 60
- > 60 - 100
- > 100 - 240
- Area From Which Bed Sediment is Tracked
- River Mile Marker
- Navigation Channel

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			**Special Scenario 3: 10 Year Total PCB Surface Sediment Concentrations**
DATE: 10/31/12	DWRN:mvi/SEA	Revision: 0	**FIGURE 3-7**

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC4_3,7_Special Scenario 3.mxd

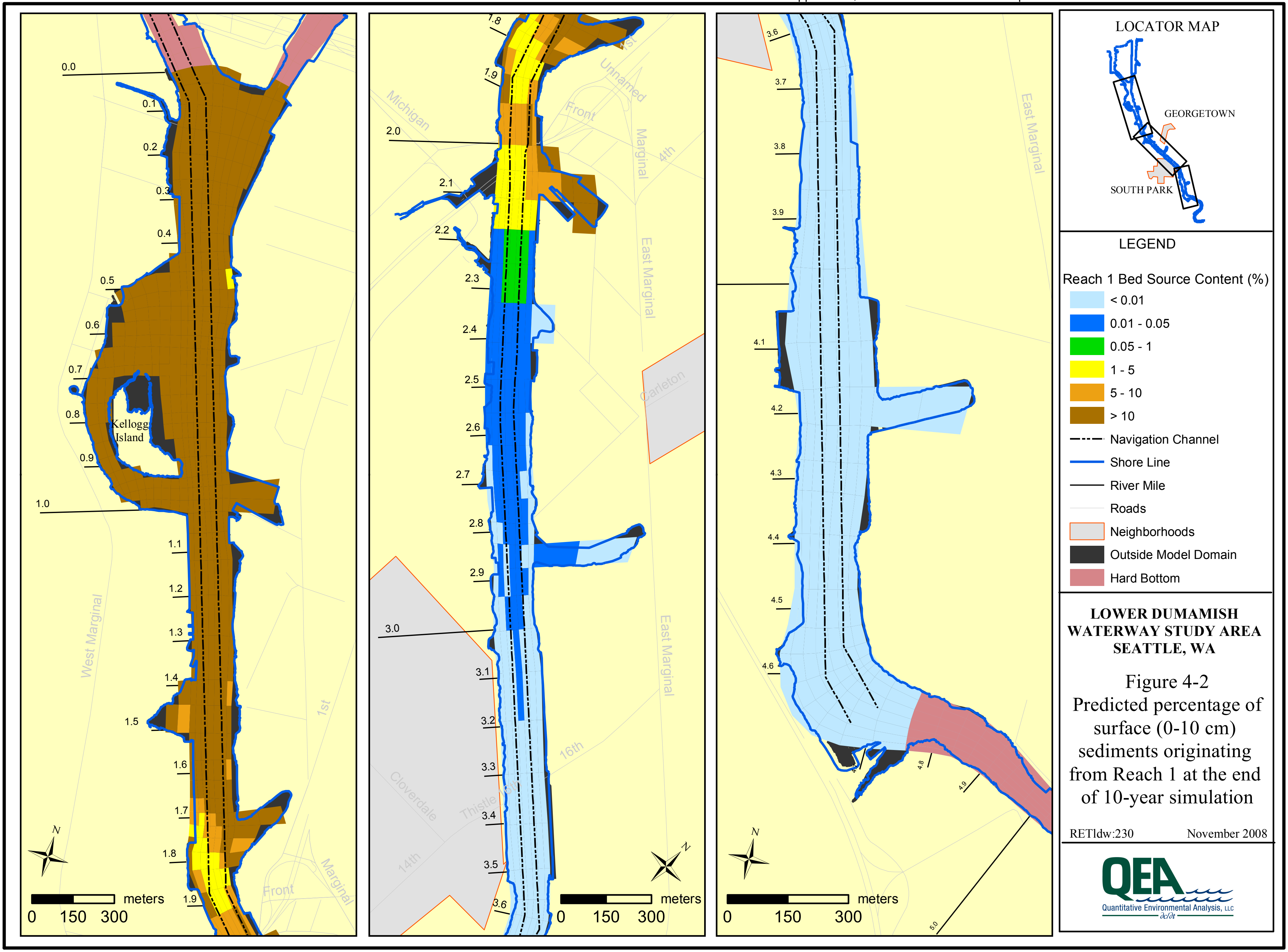


LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 4-1
Delineation of Reaches 1, 2, and 3 for Scenario 4 simulation

RETldw: 230 November 2008

QEA Quantitative Environmental Analysis, LLC



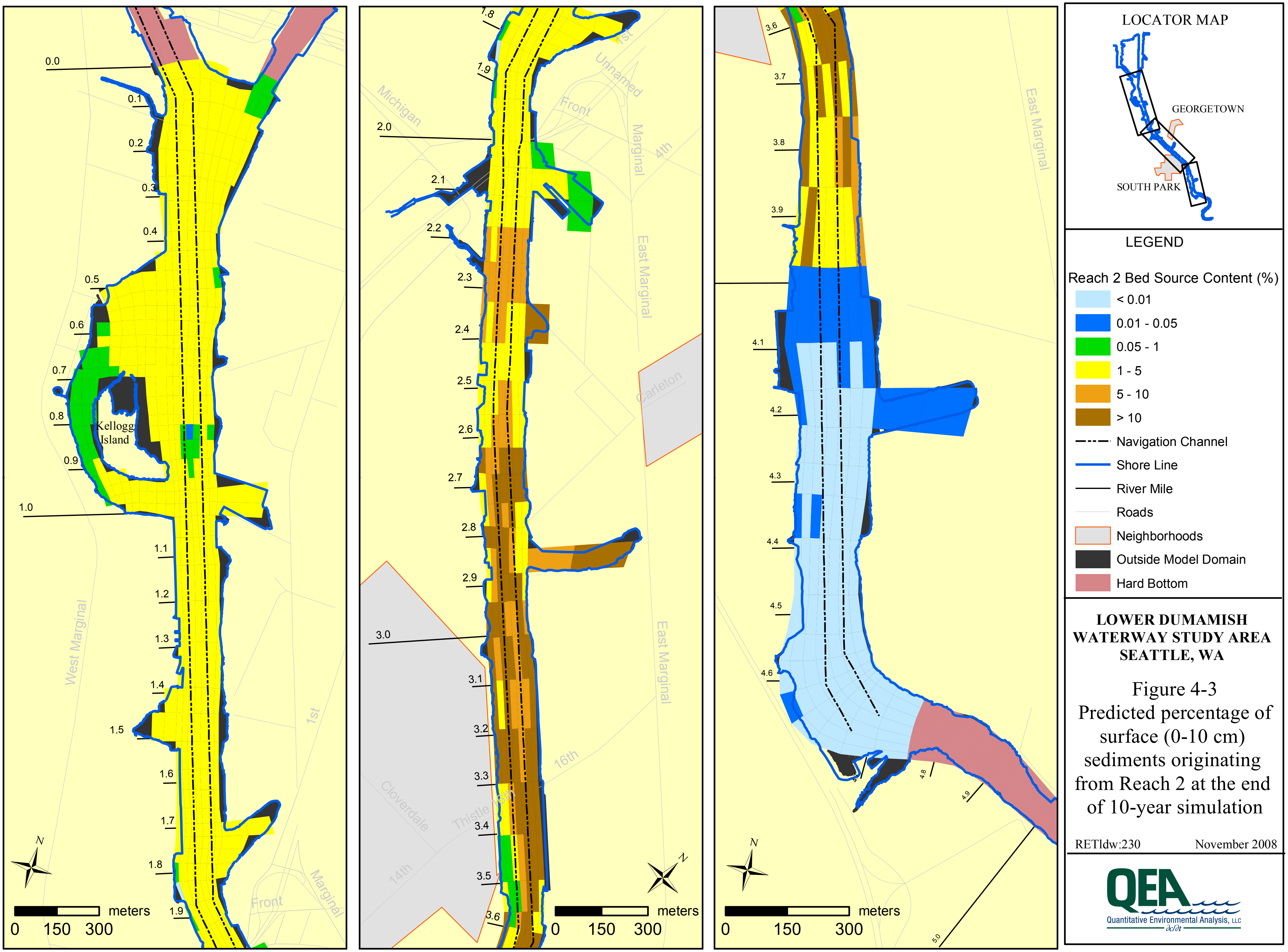
LOWER DUMAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 4-2
Predicted percentage of surface (0-10 cm) sediments originating from Reach 1 at the end of 10-year simulation

RETldw:230 November 2008

QEA Quantitative Environmental Analysis, LLC

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_4-2_20121107.mxd inmanm 11/14/2012 2:19:36 PM

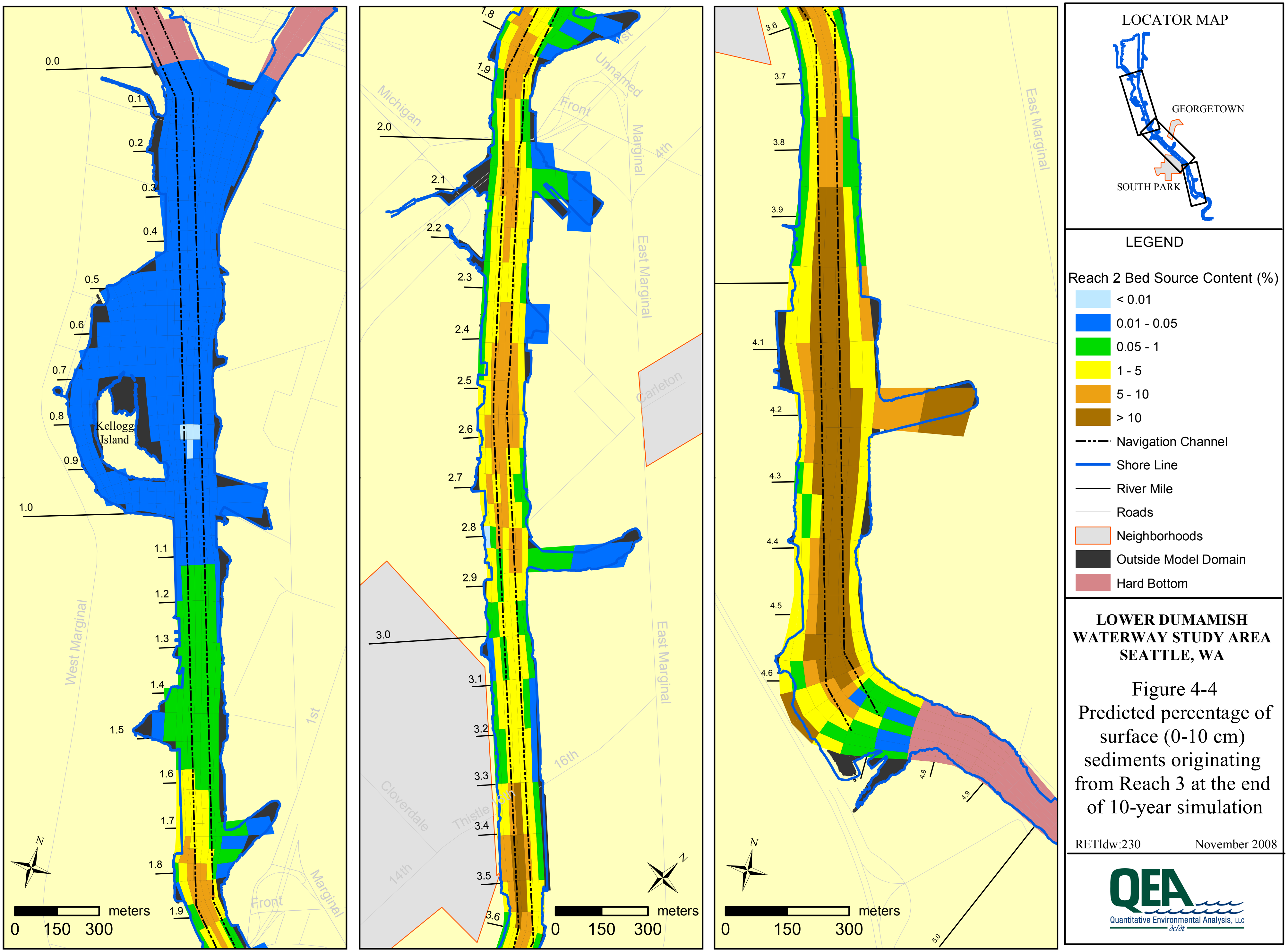


LOWER DUMAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 4-3
Predicted percentage of surface (0-10 cm) sediments originating from Reach 2 at the end of 10-year simulation

RETldw:230 November 2008

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_4-3_20121107.mxd inmanm 11/14/2012 2:20:26 PM



LOWER DUMAMISH WATERWAY STUDY AREA SEATTLE, WA

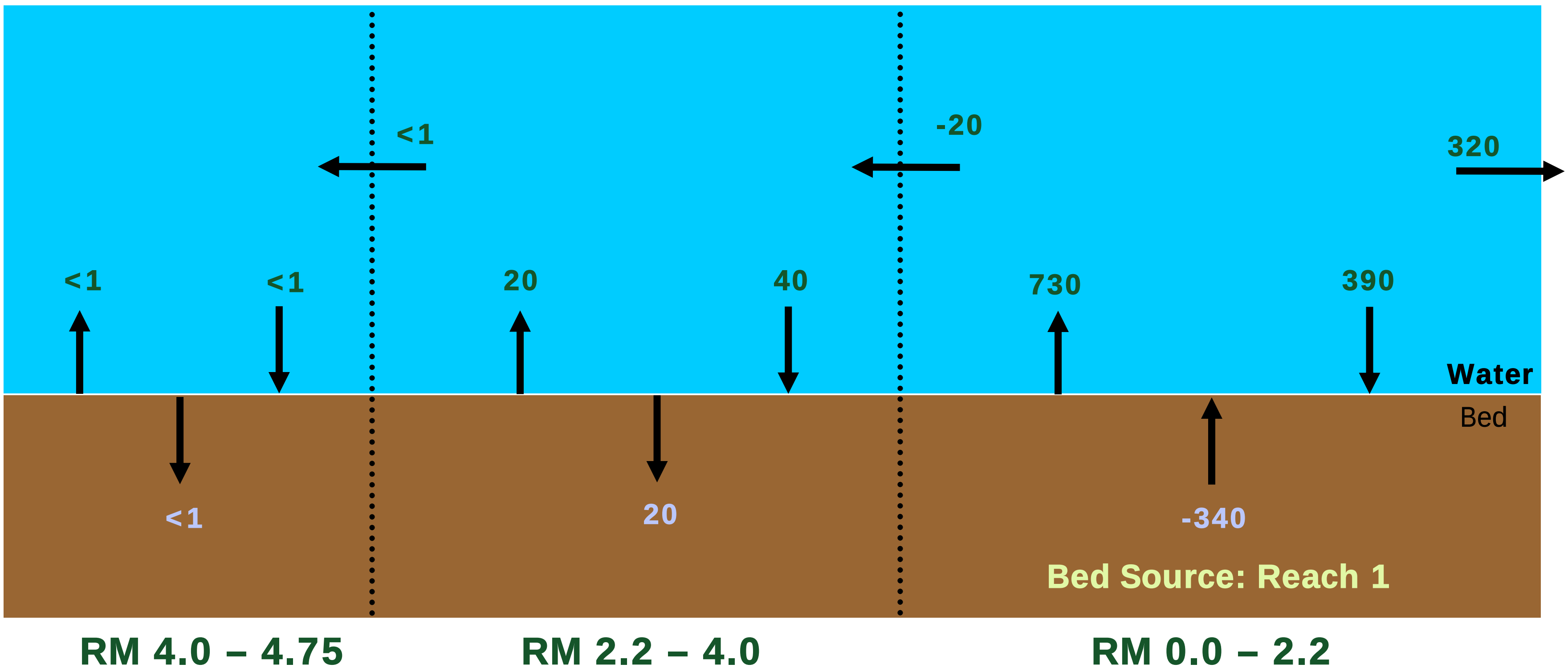
Figure 4-4
Predicted percentage of surface (0-10 cm) sediments originating from Reach 3 at the end of 10-year simulation

RETldw:230 November 2008

QEA Quantitative Environmental Analysis, LLC

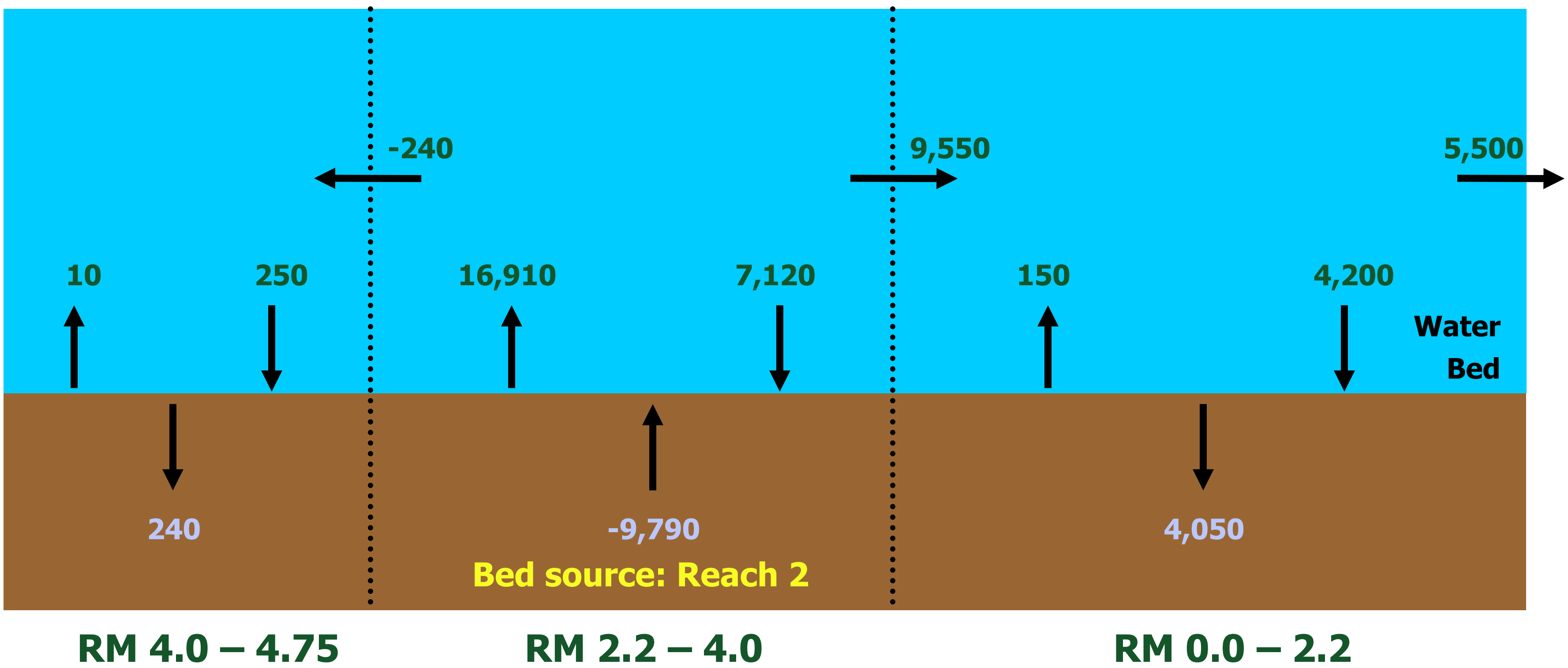
fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_4-4_20121107.mxd inmanm 11/14/2012 2:21:16 PM

Figure 4-5 Mass balance for bed sediment originating from Reach 1 (RM 0.0 to 2.2) for 10-year period



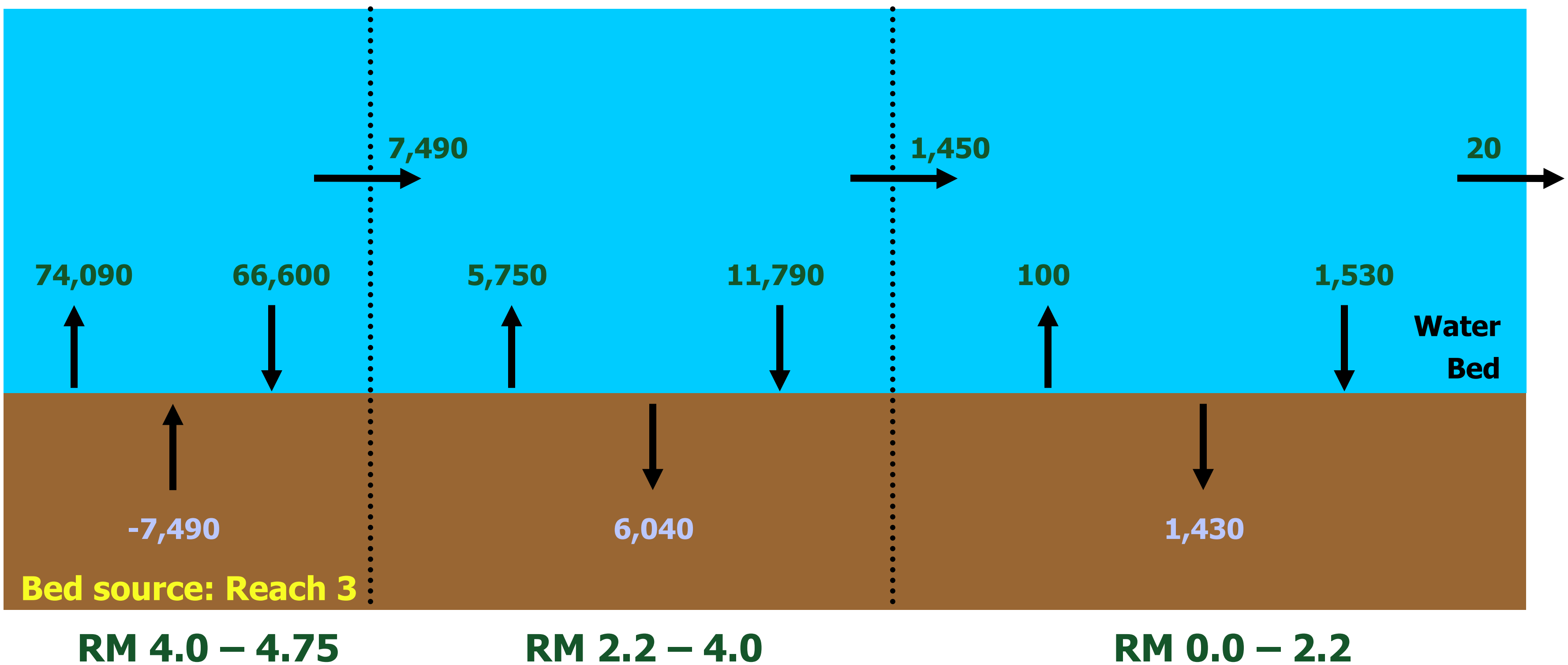
Notes:
Sediment mass units are reported in metric tons.
Mass balance results are rounded to the nearest 10 metric tons.

Figure 4-6 Mass balance for bed sediment originating from Reach 2 (RM 2.2 to 4.0) for 10-year period



Notes:
Sediment mass units are in metric tons.
Mass balance results are rounded to the nearest 10 metric tons.

Figure 4-7 Mass balance for bed sediment originating from Reach 3 (RM 4.0 to 4.8) for 10-year period



Notes:
Sediment mass units are in metric tons.
Mass balance results are rounded to the nearest 10 metric tons.

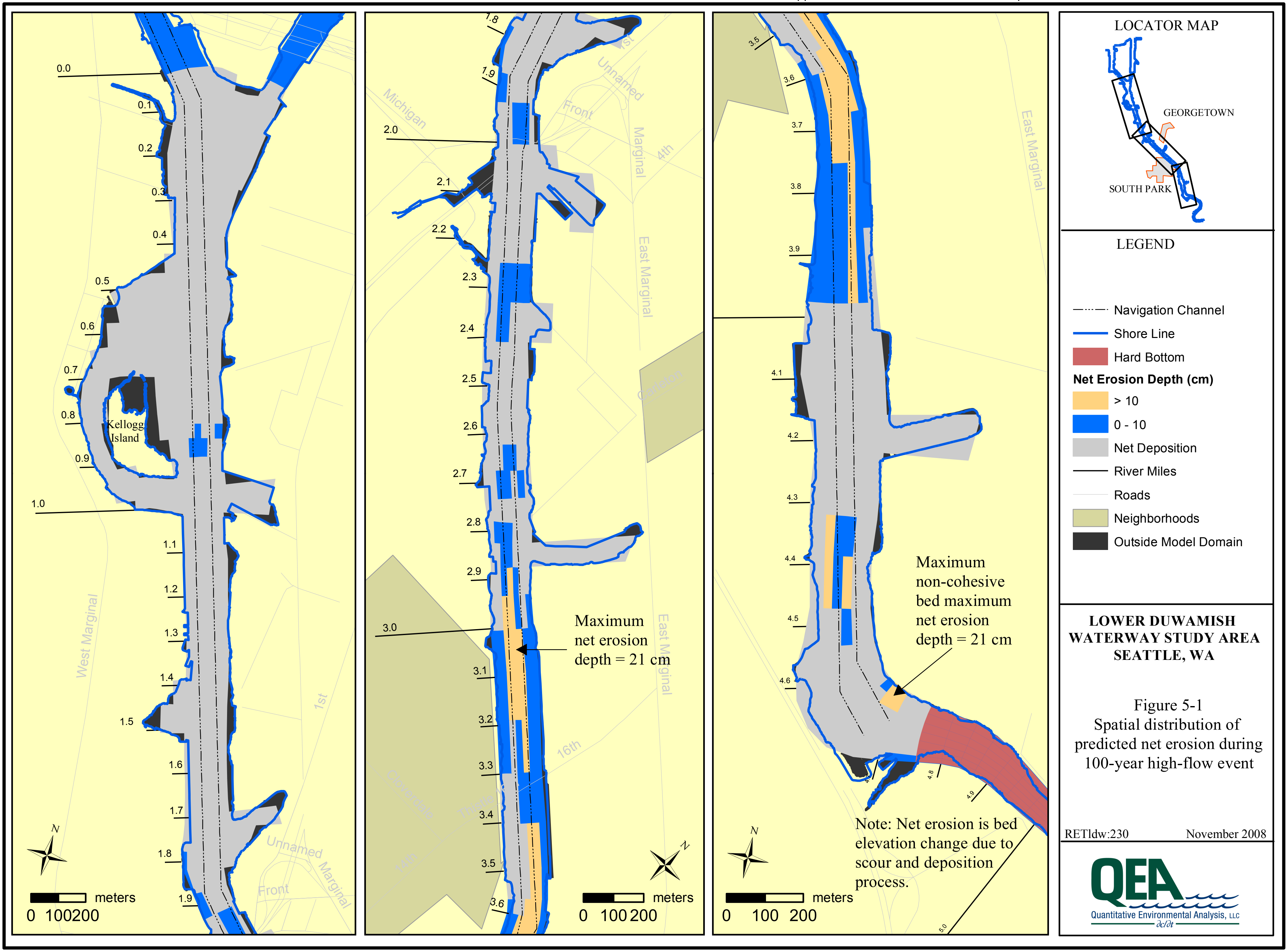
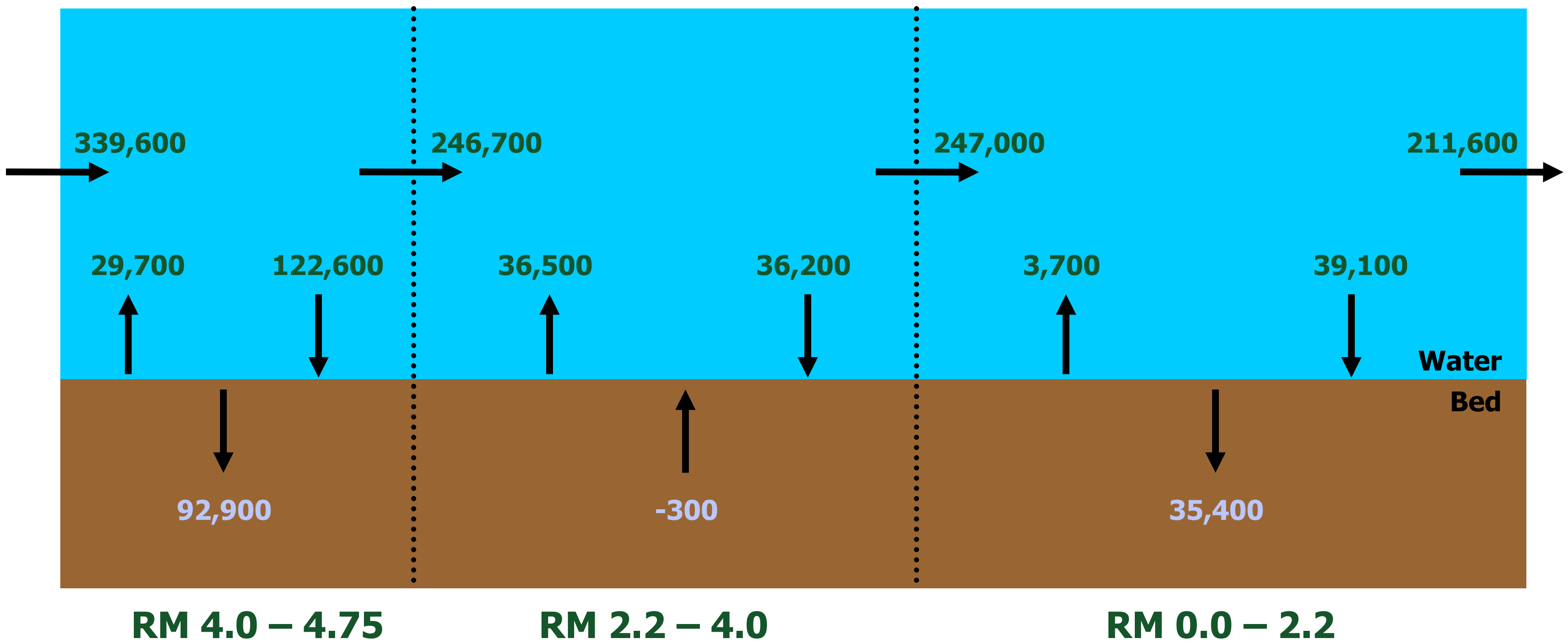


Figure 5-1
Spatial distribution of predicted net erosion during 100-year high-flow event

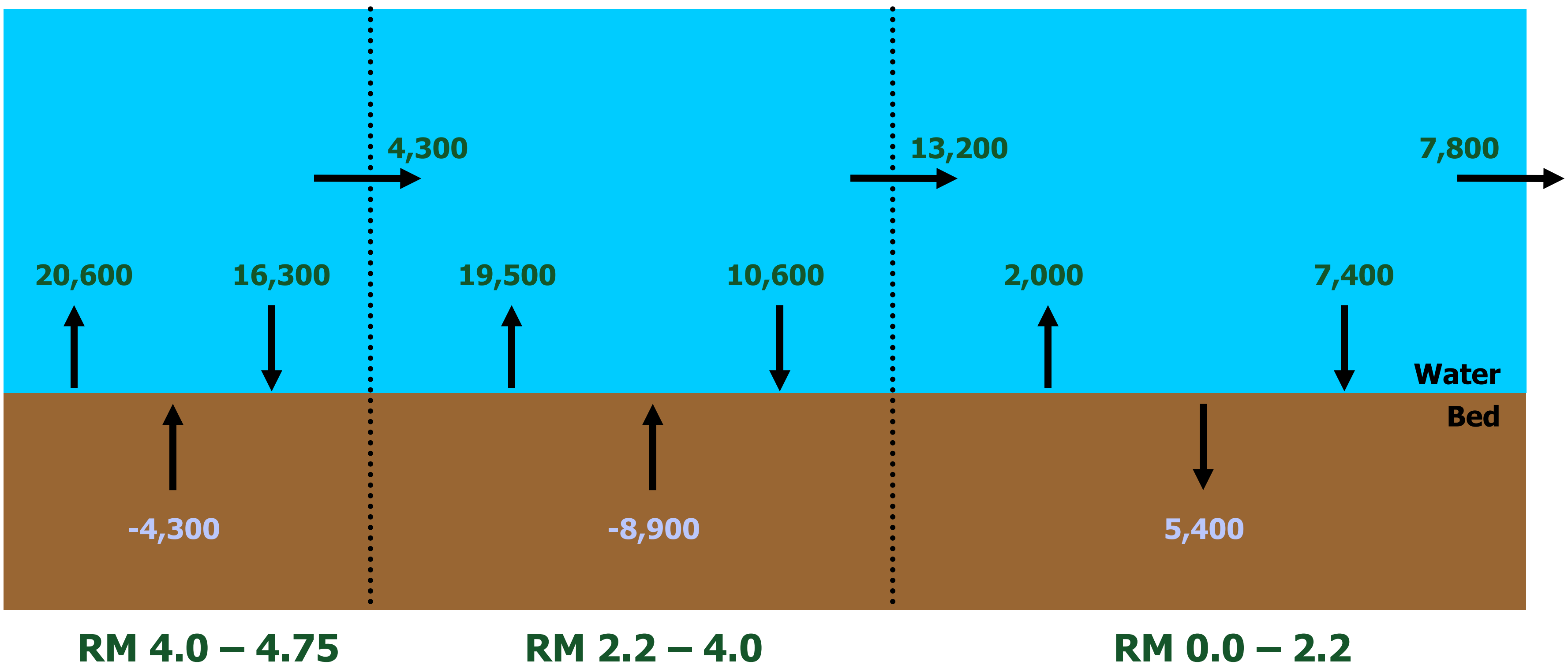
fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\RETldw_tech_memo_fig_5-1_20121107.mxd inmanm 11/14/2012 2:22:11 PM

Figure 5-2 Total sediment mass balance for 100-year high-flow event simulation



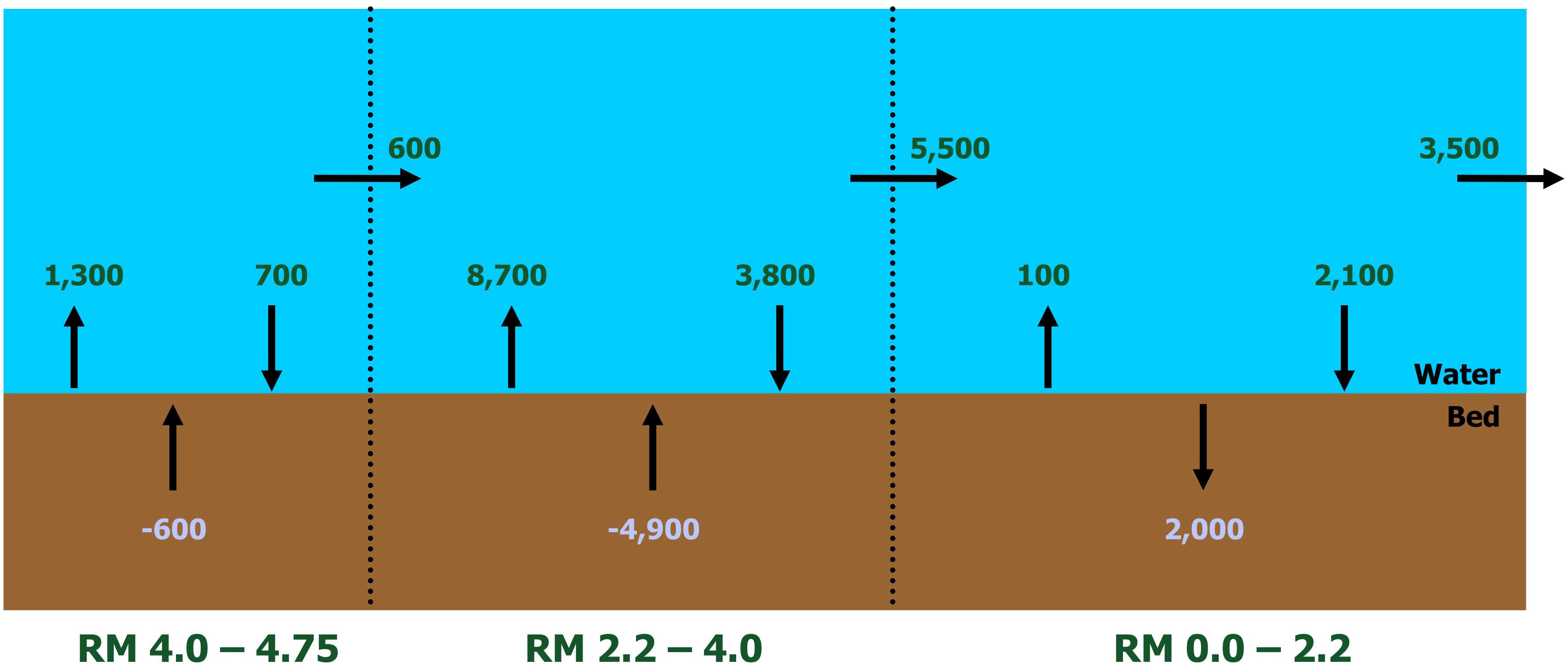
Notes:
Sediment mass units are in metric tons.
Mass balance results are rounded to the nearest 100 metric tons.

Figure 5-3 Mass balance for bed sediment originating from 0-to-10-cm layer during 100-year high-flow event simulation

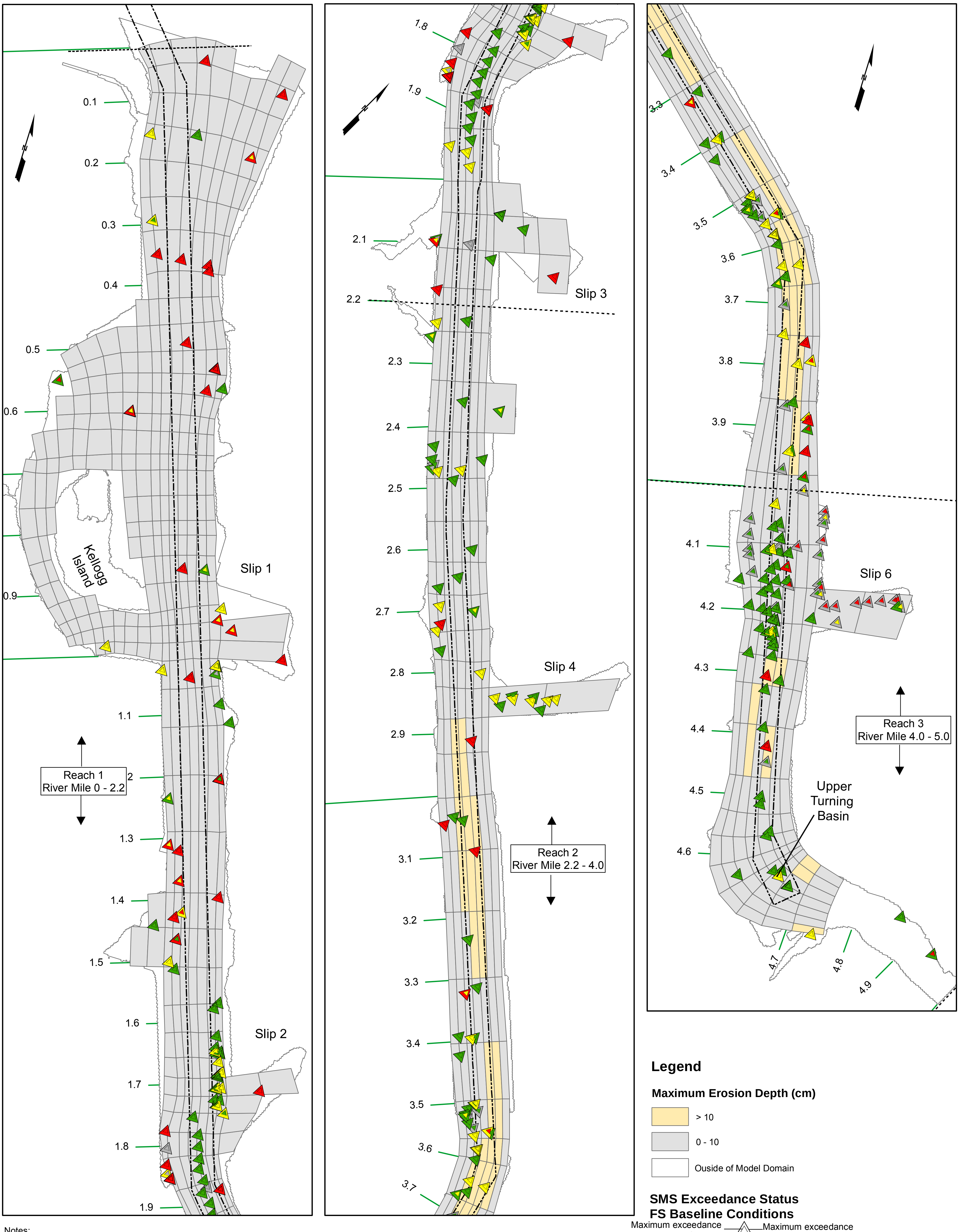


Notes:
Sediment mass units are in metric tons.
Mass balance results are rounded to the nearest 100 metric tons.

Figure 5-4 Mass balance for bed sediment originating from deeper-than-10-cm layer during 100-year high-flow event simulation



Notes:
Sediment mass units are in metric tons.
Mass balance results are rounded to the nearest 100 metric tons.



Legend

Maximum Erosion Depth (cm)

- > 10
- 0 - 10
- Ouside of Model Domain

SMS Exceedance Status
FS Baseline Conditions

Maximum exceedance 0-2 ft in core
Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed

- Extent of Conceptual Site Model Reach
- Navigation Channel
- River Mile Marker

Notes:
1. Scenario 5 STM run showing maximum erosion for a 100-year high-flow event in each model grid cell (QEA 2009).
2. Sediment cores form the FS baseline dataset show the Sediment Management Standard (SMS) exceedance status in the upper 2 and 4 Ft intervals of each core, at baseline conditions.
3. Sample intervals are approximate.

Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 1

Subsurface Sediment SMS Exceedance Locations with > 10 cm Erosion Depth During 100-year High-flow Event

FIGURE 5-5

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Section 5\Figure5-5Cores_NetErosion.mxd

Part 5: LDW STM and BCM Bed-tracking Scenario Simulation (Scenario 6)

MEMORANDUM (REVISED)

To:	Sediment Transport Modeling Group and Lower Duwamish Waterway Group	**Date:**	August 5, 2011
From:	C. Kirk Ziegler, Mike Riley, Anchor QEA; Anne Fitzpatrick, AECOM	**Project:**	RETldw
Cc:	Files		
Re:	LDW STM and BCM Bed-tracking Scenario Simulation (Scenario 6)		

The Lower Duwamish Waterway (LDW) sediment transport model (STM) is being used to track the fate and transport of sediments from three sources: 1) upstream (i.e., Green River); 2) original bed; and 3) lateral (i.e., combined sewer overflows [CSOs], storm drains, and streams). Temporal changes in the relative amounts of sediment from these three sources in the surface layer (top 10 cm) of the bed are calculated by the STM in each grid cell within the study area. There are 727 grid cells (in the horizontal plane) in the LDW, with the grid spanning bank-to-bank from river mile (RM) 0.0 up to RM 4.8. The areal sizes of the grid cells in this region range from 0.1 to 4 acres, with the median area of a grid cell being 0.5 acre. These results are used in the bed composition model (BCM) to calculate changes in bed sediment chemical concentrations and to evaluate the effectiveness of various remedial alternatives for the feasibility study (FS).

A limitation of the STM output is that the bed source content does not differentiate between the original bed and bedded material originating from other areas (i.e., "distal" sediment) that is resuspended from one grid cell and transported and redeposited in another grid cell. A limitation of the BCM is that bed-source sediment within a specific grid cell is assigned the same chemical concentration throughout the entire simulation period. The BCM cannot incorporate the potential effects of bed-source sediment eroded from other grid cells and subsequently transported to and redeposited in a specific grid cell. The bed-source sediment from other grid cells (i.e., "distal" sediment) may have a different chemical concentration than bed-source sediment in the grid cell (i.e., "local" sediment) where the distal sediment is redeposited.

The potential effects of this limitation of the BCM on model calculations were evaluated using the STM in diagnostic mode. The bed model in the STM was modified such that in addition to tracking the bed-source content, the local and distal components of the bed-source material were tracked by the model. This scenario simulation required modification of the STM bed model as described below. After modification of the bed model, the STM was used to conduct a 10-year simulation and track spatial and temporal changes in the composition of local and distal bed-source sediment within the cohesive bed area of the LDW.

MODIFICATION OF STM BED MODEL

The fraction of total bed-source sediment in the surface layer (top 10-cm) of the bed for sediment size class k ($f_{10,bed,k}$) is the sum of two components of bed-source sediment:

$$f_{10,bed,k} = f_{10,local,k} + f_{10,distal,k} \tag{1}$$

where $f_{10,local,k}$ is the fraction of local bed-source sediment and $f_{10,distal,k}$ is the fraction of distal bed-source sediment for size class k in the top 10-cm layer. Similarly, the fraction of total bed-source sediment in the parent-bed layer ($f_{PB,bed,k}$) may be decomposed into two components:

$$f_{PB,bed,k} = f_{PB,local,k} + f_{PB,distal,k} \tag{2}$$

where $f_{PB,local,k}$ is the fraction of local bed-source sediment and $f_{PB,distal,k}$ is the fraction of distal bed-source sediment for size class k in the parent-bed layer.

Constructing a mass balance for the top 10-cm layer for total bed-source sediment for size class k ($M_{10,bed,k}$) results in the following equation:

$$^{n+1}M_{10,bed,k} = {}^{n}M_{10,bed,k} - E_{bed,k} + D_{bed,k} + f_{PB,bed,k}E_{total,k} - f_{10,bed,k}\, D_{total,k} \tag{3}$$

where $E_{bed,k}$ is the mass of total bed-source sediment for size class k eroded during one time step, $D_{bed,k}$ is the mass of total bed-source sediment for size class k deposited during one time step, $E_{total,k}$ is the total mass of class k sediment eroded during one time step, and $D_{total,k}$ is the total mass of class k sediment deposited during one time step. The superscripts n and n+1 refer to time periods in the calculation.

Constructing a mass balance for the top 10-cm layer for local bed-source sediment for size class k ($M_{10,local,k}$) yields:

$$^{n+1}M_{10,local,k} = {}^{n}M_{10,local,k} - (f_{10,local,k} / f_{10,bed,k})E_{bed,k} + f_{PB,local,k}E_{total,k} - f_{10,local,k}\, D_{total,k} \quad (4)$$

Similarly, a mass balance for the top 10-cm layer for distal bed-source sediment for size class k ($M_{10,distal,k}$) yields:

$$^{n+1}M_{10,distal,k} = {}^{n}M_{10,distal,k} - (f_{10,distal,k} / f_{10,bed,k})E_{bed,k} + D_{bed,k} + f_{PB,distal,k}E_{total,k} - f_{10,distal,k}\, D_{total,k} \quad (5)$$

It is assumed that deposited bed-source sediment is composed entirely of distal material (i.e., eroded local sediment is not redeposited in the same grid cell). Note that the summation of Equations 4 and 5 produces Equation 3. Similar mass balance equations were developed for the parent-bed layer.

LIMITATIONS OF BED-TRACKING SIMULATION

The bed-tracking simulation has provided useful information on the potential for and extent of bed-source sediment to be eroded and redeposited within the LDW. However, the limitations of this analysis need to be acknowledged. First, it was assumed that bed-source sediment that is deposited in a specific grid cell is completely composed of distal material and that local material is not redeposited in the same grid cell after it is eroded. This assumption results in an over-estimation of the amount of material transported between grid cells. However, it is likely that, generally, the over-estimation due to this assumption is relatively minor. The second, and most important, limitation of this analysis is that the origin of distal sediment that is deposited within a specific grid cell cannot be determined. In some cases, the distal sediment will have originated in close proximity (i.e., immediately adjacent grid cells), whereas in other situations, the distal sediment will have come from a grid cell located 2 or 3 miles upstream. This situation would make it difficult to assign the appropriate chemical concentration to the distal sediment if these results were used in the BCM.

RESULTS OF STM BED-TRACKING SIMULATION

A 10-year simulation, corresponding to the first 10 years of the 30-year simulation presented in the STM report (QEA 2008), was conducted for this analysis. The STM was used to track sediment originating from three sources: 1) original bed sediments (total, local, and distal); 2) upstream source sediments (i.e., Green River); and 3) lateral source sediments (i.e., storm drains, CSOs, streams). Five variables were tracked by the bed model. The lateral loads were specified using the distributed approach (see Part 4 Scenario 2 of this appendix) so as to more realistically represent the transport of lateral source sediments in the STM.

Spatial distributions of local and distal bed-source sediment in the surface layer (top 10 cm) of the bed at the end of the 10-year period are presented in Figures 1 and 2, respectively. Local and distal bed-source sediments were tracked only in the cohesive bed of the study area. The non-cohesive bed area in the vicinity of the Upper Turning Basin was not included in this analysis and that area is denoted on these two figures. Generally, Reaches 2 (RM 2.2 to 4.0) and 3 (RM 4.0 to 4.8) contain relatively higher amounts of distal sediment than local sediment, which is consistent with the dynamic erosion and deposition characteristics of these two reaches. Reach 1 (RM 0 to 2.2) generally contains more local sediment than distal sediment, which is expected because of the minor amount of erosion that occurs in this reach.

The results of diagnostic analyses of the STM bed model were presented in Appendix F of the STM report (QEA 2008). For example, Figures F-59 through F-74 showed temporal changes in bed elevation and bed composition at 16 grid cell locations, which represent a range of net depositional environments. To evaluate the temporal variation in local and distal bed-source composition at these 16 locations (see Figure 3, which is a reproduction of Figure F-58 in of the STM report [QEA 2008]), a similar analysis was conducted for the 10-year bed-tracking simulation. Figures 4 through 19 show temporal changes in bed elevation and bed composition in the top 10-cm layer for the 10-year period at these 16 locations. Generally, the local bed-source content tends to continuously decrease, whereas the distal bed-source content increases during the first few years and then levels out at an approximately constant value.

APPLICATION OF THE BED-TRACKING ANALYSIS IN THE BCM

The bed-tracking analysis provides a breakdown of sediment that settles in a STM cell from one of two sources: 1) sediment that is resuspended and resettled in the same STM cell and

2) bedded material originating from other areas (distal sediment). For the BCM, the distal sediment is essentially another sediment source. This additional sediment source can be represented in the BCM by including a fourth term in the BCM equation. The standard BCM equation is:

$$C_{(time)} = C_{lateral}*f_{lateral} + C_{river}*f_{river} + C_{bed}*f_{bed} \quad (6)$$

Where $C_{lateral}$, C_{river}, and C_{bed} represent the contaminant concentrations associated with sediment from the lateral inflows, upstream, and original bed sediment, respectively. The $f_{lateral}$, f_{river}, and f_{bed} variables represent the fractions of sediment at each BCM grid cell associated with those same sources of sediment.

In the distal sediment BCM version, the equation becomes:

$$C_{(time)} = C_{lateral}*f_{lateral} + C_{river}*f_{river} + C_{bed}*f_{bed} + C_{distal}*f_{distal} \quad (7)$$

Where C_{distal} refers to the contaminant concentration associated with distal sediment and f_{distal} refers to the fraction of distal sediment at each BCM grid cell. The fraction of distal sediment is an output from the STM bed-tracking simulation and, therefore, the only additional input needed is the contaminant concentration associated with the distal sediment fraction.

The contaminant concentration associated with the distal sediment input was computed separately as an average for each reach based on the reach-average fraction of sediment settling from each reach. This reach average fraction for each reach is taken from the simulation of sediment movement between reaches (Part 4, Scenario 4 of this appendix). The PCB concentration associated with the distal sediment input for a reach is computed as the mass-weighted average concentration based on the mass of sediment that settles in a reach from all three reaches and the Post-Alternative 1 spatially-weighted average concentration (SWAC) at Year 0 in each reach. For example, the distal input for Reach 1 is computed as:

The $SWAC_1$, $SWAC_2$, and $SWAC_3$ are the post-Alternative 1 (Year 0) SWACs in each reach. This is an approximation that does not strictly conserve chemical mass. However, it provides a check on the standard BCM analysis and shows the importance of resuspension and redeposition of bed sediment relative to other processes in the LDW.

RESULTS OF BCM BED-TRACKING SIMULATION

The BCM results from the bed-tracking analysis are shown in Table 1 (Year 0 and Year 10 following completion of the early action areas under Alternative 1). For comparison, results from the base-case BCM are also shown. Both the bed-tracking analysis and the BCM base case simulate natural recovery following completion of early actions with the assumption that no further action takes place over the simulation period.

This analysis indicates that accounting for bed sediment movement in the BCM produces either no change or a slightly lower total PCB SWAC at the end of 10 years, both on a site-wide and reach-wide basis. Compared to the base case, the bed-tracking PCB SWACs are the same in Reaches 1 and 3, and 6% lower in Reach 2. The change in calculated SWAC is approximately 1% lower site-wide.

The changes are small because throughout the LDW, resuspended sediment that resettles in the LDW is a small component of the sediment mass balance. The resuspended bed sediment that settles in the LDW is only 5%, 12%, and 9% of the sediment mass balance in Reaches 1, 2, and 3, respectively. In Reach 2, which has the highest fraction of bed sediment that resettles, most of the sediment that resettles originates in Reach 3, where total PCB average concentration of the resuspended bed sediment is generally lower than in the receiving cells in the other reaches. Overall, this simulation shows that redistribution of existing bed sediment has a minor effect on recovery predictions, except in Reach 2 where the approach used in the BCM base-case analysis likely underestimates natural recovery compared to a model that actually tracks the movement and concentration of individual sediment particles.

ATTACHMENTS

REFERENCES

AECOM 2009. *Draft Feasibility Study, Lower Duwamish Waterway, Seattle, Washington.* Prepared for the Lower Duwamish Waterway Group for submittal to the U.S. Environmental Protection Agency, Region 10, and Washington State Department of Ecology. AECOM, Seattle, WA. April 24, 2009.

QEA 2008. *Lower Duwamish Waterway Sediment Transport Modeling Report. Final.* Prepared for the Lower Duwamish Waterway Group for submittal to the U.S. Environmental Protection Agency, Region 10, and Washington State Department of Ecology. Quantitative Environmental Analysis, LLC, Montvale, NJ. October 2008.

Table 1 Comparison of Year 10 Total PCB SWACs between the Bed-Tracking Scenario and STM Base Case

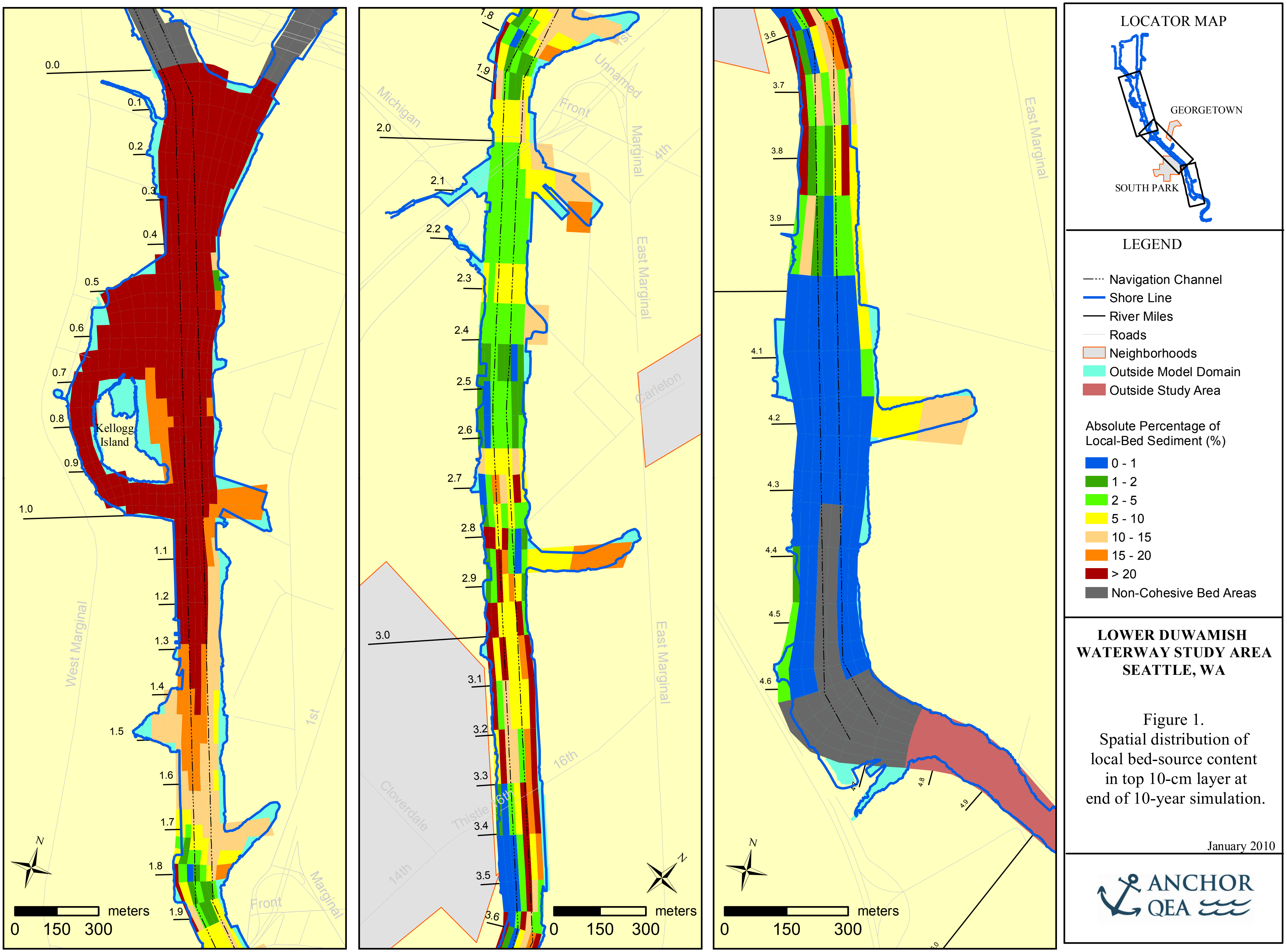
Scenario	Total PCB SWACs (µg/kg dw)			
	Site-wide	Reach 1	Reach 2	Reach 3
Post-Alternative 1 Bed-Tracking Results				
Year 0	180	190	220	57
Year 10 STM Base Case	73	84	67	40
Year 10 modified STM Bed-Tracking Scenario with resuspended bed variable	72	84	63	40
Distal Sediment Concentration Input Values to the Analysis				
Distal Bed (µg/kg dw) – reach-wide post-Alternative 1 mass-weighted SWAC	n/a	176	117	57

Shaded Cell = Greatest difference between bed-tracking and STM base case

Notes:

1. The distal input refers to sediments originating from the initial bed that resuspend and settle in a different STM model cell over time, as opposed to original bed sediments that are not eroded over time (remain in place) The distal input to the sediment bed for each reach is computed as the mass-weighted average total PCB concentration based on the mass of sediment that settles in a reach from all three reaches and the beginning (Year 0) Post-Alternative 1 SWAC in each reach.
2. The chemical input values used in this bed-tracking analysis include:
   a) Local Bed_c = Baseline IDW value in unremediated areas, or post-remedy bed sediment replacement value for total PCBs of 60 µg/kg dw in remediated areas (EAA footprints).
   b) Distal Bed_c = Reach-wide Post-Alternative 1 Mass-Weighted SWAC.
   c) $Upstream_c$ = Mid BCM input value of 35 µg/kg dw.
   d) $Lateral_c$ = Mid BCM input value of 300 µg/kg dw.
3. Three scenario results are shown. Year 0 - immediately after completion of the EAAs under Alternative 1; Year 10 – ten years after completion of the EAAs under Alternative1, assuming only recovery over the 10-year period (shown for comparison as the "STM base case"); and Year 10 modified – ten years after completion of the EAAs under Alternative 1, modified to track movement and reach-average concentration of the distal sediment fraction.
4. See text for calculation equations.

BCM = bed composition model; EAA = early action area; IDW = inverse distance weighting; µg/kg dw = micrograms per kilogram dry weight; n/a = not applicable; PCB = polychlorinated biphenyl; STM = sediment transport model; SWAC = spatially-weighted average concentration



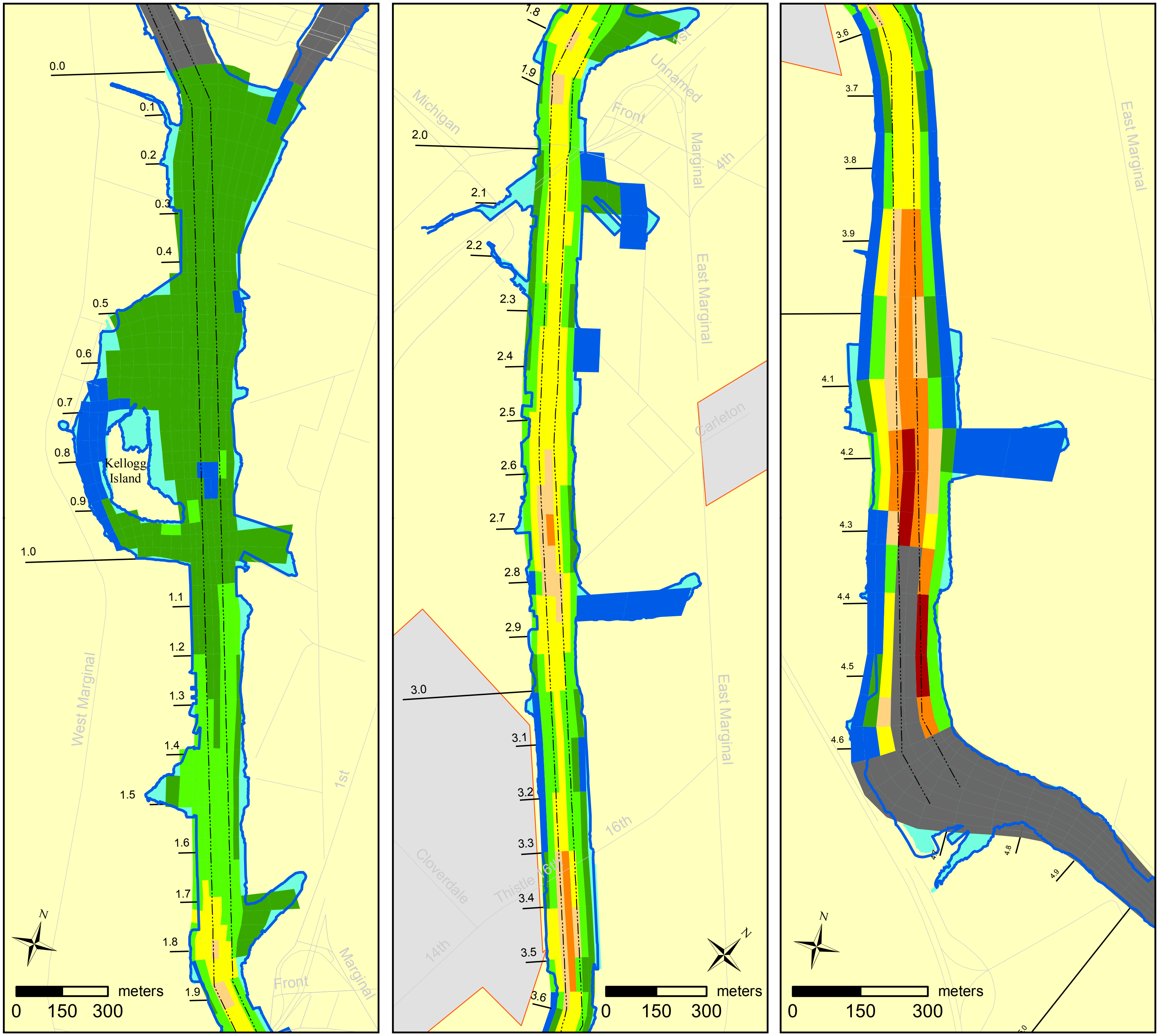
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 1.
Spatial distribution of local bed-source content in top 10-cm layer at end of 10-year simulation.

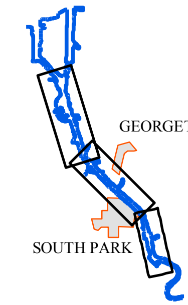
January 2010

ANCHOR QEA

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\BedTrackingMemo_Fig_1_20121107.mxd inmanm 11/14/2012 2:23:38 PM



LOCATOR MAP



LEGEND

- Navigation Channel
- Shore Line
- River Miles
- Roads
- Neighborhoods
- Outside Model Domain
- Outside Study Area

Absolute Percentage of Distal-Bed Sediment (%)

- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- > 20
- Non-Cohesive Bed Areas

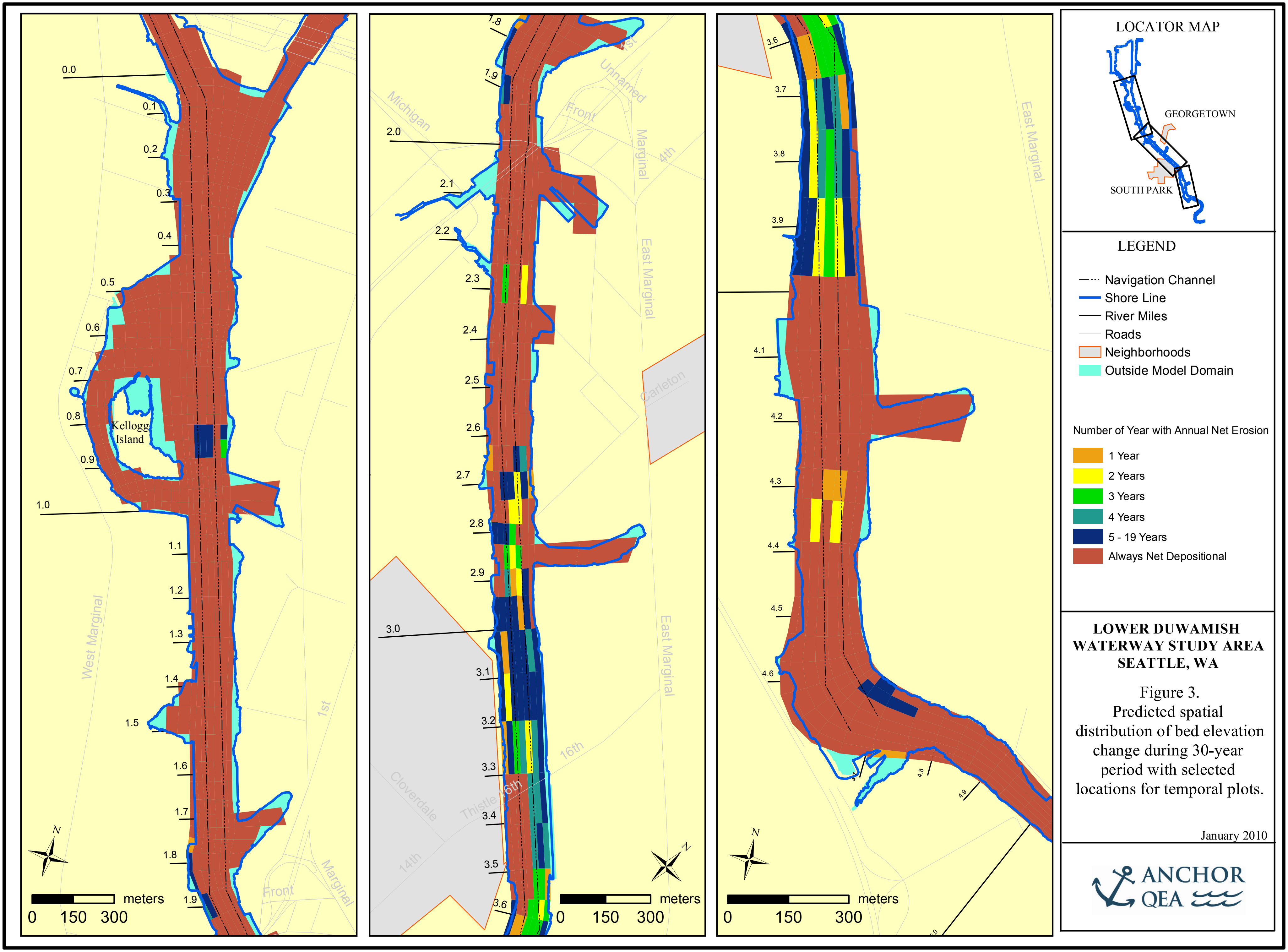
LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 2.
Spatial distribution of distal bed-source content in top 10-cm layer at end of 10-year simulation.

January 2010

ANCHOR QEA

fc, L:\Lower Duwamish FS\FS_Final_GISOct2012\QEA_Figures\RETldw_GIS_mxd_files\BedTrackingMemo_Fig_2_20121107.mxd inmanm 11/14/2012 2:24:24 PM



LOWER DUWAMISH WATERWAY STUDY AREA SEATTLE, WA

Figure 3.
Predicted spatial distribution of bed elevation change during 30-year period with selected locations for temporal plots.

January 2010

ANCHOR QEA

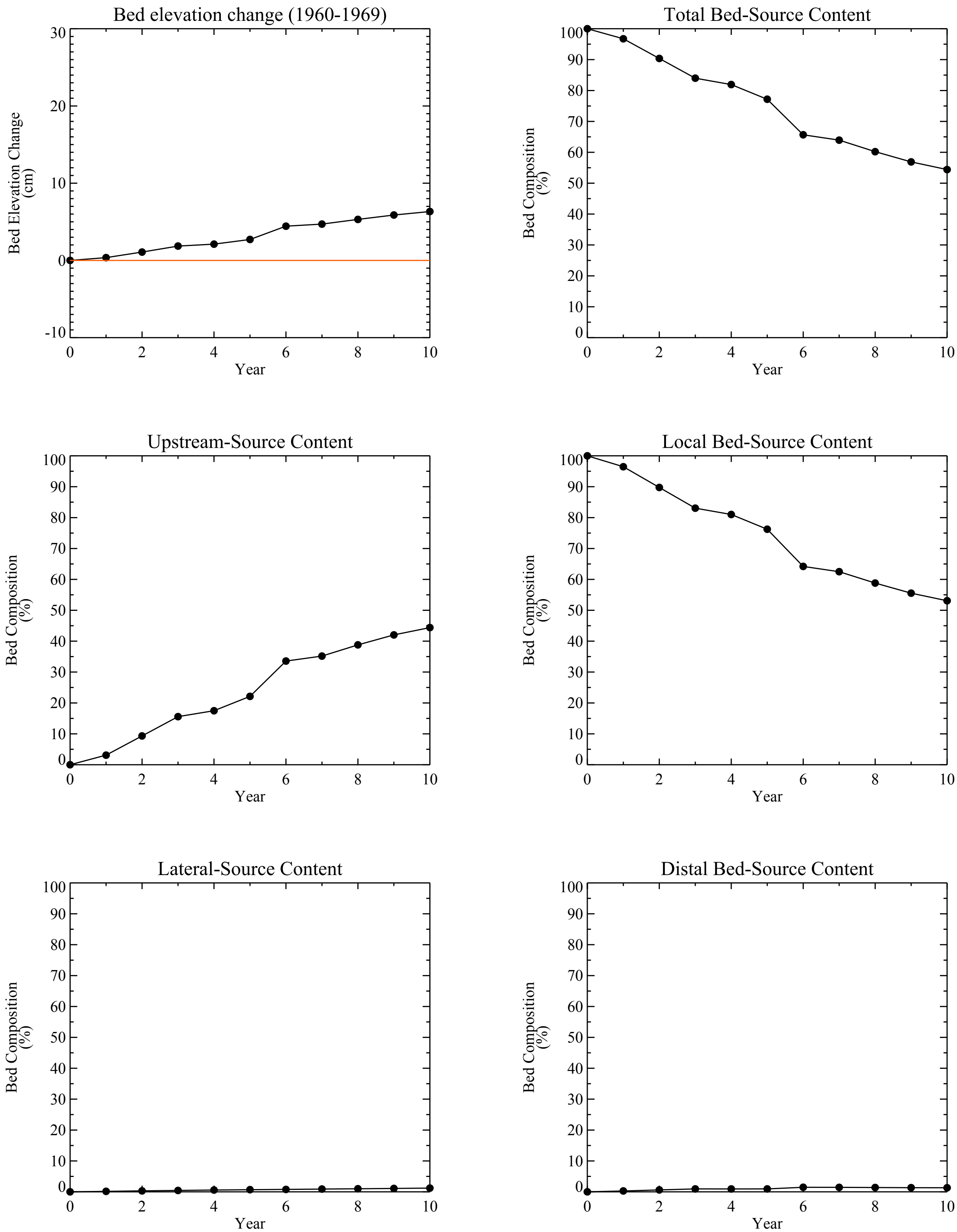


Figure 4. Temporal variation of bed elevation change and bed composition at grid cell: (18, 349), RM 0.20, East Bench.

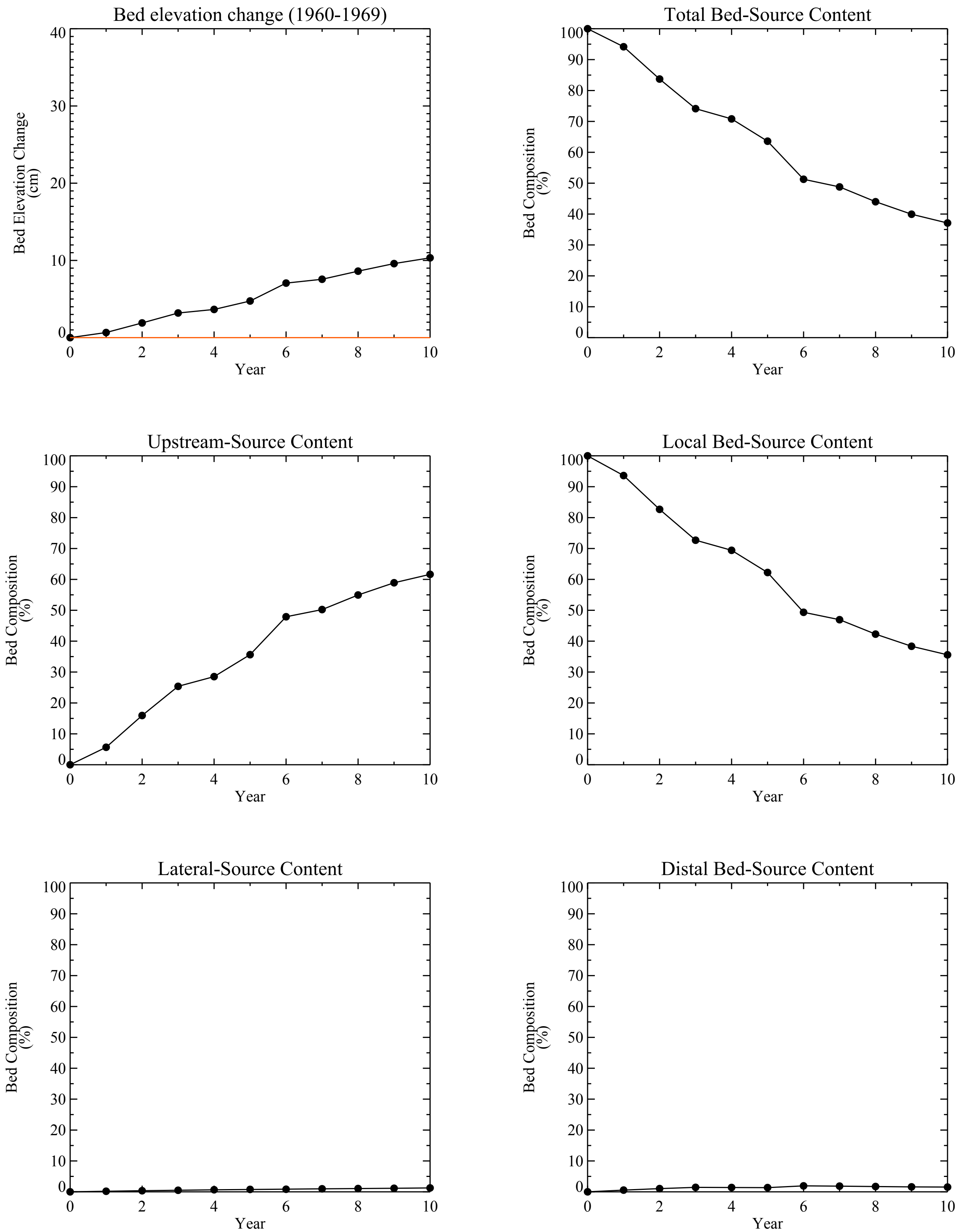


Figure 5. Temporal variation of bed elevation change and bed composition at grid cell: (13, 349), RM 0.17, Navigation Channel.

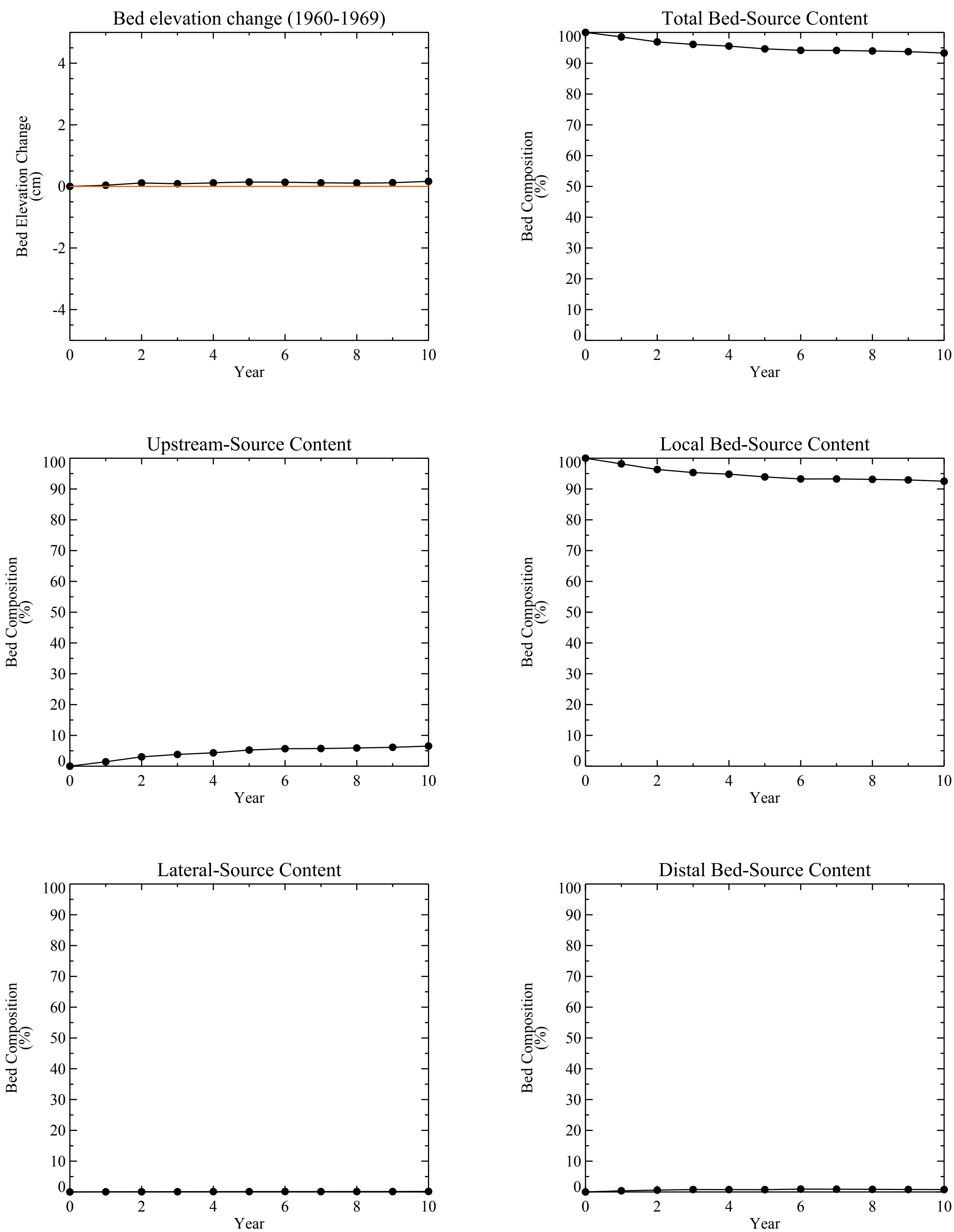


Figure 6. Temporal variation of bed elevation change and bed composition at grid cell: (14, 333), RM 0.82, Navigation Channel.

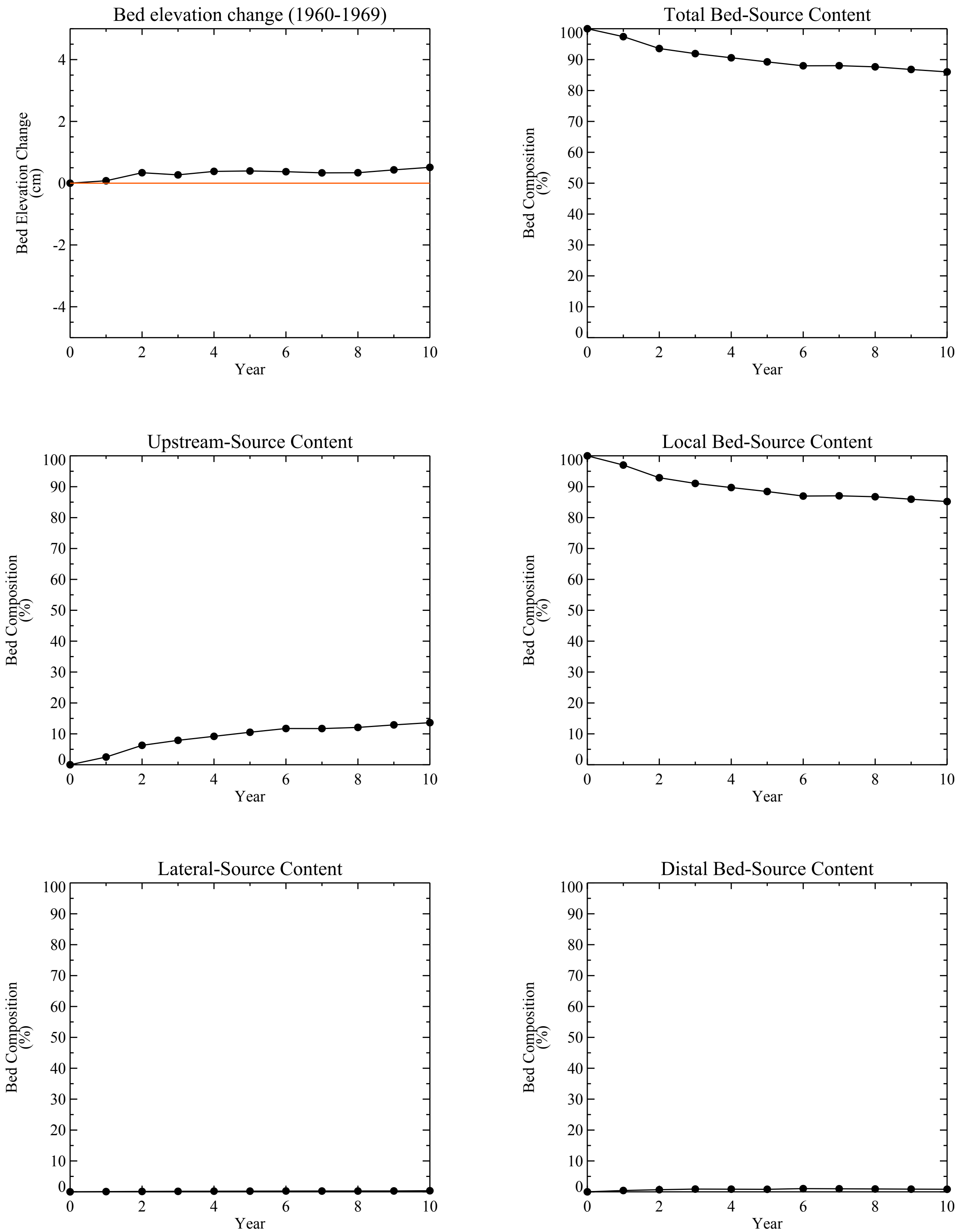


Figure 7. Temporal variation of bed elevation change and bed composition at grid cell: (14, 332), RM 0.86, Navigation Channel.

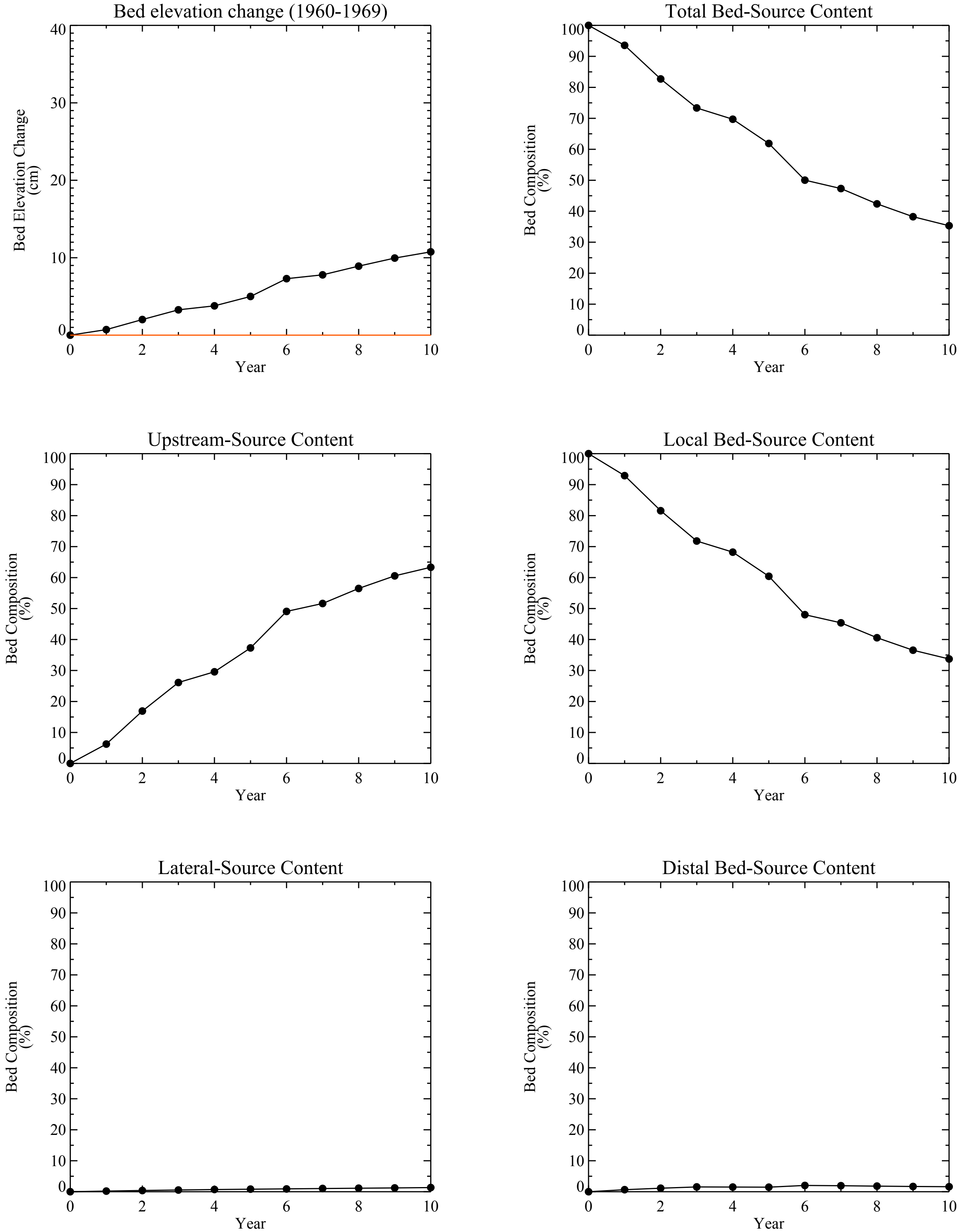


Figure 8. Temporal variation of bed elevation change and bed composition at grid cell: (14, 330), RM 0.94, Navigation Channel.

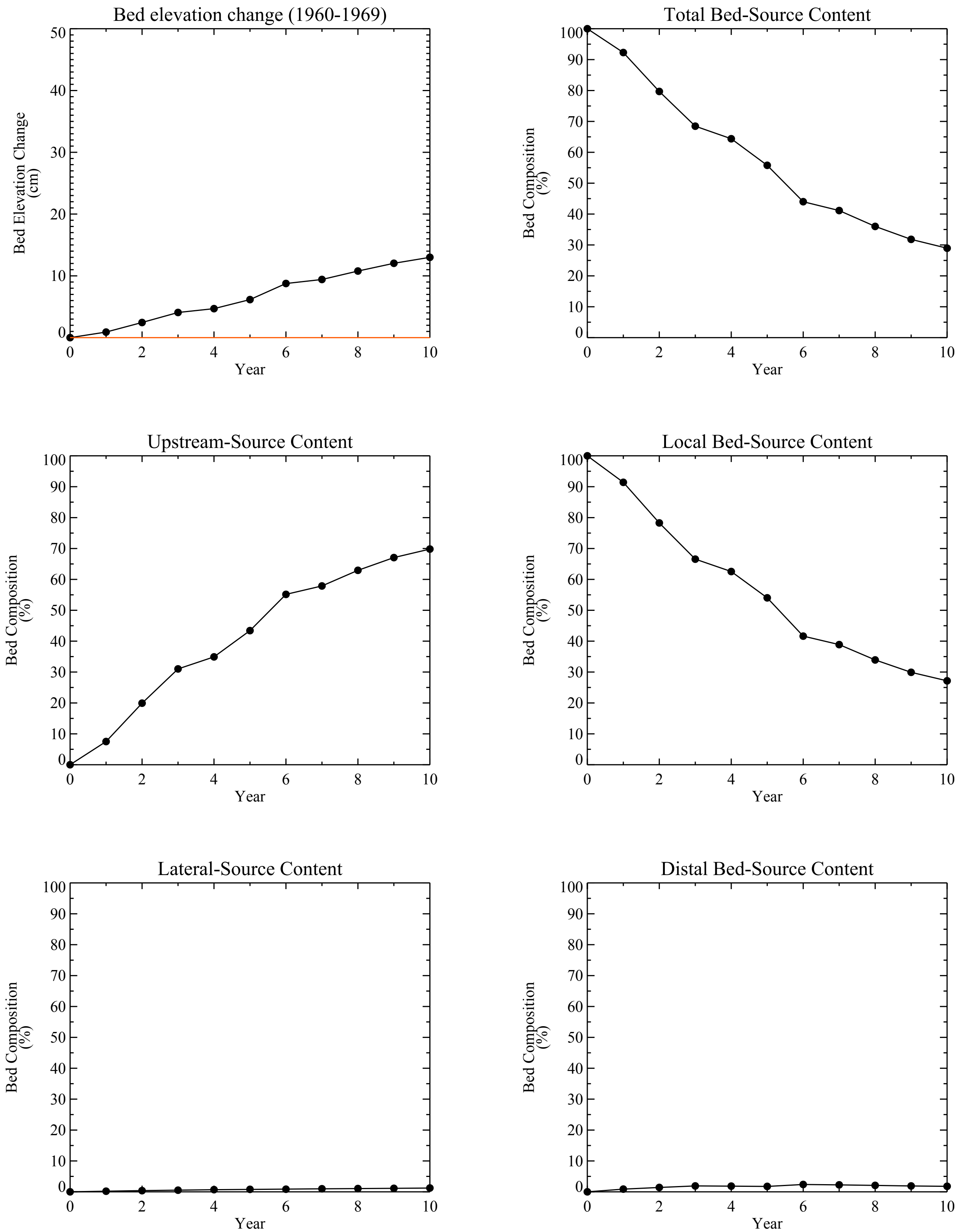


Figure 9. Temporal variation of bed elevation change and bed composition at grid cell: (14, 324), RM 1.2, Navigation Channel.

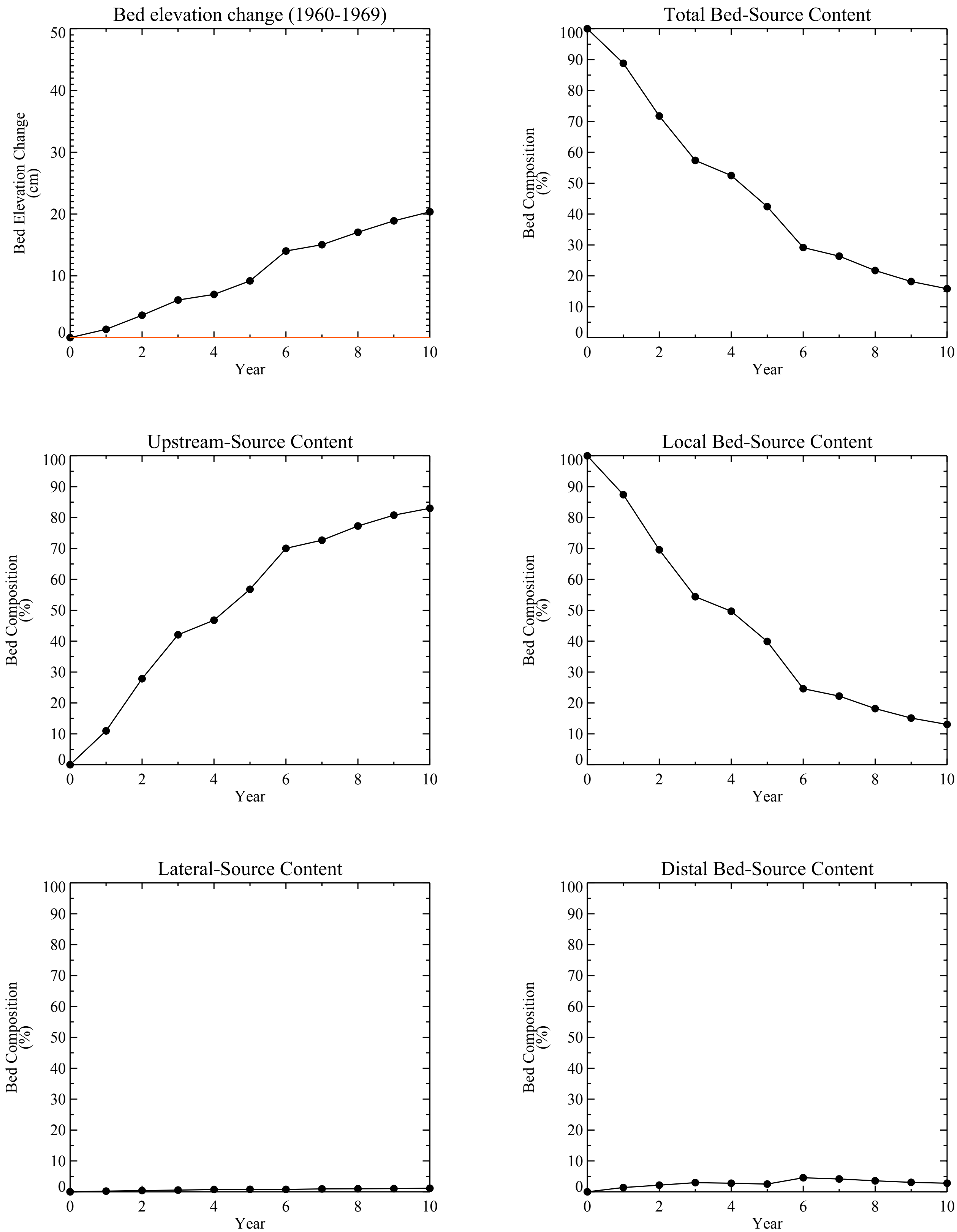


Figure 10. Temporal variation of bed elevation change and bed composition at grid cell: (15, 319), RM 1.6, Navigation Channel.

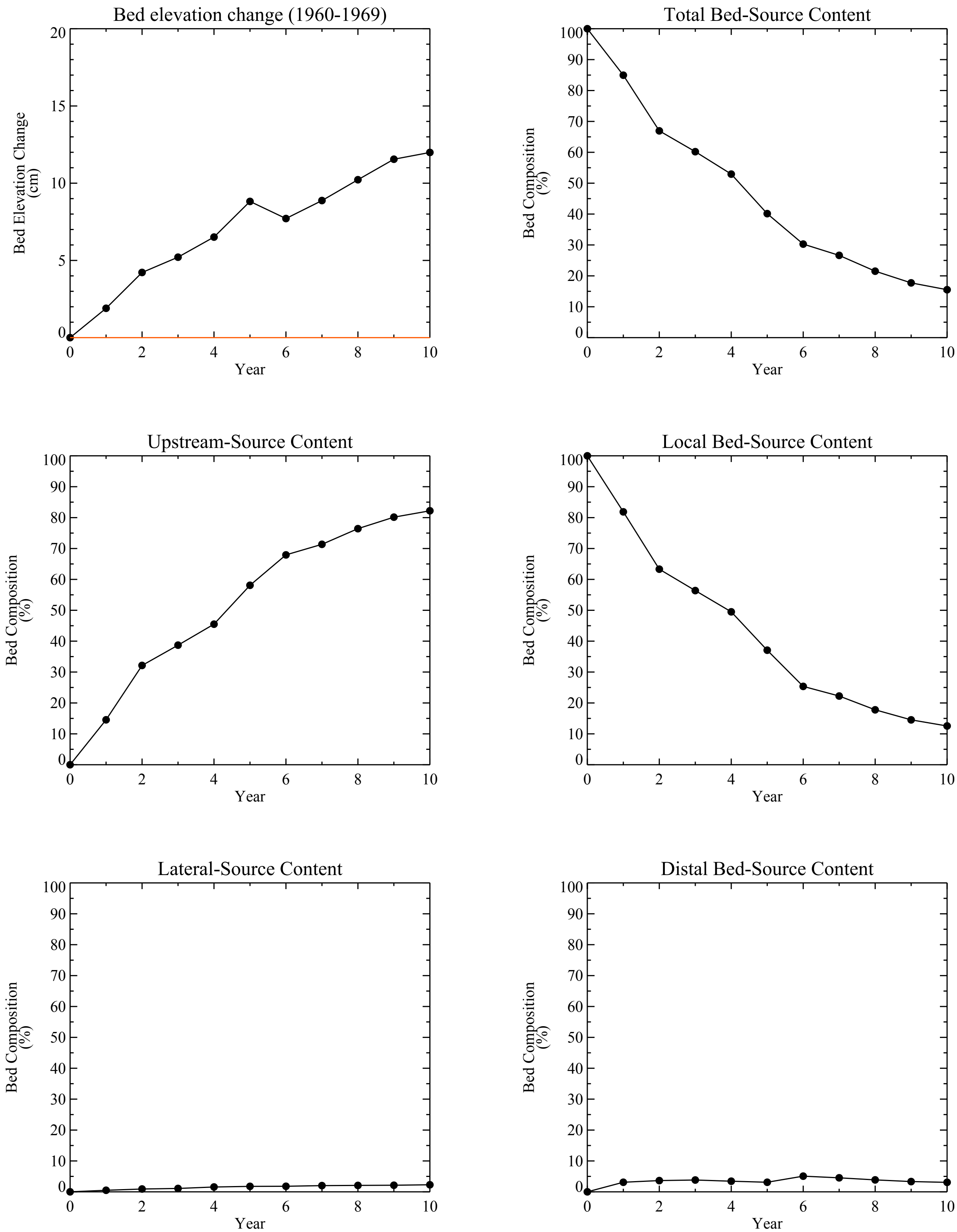


Figure 11. Temporal variation of bed elevation change and bed composition at grid cell: (12, 311), RM 1.9, West Bench.

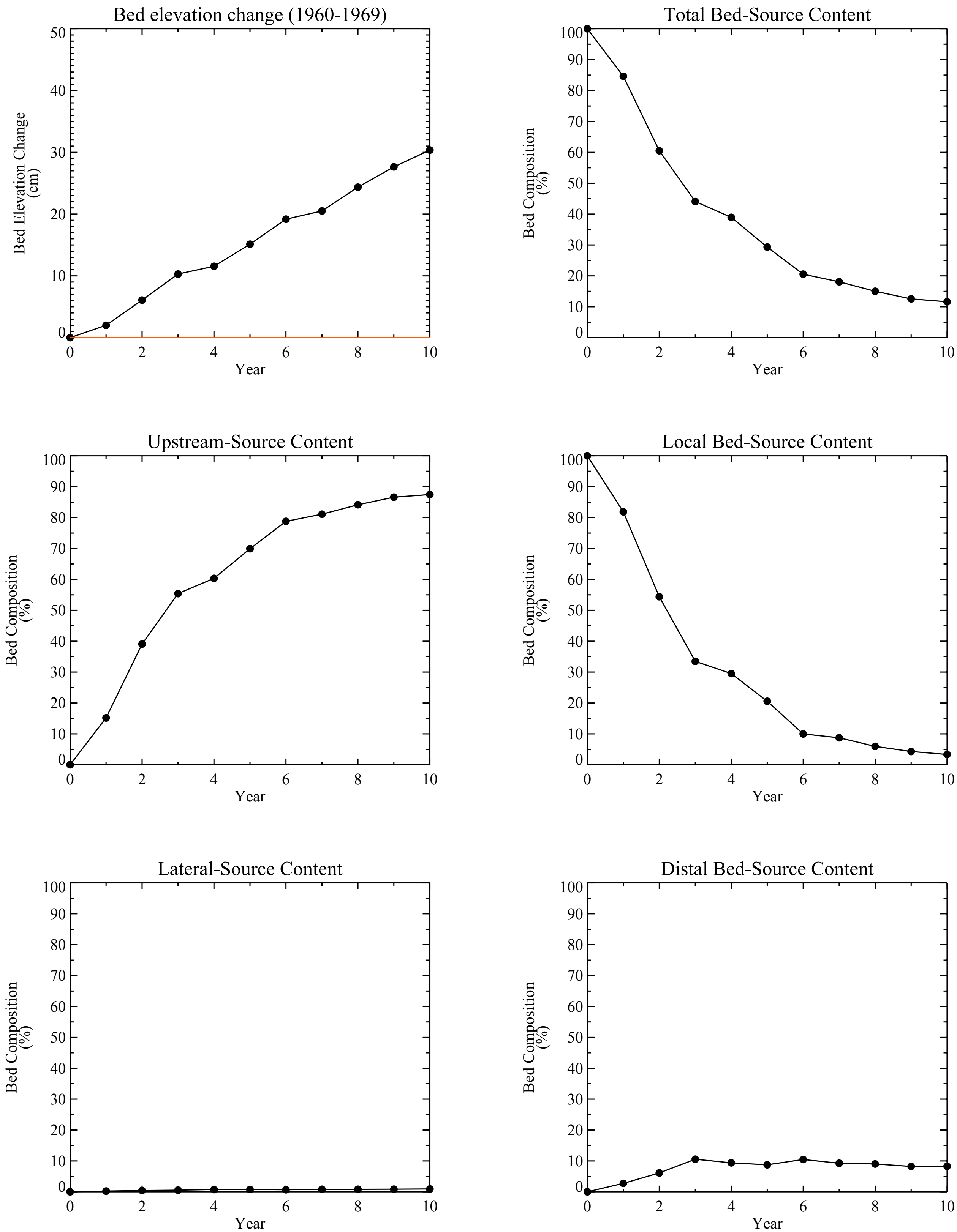


Figure 12. Temporal variation of bed elevation change and bed composition at grid cell: (14, 308), RM 2.1, Navigation Channel.

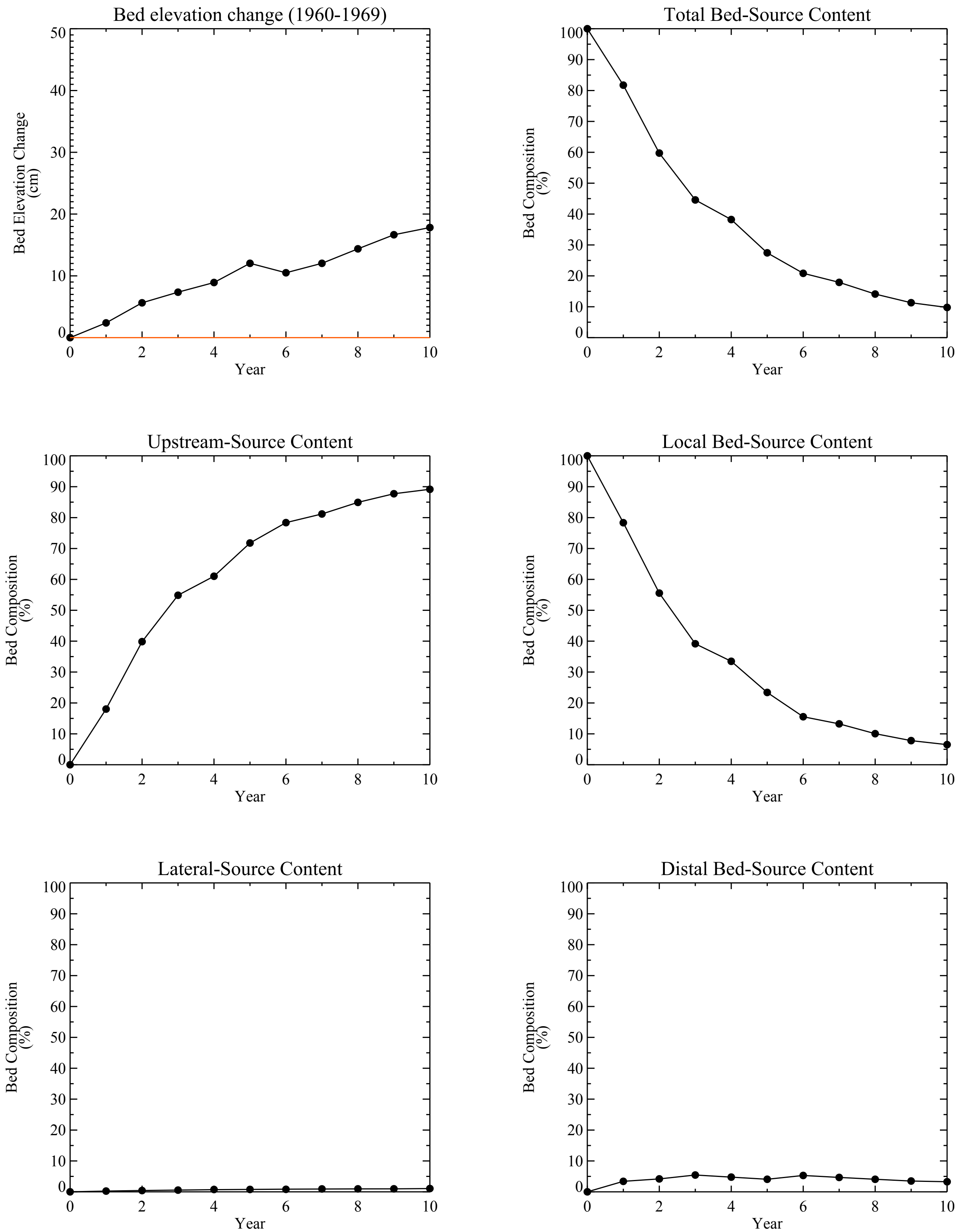


Figure 13. Temporal variation of bed elevation change and bed composition at grid cell: (16, 305), RM 2.3, East Bench.

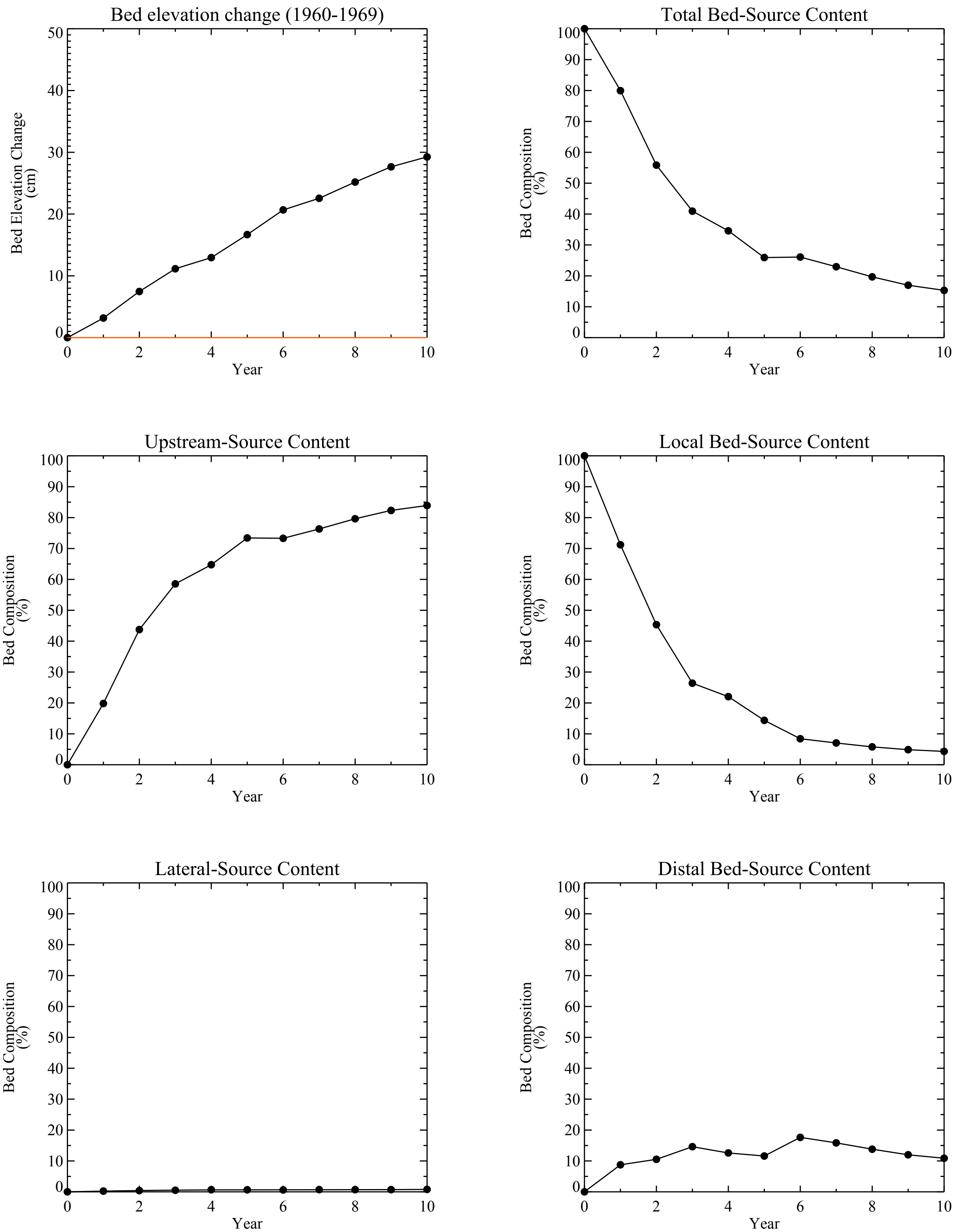


Figure 14. Temporal variation of bed elevation change and bed composition at grid cell: (14, 301), RM 2.6, Navigation Channel.

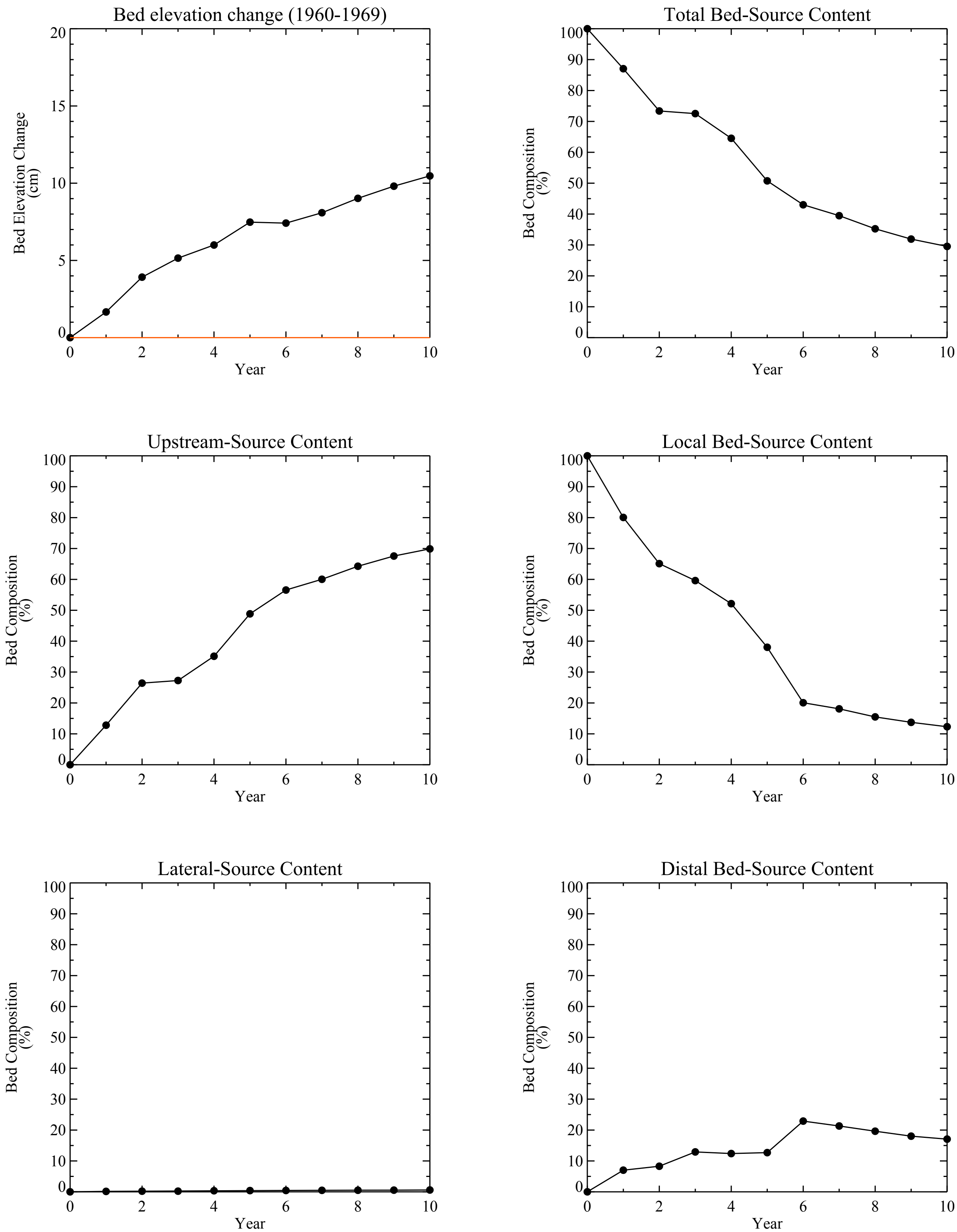


Figure 15. Temporal variation of bed elevation change and bed composition at grid cell: (14, 299), RM 2.7, Navigation Channel.

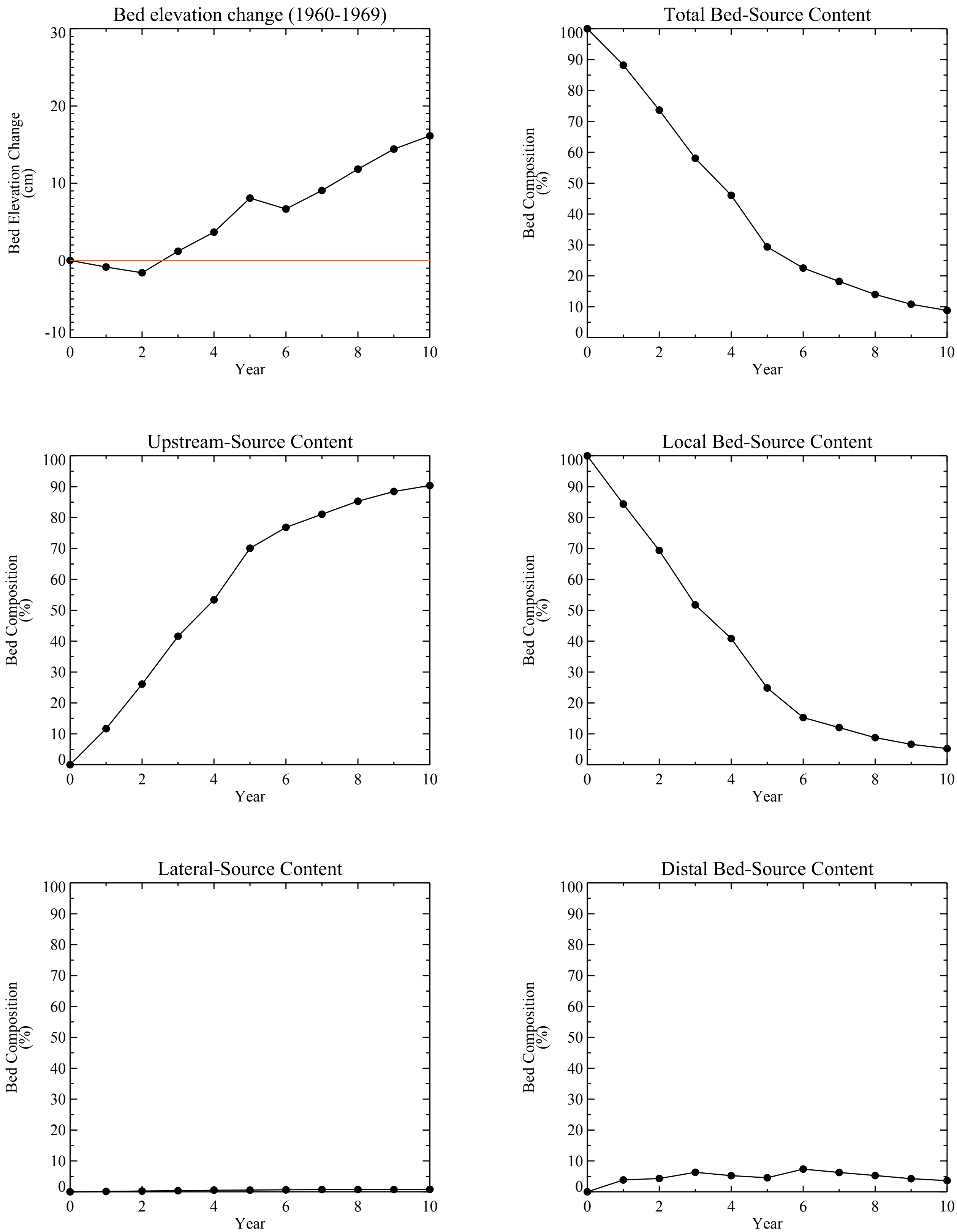


Figure 16. Temporal variation of bed elevation change and bed composition at grid cell: (15, 292), RM 3.1, Navigation Channel.

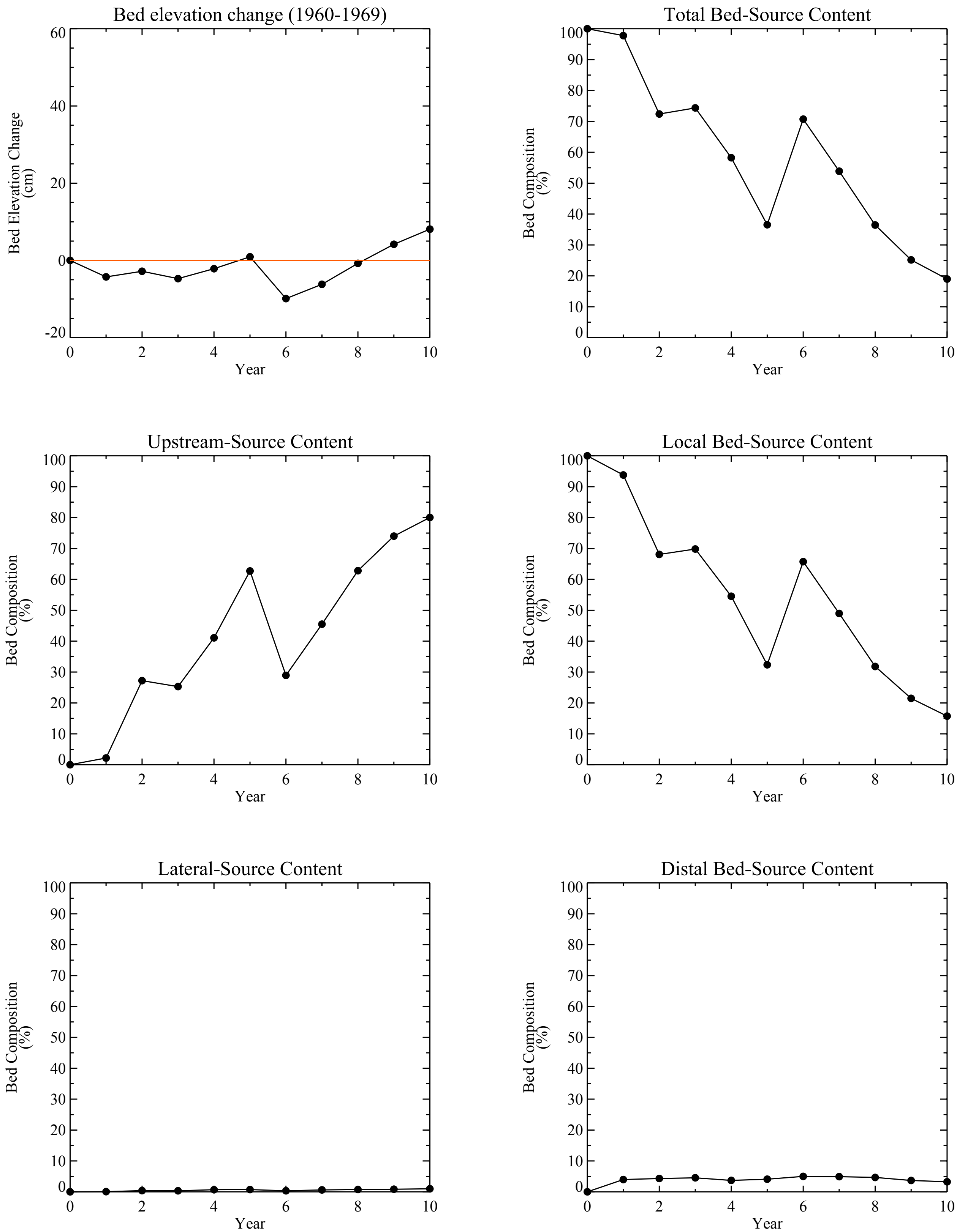


Figure 17. Temporal variation of bed elevation change and bed composition at grid cell: (16, 286), RM 3.6, East Bench.

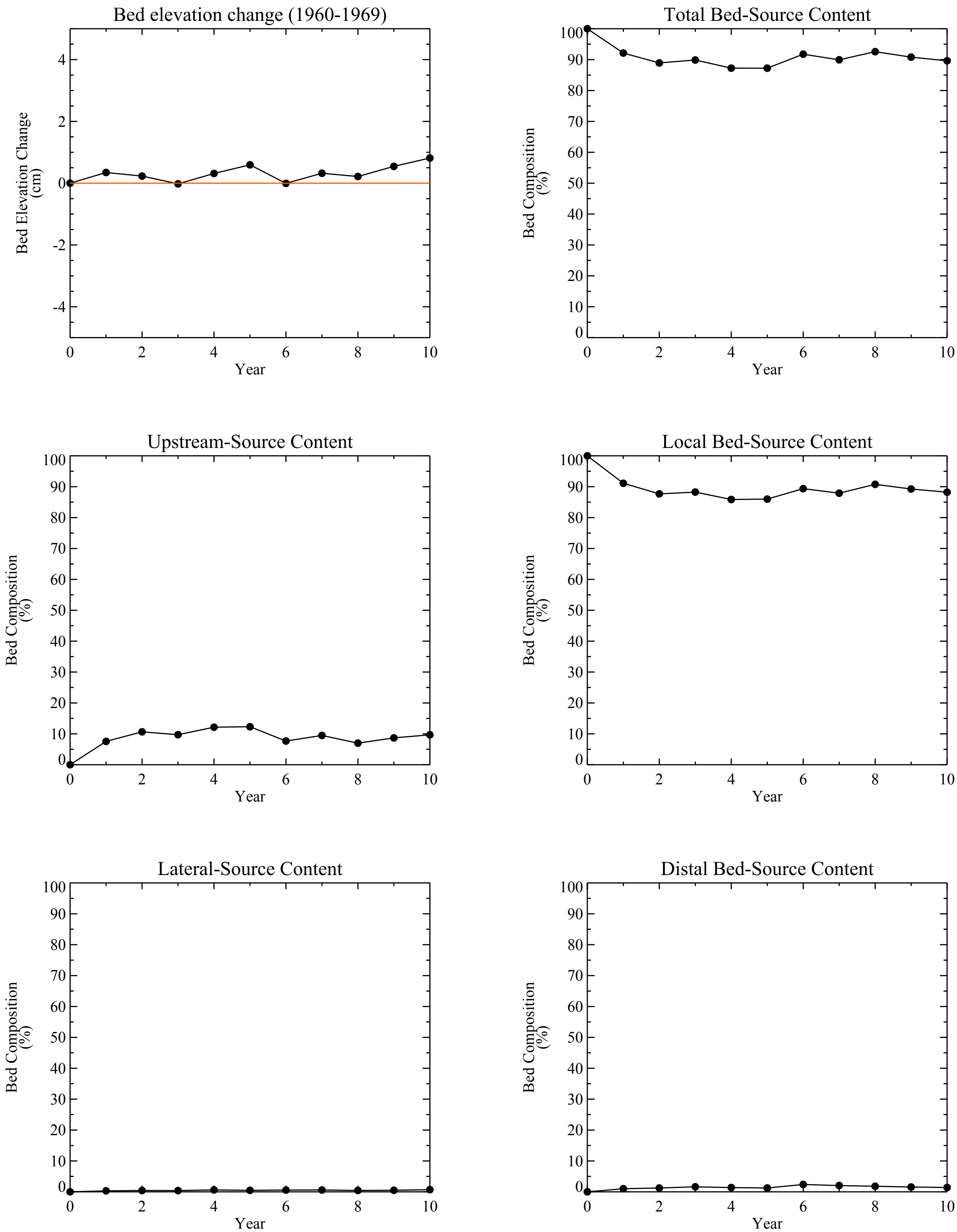


Figure 18. Temporal variation of bed elevation change and bed composition at grid cell: (17, 286), RM 3.6, East Bench.

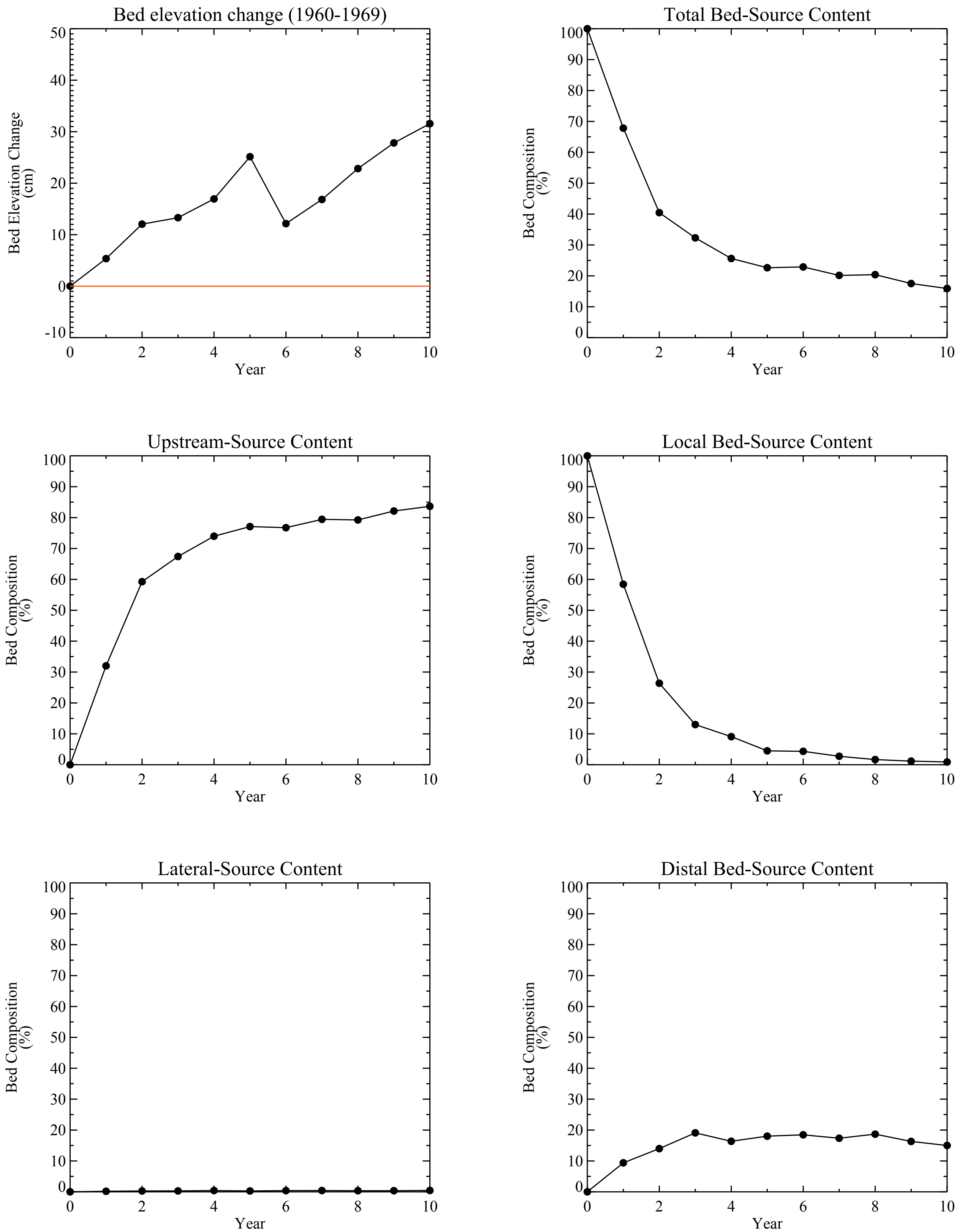


Figure 19. Temporal variation of bed elevation change and bed composition at grid cell: (14, 283), RM 3.9, Navigation Channel.

Part 6: Effects of STM Bounding Simulations on BCM Results

305 West Grand Avenue, Suite 300
Montvale, New Jersey 07645
Phone 201.930.9890
Fax 201.930.9805
www.anchorqea.com

MEMORANDUM

To:	Sediment Transport Modeling Group	**Date:**	October 15, 2010
From:	C. Kirk Ziegler, Anchor QEA, and AECOM	**Project:**	RETldw
Cc:	LDWG, Files		
Re:	Effects of STM Bounding Simulations on BCM Results		

Results from the sediment transport model (STM) are being used in the bed composition model (BCM) to evaluate various remedial alternatives in the Lower Duwamish Waterway (LDW). The effects on STM predictions due to uncertainty in model inputs were investigated by varying five model inputs: upstream sediment load, class 1A/1B settling speed, class 2/3 particle diameter, erosion rate parameters, and effective bed roughness. A complete description of that analysis is provided in Appendix D of the Final STM report (QEA 2008). The effects of model-input uncertainty in STM predictions on BCM results were evaluated by using lower- and upper-bound STM simulations in the BCM and comparing those results to results using the base-case STM simulation.

Ten-year simulations, corresponding to the first ten years of the 30-year simulation presented in the final STM report (QEA 2008), were conducted for this analysis. The STM was used to track sediment originating from three sources: 1) original bed sediment; 2) upstream loads (i.e., Green River); and 3) lateral loads (i.e., storm drains, combined sewer overflows [CSOs], streams). The lateral loads were specified using the distributed approach (see Part 4 Scenario 2 of this appendix) so as to more realistically represent the transport of those sediment sources in the STM.

The ranges of model inputs used in the base-case and bounding simulations (i.e., upper- and lower-bound) are listed in Table 1. Of the 32 simulations conducted in the STM uncertainty analysis (QEA 2008), four simulations were selected as reasonable bounding simulations for this BCM uncertainty analysis based on a review of the spatial-scale analyses (see Figures D-101 through D-132 of the STM report [QEA 2008]): runs 19 and 20 for lower-bounds; and runs 9 and 26 for upper-bounds. Runs 9 and 20 are the maximum reasonable bounding simulations, while runs 19 and 26 are the reasonable bounding simulations. The average difference between predicted and estimated net sedimentation rates (NSRs) for runs 20 and

9 were about -1 and +1 cm/yr, respectively, whereas the average difference in NSRs for runs 19 and 26 were approximately -0.5 and +0.5 cm/yr, respectively. The average difference for the base-case simulation was about 0.0 cm/yr. A summary of the model inputs for these four bounding simulations is provided in Table 2. The primary differences between the lower-bound (runs 19 and 20) and upper-bound (runs 9 and 26) simulations were the upstream sediment load and class 1A/1B settling speed.

Table 1. Model input values for STM bounding simulations.

Model Input	Base-Case Value	Lower-Bound Value	Upper-Bound Value
Upstream sediment load for 10-yr simulation period (MT)	1,852,100	926,700	3,703,000
Class 1A/1B settling speed (m/day)	1.3/20	0.65/10	2.6/40
Effective bed roughness (range in µm)	360 to 1,280	300 to 930	420 to 1,630
Class 2/3 particle diameter (µm)	130/540	110/450	150/630

Note: Erosion rate parameters vary among sediment layers in the model. See QEA 2008, Appendix E for bounding values.

Table 2. Model-input bounding limits for STM bounding simulations.

Bounding Simulation	Upstream Sediment Load	Class 1A/1B Settling Speed	Class 2/3 Particle Diameter	Erosion Rate Parameters	Effective Bed Roughness
Run 20: max reasonable lower-bound	Lower	Upper	Upper	Upper	Lower
Run 19: reasonable lower-bound	Lower	Upper	Lower	Upper	Lower
Run 26: reasonable upper-bound	Upper	Lower	Upper	Upper	Lower
Run 9: max reasonable upper-bound	Upper	Lower	Lower	Lower	Lower

<u>**Results**</u>

Sediment mass balances for the base-case and bounding simulations are shown in Figures 1 through 5. For the lower-bound simulations, the net deposition in the LDW decreases, relative to the base-case simulation, due to the upstream sediment load decreasing by about 50%. However, the predicted trapping efficiency increases for the lower-bound simulations primarily because of the increase in class 1A/1B settling speed. Net deposition in the LDW increases for the upper-bound simulations because of the 100% increase in upstream sediment load, with the trapping efficiency decreasing mainly because of a lower class 1A/1B settling speed.

Average NSR values for different reaches of the LDW for the base-case and lower- and upper-bound simulations are presented in Table 3. Graphical comparisons of the average NSR values for the three reaches [Reach 1, river mile [RM] 0 to 2.2; Reach 2, RM 2.2 to 4.0; and Reach 3, RM 4.0 to 4.8] are shown in Figures 6 through 10, with Figure 9 showing the average value for Reaches 1 and 2 combined. The average NSR for Reach 3 is for the cohesive bed area within that reach. In Reach 1, relatively small differences in average NSR values (i.e., 0.1 cm/yr) occurred between the two lower-bound (runs 19 and 20) and two upper-bound (runs 9 and 26) simulations, with larger differences occurring in Reach 2. Combining Reaches 1 and 2 produces average NSR values for the bounding simulations that are about $\pm$ 0.5 and $\pm$ 1.0 cm/yr different from the base-case value.

Table 3. Average net sedimentation rates (NSR) for STM uncertainty simulations.

Simulation	Site-Wide NSR (cm/yr)	Reach 1 NSR (cm/yr)	Reach 2 NSR (cm/yr)	Reach 1-2 NSR (cm/yr)	Reach 3 NSR (cm/yr)
Run 20: maximum reasonable lower-bound	1.9	1.2	1.2	1.2	9.2
Run 19: reasonable lower-bound	2.1	1.3	1.7	1.4	9.7
Base Case	**3.3**	**1.6**	**2.5**	**1.9**	**17**
Run 26: reasonable upper-bound	4.3	2.1	3.0	2.4	24
Run 9: maximum reasonable upper bound	5.0	2.2	4.5	2.8	27

The net sedimentation rates from base-case and bounding STM simulations were used by AECOM in the BCM to estimate spatially-weighted average concentrations (SWACs) for total PCBs within 10 years following completion of Alternative 1: No Further Action (Completion of EAAs). The BCM input parameters proposed by the Lower Duwamish Waterway Group (LDWG) as representing the total PCB concentrations for upstream Green/Duwamish River solids, lateral source solids (from storm drains, CSOs, and creeks), and post-remedy bed sediment replacement values were varied between low, mid, and high values (Table 4).

Table 4. LDWG-proposed total PCB input parameters for the BCM[1]

	Low (µg/kg dw)	Mid (µg/kg dw)	High (µg/kg dw)
Upstream Green/Duwamish River Solids	5	35	82
Lateral Source Solids	200	500	1,000
Post-Remedy Bed Sediment Replacement	30	60	90

This produced a total of 15 predictions of total PCB SWACs in the three reaches of the LDW. The site-wide results are presented in Table 5, with the results for Reaches 1, 2, and 3 presented in Tables 6, 7, and 8, respectively. The effects of uncertainty in STM predictions on BCM results are graphically illustrated in Figures 11 through 14. The following conclusions were developed from these figures:

- Generally, the site-wide PCB SWACs for the two lower-bound and two upper-bound simulations are similar. Thus, it is recommended that the maximum reasonable bounding simulations (i.e., runs 20 and 9) be used for future analyses and reporting, and that the reasonable bounding simulations (i.e., runs 19 and 26) not be considered in future analyses or discussions.
- The STM base case with the low and high BCM total PCB input values (Table 4) resulted in a wider range in PCB SWACs compared to the BCM mid values applied to the STM bounding runs.
- The total PCB SWACs estimated using the BCM respond in a non-linear fashion to average NSR values estimated by the STM.

[1] Values in Table 4 were the proposed input values as of November 17, 2009, when the analysis presented here was conducted. Final BCM input parameters are essentially the same for upstream and post-remedy bed sediment replacement values, but lower lateral low and mid values were used in the FS (see FS Table 5-1a).

Table 5. Year 10 Post Alternative 1 Total PCB SWACs: Site-Wide

Simulation	Total PCB SWAC (µg/kg dw)		
	Using Low BCM Input Parameter Values	Using Mid BCM Input Parameter Values	Using High BCM Input Parameter Values
Run 20: maximum reasonable lower-bound	78	104	145
Run 19: reasonable lower-bound	75	101	144
Base Case	**49**	**77**	**122**
Run 26: reasonable upper-bound	36	65	110
Run 9: maximum reasonable upper-bound	32	62	109

Table 6. Year 10 Post Alternative 1 Total PCB SWACs: Reach 1

Simulation	Total PCB SWAC (µg/kg dw)		
	Using Low BCM Input Parameter Values	Using Mid BCM Input Parameter Values	Using High BCM Input Parameter Values
Run 20: maximum reasonable lower-bound	89	114	154
Run 19: reasonable lower-bound	91	116	156
Base Case	**61**	**88**	**132**
Run 26: reasonable upper-bound	46	74	118
Run 9: maximum reasonable upper bound	43	72	117

Table 7. Year 10 Post Alternative 1 Total PCB SWACs: Reach 2

Simulation	Total PCB SWAC (µg/kg dw)		
	Using Low BCM Input Parameter Values	Using Mid BCM Input Parameter Values	Using High BCM Input Parameter Values
Run 20: maximum reasonable lower-bound	88	115	155
Run 19: reasonable lower-bound	72	101	145
Base Case	**43**	**73**	**119**
Run 26: reasonable upper-bound	29	59	106
Run 9: maximum reasonable upper-bound	22	54	102

Table 8. Year 10 Post Alternative 1 Total PCB SWACs: Reach 3

Simulation	Total PCB SWAC (µg/kg dw)		
	Using Low BCM Input Parameter Values	Using Mid BCM Input Parameter Values	Using High BCM Input Parameter Values
Run 20: maximum reasonable lower-bound	15	46	95
Run 19: reasonable lower-bound	16	46	94
Base Case	**12**	**42**	**90**
Run 26: reasonable upper-bound	9	40	88
Run 9: maximum reasonable upper-bound	9	40	88

Ranges of total PCB SWACs predicted by the BCM for the base-case STM results and for the lower- and upper-bound STM results are presented in Table 9 and graphically illustrated in Figures 15 through 18. For the STM base-case results (first column in Table 9), the ranges correspond to the differences resulting from using the high and low BCM input parameter values for total PCBs. For the STM range results (columns 2 through 4 in Table 9) the difference is the maximum difference among the upper and lower bound runs.

Table 9. Range of total PCB SWACs for STM uncertainty simulations.

LDW Reach	Range in Total PCB SWACs (µg/kg dw)			
	STM Base-Case Varying Only the BCM Input Parameters	Over the Range of STM Uncertainty Results		
		Using the Low BCM Input Parameters	Using the Mid BCM Input Parameters	Using the High BCM Input Parameters
Site-Wide	73	46	42	36
Reach 1	71	48	44	39
Reach 2	76	66	61	53
Reach 3	78	7	6	7

Discussion

A non-linear relationship exists between average NSR values estimated by the STM and total PCB SWACs predicted by the BCM. This non-linearity is caused primarily by mixing in the surface (top 10 cm) layer of the bed due to erosion and deposition processes. As discussed in the STM report (QEA 2008), the relationship between half-time of bed-source content in the surface layer and NSR is non-linear and multi-valued (i.e., range of half-time values for a specific NSR value) (see Figure F-37 [QEA 2008]). The primary cause of this non-linear relationship is episodic erosion and deposition at the spatial scale of a grid cell.

The following simplified calculation will help illustrate this non-linear process. First, it is useful to note that NSR is determined by the difference between the gross deposition (D_g) and erosion (E_g) rates:

$$NSR = D_g - E_g$$

where D_g and E_g are calculated by the STM. Second, the rate of change (decrease) of bed-source content in the surface layer is affected by both the absolute value of NSR and the relative values of D_g and E_g. A simplified example of the effect of the relative values of D_g and E_g is shown in Figure 19. This example calculation makes the following assumptions: 1) a generic chemical is permanently bound to sediment particles; 2) change in bed concentration is only due to erosion and deposition processes; 3) initial bed concentration is 10 ppm; 4) depositing sediment is "clean" (i.e., concentration on depositing particles is 0 ppm); 5) surface layer is 10 cm thick; and 6) NSR is 0.5 cm/yr. Two different combinations of D_g and E_g, with the difference between the gross fluxes being 0.5 cm/yr for each combination, were used to calculate the change in bed concentration at a specific location over a 1-year period. For the lower values of D_g and E_g (left-hand panel in Figure 19), the bed concentration decreased by 9%, from 10 to 9.1 ppm. For the higher values of D_g and E_g (right-hand panel in Figure 19), the bed concentration decreased from 10 to 7.1 ppm, which corresponds to a much higher rate of change than for the situation with lower values of D_g and E_g. Thus, significant differences in the rate of change in sediment chemical concentrations can occur at two grid cells with the same NSR values but with different gross erosion and deposition fluxes.

Additional Results

Spatial distributions of estimated NSRs for the maximum reasonable bounding simulations as compared to the base-case simulation for Reaches 1, 2, and 3 are presented on Figures 20 through 22. Generally, the lower-bound simulation yielded lower NSR values than the base-case simulation and higher NSR values were estimated by the upper-bound simulation. The spatial distribution of differences in NSR values between the upper- and lower-bound simulations are shown in Figure 23.

Predicted total PCB concentrations for 10 years following completion of Alternative 1, using the mid PCB concentrations for input to the BCM, are compared for the base-case, lower-bound, and upper-bound STM simulations in Figures 24, 25, and 26. The comparisons shown on these figures illustrate the effects of STM sensitivity simulations on the spatial distributions of total PCB concentrations.

Spatial distributions of predicted total PCB concentrations for 10 years following completion of Alternative 1, using the base-case STM results, are compared for the low, mid, and high inputs to the BCM in Figures 27, 28, and 29. These results demonstrate the sensitivity of the BCM to variations in the PCB input parameters.

Conclusions

The results presented above demonstrate that:

- The range in total PCB SWACs attributable to STM uncertainty is similar using the low and mid BCM input parameter values for total PCBs, and lower using the high BCM input parameter values.
- For site-wide and Reach 1 averages, the range in total PCB SWACs attributable to STM uncertainty is about 40% lower than the range attributable to uncertainty in the BCM input parameter values. For Reach 2, the range in total PCB SWACs attributable to STM uncertainty is about 20% lower than the range attributable to uncertainty in the BCM input parameter values. For Reach 3, STM uncertainty results in minimal uncertainty in BCM predictions.

Attachments

Figures 1 - 5	Sediment mass balances in the LDW for 10-year period for base-case and bounding simulations
Figures 6 - 10	Estimated average net sedimentation rates for base-case and bounding simulations
Figures 11 - 14	Effects of uncertainty in STM predictions on BCM results, expressed as total PCB SWAC
Figures 15 - 18	Estimated range of total PCB SWACs
Figure 19	Comparison of rate of bed concentration change due to differences in erosion-deposition conditions
Figure 20	Year 10 Net Sedimentation Rates for Redistributed Lateral Load Base Case, Upper, and Lower Bounding Runs: RM 0.0 to 1.9 (+/- 1.0 cm/yr)
Figure 21	Year 10 Net Sedimentation Rates for Redistributed Lateral Load Base Case, Upper, and Lower Bounding Runs: RM 1.9 to 3.6 (+/- 1.0 cm/yr)
Figure 22	Year 10 Net Sedimentation Rates for Redistributed Lateral Load Base Case, Upper, and Lower Bounding Runs: RM 3.6 to 5.0 (+/- 1.0 cm/yr)
Figure 23	Difference Between 10 Year Redistributed Lateral Load Base Case and Bounding Run Sedimentation Rates (+/- 1.0 cm/yr)
Figure 24	Year 10 Post Alternative 1 Total PCB Concentrations: STM Bounding Runs and BCM Mid Input Values (RM 0.0 to 1.9)
Figure 25	Year 10 Post Alternative 1 Total PCB Concentrations: STM Bounding Runs and BCM Mid Input Values (RM 1.9 to 3.6)
Figure 26	Year 10 Post Alternative 1 Total PCB Concentrations: STM Bounding Runs and BCM Mid Input Values (RM 3.6 to 5.0)
Figure 27	Year 10 Post Alternative 1 Total PCB Concentrations: BCM Bounding Values and STM Base Case (RM 0.0 to 1.9)
Figure 28	Year 10 Post Alternative 1 Total PCB Concentrations: BCM Bounding Values and STM Base Case (RM 1.9 to 3.6)
Figure 29	Year 10 post Alternative 1 total PCB concentrations: BCM Bounding Values and STM Base Case (RM 3.6 to 5.0)

Reference

QEA 2008. *Lower Duwamish Waterway Sediment Transport Modeling Report. Final.* Prepared for the Lower Duwamish Waterway Group for submittal to the U.S. Environmental Protection Agency, Region 10, and Washington State Department of Ecology. Quantitative Environmental Analysis, LLC, Montvale, NJ. October 2008.

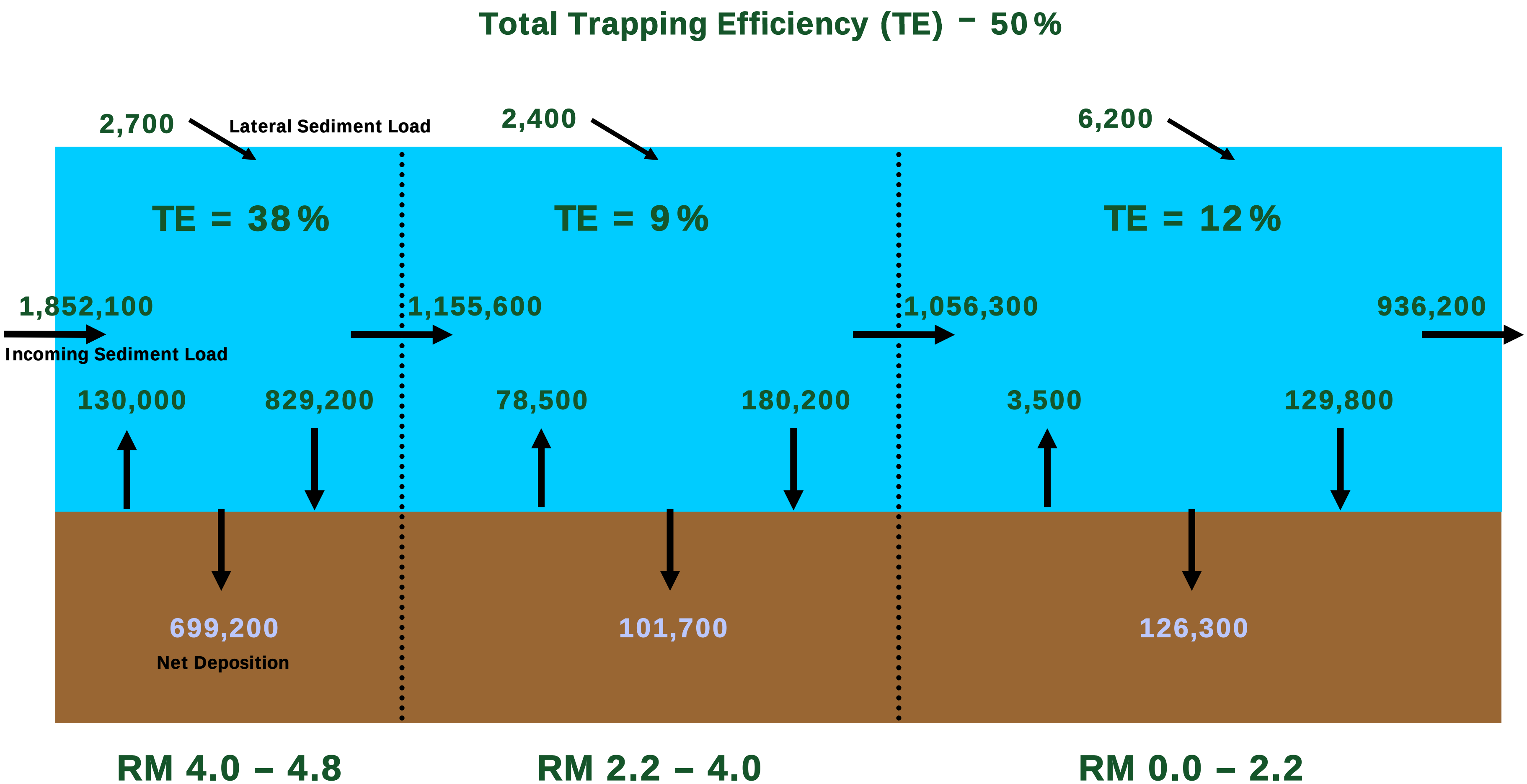


Figure 1. Sediment mass balance in the LDW (RM 0 – 4.8) for 10-year period: base case. Mass units are metric tons. Trapping efficiency is percentage of incoming sediment load that is deposited within a reach.

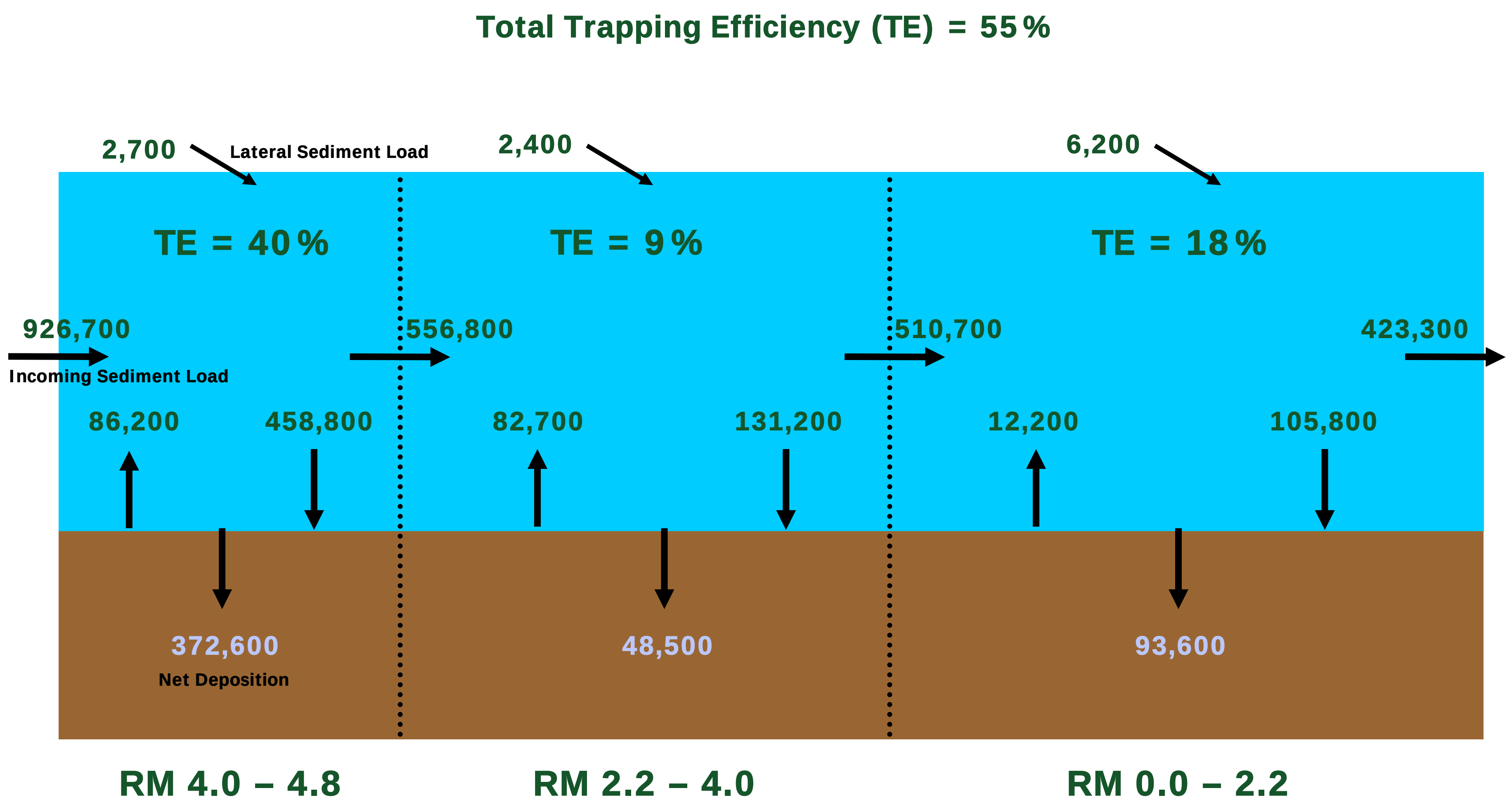


Figure 2. Sediment mass balance in the LDW (RM 0 – 4.8) for 10-year period: run 20, lower-bound 1. Mass units are metric tons. Trapping efficiency is percentage of incoming sediment load that is deposited within a reach.

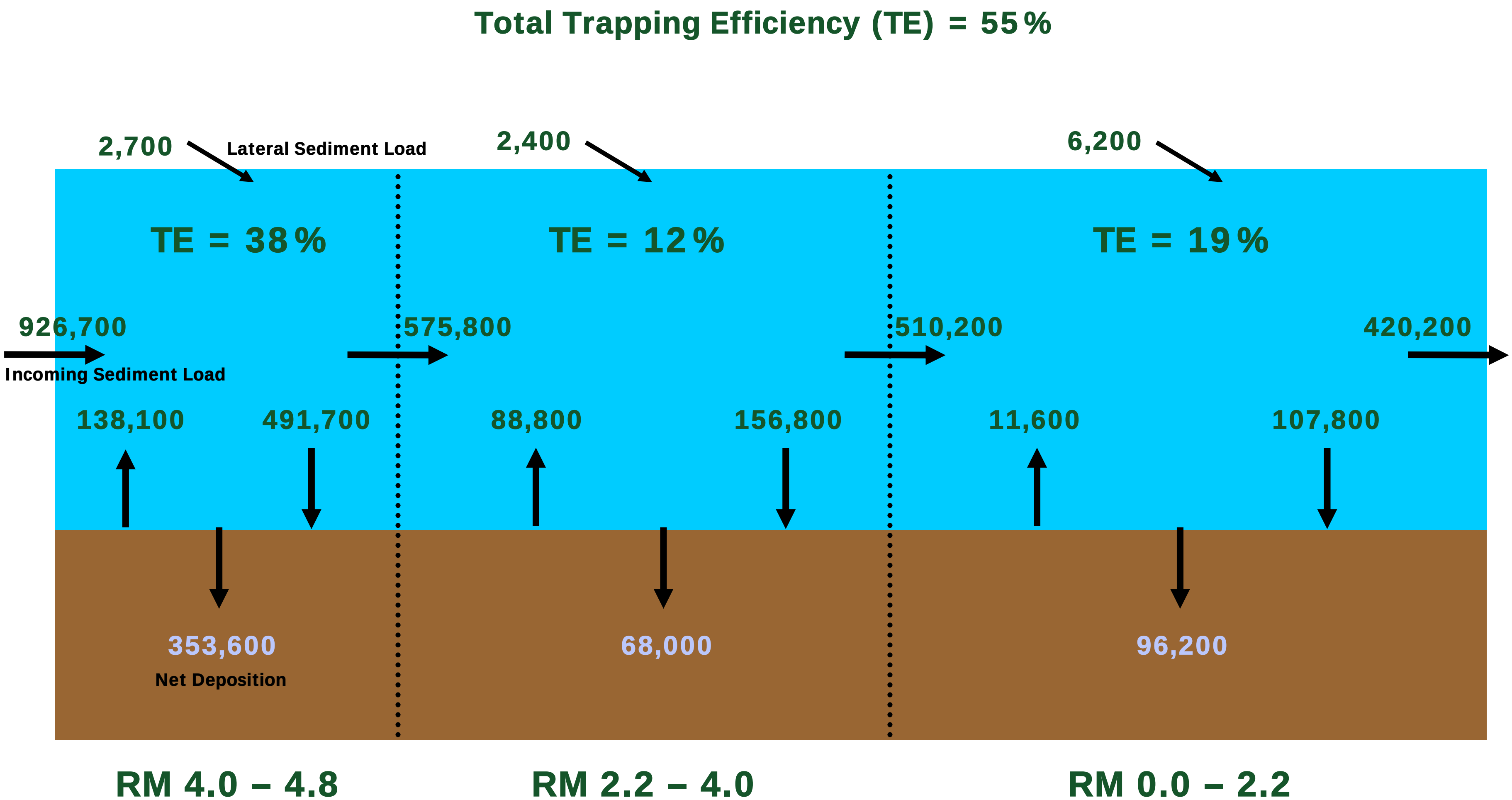


Figure 3. Sediment mass balance in the LDW (RM 0 – 4.8) for 10-year period: run 19, lower-bound 2. Mass units are metric tons. Trapping efficiency is percentage of incoming sediment load that is deposited within a reach.

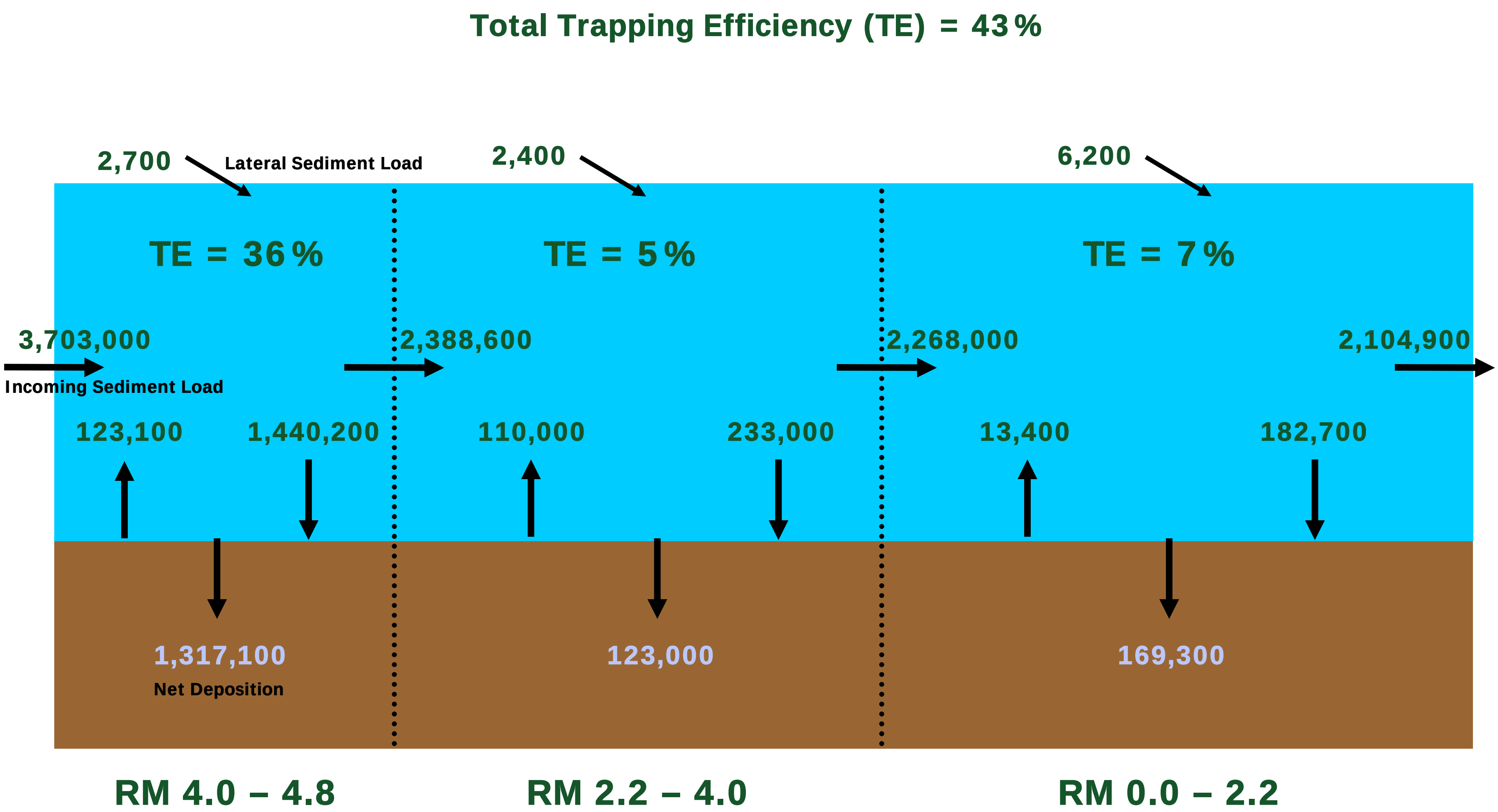


Figure 4. Sediment mass balance in the LDW (RM 0 – 4.8) for 10-year period: run 26, upper-bound 2. Mass units are metric tons. Trapping efficiency is percentage of incoming sediment load that is deposited within a reach.

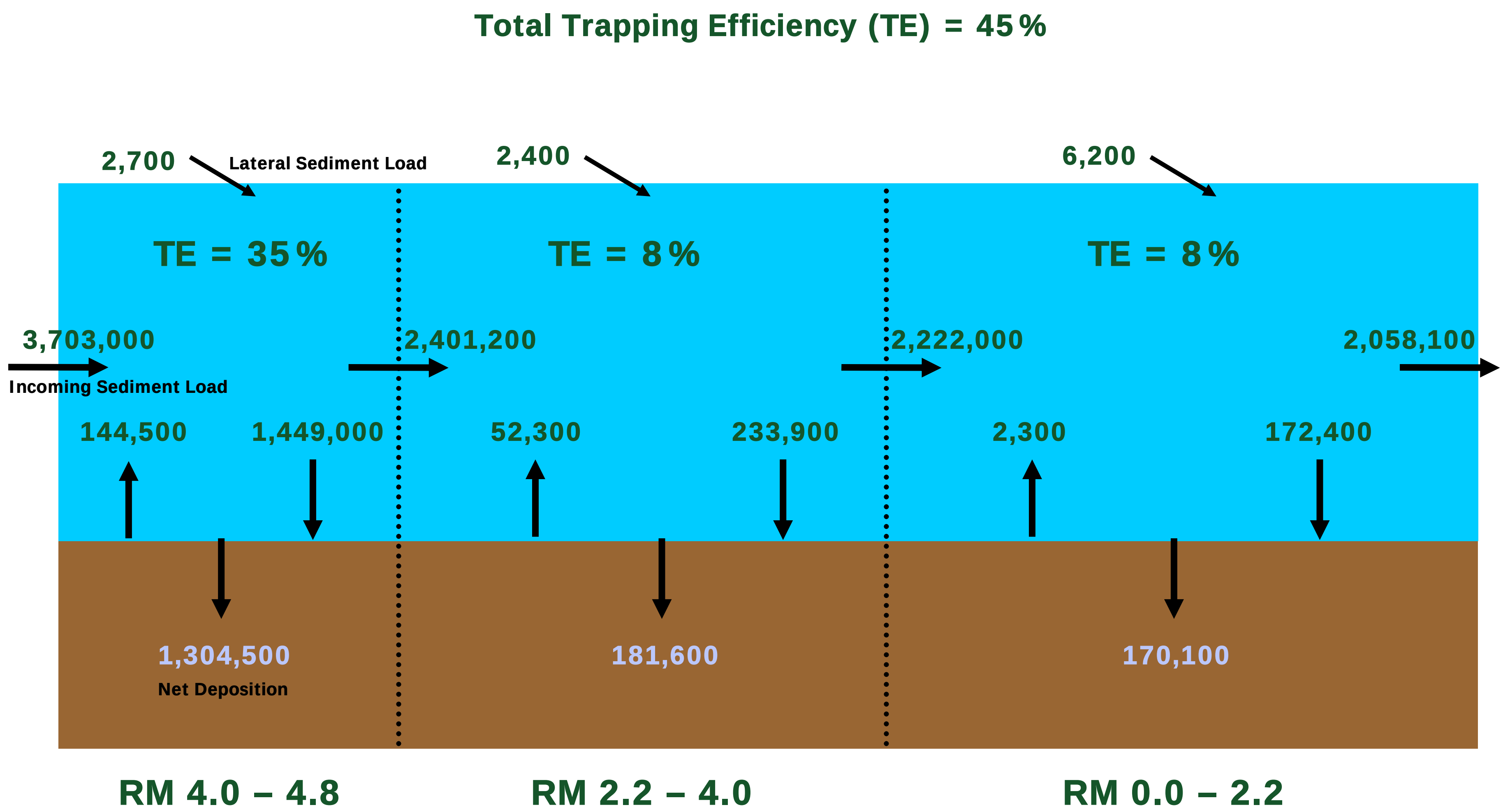


Figure 5. Sediment mass balance in the LDW (RM 0 – 4.8) for 10-year period, run 9, upper-bound 1. Mass units are metric tons. Trapping efficiency is percentage of incoming sediment load that is deposited within a reach.

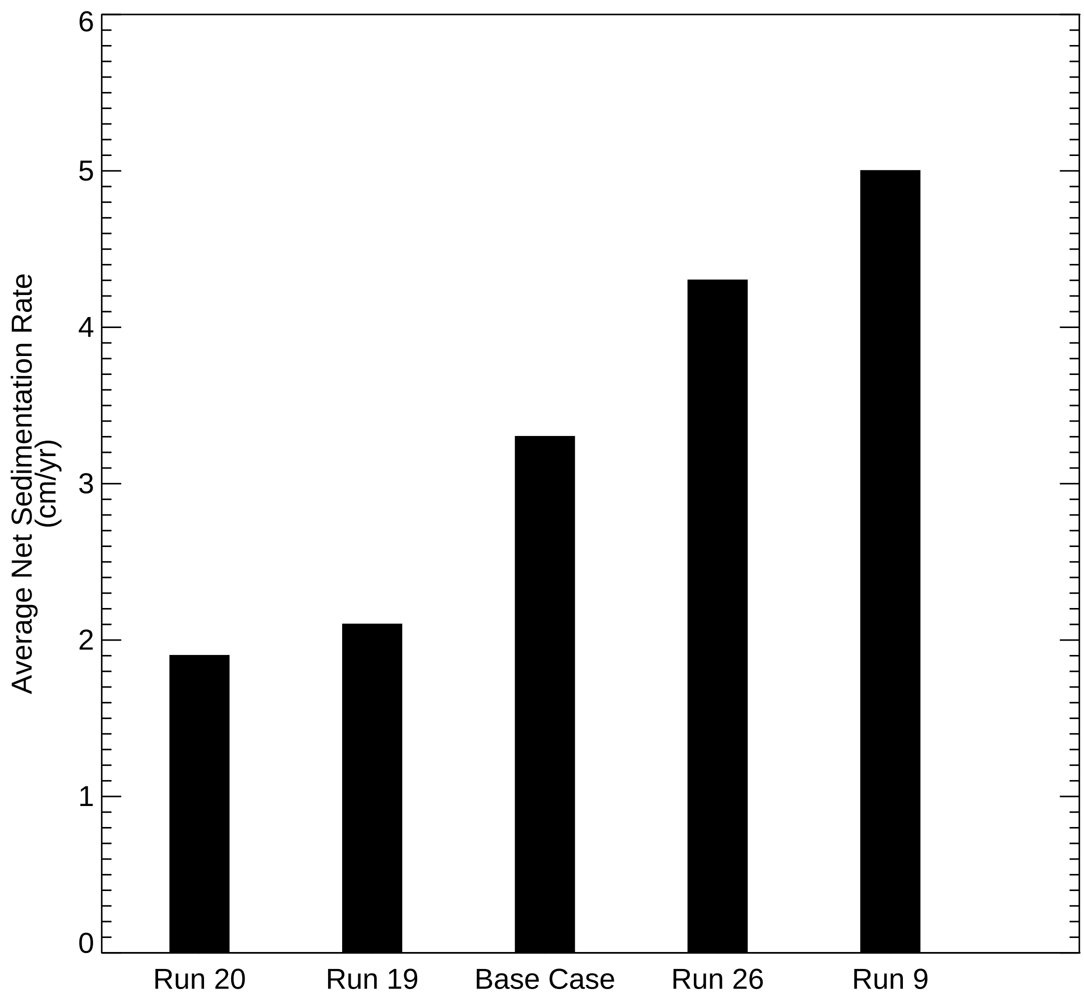


Figure 6. Estimated site-wide average net sedimentation rate.

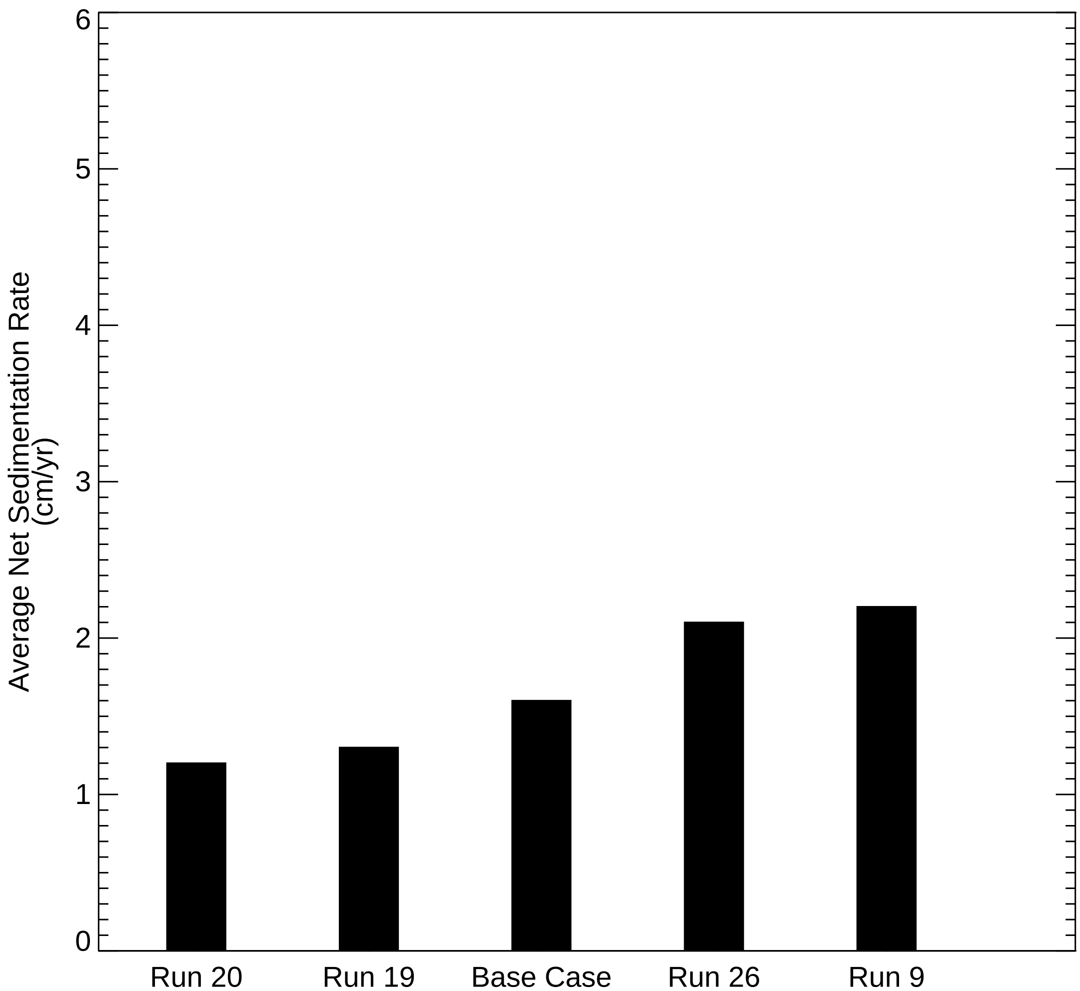


Figure 7. Estimated Reach 1 average net sedimentation rate.

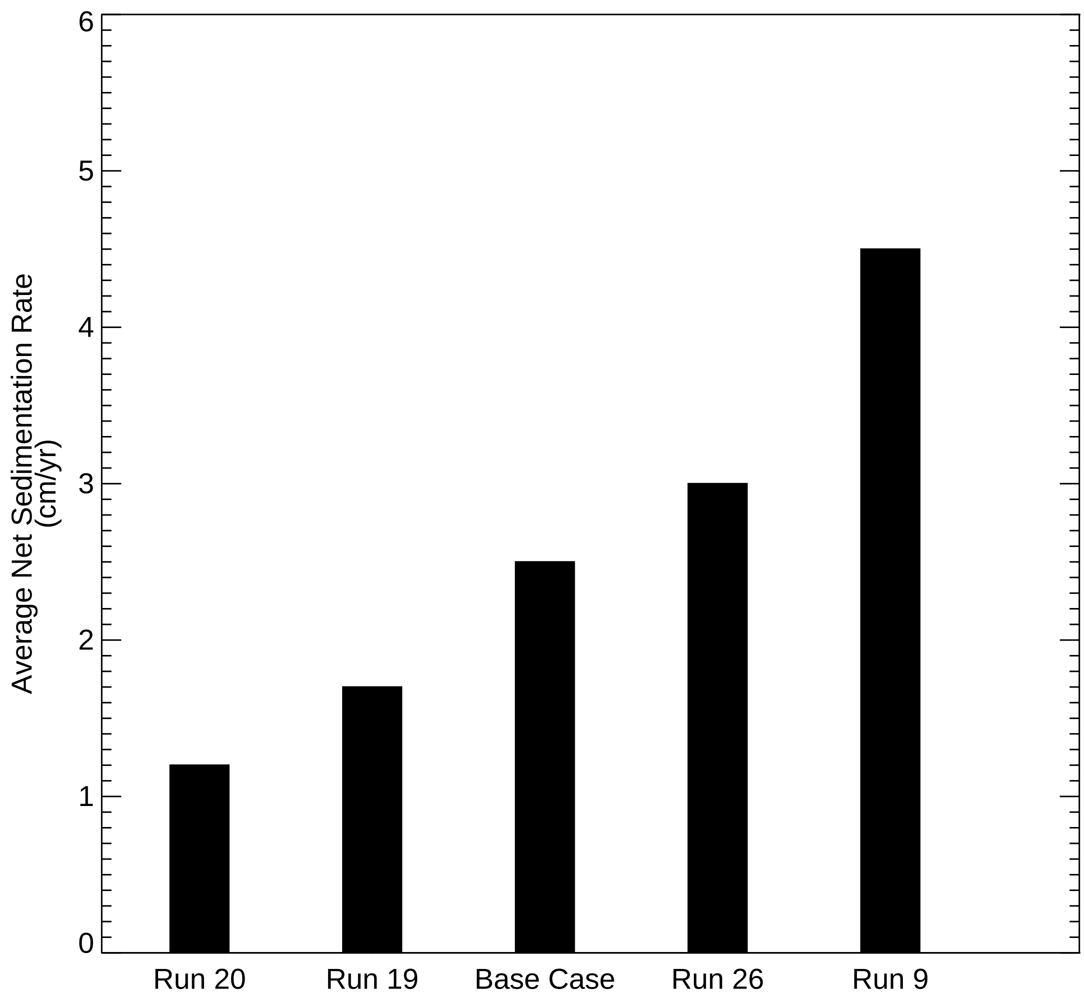


Figure 8. Estimated Reach 2 average net sedimentation rate.

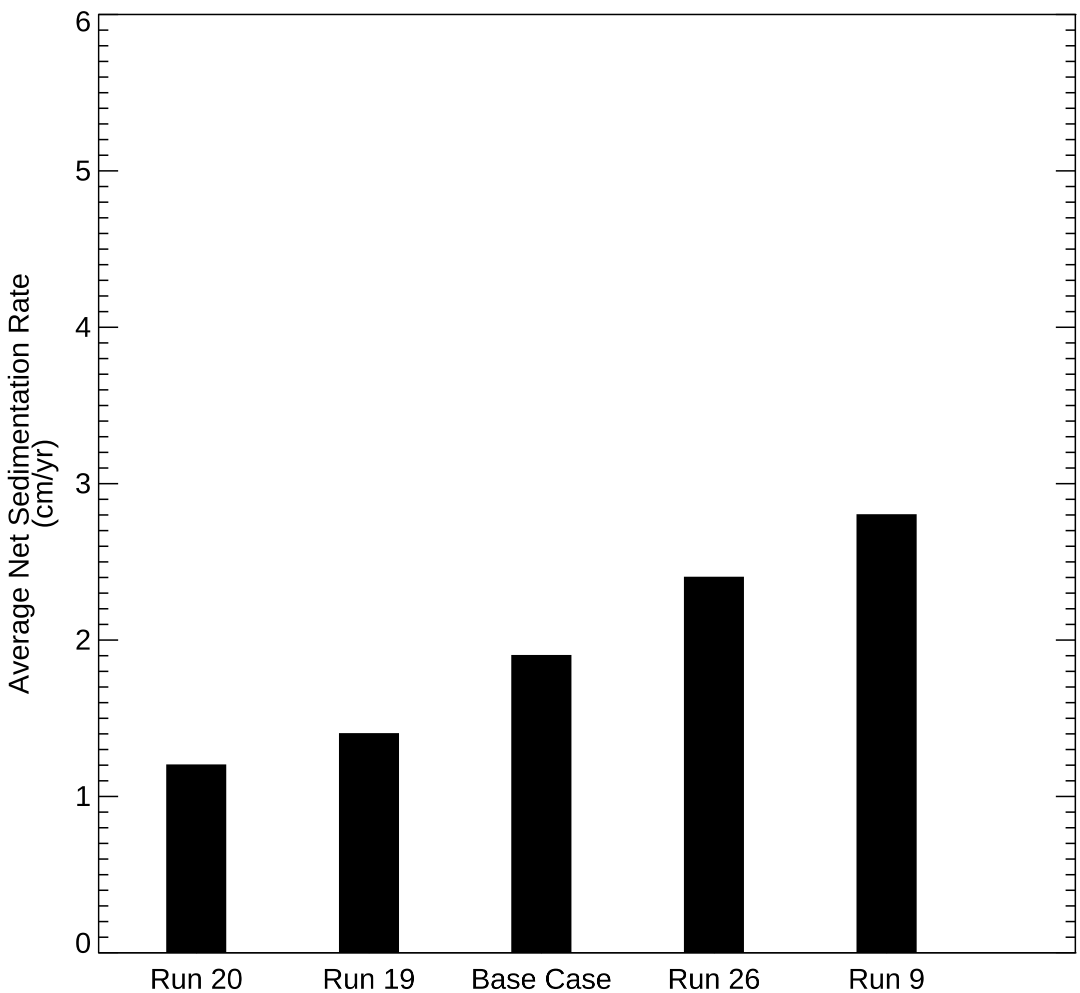


Figure 9. Estimated Reach 1 and 2 average net sedimentation rate.

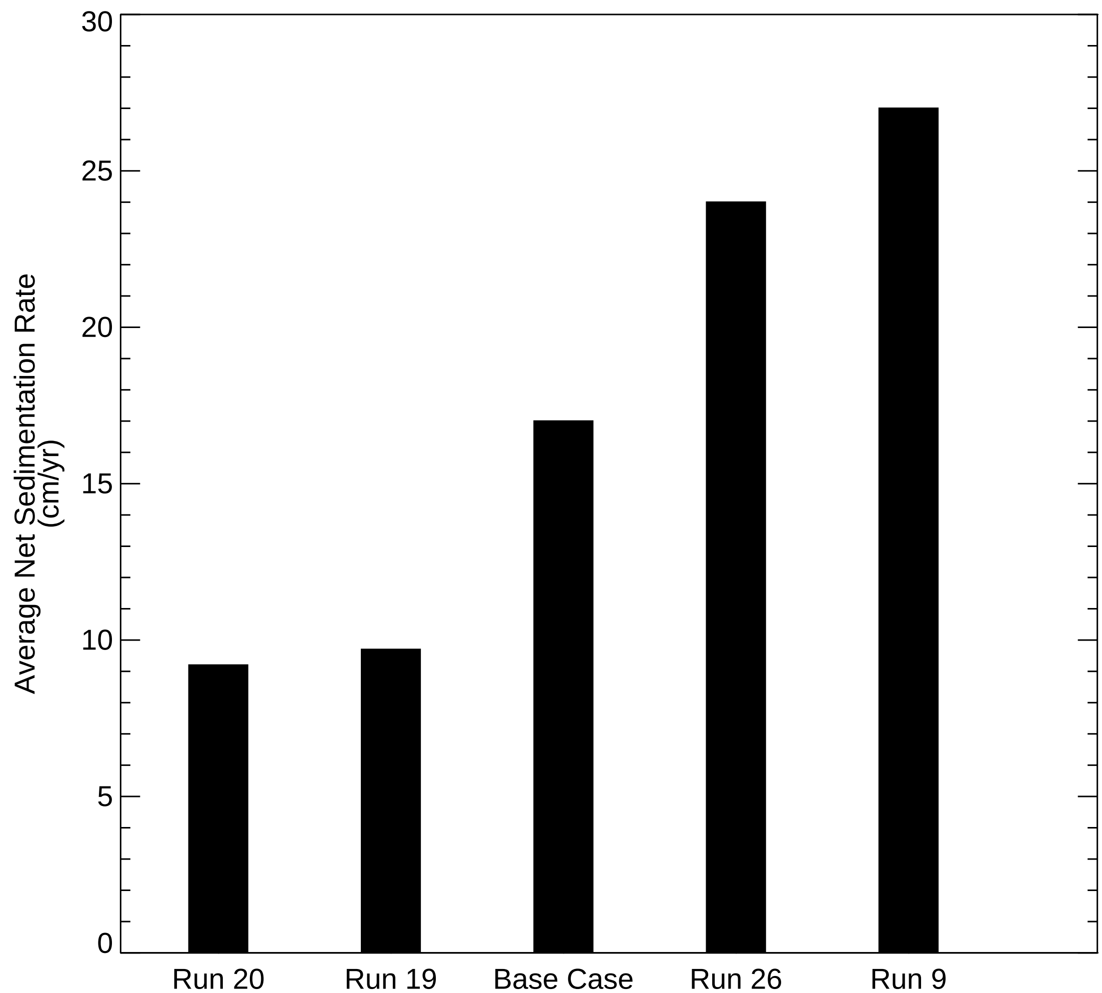


Figure 10. Estimated Reach 3 average net sedimentation rate (cohesive bed area).

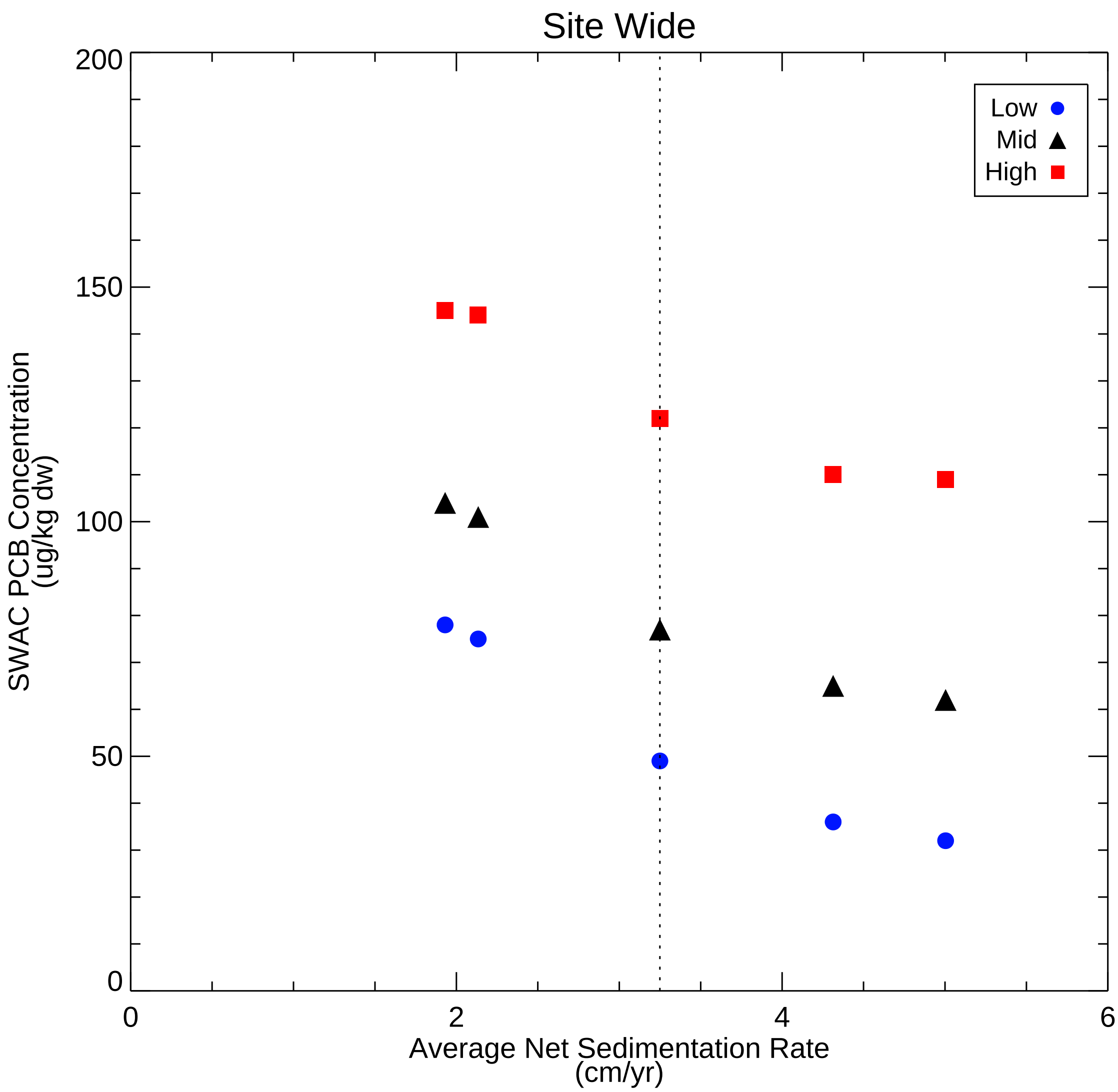


Figure 11. Year 10 Post Alt 1 (post-EAAs) distributed Lateral Load SWACs - Total PCBs.

Exploratory STM/BCM Analysis, last updated by AGF on November 20, 2009.

Dashed line represents base case sedimentation rate.

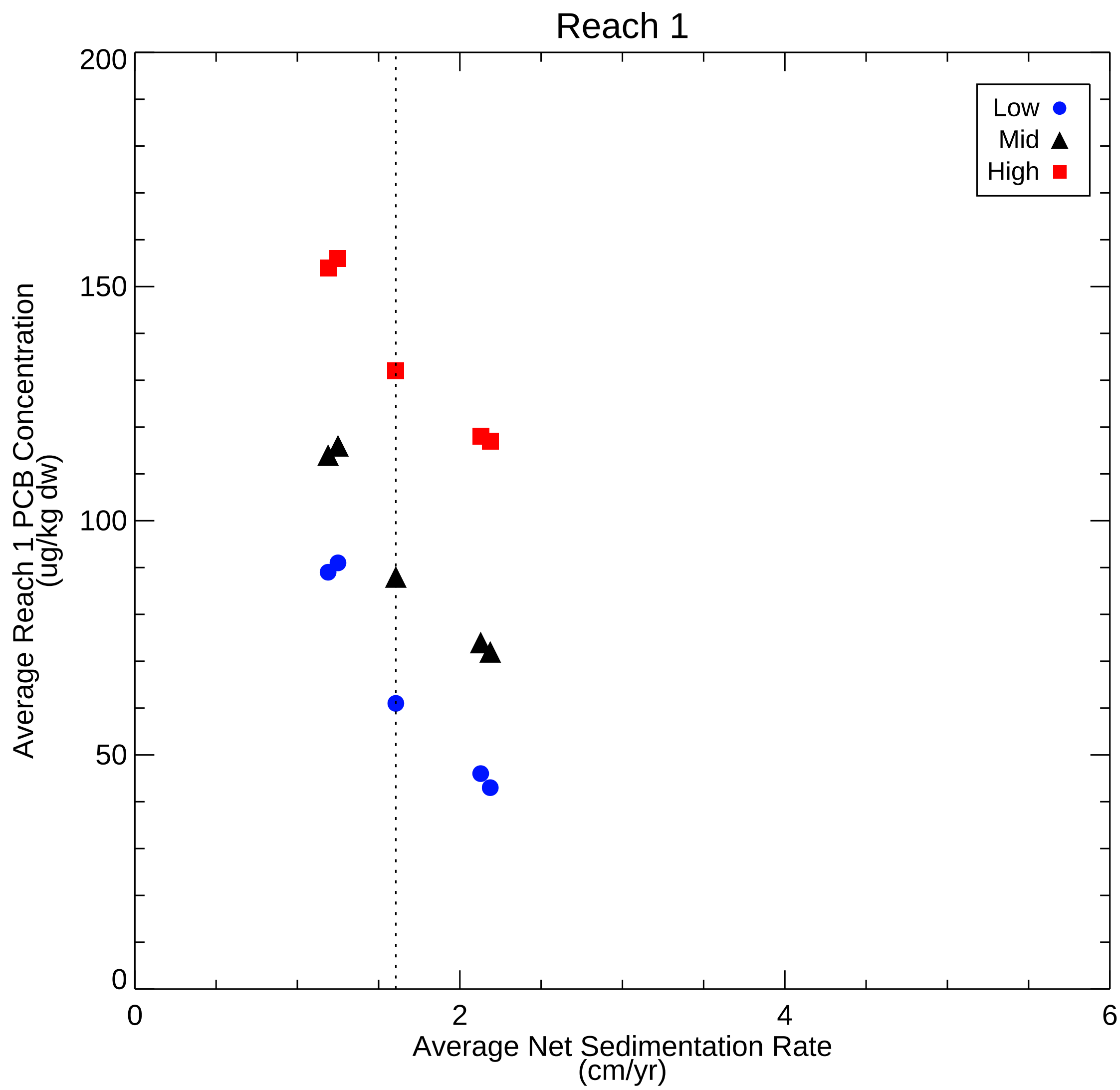


Figure 12. Year 10 Post Alt 1 (post-EAAs) distributed Lateral Load SWACs - Total PCBs.

Exploratory STM/BCM Analysis, last updated by AGF on November 20, 2009.

Dashed line represents base case sedimentation rate.

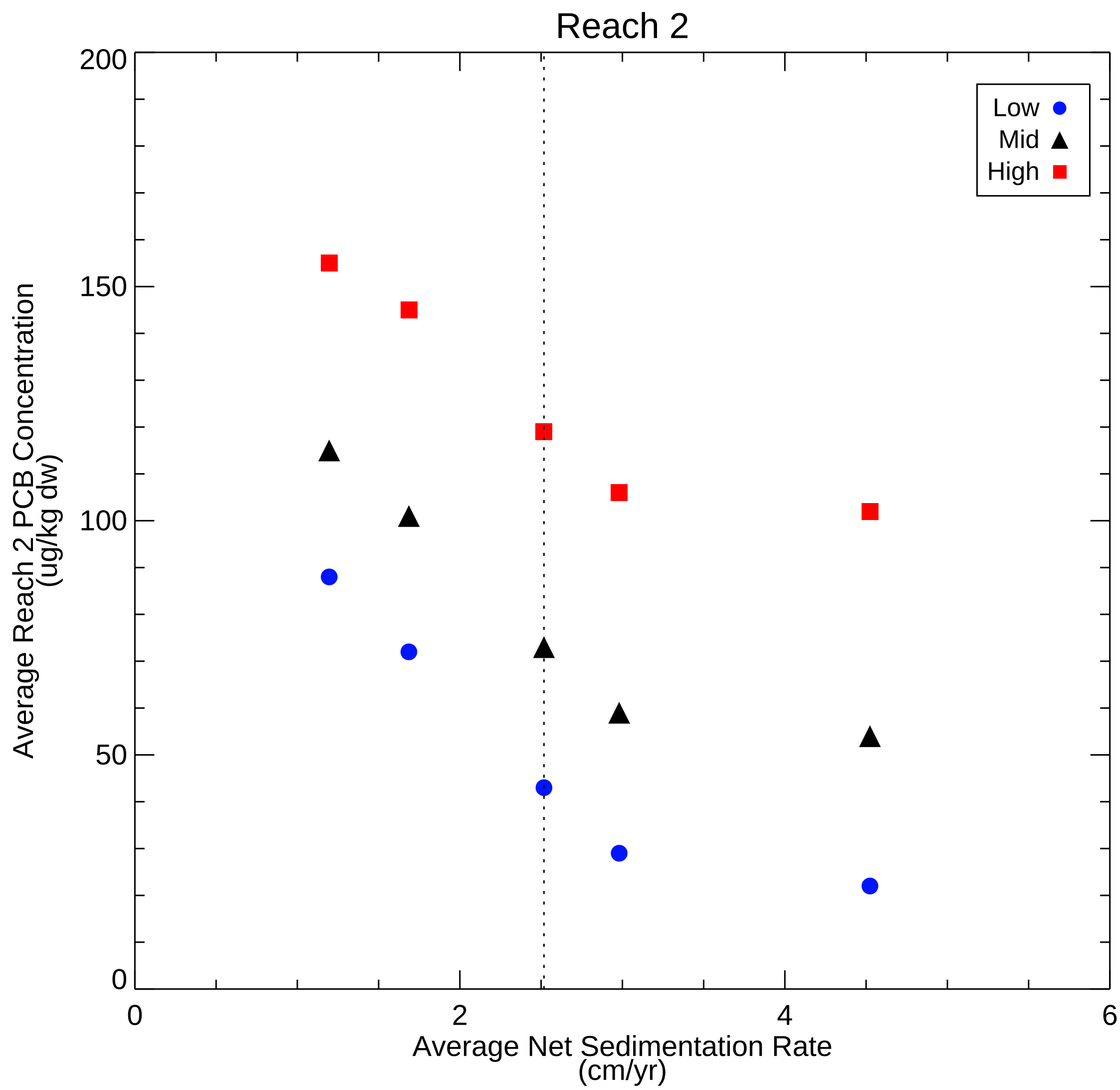


Figure 13. Year 10 Post Alt 1 (post-EAAs) distributed Lateral Load SWACs - Total PCBs.

Exploratory STM/BCM Analysis, last updated by AGF on November 20, 2009.

Dashed line represents base case sedimentation rate.

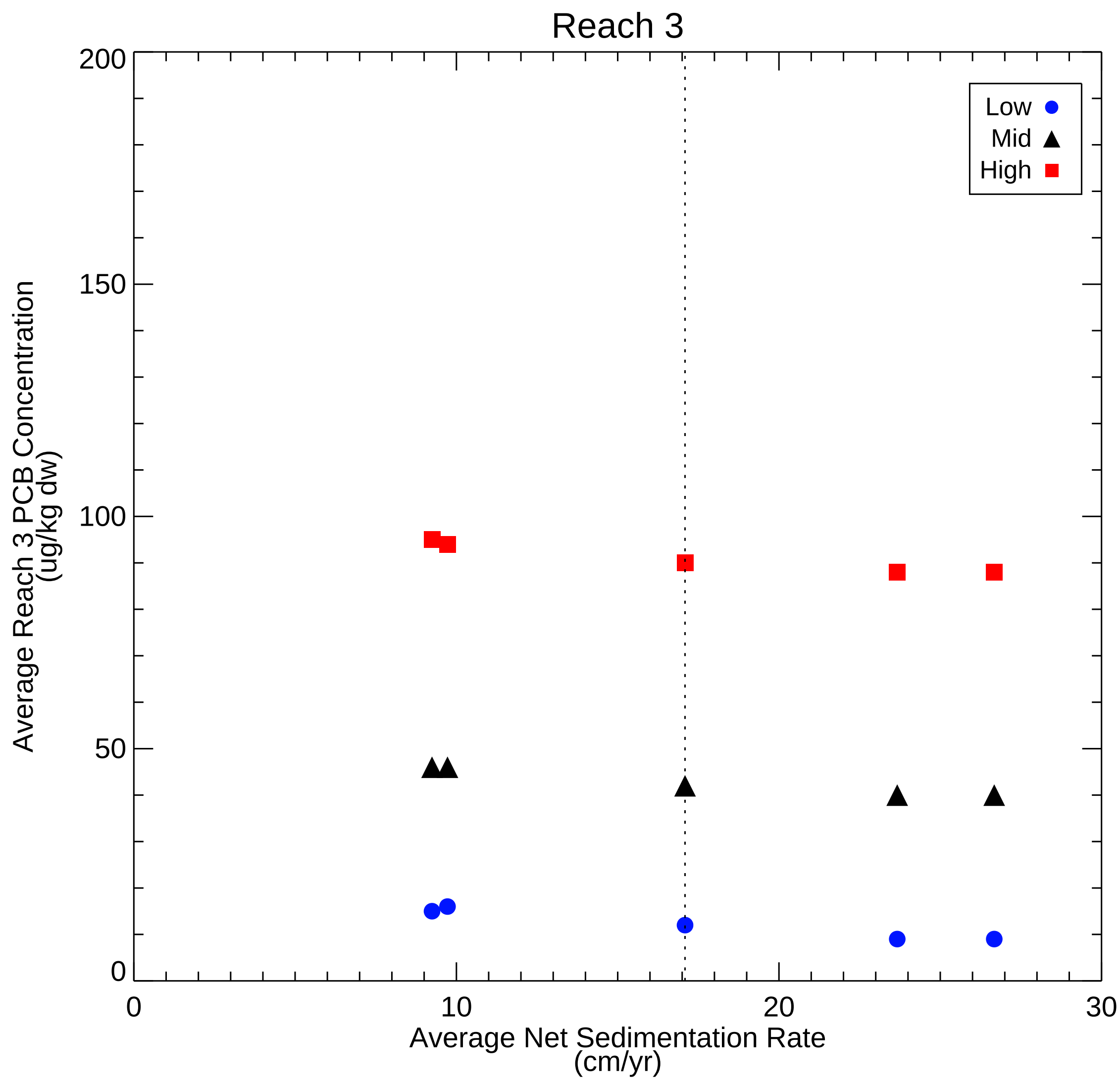


Figure 14. Year 10 Post Alt 1 (post-EAAs) distributed Lateral Load SWACs - Total PCBs.

Exploratory STM/BCM Analysis, last updated by AGF on November 20, 2009.

Dashed line represents base case sedimentation rate.

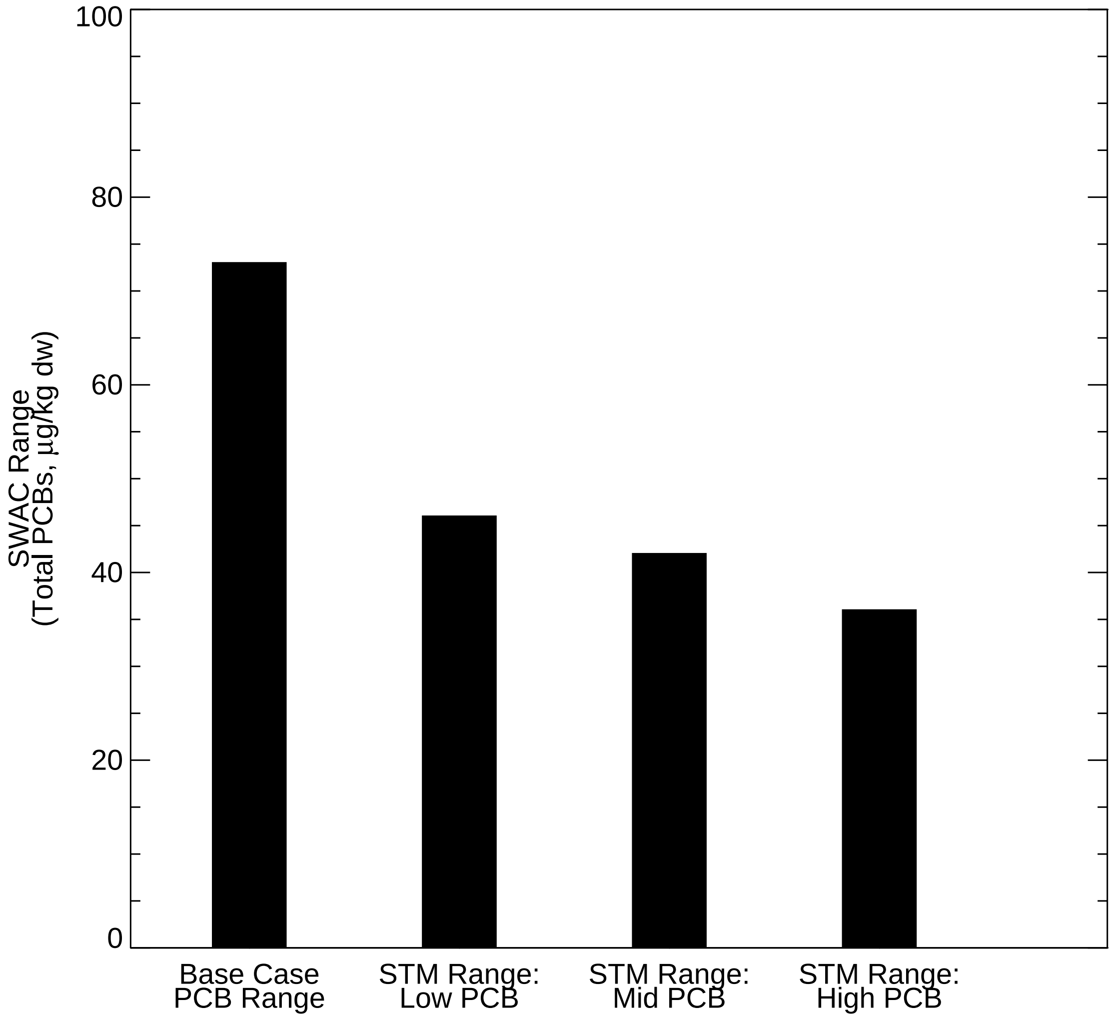


Figure 15. Estimated range of SWACs (total PCBs) in site-wide area.

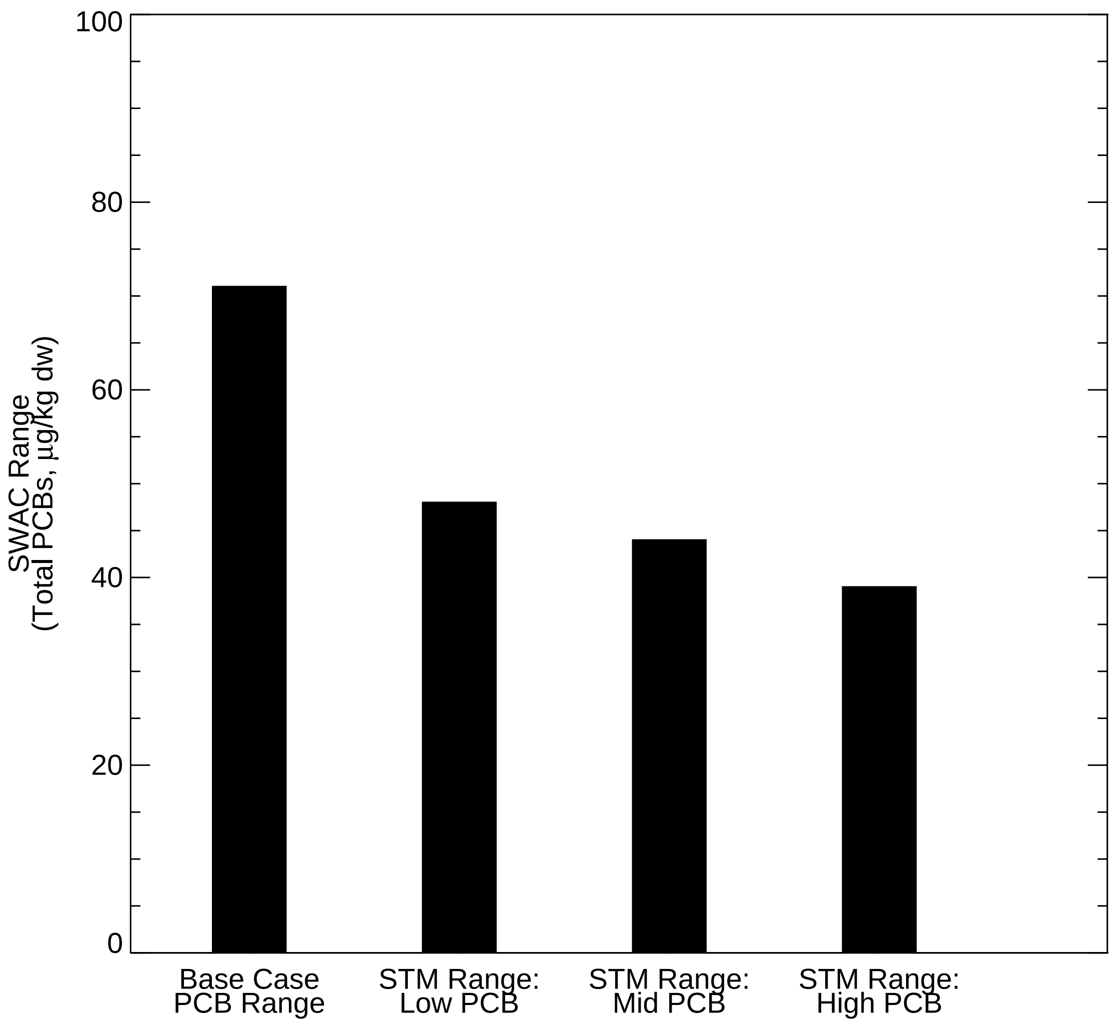


Figure 16. Estimated range of SWACs (total PCBs) in Reach 1.

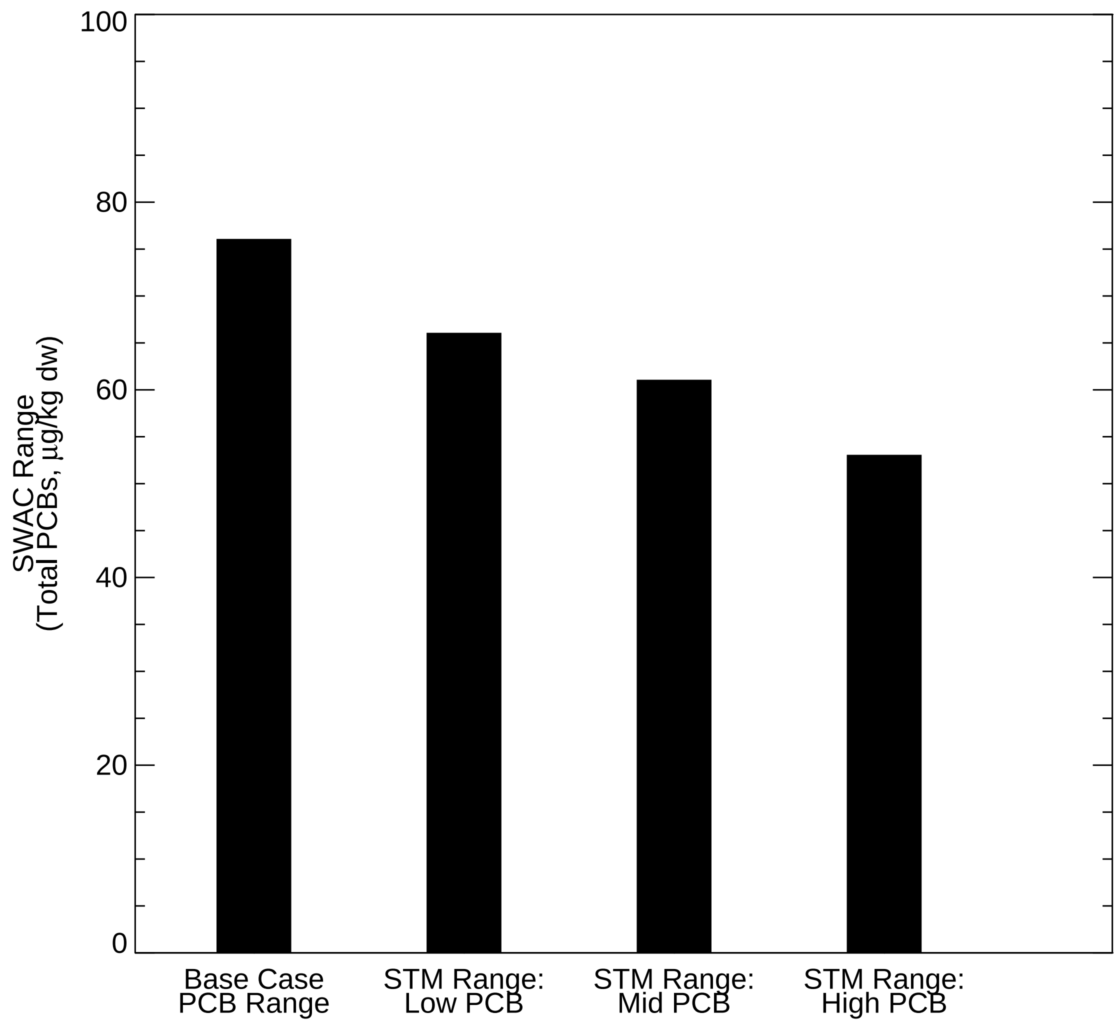


Figure 17. Estimated range of SWACs (total PCBs) in Reach 2.

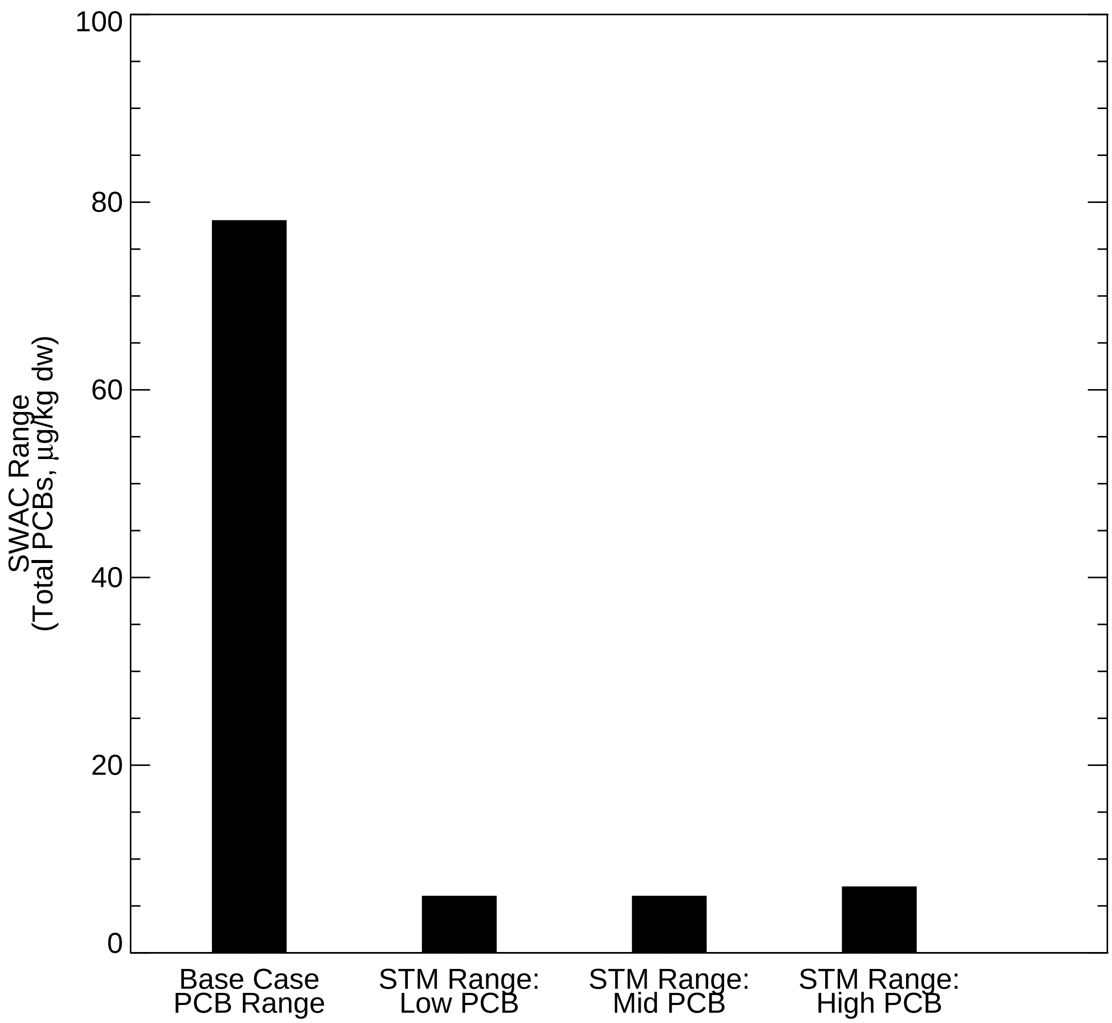
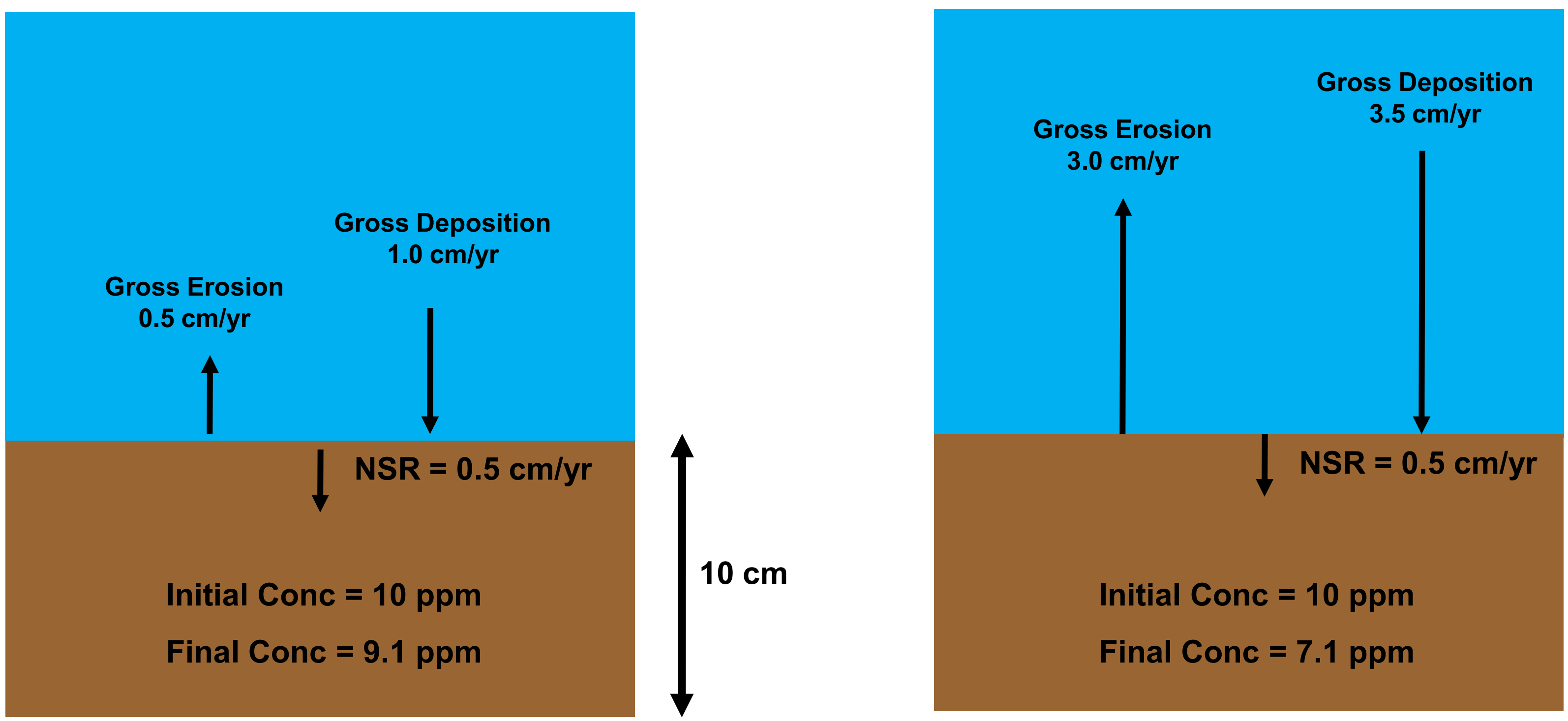
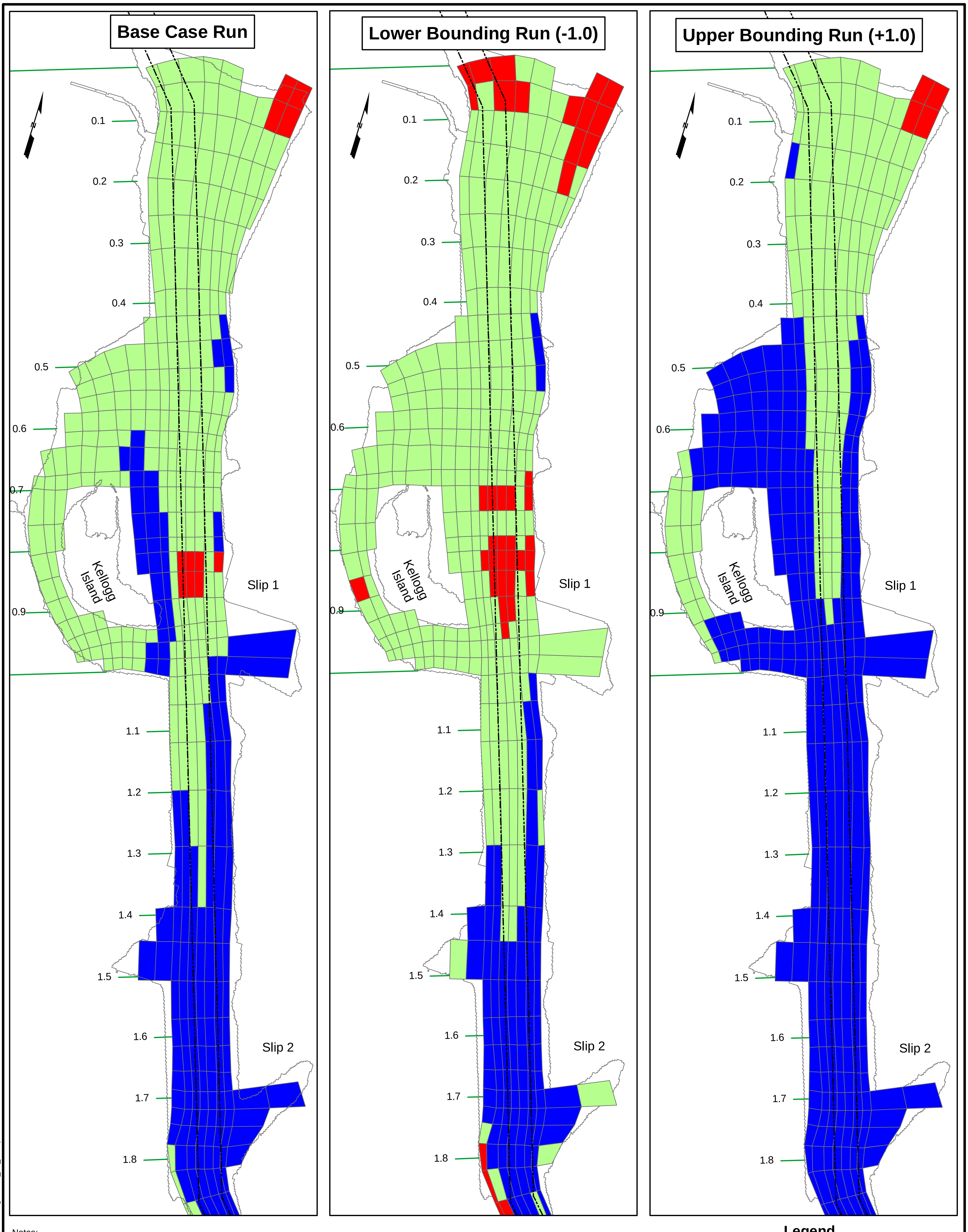


Figure 18. Estimated range of SWACs (total PCBs) in Reach 3.

Figure 19. Comparison of rate of bed concentration change due to differences in erosion-deposition conditions.





Notes:
1. New (11/16/09) reasonable STM runs showing net sedimentation at Year 10 (QEA):
   a. Redistributed lateral load Base Case: (No run #).
   b. Redistributed lateral load Lower bounding run: (-1.0 cm/yr); (run #20).
   c. Redistributed lateral load Upper bounding run: (+1.0 cm/yr); (run #9).

Legend

Net Sedimentation Rate (cm/yr)
- < 0.5
- 0.5 to 1.5
- > 1.5

- Outside of Model Domain
- Navigation Channel
- River Mile Marker

Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

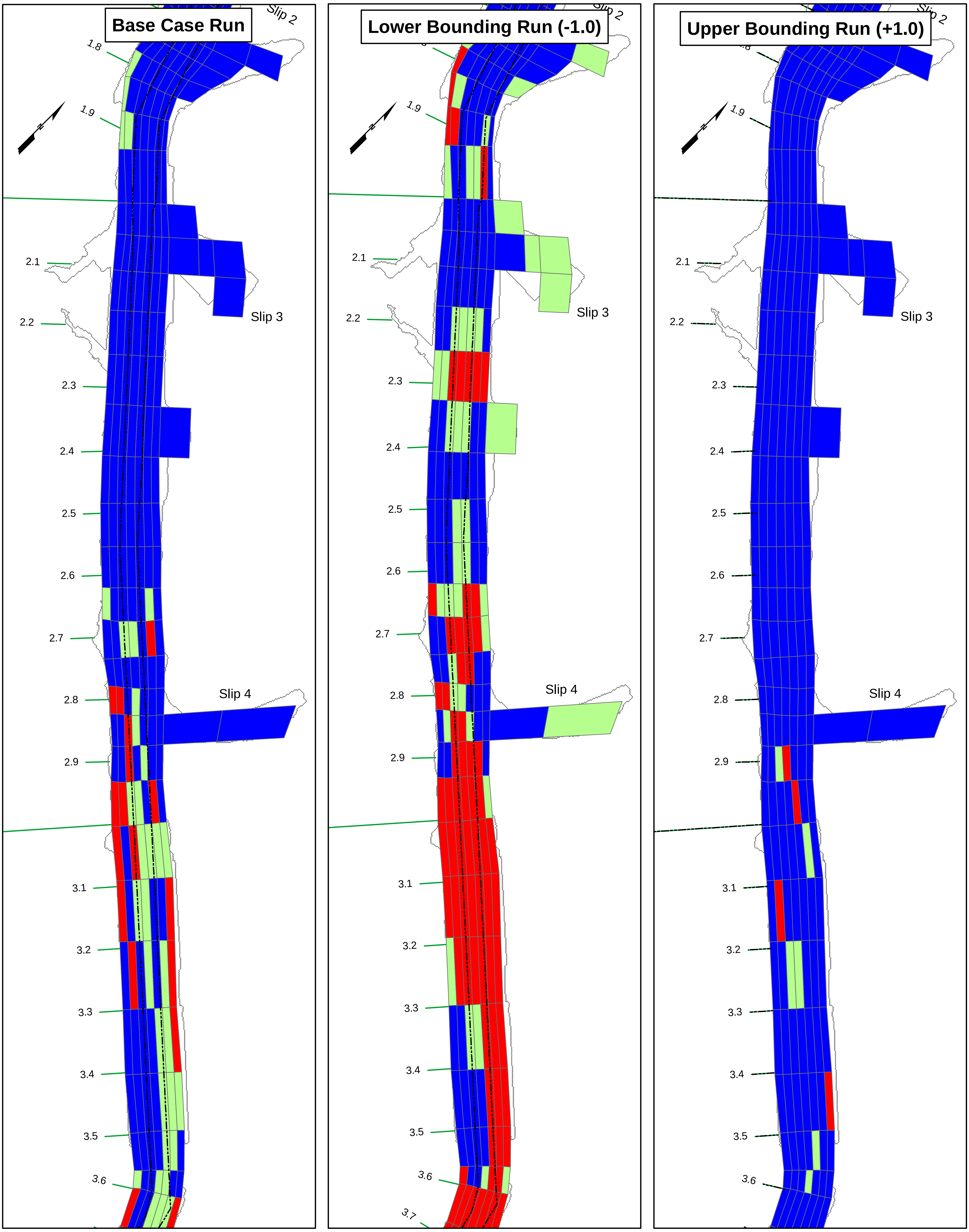
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Year 10 Net Sedimentation Rates for Redistributed Lateral Load Base Case, Upper, and Lower Bounding Runs: RM 0.0 to 1.9 (+/- 1.0 cm/yr)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE 20

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-6_20_ComparisonReach1.mxd



Notes:
1. New (11/16/09) reasonable STM runs showing net sedimentation at Year 10 (QEA):
   a. Redistributed lateral load Base Case: (No run #).
   b. Redistributed lateral load Lower bounding run: (-1.0 cm/yr); (run #20).
   c. Redistributed lateral load Upper bounding run: (+1.0 cm/yr); (run #9).

Legend

Net Sedimentation Rate (cm/yr)

- < 0.5
- 0.5 to 1.5
- > 1.5

- Outside of Model Domain
- Navigation Channel
- River Mile Marker

Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-6_21_ComparisonReach2.mxd

AECOM

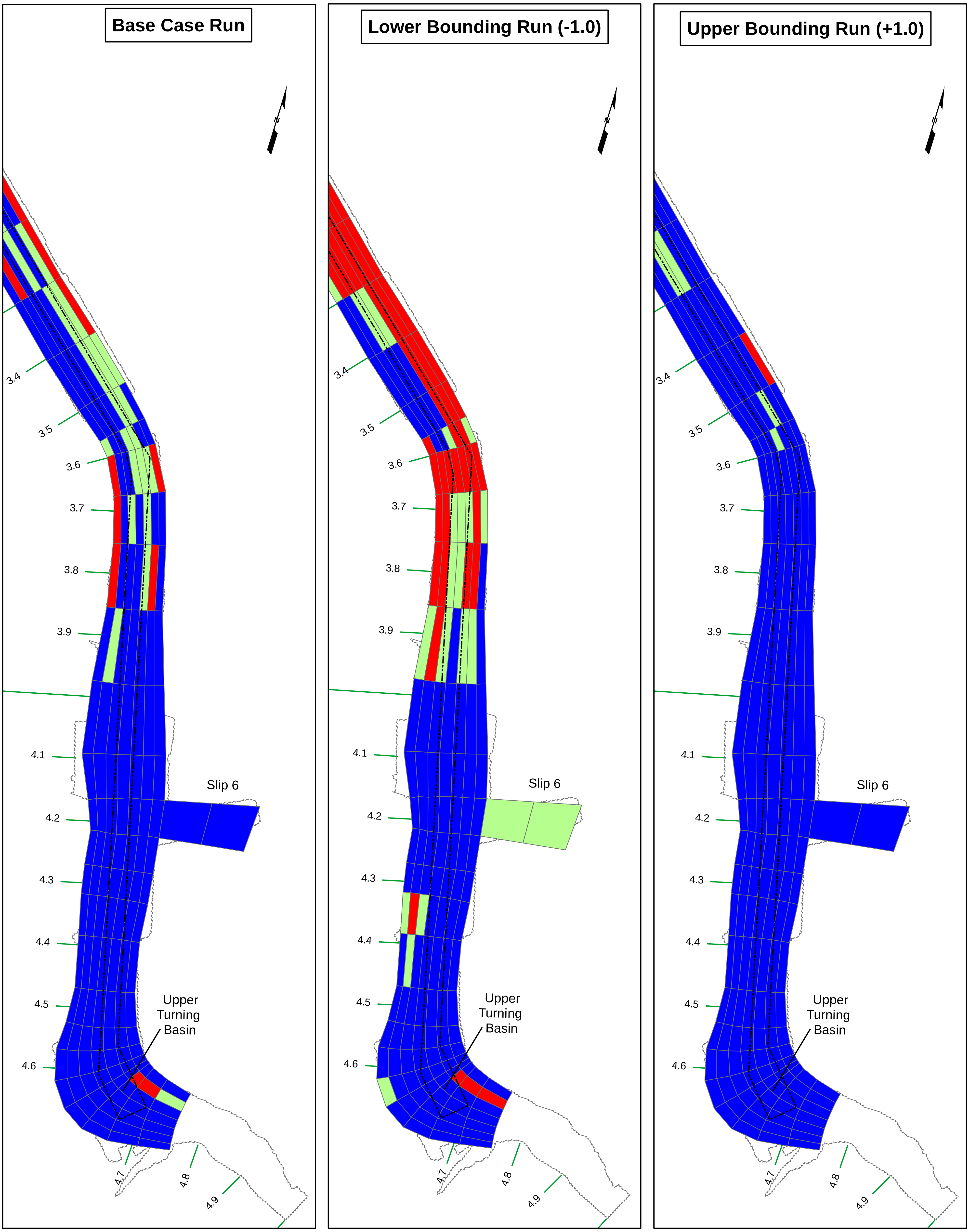
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Year 10 Net Sedimentation Rates for Redistributed Lateral Load Base Case, Upper, and Lower Bounding Runs: RM 1.9 to 3.6 (+/- 1.0 cm/yr)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE 21



Notes:
1. New (11/16/09) reasonable STM runs showing net sedimentation at Year 10 (QEA):
   a. Redistributed lateral load Base Case: (No run #).
   b. Redistributed lateral load Lower bounding run: (-1.0 cm/yr); (run #20).
   c. Redistributed lateral load Upper bounding run: (+1.0 cm/yr); (run #9).

Legend

Net Sedimentation Rate (cm/yr)
- < 0.5
- 0.5 to 1.5
- > 1.5

- Outside of Model Domain
- Navigation Channel
- River Mile Marker

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

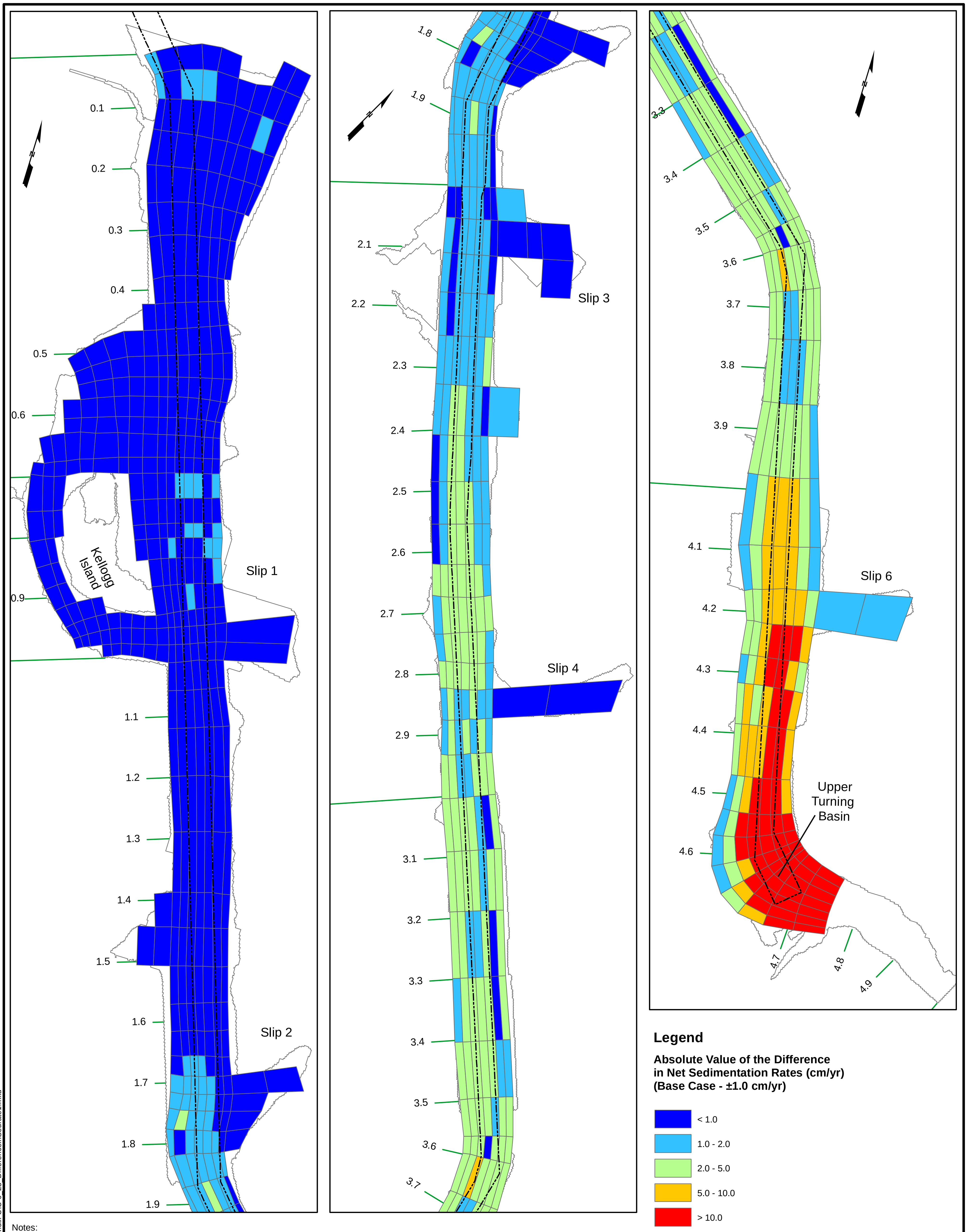
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Year 10 Net Sedimentation Rates for Redistributed Lateral Load Base Case, Upper, and Lower Bounding Runs: RM 3.6 to 5.0 (+/- 1.0 cm/yr)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE 22

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-6_22_ComparisonReach3.mxd



Notes:
1. New (11/16/09) reasonable STM runs showing net sedimentation at Year 10 (QEA):
   a. Redistributed lateral load Base Case: (No run #).
   b. Redistributed lateral load Lower bounding run: (-1.0 cm/yr); (run #20).
   c. Redistributed lateral load Upper bounding run: (+1.0 cm/yr); (run #9).
2. The difference between the reasonable bounding run sedimentation rate and the base case run sedimentation rate was calculated by subtracting the upper/lower sedimentation rate from the base case sedimentation rate in each cell and selecting the maximum absolute value of the difference between the two.

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix C\C-6_23_DifferenceinSedrate1.mxd

AECOM

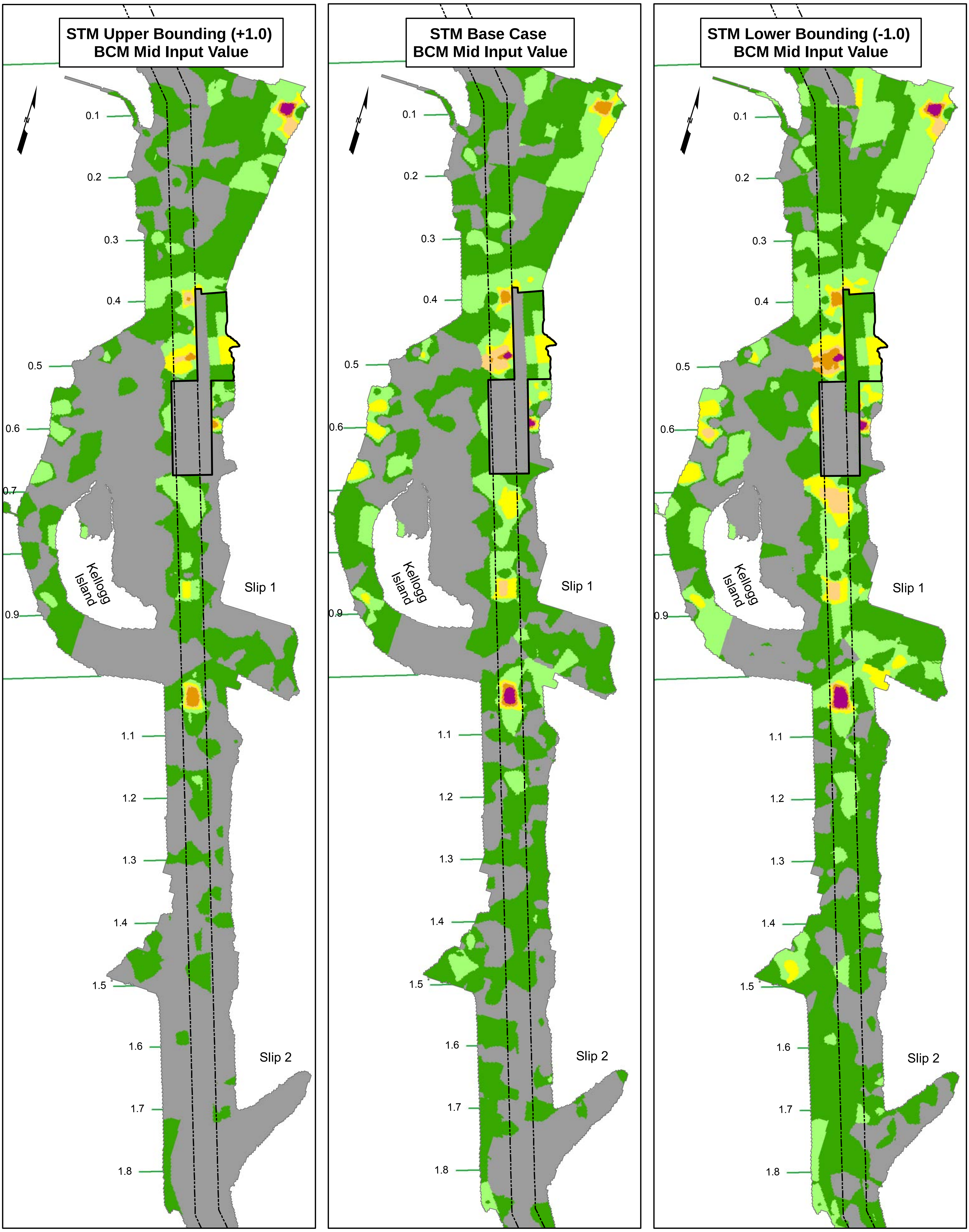
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Difference Between 10 Year Redistributed Lateral Load Base Case and Bounding Run Sedimentation Rates (+/- 1.0 cm/yr)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE 23



Notes:
1. New (11/16/09) reasonable STM runs at Year 10 (QEA):
   a. Redistributed lateral load base case: (No run #).
   b. Redistributed lateral load lower bounding run: (-1.0 cm/yr); (run #20).
   c. Redistributed lateral load upper bounding run: (+1.0 cm/yr); (run #9).
2. Year 10 total PCB concentrations calculated for post alternative 1 (EAAs) using the following input parameters (µg/kg dw):
   a. Mid upstream: 35
   Mid lateral: 400
   Mid post-remedy bed sediment replacement value: 60
3. Alternative 1 (remediation of EAAs only) footprint is from December 2009. The alternative footprint was modified slightly for the Final FS.

Early Action Area
Outside of Model Domain
Navigation Channel
River Mile Marker

0 200 400 800 Feet

Legend

Year 10 Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1,300
- > 1,300 (>CSL)

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\C-6_24_ComparisonReach1Scenario2V2.mxd

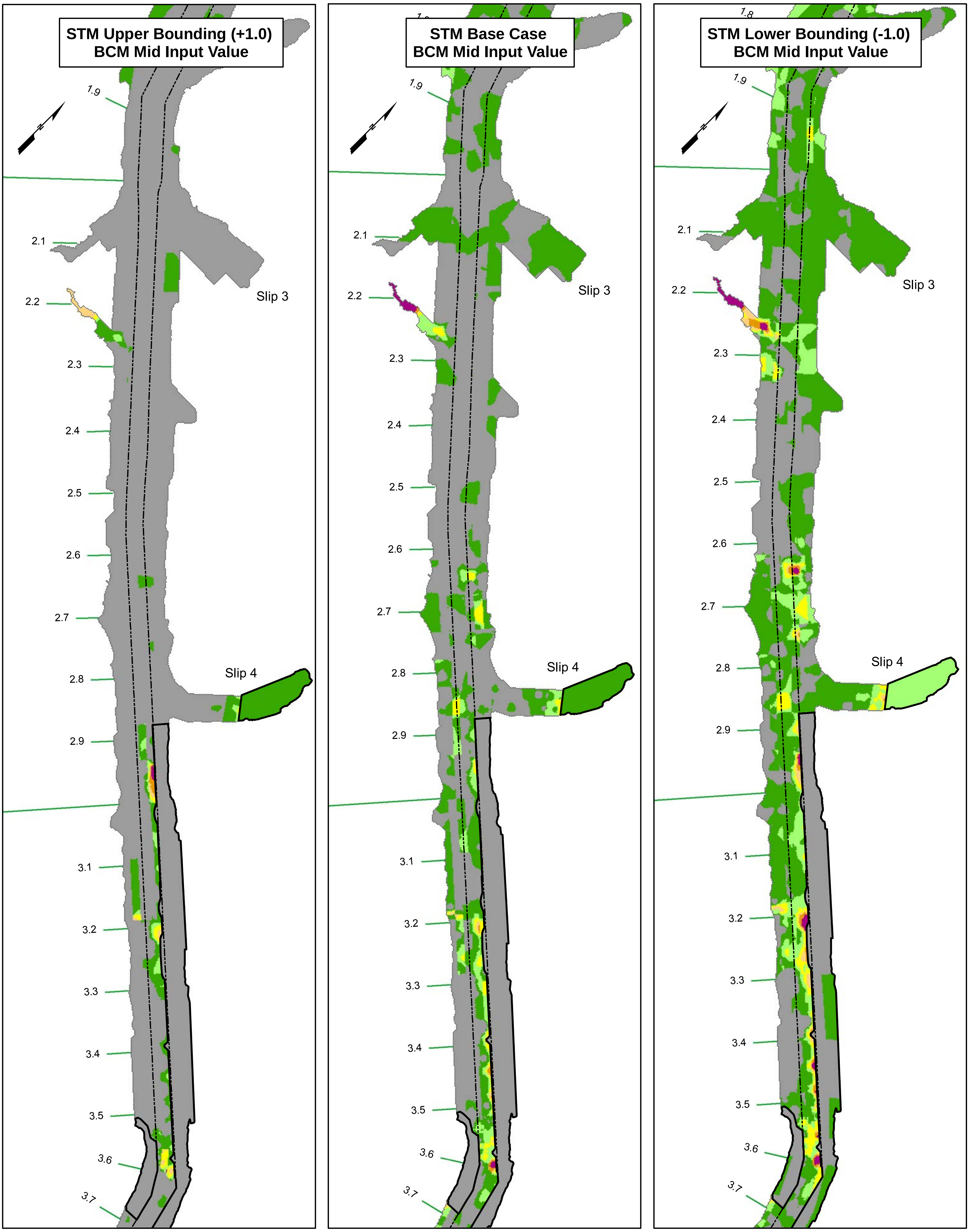
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Year 10 Post Alternative 1 Total PCB Concentrations: STM Bounding Runs and BCM Mid Input Values (RM 0.0 to 1.9)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE 24**



Notes:
1. New (11/16/09) reasonable STM runs at Year 10 (QEA):
   a. Redistributed lateral load base case: (No run #).
   b. Redistributed lateral load lower bounding run: (-1.0 cm/yr); (run #20).
   c. Redistributed lateral load upper bounding run: (+1.0 cm/yr); (run #9).
2. Year 10 total PCB concentrations calculated for post alternative 1 (EAAs) using the following input parameters (µg/kg dw):
a. Mid upstream: 35
   Mid lateral: 400
   Mid post-remedy bed sediment replacement value: 60
3. Alternative 1 (remediation of EAAs only) footprint is from December 2009. The alternative footprint was modified slightly for the Final FS.

Early Action Area
Outside of Model Domain
Navigation Channel
River Mile Marker

Legend

Year 10 Total PCB Concentration (µg/kg dw)

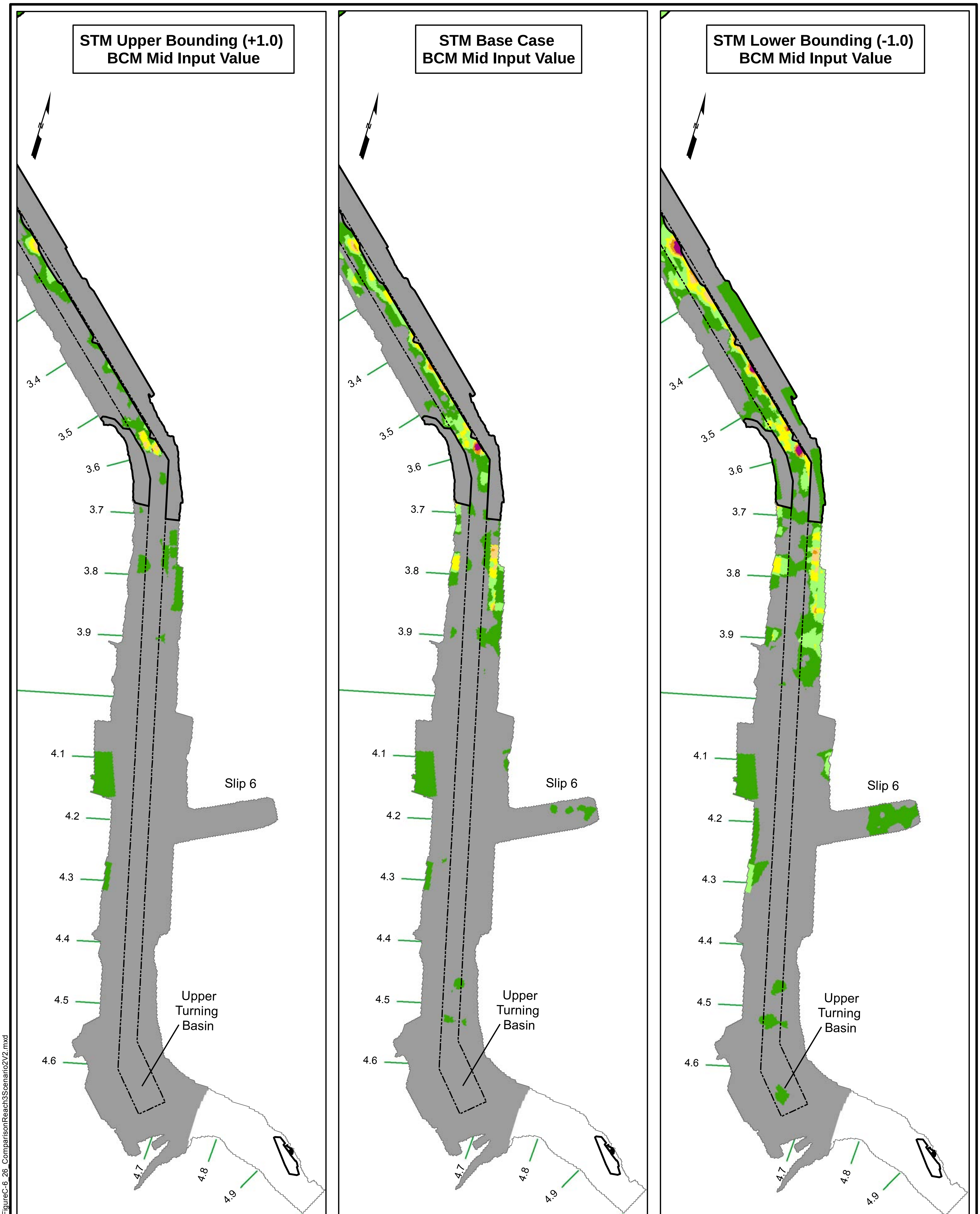
- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1,300
- > 1,300 (>CSL)

Feet
0 200 400 800

AECOM
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			**Year 10 Post Alternative 1 Total PCB Concentrations: STM Bounding Runs and BCM Mid Input Values (RM 1.9 to 3.6)**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE 25**

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-6_25_ComparisonReach2Scenario2V2.mxd



Notes:
1. New (11/16/09) reasonable STM runs at Year 10 (QEA):
   a. Redistributed lateral load base case: (No run #).
   b. Redistributed lateral load lower bounding run: (-1.0 cm/yr); (run #20).
   c. Redistributed lateral load upper bounding run: (+1.0 cm/yr); (run #9).
2. Year 10 total PCB concentrations calculated for post alternative 1 (EAAs) using the following input parameters (µg/kg dw):
   a. Mid upstream: 35
      Mid lateral: 400
      Mid post-remedy bed sediment replacement value: 60
3. Alternative 1 (remediation of EAAs only) footprint is from December 2009. The alternative footprint was modified slightly for the Final FS.

Early Action Area
Outside of Model Domain
Navigation Channel
River Mile Marker

Feet
0 200 400 800

Legend

Year 10 Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1,300
- > 1,300 (>CSL)

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

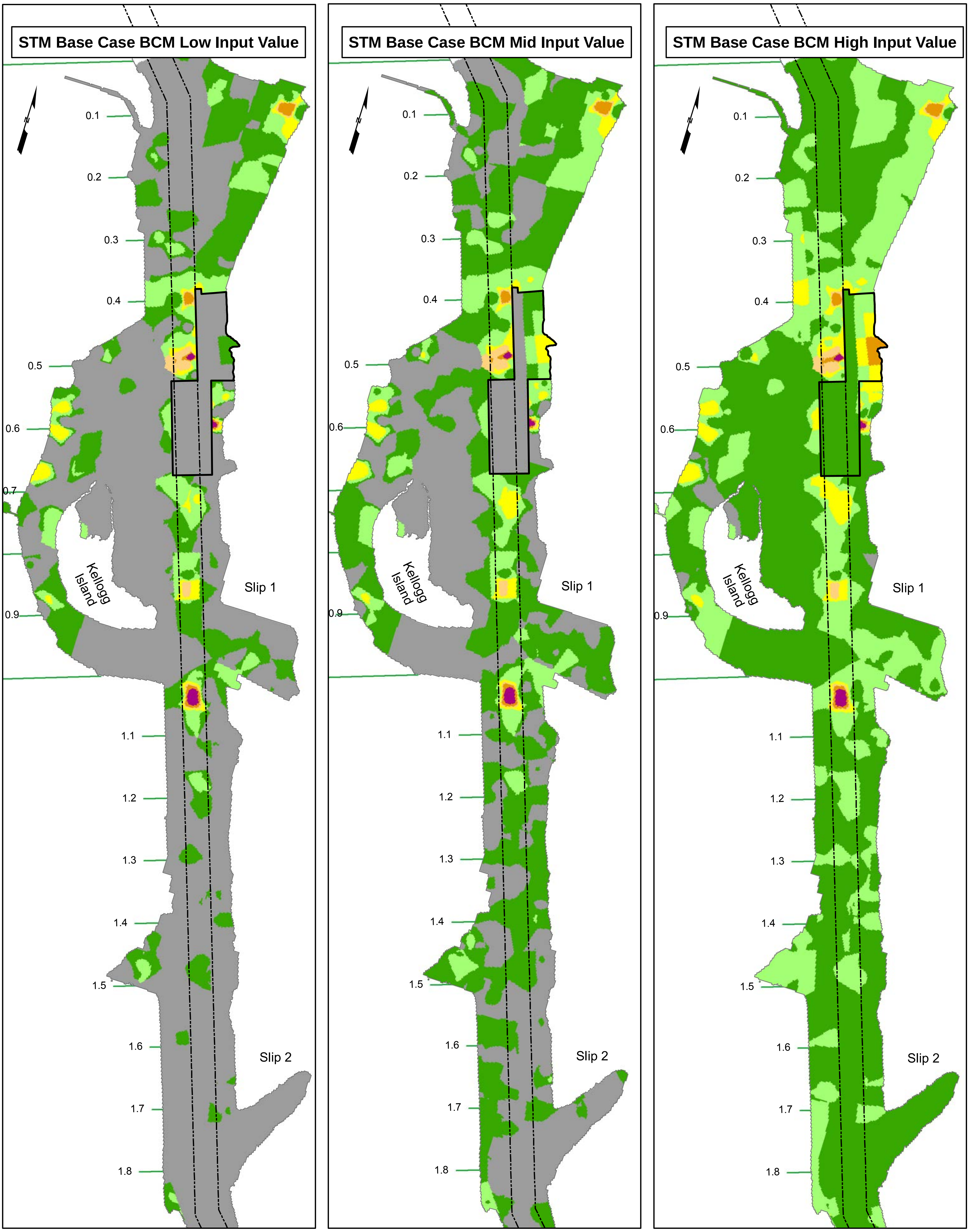
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Year 10 Post Alternative 1 Total PCB Concentrations: STM Bounding Runs and BCM Mid Input Values (RM 3.6 to 5.0)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE 26

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-6_26_ComparisonReach3Scenario2V2.mxd



Notes:
1. New (11/16/09) reasonable STM runs at 10 years (QEA):
   a. Distributed lateral load base case: (No run #).
2. 10 Year total PCB concentrations calculated for post alternative 1 (EAAs) using the following input parameters (µg/kg dw):
   a. Low upstream: 5
      Low lateral: 100
      Low post-remedy bed sediment replacement value: 30
   b. Mid upstream: 35
      Mid lateral: 400
      Mid post-remedy bed sediment replacement value: 60
   c. High upstream: 80
      High lateral: 1000
      High post-remedy bed sediment replacement value: 90
3. Alternative 1 (remediation of EAAs only) footprint is from December 2009. The alternative footprint was modified slightly for the Final FS.

Early Action Area
Outside of Model Domain
Navigation Channel
River Mile Marker

0 200 400 800 Feet

Legend

Year 10 Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1,300
- > 1,300 (>CSL)

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

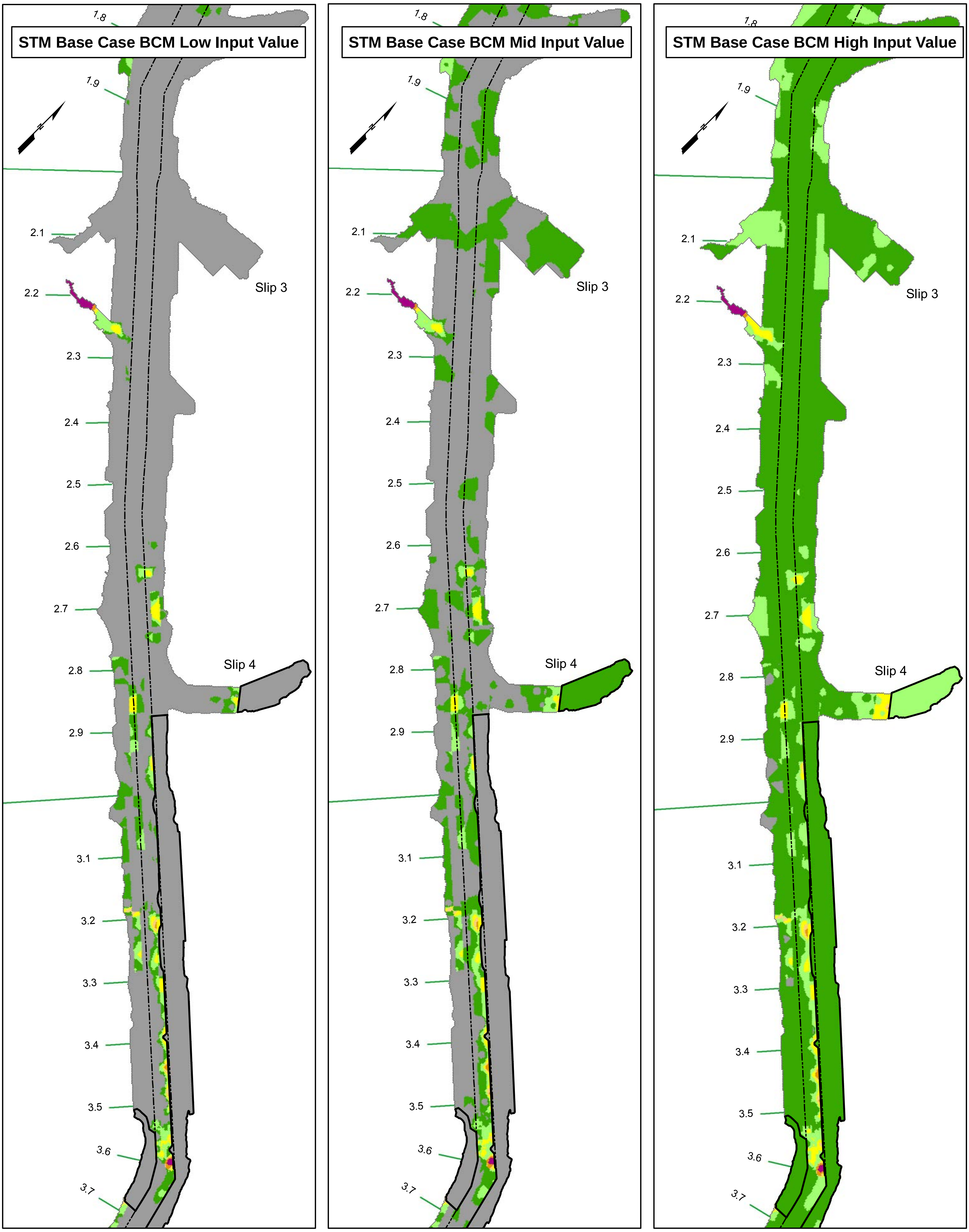
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

10 Year Post Alternative 1 Total PCB Concentrations: BCM Bounding Values and STM Base Case (RM 0.0 to 1.9)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE 27

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix C\C-6_27_ComparisonReach1Scenario1.mxd



Notes:
1. New (11/16/09) reasonable STM runs at Year 10 (QEA):
   a. Redistributed lateral load base case: (No run #).
2. Year 10 total PCB concentrations calculated for post alternative 1 (EAAs) using the following input parameters (µg/kg dw):
   a. Low upstream: 5
      Low lateral: 100
      Low post-remedy bed sediment replacement value: 30
   b. Mid upstream: 35
      Mid lateral: 400
      Mid post-remedy bed sediment replacement value: 60
   c. High upstream: 80
      High lateral: 1000
      High post-remedy bed sediment replacement value: 90
3. Alternative 1 (remediation of EAAs only) footprint is from December 2009. The alternative footprint was modified slightly for the Final FS.

Legend

Year 10 Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1,300
- > 1,300 (>CSL)

- Early Action Area
- Outside of Model Domain
- Navigation Channel
- River Mile Marker

Feet
0 200 400 800

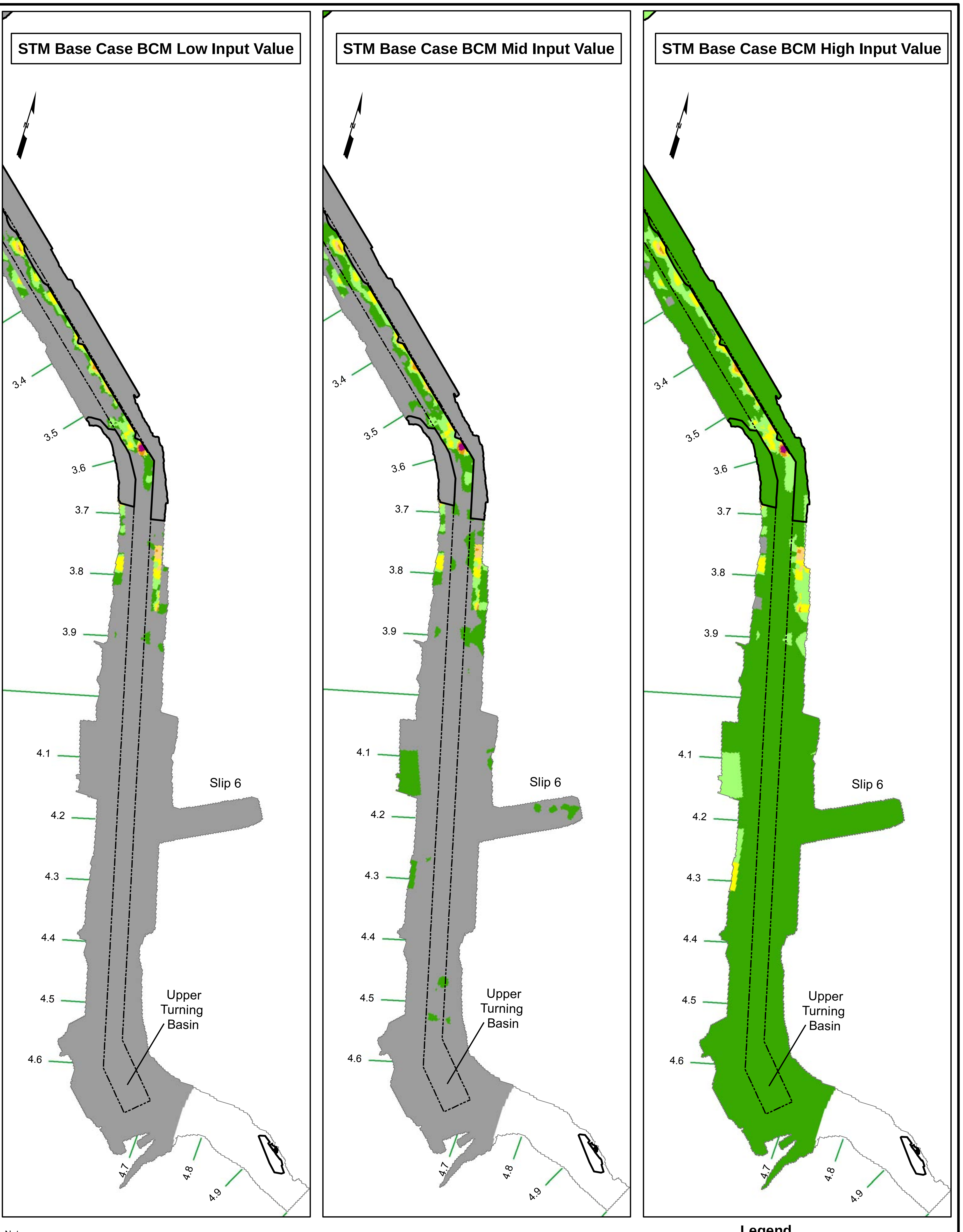
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Year 10 Post Alternative 1 Total PCB Concentrations: BCM Bounding Values and STM Base Case (RM 1.9 to 3.6)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE 28**



Notes:
1. New (11/16/09) reasonable STM runs at 10 years (QEA):
   a. Distributed lateral load base case: (No run #).
2. 10 year total PCB concentrations calculated for post alternative 1 (EAAs) using the following input parameters (µg/kg dw):
   a. Low upstream: 5
      Low lateral: 100
      Low post-remedy bed sediment replacement value: 30
   b. Mid upstream: 35
      Mid lateral: 400
      Mid post-remedy bed sediment replacement value: 60
   c. High upstream: 80
      High lateral: 1000
      High post-remedy bed sediment replacement value: 90
3. Alternative 1 (remediation of EAAs only) footprint is from December 2009. The alternative footprint was modified slightly for the Final FS.

Early Action Area
Outside of Model Domain
Navigation Channel
River Mile Marker

0 200 400 800 Feet

Legend

Year 10 Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- > 120 - 240
- > 240 - 480 (>SQS)
- > 480 - 720
- > 720 - 1,300
- > 1,300 (>CSL)

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

10 Year Post Alternative 1 Total PCB Concentrations: BCM Bounding Values and STM Base Case (RM 3.6 to 5.0)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE 29

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix C\FigureC-6_29_ComparisonReach3Scenario1.mxd

Part 7: Propeller-induced Riverbed Scour from Stationary Tugs

AECOM Environment
710 Second Avenue, Suite 1000, Seattle, WA 98104
T 206.624.9349 F 206.623.3793 www.aecom.com

Memorandum

Date: April 23, 2009[1]

To: Lower Duwamish Waterway Group

From: AECOM and Mike Riley of SSPA

Subject: Propeller-induced Riverbed Scour from Stationary Tugs

Propeller-induced Riverbed Scour from Stationary Tugs

This analysis evaluates the potential for tug-induced bed scour within the Lower Duwamish Waterway (LDW). A prior analysis was conducted for the *Sediment Transport Analysis Report* (STAR; Windward and QEA 2008) that addressed scour potential for vessels in transit within the navigation channel. The STAR did not focus on the localized effects caused by complex vessel movements such as maneuvering, stopping and starting, and berthing activities. This analysis addresses scour potential induced by tugboats engaged in activities alongside berthing areas.

A number of methods were considered for this analysis. Among the methods reviewed were those used in the propeller wash analyses for stationary and maneuvering tugs conducted at Boeing Plant #2 where they used the Hamill et al. (1999), Verhey (1983) and Blaauw and Van de Kaa (1978) models and for the Duwamish/Diagonal cap where the Verhey model and Blaauw and Van de Kaa (1978) model were used. In addition, the U.S. Army Corps of Engineers (USACE) method presented by Maynord (2000), which was used in the STAR (Windward and QEA 2008), was also considered. The Maynord (2000), Verhey (1983), and Blaauw and Van de Kaa (1978) models have similar methodologies to define a velocity distribution behind the vessel caused by the propellers. All rely heavily on earlier work by Albertson (1948), which is based on jet theory coupled with site-specific empirical data.

Literature Review of Available Models

A literature review was conducted to investigate models that are capable of estimating the propeller-induced scour from stationary tug operation. The three models that are available for scour modeling of stationary vessels are the Hamill et al. model (1999), the Maynord model (2000), and the Verhey model (1983).

The Hamill et al. model calculates the maximum scour and its location behind the vessel. However, the model is not able to calculate erosion at any other location than where maximum scour occurs. The Hamill et al. model is not able to account for cohesive sediments and different sediment characteristics at different sediment layer depths. Furthermore, the Hamill et al. model has a specific range within which it is valid, when the distance between the sediment surface and the propeller tip (clearance C) is between $>0.5*D_p$ and $< 2.5*D_p$, where D_p is propeller diameter.

[1] Revised June 18, 2010 to be consistent with revisions to the FS requested by the agencies.

The Verhey model is only applicable for large grain sizes (0.1 m < d_s < 0.3 m) (Verhey 1983). Therefore, because LDW sediments typically have relatively small grain sizes, this model was ruled out. However, the Verhey model was used to estimate bottom velocities. The results were consistent with calculations using the Maynord model. This is to be expected, as the main structure of the equations in the two models are similar, since both models are based on previous work done by Albertson et al. (1948).

Considering the specific depth and grain size limitations of the Hamill et al. and Verhey models, the Maynord model was selected for use in the LDW. The Maynord model can be applied to the Sedflume data from the STAR and provide a more site-specific model that accounted for several sediment characteristics in different areas and for different sediment depths. Table 1 summarizes the input and output parameters for the Maynord and Hamill models. Table 2 summarizes the strengths and limitations associated with the models.

Table 1 Summary of Model Parameters for the Hamill et al. (1999) and Maynord (2000) Models

Model Parameters		Units	Model: Hamill (1999)	Model: Maynord (2000)
Input Parameters				
Sediment and Water Properties	Water Depth	d [m]		X
	Density of Water	ρ_w [kg/m^3]	X	X
	Density of Sediments	d50 [m]	X	
	Average Stone Size	ρs [kg/m^3]	X	
Tug Parameters	Propeller Diameter	D_p [m]	X	X
	Propeller Rotational Speed	n [rps]	X	
	Propeller Tip Clearance	C [m]	X	
	Propeller Thrust Coefficient	Ct	X	
	Total Ship Power	hp		X
	Ship Speed	V_w [m/s]		X
	Propeller Configuration Open/Kort	—		X
	Distance Between Screws	W_p [m]		X
	Propeller Axis Depth	δ_p [m]		X
	Length of Tugboat	L_{tb} [m]		X
	Distance from Stern to Propeller	L_{set} [m]		X
	Vessels Stationary Operation Time	t [s]		X

Model Parameters		Units	Model	
			Hamill (1999)	Maynord (2000)
Output Parameters				
Output Parameters	Depth of Maximum Scour	E_m [mm]	X	C
	Location of Maximum Scour	X_{mu} [m]	X	C
	Bottom Velocity	V_{xp},y_{cl} [m/s]		X
	Shear Stress	T_{peak} [Pa]		X
	Gross Erosion (at arbitrary channel location)	E_{gross} [cm/s]		X

Notes:

X = parameter is included in the model, C = computed from shear stress output from model and site-specific erosion characteristics of sediment.

Table 2 Strengths and Limitations for the Hamill (1999) and Maynord (2000) Models

	Hamill et al. (1999)	Maynord (2000)
Strengths/Weaknesses	Valid for sand and fine gravel	Valid for all grain sizes
	Not valid for cohesive sediments	Applicable for cohesive sediments
	Applicable when the propeller tip clearance C is 0.5*Dp<C< 2.5*Dp.	Able to account for site-specific sediment characteristics
	Determines the depth and location of the maximum scour	Determines the depth and location of scour at any riverbed location
	The bottom velocity does not have to be determined	Transitions between Zone 1 (jets still to merge) and Zone 2 (jets have merged) can sometimes be abrupt and therefore unrealistic
	Limited, if any, field verification of the model	Limited, if any, field verification of the model

The Maynord model is based on physical model studies and has, to our knowledge, undergone limited field verification. The model was developed for barge tows typically used on the upper Mississippi River-Illinois Waterway system, which are reasonably representative of the types and sizes of tugs and barges used on the LDW. For a more comprehensive description of the Maynord model limitations, see Maynord (2000) and the STAR, Chapter 3.

Background and Methods in the Maynord Model

The Maynord model was originally developed for use on the Upper Mississippi River-Illinois Waterway System. The study resulted in analytical/empirical methods that describe near-bed velocity and shear stress as a function of tow parameters. This model was used to calculate potential bed scour in the STAR and is applied here. The main difference between the analysis presented here and that in the STAR is that the present analysis does not include wake effects since the tug is assumed to be stationary.

Estimation of potential bed scour as a result of propeller wash-induced bed shear is determined through a series of calculation steps. These steps are:

1. Determine vessel parameters
2. Calculate maximum bottom velocity resulting from propeller wash
3. Calculate bed shear stress distribution
4. Calculate resulting potential bed scour.

For this scour analysis, the vessel parameters are based on two tugs operating in the LDW. The tug *Sea Valiant* was used for operations in the reach downstream of the First Avenue Bridge. Because the draft of the Sea Valiant is too deep to operate above the First Avenue Bridge, the *J.T. Quigg* was used to assess operations upstream of the bridge. Both tugs were referenced in the STAR and their general characteristics are presented below in Table 3.

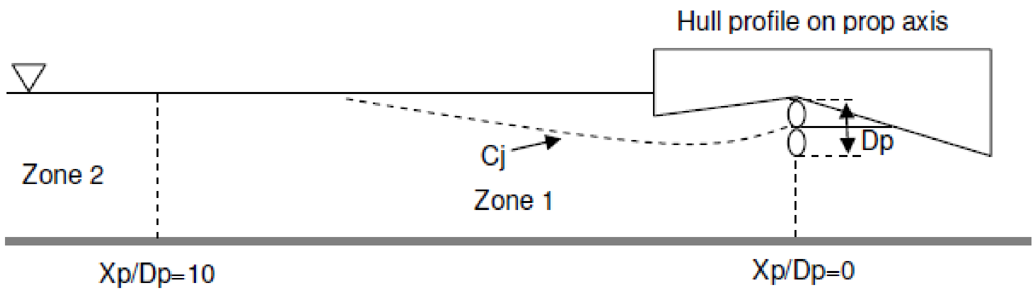
Table 3 Tug Characteristics for *J.T. Quigg* and *Sea Valiant*

Parameter		Ship	
		J.T. Quigg	***Sea Valiant***
Length of tugboat	L_{tb}	100 ft	128 ft
Tug draft depth	L_{tb}	12.3 ft	20 ft
Distance from stern to propeller	L_{set}	10 ft	13 ft
Distance between propellers	W_p	15 ft	19 ft
Propeller diameter	D_p	6.3 ft	9.3 ft
Propeller axis depth	δ_p	8 ft	8.5 ft
Type of propeller	O/K	Open-wheel	Kort nozzle
Total power	P_{hp}	3,000 hp	5,750 hp

Calculation of Maximum Bottom Velocity

For a twin-propeller tug, such as is used in the LDW, the area behind the vessel's propellers, located at X_p = 0, is divided into two distinct zones (Figure 1). In Zone 1, the propeller jet wash created by each propeller has yet to merge into one stream. This zone extends behind the propeller for a length of approximately 10 times the propeller diameter (D_p). The second zone, Zone 2, where the propeller jets have merged may be described as a single jet. Within Zone 2, the maximum jet velocity (C_j) is at the surface and the jet decays both laterally and vertically. The following is the methodology applied to both zones.

Figure 1 Zone Locations and a Maximum Jet Velocity Profile



Zone 1: X_p < 10 D_p

This zone is dominated by the central rudder effects; and the two propeller jets have not merged. The total bottom velocity distribution is determined by superposition of the velocity distribution of each propeller jet as described by Verhey (1983). Estimation of the spatial distribution of bottom velocity ^{Z1}V (X_p,Y_{cl}) caused by propeller wash is determined from the velocity increase in the water (V_2) as follows:

$$^{Z1}V(X_p,Y_{cl}) = 1.45\,V_2\left(\frac{X_p}{D_p}\right)^{-0.524}\left(\exp\left(-15.4\frac{R_1^2}{X_p^2}\right)+\exp\left(-15.4\frac{R_2^2}{X_p^2}\right)\right)$$

Where:

$$R_1^2 = \left(Y_{cl} - 0.5W_p\right)^2 + \left(H_p - C_j\right)^2$$
$$R_2^2 = \left(Y_{cl} + 0.5W_p\right)^2 + \left(H_p - C_j\right)^2$$

$$C_j = -\tan(12°)\left(X_p - 0.5\,L_{set}\right) + \frac{C_P\,g}{V_2^2\cos^2(12°)}\left(X_p - 0.5\,L_{set}\right)^2$$
$$C_j = -\left[0.213 - 1.05\left(\frac{C_p\,g}{V_2^2}\right)\left(X_p - 0.5L_{set}\right)\right]\left(X_p - 0.5\,L_{set}\right)$$

Where:

X_p= Distance behind the propeller [m] (see Figures 1 and 3)

D_p= Propeller diameter [m]

W_p= Distance between propellers [m]

L_{set}= Distance from ship stern to propeller [m]

H_p = Distance from center of propeller axis to channel bottom [m]

Y_{cl} = Lateral distance from ship centerline [m]

C_j = Vertical distance from propeller shaft to location of maximum velocity within the jet [m], Max C_j=δp

δp = Propeller depth [m]

g = acceleration of gravity [m/s^2]

C_p= 0.04 Kort nozzle propeller

$$C_p = 0.12\left(\frac{D_p}{H_p}\right)^{0.67}$$ (for open-wheel propeller)

$$V_2 = \frac{1.13}{D_O}\sqrt{\frac{T}{\rho_w}}$$

D_o = 0.71 D_p (for open-wheel propeller)

D_o = D_p (for Kort nozzle propeller)

T = Thrust [N]

ρ_w = Density of water [kg/m^3]

Estimation of propeller thrust is calculated using the Toutant (1982) equation:

$$EP = 23.57\,P_{hp}^{0.974} - 2.3V_w^2\,P_{hp}^{0.5}$$ (for open-wheel propeller)

$$EP = 31.82\,P_{hp}^{0.974} - 5.4V_w^2\,P_{hp}^{0.5}$$ (for Kort nozzles propeller)

Where:

EP= Effective Push (equivalent to thrust) from both propellers [pounds, converted to N]

P_{hp}= Total ship power [hp]

V_w= Ship speed relative to water, 0 for stationary vessels [m/s]

The Toutant equations were developed for tows operating in the upper Mississippi River-Illinois Waterway system, which as mentioned above are reasonably representative of the types and sizes of tugs and barges used on the LDW.

Figures 2 and 3 show the model nomenclature used for the propeller wash calculations in front and side views of the vessel relative to water depth, propeller placement, and vessel size.

Figure 2 Nomenclature for Parameters Used in the Maynord Model – Front View

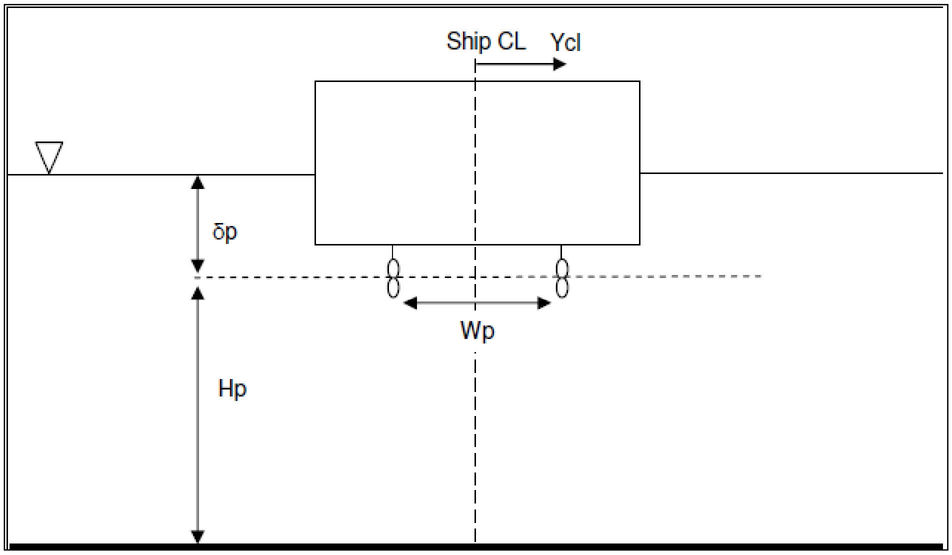
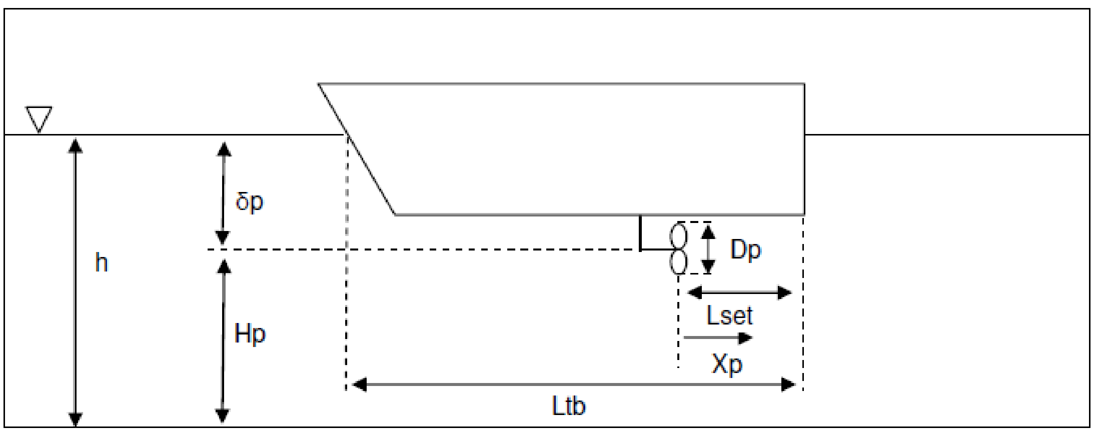


Figure 3 Nomenclature for Parameters Used in the Maynord Model – Side View



Zone 2: X_p > 10 D_p

Zone 2 is the region where the individual jets from the two propellers merged and therefore is represented by a single jet with maximum velocity at the surface. The bottom velocity distribution in Zone 2 is calculated by:

$$^{Z1}V(X_p, Y_{cl}) = 0.34 V_2 \left(\frac{D_p}{H_p}\right)^{0.93} \left(\frac{X_p}{D_p}\right)^{0.24} C_1\, EXP\left[-0.0178\frac{X_p}{D_p} - \frac{Y_{cl}^2}{2C_{z2}^2\, X_p^2}\right]$$

Where:

C_1 = 0.66 for open-wheeled propeller; 0.85 for Kort nozzle propeller

$C_{Z\,2}$ = 0.84 $(X_p/D_p)^{-0.62}$

Calculation of Bed Shear Stress

Bed shear stress (τ) is calculated with the method prescribed by Maynord (2000) as presented below:

$$\tau = 0.5 \rho_w C_{fs} V_{prop}^2$$

Where:

C_{fs} = bottom friction factor for propeller wash, as described below

V_{prop} = bottom velocity due to propeller wash, as calculated previously.

The bottom friction factor for propeller wash is:

$$C_{fs} = 0.01 \left(\frac{D_p}{H_P} \right)$$

The equation for τ and C_{fs} was computed from a combination of propeller velocity and vessel wake velocity. Since the analysis here deals with maneuvering tugs, the wake effect is minimal. Maynord gives a separate analysis for C_{fs} from wake effects alone, which results in constant value for C_{fs}. The equation above is considered more appropriate as C_{fs} will increase in shallow water where H_p decreases.

Sediment Erosion Characteristics

Sediment cores collected in the LDW were analyzed for erosion rate parameters using a Sedflume analysis. A more detailed description of the sediment characteristics in the LDW is provided in the STAR. Table 4 displays the critical shear stresses for the Sedflume core groups A, B, and C, developed in the STAR.

Estimation of Bed Scour Due to Standing Tug

As discussed in the STAR, the various Sedflume cores were grouped according to erosion properties in the various sediment depth layers (0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, and 20-25 cm).

The gross erosion rate, E_{gross} (cm/s), is calculated as follows:

$$E_{gross} = A \tau^n \quad \text{for } \tau > \tau_{cr}$$

Where τ is shear stress (Pa) and τ_{cr} is critical shear stress (Pa). The parameters A and *n* are site-specific and calculated from the Sedflume analysis as discussed in Section 3 of the STAR.

Table 4 Critical Shear Stress, Average A and Average *n* Values at Different Depth Layers for the Sedflume Core Groups A, B, C and D

Depth Layer (cm)		Sedflume Cores			
		Group A	Group B	Group C	Group D
		Critical Shear Stress, τ_{cr} (Pa)			
1	0-5	0.16	0.24	0.63	—
2	5-10	0.56	0.49	0.34	1.6
3	10-15	1.4	0.35	0.79	—
4	15-20	1.4	0.67	0.49	—
5	20-25	1.3	2.4	1.3	—
		Average A (*10^-4)			
1	0-5	14	37	4.9	—
2	5-10	5.1	4.1	24	0.22
3	10-15	0.35	12	2.5	—
4	15-20	0.42	2.6	8.6	—
5	20-25	0.49	0.047	0.53	—
		***Average* n**			
1	0-5	1.5	2.5	3.4	—
2	5-10	2.8	2	2.9	3.3
3	10-15	3.2	2.3	4	—
4	15-20	2.8	2.4	3.1	—
5	20-25	3.3	3.6	2.5	—

The analysis was performed for various water depths (5 m and 7 m for *J. T. Quigg* and 7 m and 9 m for *Sea Valiant*) to provide hypothetical results for various bottom elevations that could be vulnerable to scour encountered in the LDW.

Gross erosion rates were calculated for when the tugs are operating at a low speed for different time periods (30 s, 1 min, 2 min, 5 min, 10 min, and 15 min). Further, the gross erosion rates were calculated for different magnitudes of applied ship power (15%, 35%, and 100% of maximum ship power).

Interviews were conducted with companies that use tugs in the LDW (Table 5) to gain an understanding of the type of ship operations and the different percentages of applied ship power used during the operations. Similarly, the duration time of the different berthing activities were based on interviews conducted with tug operators (Table 5). Consideration was also given to how stationary the berthing activities are considered to be, i.e. how long the tug is likely to operate over the same area.

Table 5 Estimated Percentage of Applied Power for Different Tugboat (1,000-5,000 hp) Activities

Activities	Western Towboat	Island Tug Barge	Harley Marine	Foss Maritime	Crowley Marine	Average	Operation Time
Nosing and holding tight to dock or barge	0-30%	10-15%	10-15%	20%	No Comment	15%	15 min
Holding barge/vessel in strong current	20-30%	20-50%	50%	30%	No Comment	35%	5 min
Emergency Operations	50-100%	—	100%	50-100%	No Comment	83%	5 min
Slowing barge/vessel down for berthing	50%	30-40%	5-10%	20-50%	No Comment	32%	5 min
Acceleration from berth/dock	25-50%	10-15%	50-60%	30-40%	No Comment	35%	5 min

Source: Emmons and Hernandez-White, personal communication, 2009

The bed shear stress caused by the propeller wash is applied to the bottom for the full time that the tug is standing. Where the applied shear stress is sufficient to initiate erosion ($\tau > \tau_{cr}$) then E_{gross} is calculated for the sediment layer. If sufficient bed stress is applied to remove all material from the surface sediment layer, the remaining shear stress is applied to the next layer. This is continued until either the full 25 cm is removed or the full time-period over which bed shear stress is applied has expired.

Downstream of the First Avenue Bridge, from river miles (RM) 0 to 2.0, *Sea Valiant* was used as its characteristics are typical of tugs operating in this part of the LDW. The smaller tug, the *J.T. Quigg*, was used for simulations in the shallower, upstream portion of the LDW from RM 2.0 to 3.8. Upstream from RM 3.8 the river becomes too shallow for the *J.T. Quigg* to operate. The areas most sensitive to erosion were identified and conservative estimates of scour depths for operation with the *Sea Valiant* and *J.T. Quigg* were made. These areas were identified by considering critical shear stress values for the different sediment layer depths for all bench areas of the river. The spatial extension of the bench areas was based on the groupings of sediments layers conducted in the STAR. The composition of each sediment group is provided below in Table 6.

Table 6 Riverbed Bench Areas, and their Associated Sediment Groups for Different Layer Depths

Sediment Layer depth (cm)	*Sea Valiant*	Sediment Group				*T.G. Quigg*	Sediment Group			
	Area 1	2	3	4	5	5	6	7	8	9
0-5	1C	1A	1B	1B	1B	1B	1B	1A	1A	1A
5-10	2D	2B	2C	2B	2A	2A	2A	2B	2D	2A
10-15	3B	3A	3B	3B	3A	3A	3A	3C	3C	3B
15-20	4C	4B	4C	4A	4A	4A	4B	4B	4A	4A
20-25	5B	5A	5A	5A	5A	5A	5A	5B	5A	5B

Mean critical shear stress values were calculated for all bench areas and then the area with lowest mean critical shear stress values upstream and downstream of the First Avenue Bridge were identified and considered to be the most susceptible areas for propeller-induced scour. Numerical results are presented in Table 7. Location of all areas, and their respective average critical shear stress, is presented on Figure 4 (Table B-8 and Figure B-26 to B-30 in Appendix B, STM; QEA 2008). The most vulnerable bench area downstream of the First Avenue Bridge was Bench Area 3 located between RM 0.8-1.3 and the corresponding area upstream of the bridge was Bench Area 6 located at RM 2.2-2.5 (Figure 4).

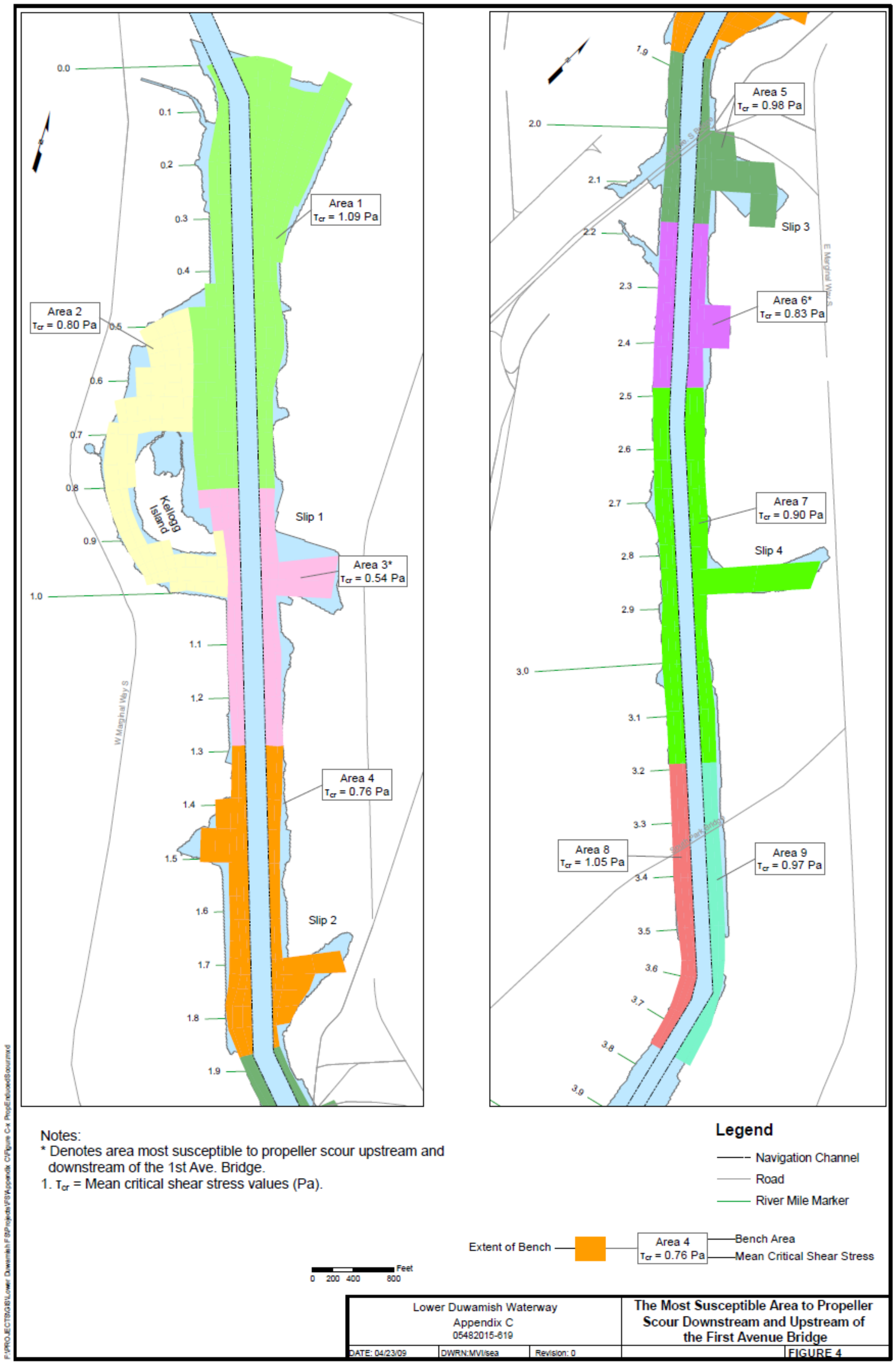
Table 7 Riverbed Bench Areas, and their Associated Critical Shear Stress Value for Different Layer Depths, and Mean Critical Shear Stress Values Calculated for Each Bench Area

Layer Depth (cm)	*Sea Valiant*	Critical Shear Stress [Pa]				*T.G. Quigg*	Critical Shear Stress [Pa]			
	Area 1	**2**	**3**	**4**	**5**	**5**	**6**	**7**	**8**	**9**
0-5	0.63	0.16	0.24	0.24	0.24	0.24	0.24	0.16	0.16	0.16
5-10	1.6	0.49	0.34	0.49	0.56	0.56	0.56	0.49	1.6	0.56
10-15	0.35	1.4	0.35	0.35	1.4	1.4	1.4	0.79	0.79	0.35
15-20	0.49	0.67	0.49	1.4	1.4	1.4	0.67	0.67	1.4	1.4
20-25	2.4	1.3	1.3	1.3	1.3	1.3	1.3	2.4	1.3	2.4
Average	1.09	0.80	0.54	0.76	0.98	0.98	0.83	0.90	1.05	0.97

Notes:

Bench area most susceptible toward scour upstream and downstream of the First Avenue Bridge

Figure 4 The Most Susceptible Area to Propeller Scour Downstream and Upstream of the First Avenue Bridge



Results and Discussion

Tug simulations for *Sea Valiant* operating over the most erodible bench area downstream of the First Avenue Bridge are presented on Figures 5 and 6, where the water depths are 7 m and 9 m (22.96 ft and 29.52 ft), respectively.

Figure 5 Maximum Scour Depths for the Tug Sea Valiant at Water Depth of 7 m

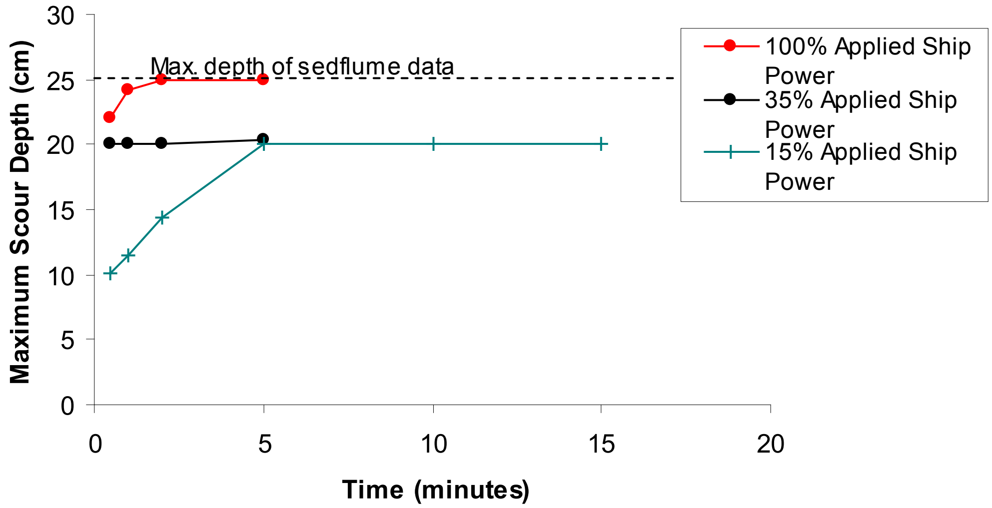
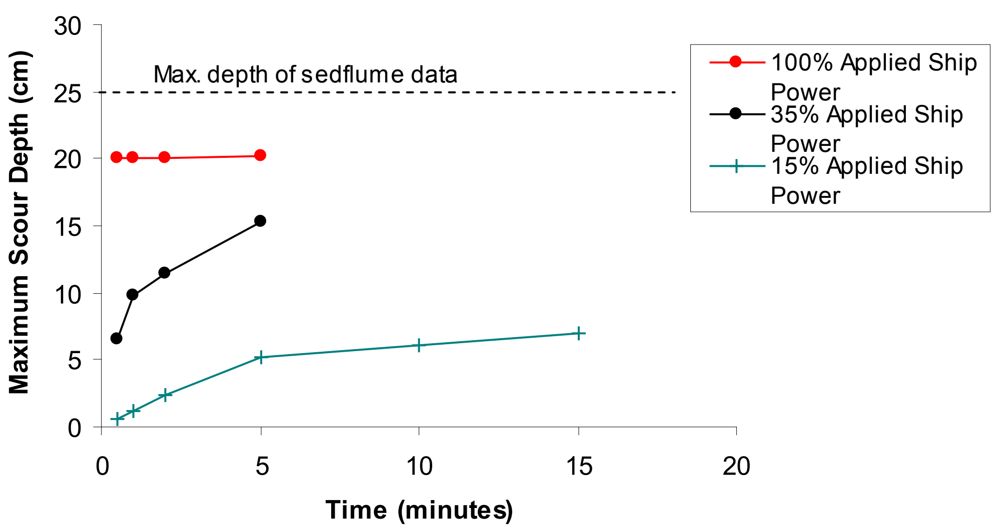


Figure 6 Maximum Scour Depths for the Tug *Sea Valiant* at Water Depth 9 m



At a water depth of 7 m, normal tug operations of the *Sea Valiant*, such as holding barge/vessel in strong current, slowing barge/vessel down for berthing, and acceleration from dock, causes scour to erode through the loose, upper sediment layers until it reaches a cohesive sediment layer at 20 cm (Figure 5). During emergency situations, the scour depth goes beyond 20 cm. However, emergency situations occur less frequently compared to other berthing activities (Emmons and Hernandez-White, personal communication, 2009).

The scour depth was also modeled for *Sea Valiant* operating in water depths of 9 m (Figure 6), where the erosion becomes less severe, demonstrating the effects of distance from the propeller to the bottom on shear stress and erosion. During normal tug activities, the more cohesive sediment layer (below 20 cm depth) is only reached during long operation times. Maneuvering with 35% applied ship power at 9 m water depth for 5 minutes a *Sea Valiant*-size tug is expected to cause scour that is 10 cm or deeper for an areal extent of approximately 270 m^2 behind the propellers.

Simulations for *J.T. Quigg* operating where the water depths are 5 m and 7 m (16.4 ft and 23.0 ft) over the most erodible bench area upstream of the First Avenue Bridge are presented on Figures 7 and 8, where the water depths are 5 m and 7 m, respectively. During emergency situations the scour reaches 25 cm within 1 minute (Figure 7).

Figure 7 Maximum Scour Depths for the Tug *J.T. Quigg* at Water Depth 5 m

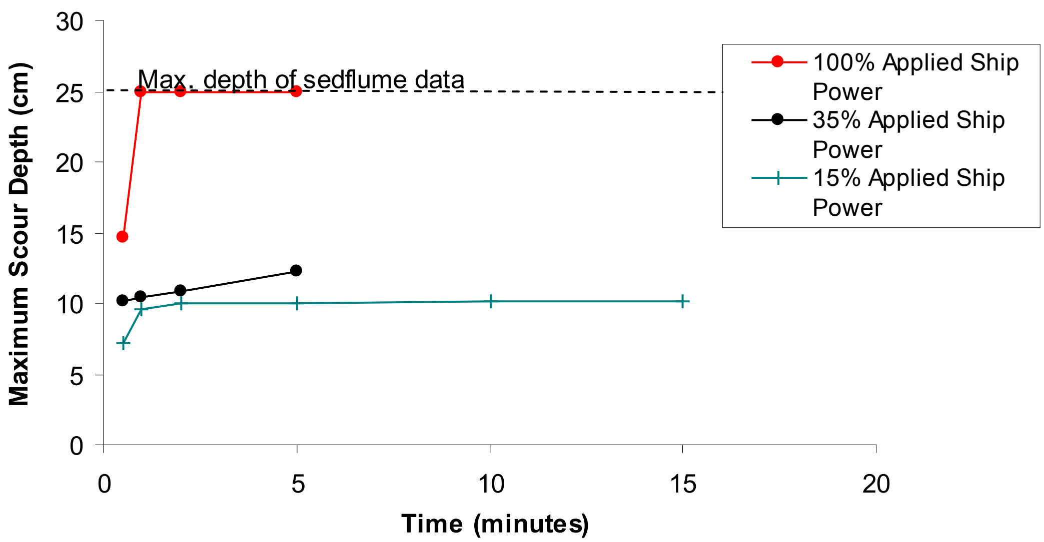
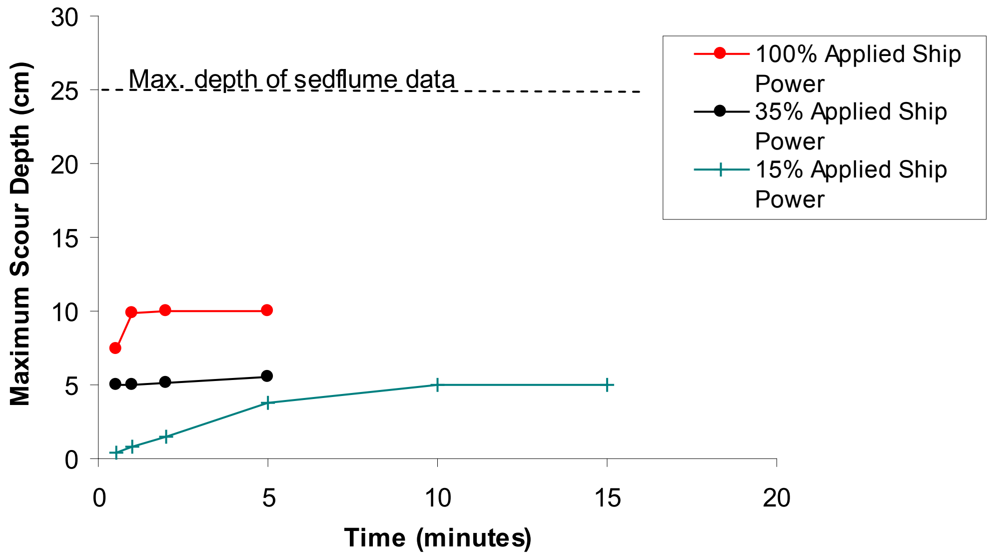


Figure 8 Maximum Scour Depths for the Tug *J.T. Quigg* at Water Depth 7 m



At a water depth of 5m, normal operations of the *J.T. Quigg* (not considering emergency situations) at shallow water depth, the erosion rate decreases at a layer depth of 10-15 cm, where the sediments appear to become more cohesive (Figure 7).

As anticipated, the scour depth decreases for operations of the *J.T. Quigg* at a water depth of 7 m (Figure 8). During normal berthing activities at this depth, the scour depth does not exceed 6 cm although it can reach 10 cm for emergency situations. Maneuvering with 35% applied ship power at a 7 m water depth a *J.T. Quigg*-size tug is expected to cause scour that is 5 cm or deeper (but not exceeding 10 cm) for an areal extent of approximately 300 m^2 behind the propellers.

Conclusion

When a *Sea Valiant*-size tug is conducting normal berthing activities (not considering emergency situations) over the most erodible area downstream of the First Avenue Bridge at a shallow water depth (7 m), erosion stops at a sediment layer depth of 20 cm where the sediments become more cohesive. During normal berthing activities at a water depth of 9 m, the scour depth reaches 20 cm for tug activities with lengthy operation times.

When a *J.T. Quigg*-size tug is conducting normal berthing activities over the most erodible area upstream of the First Avenue Bridge at a shallow water depth (5 m), the erosion rate decreases at a sediment layer depth of 10-15 cm where the sediments become more cohesive. During normal berthing activities at a water depth of 7 m, the scour depth does not exceed 6 cm.

References

Albertson M.L., Y.B. Dai, R.A. Jensen, and H. Rouse 1948. *Diffusion of Submerged Jets.* ASCE Papers, p1571-1595.

Blaauw, H.G. and E.J. van de Kaa 1978. *Erosion of Bottom and Sloping Banks Caused by the Screw Race of Maneuvering Ships.* Paper presented at the 7th International Harbour Congress, Antwerp, May 22-26, 1978.

Emmons, S. and M. Hernandez-White 2009. Personal communication: phone call interviews with various tug companies operating in the LDW. On behalf of the Lower Duwamish Water Group by AECOM, Seattle WA. February 2009.

Hamill, G.A., H.T. Johnston, and D.P. Stewart 1999. *Propeller Wash Scour Near Quay Walls*. Journal of waterway, port, coastal, and ocean engineering, July/August 1999.

Maynord, S.T. 2000. *Physical Forces near Commercial Tows*. Interim report for the Upper Mississippi River-Illinois Waterway System Navigation Study. Env Report 19, interim report. US Army Corps of Engineers Research and Development Center, Vicksburg, MS.

QEA 2008. *Sediment Transport Modeling Report. Final*. Prepared for Lower Duwamish Waterway Group for submittal to US Environmental Protection Agency, Seattle, Washington and Washington Department of Ecology, Bellevue, Washington. Prepared by Quantitative Environmental Analysis, LLC, Montvale, NJ. October 29, 2008.

Toutant, W.T. 1982. *Mathematical Performance Models for River Tows*. Winter meeting, Great Lakes and Great Rivers Section, Society of Naval Architects and Marine Engineers, Clarksville, IN.

Verhey, H.J. 1983. The Stability of Bottom and Banks Subjected to the Velocities in the Propeller Jet Behind Ships. No. 303, Delft Hydraulics Laboratory, Delft, The Netherlands.

Windward Environmental, LLC and QEA 2008. *Lower Duwamish Waterway Sediment Transport Analysis Report. Final.* Prepared for Lower Duwamish Waterway Group. Quantitative Environmental Analysis, LLC, Montvale, NJ. January 8, 2008.

Part 8: Modeling Contaminant Transport through a Sediment Cap: Summary of Preliminary Work

AECOM Environment
710 Second Avenue, Suite 1000, Seattle, WA 98104
T 206.624.9349 F 206.623.3793 www.aecom.com

Memorandum

Date: October 15, 2010

To: Lower Duwamish Waterway Group

From: AECOM

Subject: Modeling Contaminant Transport through a Sediment Cap: Summary of Preliminary Work

Introduction

Capping is a technology component of all remedial alternatives being developed and evaluated for cleanup of contaminated sediments in the Lower Duwamish Waterway (LDW) Feasibility Study (FS). Gaining an FS-level understanding of how this technology is expected to perform under conditions within the LDW is an essential consideration in assessing its technical feasibility and effectiveness. One aspect of performance is whether and when contaminants originating from buried sediments or groundwater are predicted to emerge through the cap into the biologically active zone (BAZ)[1] and overlying water column (i.e., by diffusion and groundwater advection) at levels that constitute an unacceptable risk. To this end, porewater contaminant concentrations within a hypothetical sediment cap were modeled.

The modeling analysis was conducted in two ways:

1. A parameter sensitivity analysis was used to assess the relative importance of each model input parameter to capping effectiveness. In this analysis, the parameters were varied one at a time, keeping the rest of the parameters constant. The results of this analysis were used to select key parameters to be varied in the scenarios analysis.

2. The scenarios analysis was used to assess the viability of capping under a range of conditions potentially occurring in the LDW. Five parameters were varied and the remaining parameters were held constant. These five parameters were varied in 12 different combinations (i.e., the 12 scenarios) to make FS-level conclusions regarding capping effectiveness. These parameters included: organic carbon partitioning coefficient, Darcy velocity, depositional velocity, cap placement thickness, and fraction of organic carbon in the cap.

The modeling methods, input parameters, sensitivity analysis, and scenario results are described below.

Model Selection and Technical Approach

After reviewing several potential models, the Lampert and Reible model (2009) was selected for this exercise. This selection was made because the model accounts for: 1) advection, dispersion, and

1 The BAZ is assumed to be the top 10 cm of the surface sediment.

diffusion; 2) sediment compaction resulting from cap placement; and 3) net sedimentation following cap placement. All of these processes are important in the LDW. Also, the model is a spreadsheet analysis and therefore easily manipulated for investigating various scenarios consistent with an FS-level analysis. A previous iteration of this model was employed at the Slip 4 Early Action Area (Integral 2006). The model was used to evaluate total PCBs because they are a key chemical of concern at the site, and because the analysis for PCBs can be generalized to be representative of other organic compounds, such as cPAHs (see discussion below).

Two small changes to the 2009 model were made to better represent the data and the conditions in the LDW. First, both the default Lampert and Reible spreadsheet model and the Slip 4 analysis used porewater concentration for the influent contaminant concentration below the cap. In the Slip 4 analysis, influent porewater concentrations were assumed equal to those concentrations measured in shoreline seeps. However, for the analysis presented here, very limited seep and porewater data were available to characterize the LDW, compared to the size of the potential capping footprint. Therefore, the influent porewater concentration beneath the cap was computed based on equilibrium partitioning with contaminant concentration in the underlying sediment. The partitioning coefficient (K_{oc}) was used to convert sediment concentration to influent porewater concentration for the model.

Second, the default Lampert and Reible spreadsheet model does not have a separate input for fraction of organic carbon (f_{oc}) of newly deposited sediment. Instead, the model assumes that the f_{oc} of newly deposited sediment is equal to the f_{oc} of capping material ($(f_{oc})_{eff}$). However, evidence in the LDW (Section 2) indicates that the f_{oc} of incoming sediment is closer to that in the BAZ ($(f_{oc})_{bio}$) than in the capping material (see Table 1). Therefore, new sediment was assumed to have the same f_{oc} as the BAZ ($(f_{oc})_{bio}$).

Input Parameters and Parameter Sensitivity Analysis

Model input parameters are listed in Table 1. Each parameter was varied with a low, mid, and high values (Table 1). Most of the mid parameter values are consistent with those used for the Slip 4 analysis (Integral 2006) and represent an estimate for average conditions in the LDW. The low and high parameter values represent an estimate for low and high conditions potentially occurring in the LDW. The basis for each parameter value is listed in Table 1.

The mid, low, and high parameter values used in the sensitivity analysis (Table 2) are the same as those in Table 1 with one significant exception: the depositional velocity (i.e., sedimentation rate) was set to zero for the mid values in Table 2. This change was made because of the finding that very small rates of sedimentation result in no contaminant breakthrough. In order to adequately compare the sensitivity of the other parameters, it was necessary to remove sedimentation from the analysis by setting depositional velocity to zero.

For the parameter sensitivity analysis, each parameter was varied one at a time while all the other variables were held constant at the mid values (see Table 2). Each parameter was varied from the mid to the low to the high value; the model results for each sensitivity run were recorded in the right-hand columns of Table 2. The results were reported as 1) breakthrough time,[2] and 2) maximum concentration that can be capped in steady state.[3]

The most sensitive parameters were the ones that showed the largest variance in the results, and included five key input parameters. These five parameters were retained for the scenarios analysis, and

---

2 For this analysis, breakthrough time was defined as the time to reach 100 µg/kg dw PCBs in the BAZ.

3 Steady state represents the conditions following breakthrough, generally 200 to 4,000 years into the future. For this analysis, the maximum concentration that can be capped was defined as the contaminant concentration that resulted in a BAZ concentration of 100 µg/kg dw PCBs.

were highlighted in blue in Table 2. These are: organic carbon partitioning coefficient, Darcy velocity, depositional velocity, cap placed thickness, and fraction of organic carbon in the cap.

Scenarios Analysis

Five key parameters were varied for the scenario analyses. Three of these parameters were varied to account for variations in waterway conditions: 1) Darcy velocity, 2) depositional velocity (net sedimentation rate), and 3) log K_{oc} values. These were used to evaluate capping in average (mid-range) waterway conditions and reasonable worst-case capping conditions, as shown in Table 3. The remaining two key design parameters were varied to evaluate potential cap design options: 1) a range of f_{oc} in capping material and 2) a range of cap thicknesses.

Finally, cap effectiveness was evaluated for two points of compliance: a 10-cm point of compliance for consistency with the benthic biologically active zone (BAZ) in the LDW, and a 45-cm point of compliance to address clamming direct contact risks in nearshore access areas. The point of compliance is 10 cm depth unless otherwise noted (average conditions).

In total, 12 different scenarios were selected to demonstrate various cap designs under various conditions:

1) Scenarios 1a and 1b: capping (3 ft sand) assuming sedimentation conditions consistent with empirical data of 1 cm/yr:
    a. Average mid conditions for all parameters
    b. Conditions unfavorable for capping (high or low parameter)
2) Scenarios 2a through 2c: capping with 3 ft sand assuming no sedimentation
    a. Average mid conditions for all parameters
    b. Conditions unfavorable for capping (high or low parameter)
    c. Conditions unfavorable for capping (raise to 1% f_{oc} in the cap)
3) Scenarios 3a and 3b: ENR with 0.5 ft sand assuming no physical mixing[4] assuming sedimentation conditions consistent with empirical data of 1 cm/yr
    a. Average mid conditions for all parameters
    b. Conditions unfavorable for capping
4) Scenarios 4a through 4c: ENR with 0.5 ft sand assuming no physical mixing and no sedimentation
    a. Average mid conditions for all parameters
    b. Average mid conditions for all parameters (raise to 2% f_{oc} in the cap)
    c. Conditions unfavorable for capping (raise to 2% f_{oc} in the cap)
5) Scenarios 5a and 5b: Capping with 3 ft sand assuming a 45-cm point of compliance for clamming areas[5] and no sedimentation
    a. Average mid conditions for all parameters
    b. Conditions unfavorable for capping (raise to 2% f_{oc} in the cap).

---

[4] ENR generally assumes that placed sand mixes with underlying sediment; therefore, this analysis is exploratory.

[5] The standard point of compliance for the rest of the LDW is the BAZ, or the upper 10 cm of sediment.

Conditions considered unfavorable for capping include: high groundwater flow, low sedimentation, and low K_{oc}; and in some cases, low organic carbon in the sand cap (see Table 3 for exact input parameters). This modeling framework was used to estimate:

1) The maximum concentration that can be capped to maintain total PCB concentrations in BAZ sediments of less than 100 µg/kg dw in 100 years
2) The maximum concentration that can be capped to achieve total PCB concentration of less than the Water Quality Standard (WQS) of 0.03 µg/L PCBs in 100 years.

Results

Table 3 presents results of model runs for the twelve scenarios, which provide a range of results from expected conditions based on FS base assumptions to unfavorable conditions.

Scenarios 1a and 1b show that contaminant breakthrough is not expected to occur at concentrations above the assumed performance goals. This is true even where the assumed conditions are unfavorable (high groundwater flow, low sedimentation, and low K_{oc}), because the rate of sedimentation is still greater than the rate of contaminant front migration through the cap.

Scenarios 2a through 2c show that in the absence of sedimentation, capping is still feasible. However, a higher organic carbon cap may be necessary for a cap design life of 100 years. Higher organic carbon in the cap could be achieved through cap amendments or the use of capping material with higher organic carbon content (2% oc).

Scenarios 3a and 3b show that with sedimentation and thin sand placement (i.e., ENR without physical mixing), contaminant breakthrough is not expected to occur, even in conditions unfavorable to capping.

Scenarios 4a and 4b show that in the absence of sedimentation, thin sand placement is still feasible under average conditions, but a higher organic carbon in the sand layer may be necessary. Scenario 4c shows that the thin sand layer may not be feasible in conditions unfavorable for capping in the absence of sedimentation.

Scenarios 5a and 5b show that for the 45-cm clamming point of compliance direct contact scenario, capping is feasible, even in the absence of sedimentation. However, a higher organic carbon cap (2% oc) may be necessary for a cap design life of 100 years.

The modeling and results for total PCBs can be expanded to address cPAHs because the individual compounds that comprise the latter have K_{oc} values within or above the range used for total PCBs, as shown in Table 4.

Attachments

Table 1 Input Parameters for Analysis of PCB Transport through a Sediment Cap

Table 2 Parameter Sensitivity Analysis

Table 3 Cap Model Results for Select Scenarios

Table 4 K_{oc} Values for cPAHs and PCBs

References

Fabritz, J., J. Massmann, and D. Booth, 1998. *Development of a Three-Dimensional Numerical Groundwater Flow Model for the Duwamish River Basin*. Prepared for City of Seattle and King County for the Duwamish Basin Groundwater Pathways Study.

Integral, 2006. "Appendix D: Chemical Isolation Analysis," *Lower Duwamish Waterway Slip 4 early action area: engineering evaluation/cost analysis*. Prepared for City of Seattle and King County. Integral Consulting, Inc., Mercer Island, Washington.

Lampert, David J. and Reible, Danny, 2009. "An Analytical Modeling Approach for Evaluation of Capping of Contaminated Sediments," *Soil and Sediment Contamination: An International Journal*, 18: 4, 470 - 488.

Mackay, D. W., W. Y. Shiu, K.C. Ma, S.C. Lee, 2006, *Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals.* CRC Press, Boca Raton, FL.

Table 1 Input Parameters for Analysis of PCB Transport through Sediment Cap

Input Parameters			Input Values			
Parameter Description	Parameter Symbol	Units	Mid	Low	High	Basis
Contaminant Properties						
Organic Carbon Partition Coefficient	log K_{oc}	log L/kg	5.9	5.0	6.5	Aroclor 1016: 5.03 - proxy for light Aroclors (MTCA); Aroclor 1260: 5.91 - common Aroclor at site, used in Slip 4 analysis (MTCA[a]); Aroclor 1260: 6.5 - high estimate[b]
Water Diffusivity	D_w	cm^2/s	5E-06	4E-06	6E-06	Low value: 4E-6 (model default)[c], 5E-6 (Slip 4)[a]
Cap Decay Rate	l_1	yr^{-1}	0	0	0	Assume no decay (Slip 4 estimate)[a]
Bioturbation Layer Decay Rate	l_2	yr^{-1}	0	0	0	Assume no decay (Slip 4 estimate)[a]
Sediment Properties						
Contaminant Concentration	$C_{0(dw)}$	µg/kg dw	2,600	1,300	6,500	CSL, 2xCSL, 5xCSL based on Sediment Management Standards
Contaminant Porewater Concentration	$C_{0(porewater)}$	µg/L	0.160	0.080	0.400	Calculated as C_o(dw)/(f_{oc}*K_{oc}) (partitioning equation). See sensitivity for C_o(dw)
Biological Active Zone fraction organic carbon	$(f_{oc})_{bio}$	unitless	0.02	0.01	0.04	1-4% based on conditions in the LDW (FS Section 2)
Colloidal Organic Carbon Concentration	r_{DOC}	mg/L	2.0	0.0	4.3	Low sensitivity. 0 mg/L (model default)[c], 4.3 mg/L (Slip 4 estimate)[a]
Darcy Velocity (positive is upwelling)	V	cm/yr	250	106	590	Location specific. Groundwater velocities for the STM: Reach 1:106 - 250 cm/yr, Reach 2: 230-250 cm/yr, Reach 3:260-590 cm/yr[d]
Depositional Velocity	V_{dep}	cm/yr	1.00	0.00	3.00	Not used in sensitivity analysis except to show no breakthrough predicted for very low sedimentation. Location specific deposition predictions from the STM: Reach 1: 1.0-2.0 cm/yr, Reaches 2 and 3: >3.0 cm/yr. 0 cm/yr is a very low estimate for the site.[e]
Bioturbation Layer Thickness	h_{bio}	cm	10	5	45	10 cm is the point of compliance for most of the river; 45 cm is the point of compliance and depth of clams in beaches and clamming areas (FS Section 3); 5 cm is a low estimate of BAZ thickness.
Porewater Biodiffusion Coefficient	D_{bio}^{pw}	cm^2/yr	100	50	200	Low sensitivity. 50 cm^2/yr (1/2x model estimate)[a], 100 cm^2/yr (model default)[c], 200 cm^2/yr (2x model default)[c]
Particle Biodiffusion Coefficient	D_{bio}^{p}	cm^2/yr	1.0	0.5	25.0	0.5 cm^2/yr (1/2x model default)[c], 1.0 cm^2/yr (model default)[c], 25 cm^2/yr (reasonable maximum estimate)
Cap Properties						
Cap Placed Thickness		cm	100	23	150	Design variable with low sensitivity, i.e., cap thickness does not greatly affect steady state BAZ concentration.
Cap Materials: Granular (G) or Consolidated Silty/Clay (C)			G	G	G	Assume granular cap
Cap Consolidation Depth	cm		0	0	0	Assume 0 cm (Slip 4 estimate)[a]
Underlying Sediment Consolidation Due to Cap Placement			23	10	30	Low sensitivity. 10 cm (about 1/2 Slip 4 estimate)[a], 23 cm (Slip 4 estimate)[a], 30 cm (reasonable maximum estimate)
Porosity	e	unitless	0.4	0.30	0.50	0.3 (low estimate), 0.4 (Slip 4 estimate)[a], 0.5 (high estimate)
Particle Density	ρ_P	g/cm^3	2.6	2.5	2.7	2.5 (low estimate), 2.6 (Slip 4 estimate)[a], 2.7 (high estimate)
Fraction Organic Carbon	$(f_{oc})_{eff}$	unitless	0.01	0.0010	0.0200	Key variable in cap design. 0.05% (1/2 MTCA assumption), 1% (Upper Turning Basin), 2% (high oc sand)
Boundary Layer Mass Transfer Coefficient	k_{bl}	cm/hr	0.75	0.60	0.90	0.60 cm/hr (low estimate), 0.75 (model default)[c], 0.9 (high estimate)

Sources:

a. Integral 2006. “Appendix D: Chemical Isolation Analysis,” Lower Duwamish Waterway Slip 4 Early Action Area: Engineering Evaluation/Cost Analysis. Prepared for City of Seattle and King County. Integral Consulting, Inc., Mercer Island, Washington. 2006.

b. Mackay, D. W., W. Y. Shiu, K.C. Ma, S.C. Lee, 2006, *Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals*. CRC Press, Boca Raton, FL

c. Lampert, David J. and D. Reible 2009. “An Analytical Modeling Approach for Evaluation of Capping of Contaminated Sediments,” *Soil and Sediment Contamination: An International Journal*, 18: 4, 470 - 488.

d. Fabritz, J., J. Massmann, and D. Booth 1998. *Development of a Three-Dimensional Numerical Groundwater Flow Model for the Duwamish River Basin*. Prepared for City of Seattle and King County for the Duwamish Basin Groundwater Pathways Study. 1998.

e. Sediment Transport Memo, Part 4 of this appendix.

Notes:

1. This analysis also applies to other compounds with similar K_{oc} values, such as cPAHs. See discussion in text.

oc = organic carbon

Table 2 Parameter Sensitivity Analysis

Input Parameters			Input Values[a]			Output 1) Time until Breakthrough (Years until 100 µg/kg of Contaminant Concentration Appears in the BAZ)			Output 2) Maximum Total PCB Concentration That Can Be Capped (µg/kg dw to Achieve 100 µg/kg dw in the BAZ under Steady State Conditions)[b]		
Parameter Description	Parameter Symbol	Units	Mid	Low	High	Mid	Low	High	Mid	Low	High
Contaminant Properties											
Contaminant	Contaminant		PCBs								
Organic Carbon Partition Coefficient	log K_{oc}	log L/kg	5.9	5.0	6.5	1,993	399	3,551	1,223	342	2,048
Colloidal Organic Carbon Partition Coefficient	log K_{DOC}	log L/kg	5.5	4.7	6.1	1,993	1,993	1,993	1,223	1,223	1,223
Water Diffusivity	D_w	cm^2/s	5E-06	4E-06	6E-06	1,993	2,000	1,986	1,223	1,223	1,223
Cap Decay Rate	l_1	yr^{-1}	0	0	0	1,993	1,993	1,993	1,223	1,223	1,223
Bioturbation Layer Decay Rate	l_2	yr^{-1}	0	0	0	1,993	1,993	1,993	1,223	1,223	1,223
Sediment Properties											
Contaminant Concentration	$C_{0(dw)}$	µg/kg	2,600	1,300	6,500	1,993	>2021	1,843	1,223	1,223	1,223
Contaminant Porewater Concentration	$C_{0(porewater)}$	µg/L	0.160	0.080	0.400	1,993	1,993	1,993	1,223	1,223	1,223
Biological Active Zone Fraction Organic Carbon	$(f_{oc})_{bio}$		0.02	0.01	0.04	1,993	1,876	>2021	1,223	818	1,670
Colloidal Organic Carbon Concentration	r_{DOC}	mg/L	2.0	0.0	4.3	1,993	3,375	1,355	1,223	1,223	1,223
Darcy Velocity, *V* (positive is upwelling)	V	cm/yr	250	106	590	1,993	4,597	853	1,223	2,781	563
Depositional Velocity	V_{dep}	cm/yr	0	0	0.05	1,993	1,993	no bt	1,223	1,223	no max
Bioturbation Layer Thickness	h_{bio}	cm	10	5	45	1,993	2,064	>1066	1,223	1,677	458
Porewater Biodiffusion Coefficient	D_{bio}^{pw}	cm^2/yr	100	50	200	1,993	1,993	1,993	1,223	1,222	1,226
Particle Biodiffusion Coefficient	D_{bio}^{p}	cm^2/yr	1.0	0.5	25.0	1,993	1,993	1,993	1,223	818	2,585
Cap Properties											
Depth of Interest	z	cm	10	5	15	1,993	1,993	1,993	1,223	1,223	1,223
Fraction Organic Carbon at Depth of Interest	$f_{oc}(z)$		0.02	0.010	0.040	1,993	>2021	1,876	1,223	1,223	1,223
Cap Placed Thickness		cm	100	23	150	1,993	>264	2,972	1,223	1,213	1,232
Cap Materials: Granular (G) or Consolidated Silty/Clay (C)			G	G	G	1,993	1,993	1,993	1,223	1,223	1,223
Cap Consolidation Depth			0	0	0	1,993	1,993	1,993	1,223	1,223	1,223
Underlying Sediment Consolidation Due to Cap Placement			23	10	30	1,993	1,993	1,993	1,223	1,223	1,223
Porosity	e		0.4	0.30	0.50	1,993	2,338	1,651	1,223	1,322	1,109
Particle Density	ρ_P	g/cm^3	2.6	2.5	2.7	1,993	1,916	2,070	1,223	1,198	1,247
Fraction Organic Carbon	$(f_{oc})_{eff}$		0.01	0.0010	0.0200	1,993	199	3,986	1,223	1,223	1,223
Boundary Layer Mass Transfer Coefficient	k_{bl}	cm/hr	0.75	0.60	0.90	1,993	1,993	1,993	1,223	1,111	1,316

Notes:

a. Mid-range values constitute the base case condition. Low-range and high-range parameter values constitute estimated possible low and high values for the LDW. Input values are identical to Table 1 except for sedimentation rate. Very low sedimentation results in no breakthrough; therefore, sedimentation must be set to zero to assess the sensitivity of the other parameters.

b. Steady state conditions occur following contaminant breakthrough, approximately 200 to 4,000 years into the future.

>[years] = output expressed as greater than because of analytical model limitations; BAZ = biological active zone; f_{oc} = fraction of organic carbon; no bt = no breakthrough predicted; no max = no maximum contamination concentration due to no predicted breakthrough

Shaded parameters are varied in the scenarios analysis in Table 3

Table 3 Cap Model Results for Select Scenarios

	Scenario in Bedded Sediment	Select Parameter Input Values for Scenario: Darcy Velocity (cm/yr)	Depositional Velocity (cm/yr)	log K_{oc} (log L/kg)	Cap f_{oc} (%)	Cap Thickness (cm)	Maximum Total PCB Concentration That Can Be Capped (µg/kg dw): Goal: total PCBs of 100 µg/kg dw in the BAZ in 100 years	Goal: WQS of 0.03 µg/L Total PCBs in the BAZ in 100 years
1	***Scenarios for capping assuming sedimentation conditions consistent with empirical data***							
1a	Average conditions	250	1	6	1%	100	no maximum	no maximum
1b	High groundwater flow, low sedimentation, low K_{oc}, low oc cap	590	1	5	0.05%	100	no maximum	no maximum
2	***Scenarios for capping assuming no sedimentation***							
2a	Average conditions with no sedimentation	250	0	6	1%	100	no maximum	no maximum
2b	High groundwater flow, no sedimentation, low K_{oc}, low oc cap	590	0	5	0.05%	100	204	131
2c	High groundwater flow, no sedimentation, low K_{oc}, mid oc cap	590	0	5	1%	100	no maximum	no maximum
3	***Scenarios for ENR assuming no physical mixing and low level of sedimentation[a]***							
3a	Average conditions, 6-inch ENR layer	250	1	6	1%	15	no maximum	no maximum
3b	High groundwater flow, low sedimentation, low K_{oc}, low oc ENR layer	590	1	5	0.05%	15	no maximum	no maximum
4	***Scenarios for ENR assuming no physical mixing and no sedimentation[a]***							
4a	Average conditions with no sedimentation and 6-inch ENR	250	0	6	1%	15	1,213	5,919
4b	Average conditions with no sedimentation and 6-inch ENR	250	0	6	2%	15	no maximum	no maximum
4c	High groundwater flow, no sedimentation, low K_{oc}, high oc cap	590	0	5	2%	15	181	116
5	***Scenarios for capping assuming a 45-cm POC in clamming areas***							
5a	Average conditions with no sedimentation	250	0	6	1%	100	no maximum	no maximum
5b	High groundwater flow, no sedimentation, low K_{oc}	590	0	5	2%	100	no maximum	no maximum

Notes:

1. Model used mid-range parameters from Table 1, except as noted for Darcy velocity, sedimentation rate, log K_{oc}, cap f_{oc}, and cap thickness.

a. ENR generally assumes that placed sand mixes with underlying sediment, therefore the analysis is exploratory and may need to be refined during remedial design.

BAZ = biologically active zone; C_0 = porewater concentration of contaminant; ENR = enhanced natural recovery; f_{oc} = fraction of organic carbon; K_{oc} = organic carbon partitioning coefficient; oc = organic carbon; PCB = polychlorinated biphenyl; POC = point of compliance; WQS = water quality standard

Table 4 K_{oc} values for cPAHs and PCBs

Compound	CAS #	Log K_{oc}[a]
Benz[a]anthracene	56-55-3	5.56
Benzo[a]pyrene	50-32-8	5.99
Benzo[b]fluoranthene	205-99-2	6.08
Benzo[k]fluoranthene	207-08-9	6.08
Chrysene	218-01-9	5.60
Dibenz[a,h]anthracene	53-70-3	6.26
Indeno[1,2,3-cd]pyrene[2]	193-39-5	6.54
cPAH weighted average based on TEF		6.02
PCB-Aroclor 1016	12674-11-2	5.04
PCB-Aroclor 1260	11096-82-5	5.91
PCBs (generic mixture)	1336-36-3	5.49

Notes:

a. From Washington State Department of Ecology Cleanup Levels and Risk Calculation Database

CAS# = chemical abstracts service number; cPAH = carcinogenic polycyclic aromatic hydrocarbon; K_{oc} = organic carbon partitioning coefficient; PCB = polychlorinated biphenyl; TEF = Toxicity Equivalency Factor

Part 9: BCM Sensitivity – Sediment Particle Fractionation

AECOM

ANCHOR QEA

305 West Grand Avenue, Suite 300
Montvale, New Jersey 07645
Phone 201.930.9890
Fax 201.930.9805
www.anchorqea.com

MEMORANDUM

To:	Sediment Transport Modeling Group and Lower Duwamish Waterway Group	**Date:**	July 14, 2011
From:	C. Kirk Ziegler, Mike Riley, Anchor QEA Anne Fitzpatrick, AECOM	**Project:**	RETldw
Cc:	Files		
Re:	BCM Sensitivity – Sediment Particle Fractionation		

The concentrations assigned to upstream solids for bed composition model (BCM) base case calculations are the same for all four particle sizes simulated in the sediment transport model (STM). The particle size fractions that deposit in different portions of the Lower Duwamish Waterway (LDW) are not, however, the same (the percent fines increase downriver). Some studies on other sites have concluded that contaminant concentrations vary among different size fractions. The basic assumption on the difference in contaminant concentration is that concentrations may be higher on fine grain clay and silt sized particles than on sand-sized particles due to a larger surface area per unit mass and resulting higher organic carbon content (Hedges and Keil 1995).

The Lower Duwamish Waterway Group (LDWG) discussed grain-size and total polychlorinated biphenyl (PCB) concentration distribution analyses with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) in a meeting on October 1, 2009. Two approaches were used to assign total PCB concentrations to upstream and lateral source sediments. Based on the results presented, and the uncertainty in assigning concentrations by particle size, the decision at the October 1, 2009 meeting was not to fractionate chemical concentrations on STM/BCM sediment classes used in the feasibility study (FS).

However, it is important to understand the potential uncertainty associated with spatially-weighted average concentrations (SWACs) based on these model assumptions. In the subsequent meeting held on April 8, 2011, a third approach was added to this analysis to better understand the effects of grain size and organic carbon on total PCB SWACs. The following describes the three approaches used in the present analysis:

1. Assigning high BCM sensitivity total PCB values to the Class 1A and 1B sediments (clay/silt fractions) and low BCM sensitivity total PCB values to the Class 2 and 3 sediments (sand fractions) from both the upstream and lateral sources. Table 1 presents the grain size distributions for each of the four grain size classes used in the STM.
2. Assigning total PCB values to the upstream and lateral source sediments based on an expectation that smaller particle sizes will have higher organic carbon content and therefore have higher total PCB concentrations. Organic carbon content was assigned at 5, 2.5, 1.5, and 0.3 percent for Classes 1A, 1B, 2, and 3, respectively, while maintaining the same aggregate suspended load value as the BCM base case of 35 μg/kg dw.
3. Similar to Approach 2, but Classes 1A and 1B were assumed to have the same PCB concentration; and total PCB values on Class 2 and Class 3 were assigned based on 1.5 and 0.3 percent organic carbon content.

Using these approaches, the grain size/total PCB concentrations were developed (Table 2). The mid BCM input values used in the FS are shown for reference. The average total organic carbon content of LDW bed sediment is about 2 percent.

Table 1 Characteristics of Sediment Particle Size Classes

Sediment Size Class	Particle Size Range (μm)	Effective Particle Diameter (μm)
1A: clay, fine silt	< 10	5
1B: medium, coarse silt	10 – 62	20
2: fine sand	62 – 250	130
3: medium, coarse sand	250 – 2,000	540

Table 2 Total PCB Input Value for the Grain Size Fractionation Analysis

Sediment Source and Class	Percentage of Suspended Load by Mass	Total PCB Concentration Input Value (µg/kg dw)			
		FS mid BCM Value	Approach 1	Approach 2	Approach 3
Green/Duwamish (Upstream) Sediment					
Class 1A	70	35	80	42	38
Class 1B	18	35	80	21	38
Class 2	12	35	5	13	11
Class 3	0	35	5	3	2
Aggregate concentration on suspended load		35	71	35	35
Lateral Source Sediment					
Class 1A	55	300	1,000	422	374
Class 1B	18	300	1,000	211	374
Class 2	23	300	100	127	112
Class 3	4	300	100	25	22
Aggregate concentration on suspended load		300	757	300	300

Notes:

1. For Green/Duwamish sediment Classes 1A, 1B, and 2 are suspended load and Class 3 is bed load. However, there is very little bed load that reaches the LDW beyond river mile 4.5.
2. The Draft Final FS mid BCM values are shown for reference when comparing input values for the three approaches.
3. Approach 3 has more PCB mass on 1A and 1B than in approach 2. Since in both cases, we are maintaining the same aggregate load of 35 µg/kg, the mass assigned to classes 2 and 3 must be reduced in approach 3 compared to approach 2.

Note that as a result of the high proportion of Class 1A and 1B particles in the upstream source sediment and the high total PCB concentration assigned to these sediment classes, Approach 1 results in an average total PCB concentration for upstream suspended sediment of 71 µg/kg dw, which is substantially higher than the mid BCM upstream input value used in the analysis in the draft final FS. Approaches 2 and 3 maintain the same average total PCB concentration for upstream suspended sediment as the BCM value used in the draft final FS, but assign that concentration by organic carbon and sediment composition of upstream and lateral source sediment to the different size classes.

RESULTS AND DISCUSSION:

Table 3 presents the results of these approaches after 10 years of natural recovery following completion of the EAAs (Post Alternative 1).

Table 3 Results of the Grain Size Fractionation Analysis

LDW Reach	Total PCB SWAC (µg/kg dw)			
	FS mid BCM Value	Approach 1	Approach 2	Approach 3
1	84	120	78	85
2	67	100	60	66
3	40	51	23	28
Site-Wide	73	104	65	71

Approach 1 produces substantially higher SWACs than the FS BCM mid input value case (recommended input values). This is not surprising because the allocation of total PCBs to the different size fractions results in an increase in total PCB concentration from upstream and lateral source sediments.

Approach 2 produces slightly lower SWACs for all reaches. This is because the highest concentration is assigned to the Class 1A size fraction while the other size fractions have total PCB concentrations less than the value used in the FS. The Class 1A size fraction makes up 70% of the total suspended sediment load by mass entering the LDW; however, most of this material passes through the LDW without settling. Therefore, the sediment that does settle has an average total PCB concentration slightly less than the FS mid BCM input value.

Approach 3 produces SWAC values for the LDW site-wide and for Reaches 1 and 2 that are essentially the same as for the FS mid BCM input values. While the SWAC for Reach 3 is substantially lower due to the low total PCB concentration on Class 3 material, Class 3 is the size fraction that predominantly deposits in Reach 3.

Overall, the size fractionation of PCB concentration results in either lower predicted SWACs with time or essentially the same as in the current FS base case BCM analysis. The analysis shows that the approach used in the BCM base case analysis likely underestimates natural recovery over time compared to a BCM model in which contaminant concentrations are assigned by particle size.

Lower Duwamish Waterway Group

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

Appendix D
Area of Potential Concern Analysis

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM
710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

List of Tables

List of Figures

D.1 Introduction

This appendix first provides the rationale for subdividing Area of Potential Concern 1 (AOPC 1) into smaller areas based on similar physical characteristics, similar risk-driver distribution patterns, proximity to potential sources, and other factors. Second, this appendix provides additional supporting information for the designation of recovery categories in each of these smaller areas, as described in Section 6.3.1 of the feasibility study (FS). The smaller areas are used to help organize and present this information. The recovery categories are used, in turn, to help identify appropriate remedial technologies in the development of remedial alternatives in Section 8.

D.2 Subdividing AOPC 1 into Areas with Similar Characteristics

The individual areas within AOPC 1 were delineated by grouping surface sediment samples with similar physical characteristics, similar risk-driver distribution patterns, proximity to potential sources, and other factors. Best professional judgment, site conditions, and understanding of the conceptual site model (CSM) were collectively used to refine "the edges" of the AOPC 1 footprint and manage small "slivers" that resulted from the geographic information system (GIS) mapping process. These subdivided areas are only approximate boundary estimates to be confirmed and modified during remedial design. They are grouped for tracking purposes and to facilitate assignment of recovery categories and remedial technologies in the FS.

Within the Lower Duwamish Waterway (LDW), contamination typically does not extend from one bank to the other. Where hot-spots are present, they typically exist on either the east or west benches of the LDW. Some commingling of risk drivers occurs across the navigation channel in Reach 1 but in general, the concentration gradients decline fairly rapidly with distance from shore. This delineation between the benches and the toe of the navigation channel slope was used when drawing the AOPC 1 boundary. These distribution patterns were also considered in the delineation of the 50 individual areas of AOPC 1 (Table D-1). See Section 6.1.1 for a definition of AOPC 1 and the criteria used to define it.

D.3 Assignment of AOPC 1 Areas to Recovery Categories

Section 6.3.1 of the FS describes how the LDW (downstream of river mile [RM] 4.75) was subdivided into three categories with respect to their potential for natural recovery, based on the criteria presented in Table 6-3. The recovery categories are:

- **Category 1** includes areas where recovery is presumed to be limited. It includes areas with observed and predicted scour, net scour, and empirical data demonstrating increasing concentrations over time.
- **Category 2** includes areas where recovery is less certain. It includes areas with net sedimentation and mixed empirical trends.

- **Category 3** includes areas where recovery is predicted. It includes areas with minimal scour potential, net sedimentation, and empirical trends of decreasing concentrations.

The subdivision of the LDW into these three recovery categories is shown on Figure 6-4a. The supporting information for each line of evidence considered in assigning recovery categories within AOPC 1 is provided in Table D-1. Empirical data trends are described in Appendix F and in Section 6.3.1. The empirical trend data resulted in a change to the recovery category designation in 18 areas; these changes are summarized in Table D-2.

Each area was assigned to the recovery category overlapping the majority of that area, as displayed in Figures D-1 through D-5. If two recovery categories occupied roughly equal acreage in an area, the lower numbered category was assigned. The assignment of a recovery category to each area is useful for remedial decision-making because it synthesizes all of the lines of evidence into one mapping layer, which points to the feasibility of using either enhanced natural recovery (ENR) or monitored natural recovery (MNR) as a remedial technology within an area (i.e., it describes the predicted ability of the area to recover naturally). However, this appendix only simplifies and presents the complex array of data into data tables; the assignment of remedial technologies in Section 8 is performed in GIS as a multi-layered mapping exercise.

Figures D-1 through D-5 display the areas identified in Table D-1, along with their recovery categories, core data, and resampled surface sediment locations. The maps also display the areas assigned to verification monitoring (described in Section 8). The verification monitoring areas are those with minor sediment quality standards exceedances in relatively old data (> 10 years old), isolated samples (i.e., only one sample with an exceedance in an approximate 0.5-acre or larger area), and no scour potential; all are assigned to Recovery Category 3. Figures D-1 through D-5 display the footprint of AOPC 2, although recovery category assignments in AOPC 2 are not displayed.

For all FS-level analyses and remedial decision-making, the AOPC boundaries are considered conservative and adequate. These boundaries will need to be verified and refined, as necessary, during remedial design and even, perhaps, during implementation of the remedial alternative.

D.4 Summary

The mapping layers presented in this appendix were used to delineate the AOPC 1 footprint and the recovery categories. This analysis supports the assignment of remedial technologies for individual areas in Section 8. Data from these layers are described on an area-by-area basis (of AOPC 1) in Table D-1. This table represents a way to organize and present data useful for decision-making and FS remedial alternative development.

D.5 References

Herrera 2004. *Summary Report, Lower Duwamish Waterway Outfall Survey.* Prepared for Seattle Public Utilities. Herrera Environmental Consultants, Inc., Seattle, WA. January 2004.

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 1A	0	Harbor Island Marina	2.6	No	No	No	No	(1) SC-1	CSL 0-2', 1-1.5', 1.5-2' (PCBs); SQS 2-4', 0.5-1' (PCBs); 0-0.5' data pass, as shown on figure	SC-1	Decrease (based on 0.5-ft data)	Mixed (based on 0.5-ft data)	—	—	—	3	Although BEHP is increasing in core SC-1, this area was assigned to Recovery Category 3 because it is a marina with decreasing total PCB trends with no evidence of scour.
Area 1B	0	Harbor Island Marina	2.3	No	No	No	No	No cores	—	—	—	—	—	—	—	3	
Area 2	0.1 E	Ash Grove Cement	1.6	No	Yes	No	Yes	(1) SC-2	CSL 0-6' (PCBs, As, Pb, Zn)	SC-2	Equilibrium	Mixed	—	—	—	1	
Area 3	0.2 E	Ash Grove Cement	5.2	No	Yes	Yes	Yes	(1) SC-4	SQS 0-2' (PCBs, Hg, As); CSL 2-4' (2,4-Dimethylphenol)	SC-4	Decrease	Mixed	—	—	—	1	
Area 4A	0.1 - 0.2 W	Terminal 103 Park/ Ferguson	1.5	No, but most of area outside of STM	No, but most of area outside of STM	No	No	(1) SC-5	SQS 0-2.2' (PCBs, Hg)	SC-5	Increase	Equilibrium	—	—	—	2	
Area 4B	0.1 - 0.25 W	Terminal 103 Park/ Ferguson	2.0	No	No	No	No	No cores	—	—	—	—	SS-10, TRI-010	Below SQS, Below SQS	Decrease, Increase	3	
Area 5	0.25 - 0.4 W	General Recycling and Herring's House	6.2	No	No	Yes in part of area	Yes	(3) SC-6, SC-8, DR068	SC-6: CSL 2-4.5' (PCBs); DRO68: CSL 0-2' (PCBs); SC-8: SQS 0-1' (PCBs); CSL 1-10' (PCBs, BEHP, Hg, N-Nitrosodiphenylamine, and benzyl alcohol)	SC-6, SC-8, DR068	Below SQS, Decrease, Decrease	Below SQS, Mixed, Below SQS	TRI-016, SS-15	Equilibrium, Below SQS	Increase, Increase	1	
Area 6 A-E	0.3 - 0.55 E and navigation channel	Adjacent to Duwamish/ Diagonal EAA	21.8	No	No	No	No	(5) SC-7, SC-9, SC-10, DUD 250, DUD258	SC-7: SQS 0-1' (PCBs) CSL 1-1.7' (PCBs); SC-9: CSL 0-2.6' (PCBs); SC-10: SQS 0-1', 4-5', and 6-8' (PCBs), CSL 1-4' (BEHP, Hg); DUD250: CSL 0-3' (PCBs, BEHP); DUD 258: CSL 0-3' (BEHP), CSL 3-6' (PCBs).	SC-7, SC-9, SC-10	Decrease, Equilibrium, Equilibrium	Mixed, Mixed, Decrease	SS-17	Decrease	Mixed	3; VM in Area 6C	Although some of the older data exhibit mixed trends and equilibrium, these areas are around the EAA. Enhanced natural recovery was applied in Area 6C in 2005. Recovery category and technology assignments considered post-remedy monitoring data trends, which are presented in Appendices F and J.
Area 7A	0.5 - 0.6 W	Northwest of Kellogg Island	2.5	No	No	No	No	(1) SC-11	CSL 0-0.8' (PCBs)	SC-11	Increase	Mixed	—	—	—	1	
Area 7B-C	0.5 - 0.7 W	Northwest of Kellogg Island	6.4	No	No	No	No	No cores	—	—	—	—	—	—	—	3	
Area 7D	0.6 W	North of Kellogg Island	2.7	No	No	No	No	(2) SC-12, DRO44	SC-12: SQS 0-2' (PCBs), CSL 2-6.6' (PCBs, Hg); DR044: CSL 2-4' (PCBs)	SC-12, DR044	Equilibrium, Lack of Data Density	Increase, Increase	—	—	—	2	
Area 7E	0.5 - 0.55 W	North of Kellogg Island	0.8	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 7F	0.7 W	North of Kellogg Island	1.1	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 8A	0.85 W	West side of Kellogg Island	1.6	No	Yes	No	No	No cores	—	—	—	—	—	—	—	3	Although the net sedimentation rate does not exceed 1 cm/yr, these areas are not subject to scour and have relatively low surface sediment concentrations.

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint (continued)

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 8B	0.7 - 0.85 W	West side of Kellogg Island	4.1	No	Yes	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 8C	0.9 - 0.95 W	West side of Kellogg Island	2.2	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 9A	0.8 - 0.9 navigation channel	East of Kellogg Island	3.6	No	No	No	No	(2) SC-13, SC-14	SC-13: SQS 0-2; (PCBs); SC-14: CSL 0-6' (PCBs, Hg), SQS 6-8.6' (Hg)	SC-13, SC-14	Equilibrium, Decrease	Lack of Data Density, Decrease	SSB2b	Increase	Below SQS	2	
Area 9B	0.8 - 0.9 W	East of Kellogg Island	2.3	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 10A	Slip 1	Head of Slip 1	4.4	No	No	Yes	Yes	(1) SC-17	CSL 0-4' and 6-8.6' (PCBs, Hg, Zn, Cd)	SC-17	Decrease	Mixed	SS-31, SS-32	Below SQS, Below SQS	Equilibrium, Decrease	2	Decreasing trends override the scour potential.
Area 10B	Slip 1	Slip 1	5.0	No	No	Yes	Yes	(6) SC-15, SC-16, SC-18, DRO21, C2 and C3	SC-15: SQS 0-4', CSL 4-6' (PCBs); SC-16: SQS 0-2', CSL 2-6' (PCBs); DRO21: SQS 0-2', CSL 2-4' (PCBs); C2: SQS 0-4' (PCBs)	SC-15, SC-16, SC-18, DR021	Equilibrium, Equilibrium, Increase, Equilibrium	Below SQS, Decrease, Increase, Increase	SS-319	Increase	Increase	1	
Area 11A	0.95 - 1.0 W	Lafarge berth	4.7	No	No	Yes	Yes	(1) SC-19	SQS 1-6', CSL 6-7' (PCBs)	SC-19	Equilibrium	Below SQS	DR048	Below SQS	No data	2	
Area 11B	1.05 W	Lafarge berth	1.1	No	No	Yes	Yes	(1) SC-21	SQS 0-1' and 2-4', CSL 4-6.2' (PCBs)	SC-21	Increase	Below SQS	—	—	—	1	
Area 11C	1.0 - 1.1 navigation channel	Navigation Channel	3.4	No	No	Yes in portion of area outside of navigation channel	No	(1) SC-20	CSL 0-2', SQS 2-6' (PCBs)	SC-20	Increase	Equilibrium	SS-37	Increase	Mixed	2	
Area 12	1.1 E	Lehigh NW	0.4	No	No	No	No	(1) SC-22	below SQS	SC-22	Below SQS	Below SQS	—	—	—	3	
Area 13	1.1 - 1.2 navigation channel	Navigation Channel	2.7	No	No	No	No	No cores	—	—	—	—	SS-40	Equilibrium	Below SQS	3	
Area 14A	1.25 - 1.45 W	Duwamish Shipyard	2.7	No	No	Yes	Yes	(4) SC-25, SC-26, SC-28, DR054	SC-25: SQS 0-2' (PCBs), CSL 2-6' (As, Zn, Cu); SC-26: SQS 0-1' and 11-12.1' (PCBs), CSL 2-4' and 6-8' (PCBs, Cu, Hg, 1,2-Dichlorobenzene, As, BEHP, Pb, Pentachlorophenol, Zn); SC-28: CSL 0-1' and 5.5-7.5' (PCBs, As, benzyl alcohol, 1,2-Dichlorobenzene, Cu, Hg, Pb, Zn), SQS 1-2' and 12-12.6' (PCBs); DR054: CSL 0-4' (As, Cu, Zn, Pb, Hg)	SC-25, SC-26, SC-28, DR054 (using surface vs. 0-2')	Equilibrium, Equilibrium, Equilibrium, Decrease	Equilibrium, Below SQS, Increase, Decrease	TRI-045	Equilibrium	Increase	1	
Area 14B	1.2 - 1.25 W	North of Duwamish Shipyard	1.0	No	No	Yes	Yes	(1) SC-24	SQS 0-1' (PCBs)	SC-24	Increase	Below SQS	—	—	—	1	

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint (continued)

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 15A	1.3 E	Saint Gobain	1.1	No	No	No	No	No cores	—	—	—	—	—	—	—	3	
Area 15B	1.4 E	Saint Gobain	0.8	No	No	No	No	(1) SC-27	CSL 0.5-1.0', 1.0-1.5', 1.5-2.0', and 0-2' (PCBs), SQS 0-0.5' and 2.0-3.5' (PCBs)	SC-27	Decrease	Equilibrium	SS-50	Decrease	Equilibrium	3	
Area 16A	1.4-1.5 W	Head of Glacier Bay	4.6	Outside of STM domain	Outside of STM domain	No bathymetry data	No	(1) SC-29	below SQS	SC-29	Below SQS	Equilibrium	SS-57	Equilibrium	Equilibrium	3	Minimal scour potential is expected because this area is behind a pier.
Area 16B	1.4-1.5 W	Mouth of Glacier Bay	2.8	No	No	Yes	Yes	(7) SCDMMU1, SCDMMU1R, SCDMMU2, SCDMMU2R, SCDMMU3, SCDMMU3R, C-1	SCDMMU2R: CSL 3-4' (Hg); SCDMMU3: CSL 0-5.6' (arsenic); C-1: SQS 0-4' (PCBs, arsenic); 1R and 3R not analyzed for SMS contaminants	—	—	—	no trend data, but high surface concentrations			1	
Area 17	1.45 - 1.5 navigation channel	Navigation Channel near Glacier Bay	2.4	No; but portion of area is outside of STM	No; but portion of area is outside STM	No	Yes	No cores	—	—	—	—	—	—	—	2	
Area 18A	1.55 - 1.6 E	Downstream of Slip 2	0.5	No	No	Yes	No	(1) SC-30	below SQS	—	—	—	—	—	—	1	
Area 18B	1.55 - 1.6 E	Downstream of Slip 2	0.6	No	No	Yes	No	(1) C-4	below SQS	—	—	—	—	—	—	1	
Area 18C	1.65 - 1.7 E	Downstream of Slip 2	0.8	No	No	Yes, in portion	No	No cores	—	—	—	—	—	—	—	3	
Area 18D	1.65 - 1.7 E	Downstream of Slip 2	1.5	No	No	Yes	Yes	(17) SC-31, Hardie Gypsum-1: 2, 3, 4, 5; Hardie Gypsum-2: A, 2b, B, C, 3, 4, 5.2, D, E; Lone Star Hardie Gypsum: c-1, c-2, c-3	SC-31: SQS 0-2.8' (PCBs); C SQS 0-3' (phenanthrene); D SQS 0-3' (PCBs, Hg); 2 SQS 0-4' (PCBs); E SQS 0-3' (PCBs)	—	—	—	—	—	—	1	
Area 19	Slip 2	Slip 2	3.6	No	No	Yes at mouth of slip	Yes	(1) SC-32	SQS 0-1' (PCBs); CSL 1-2 (PCBs, acenaphthene, dibenzofuran, fluorene), 2-4' (PCBs)	SC-32	Decrease	Mixed	SS-63	Below SQS	Below SQS	3	Although vessel scour was observed at the mouth of Slip 2, sedimentation up to 3 cm/yr is expected, and empirical data demonstrate decreases in risk-driver concentrations over time. Therefore, this area is assigned to Recovery Category 3.

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint (continued)

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 20	1.8 - 1.9 W	Terminal 115	2.3	No	No	Yes	Yes	(6) SC-34, SC-203, S1-01, S1-02, S2-01, S2-02	SC-34: SQS 0-1' (butyl benzyl phthalate, benzyl alcohol, BEHP), CSL 1-2' (benzyl alcohol, BEHP); SC 203: SQS 0-1' (benzyl alcohol, BEHP, butyl benzyl phthalate, dimethyl phthalate), CSL 1-4' (BEHP, dimethyl phthalate); S1-01: CSL 0-3' (chrysene, fluoranthene, total benzofluoranthenes); S1-02: SQS 3-4' (chrysene, fluoranthene, total HPAHs); S2-01: CSL 0-3' (BEHP), SQS 3-6' (PCBs); S2-02: SQS 3-4' and CSL 4-5' (BEHP).	SC-34, SC-203	Below SQS, Below SQS	Mixed, Mixed	SS-70	Below SQS	Mixed	1	Empirical trends were not used to change from Recovery Category 1 to 2 because the data were located in a small portion of area.
Area 21A	1.9 - 2.0 E	First Ave Bridge, Duwamish Marine Center	1.1	No	No	No	No	(2) SC-33, SC 201	SC-33: CSL 0-2', SQS 2-6' (PCBs); SC 201: CSL 0-1.5', SQS 1.5-6' (PCBs)	SC-33	Equilibrium	Lack of Data Density	—	—	—	3	
Area 21B	RM 2.0 E	Downstream of Slip 3; under First Avenue Bridge	0.5	No	No	No	No	No cores	—	—	—	—	—	—	—	3	
Area 22A	1.95 - 2.0 W	North of First Avenue Bridge/Terminal 115	0.7	No	No	No	Yes	(1) SC-35	SQS 0-2' (PCBs)	—	—	—	SS-75	Decrease	Below SQS	2	
Area 22B	1.95 - 2.0 navigation channel	Navigation Channel RM 1.95-2.0	0.9	No	No	No	No	(2) S11, S12	S11: 0-4' (PCBs); S12: 0-4' (PCBs)	—	—	—	—	—	—	3	
Area 23	2.1 - 2.2 W	Alaska Marine Lines, south of First Ave Bridge	2.2	No	No	No	Yes	(2) SC-38 and SC-39	SC-38: SQS 0-2', CSL 2-3' (PCBs); SC-39: SQS 0-1' and 2-4', CSL 1-2' (PCBs)	SC-38, SC-39	Equilibrium, Equilibrium	Below SQS, Below SQS	—	—	—	2	
Area 24A	2.05 - 2.2 E	Mouth and upstream of Slip 3	3.3	No	No	No	Yes	(1) DR112	—	DR112	Lack of Data Density	Increase	SS-81	Decrease	Below SQS	2	
Area 24B	2.1 - 2.15 navigation channel	Navigation Channel	1.3	No	No	No	No	(1) B2	SQS 4-8' (PCBs)	—	—	—	—	—	—	3	
Area 25	Slip 3	Head of Slip 3	1.8	No	No	Yes	Yes	(1) SC-37	CSL 0-4' (As, 1,2,4-Trichlorobenzene, 1,2-Dichlorobenzene, Cu, Pb, Zn)	SC-37	Decrease	Mixed	—	—	—	2	
Area 26	2.2 W	Trotsky Inlet	2.1	No	No	No	No	(1) SC-40	SQS 0-1.3' (PCBs)	SC-40	Increase	Below SQS	B5a-2	Decrease	-	2	Although the Trotsky Inlet is assigned to Category 2, it is actively remediated by Alternative 2 because of high surface sediment concentrations. It contains 2 total PCB samples that were removed as outliers from the baseline interpolation and site-wide spatially-weighted average concentration calculation.

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint (continued)

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 27A	2.4 E	Seattle Boiler Works	0.7	No	No	Yes	Yes	(1) SC-41	SQS 0-1' and 4-8' (PCBs)	SC-41	Equilibrium	Below SQS	—	—	—	1	
Area 27B	2.3 - 2.4 E	Seattle Boiler Works	2.3	No	No	Yes	Yes	No cores	—	—	—	—	—	—	—	1	
Area 27C	2.36 - 2.4 W	Upstream of Trotsky Inlet	0.6	No	No	Yes	No	No cores	—	—	—	—	DR141	Below SQS	No data	1	
Area 27D	2.0 - 2.5 W	Upstream of Trotsky Inlet	0.9	No	No	No	No	No cores	—	—	—	—	—	—	—	2	
Area 28A	2.4 - 2.5 W	Hurlen-Boyer	1.3	No	No	Yes	Yes	(5) C5, C6,WRC-SS-B1, WRC-SS-B2, WRC-SS-B3	C6: SQS 0-3.8' (PCBs)	WRC-SS-B1, WRC-SS-B2, WRC-SS-B3	Lack of Data Density, Lack of Data Density, Lack of Data Density	Below SQS, Below SQS, Increase	—	—	—	1	Most surface data below the SQS.
Area 28B	2.4 - 2.5 Nav Channel	Navigation Channel	0.8	No	No	No	No	(1) S15	SQS 0-4' (PCBs)	—	—	—	—	—	—	3	
Area 29	2.5 E	Alaska Washington Building Materials Co.	0.7	No	No	Yes	Yes	No cores	—	—	—	—	—	—	—	1	
Area 30A	2.55 W	Beach 5a	2.7	No	No	No bathymetry data	Yes	(1) Hurlen-Boyer: C1	below SQS	—	—	—	—	—	—	2	
Area 30B	2.7 W	South end Beach 5a and south of beach	2.1	No	No	Yes	Yes	(3) SC-46; Hurlen-Boyer: C2, C3	SC-46: SQS 0-4' (PCBs, benzyl alcohol, fluoranthene, hexachlorobenzene); C2: SQS 0-4.2' (fluoranthene, total HPAHs); C3: CSL 0-3.3' (Acenaphthene)	SC-46	Equilibrium	Mixed	—	—	—	1	
Area 31A	2.6 - 2.7 E	Downstream of Slip 4	2.7	No	No	No	No	(2) SC-43, SC-44	SC-44: SQS 0-3.2' (PCBs)	SC-44	Decrease	Lack of Data Density	SS-88	Equilibrium	No data	3	
Area 31B	2.7 - 2.8 E	Downstream of Slip 4	1.5	No	No	Some at upstream end	No	(1) SC-45	SQS 0-4' (PCBs)	SC-45	Equilibrium	Below SQS	SS-92, SS-94	Increase, Below SQS	No data, Decrease	2	
Area 32	2.8 - 2.9 W and navigation channel	Morton	4.3	Yes	No	Yes	Yes	(1) Hurlen Boyer: C4	—	—	—	—	TRI-096	Below SQS	Increase	1	
Area 33a	Slip 4	Mouth of Slip 4	3.4	No	No	Yes	Yes	(7) Crowley DMMUs 2-4, SC06, SC08, SC09, SC10	DMMUs: 0-4' SQS (PCBs and PAHs); SC06: SQS 0-6' (PCBs)	SC06	Equilibrium	Lack of Data Density	DR-181	Decrease	Increase	3 (VM)	The mouth of Slip 4 has some vessel scour, but was assigned to Category 3 based on area-wide empirical chemical trends that demonstrate recovery (no co-located data).

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint (continued)

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 33B	RM 2.85 W	Mouth and outside of Slip 4	0.3	No	No	Yes	No	(2) Crowley DMMU 1, SC11	DMMU 1: 0-4' SQS (PCBs and PAHs)	—	—	—	—	—	—	1	
Area 34	3.0 W	South of Morton	0.3	No	Yes	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	Although the net sedimentation rate does not exceed 1 cm/yr, this area is not subject to scour and has relatively low surface sediment concentrations.
Area 35A	3.05 W	South of Morton	0.3	No	No	No	No	(1) SC-47	—	SC-47	Decrease	Below SQS	—	—	—	3	
Area 35b	3.2 W	West of Boeing Plant 2/ Jorgensen Forge EAA	0.6	No	No	No	No	No cores	—	—	—	—	—	—	—	3	
Area 35C	3.25 - 3.28 W	West of Boeing Plant 2/ Jorgensen Forge EAA	0.6	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 35D	3.3 - 3.35 W	Downstream of South Park Bridge	0.7	No	No	No	No	(1) SB-5	CSL 2.5-5' (PCBs), SQS 0-2.5' and 5-7.5' (PCBs), 72.5 - 75' (BEHP, Butyl benzyl phthalate)	—	—	—	—	—	—	3 (VM)	
Area 36	3.05 - 3.1 navigation channel	South of Morton	1.1	Yes	No	No	No	(1) DU9007XX	CSL 0-5' (PCBs)	—	—	—	—	—	—	1	
Area 37A	3.5 W	South Park Marina	0.7	No	No	No	No	(6) T117-SE-COMP1-SC, T117-SE-91-SC, 93-SC, 94-SC, T117-SE-COMP4-SC, T117-SE-COMP2 and 3-SC	T117-SE-COMP2 and 3-SC: SQS 0-2' (PCBs)	—	—	—	—	—	—	3	
Area 37B	3.7 - 3.75 W	Upstream of Terminal 117 EAA	0.6	No	No	No	No	No cores	—	—	—	—	113-G, 114-G, 117-G, SS-113b	Below SQS, Below SQS, Below SQS, Below SQS	Below SQS, Below SQS, Below SQS, Below SQS	3	
Area 38	3.0 - 3.6 navigation channel	In navigation channel near Boeing Plant 2 / Jorgensen Forge EAA	0.8	Yes	No	No	No	(3) SC-49a, 49b, DU9002XX	SC-49a: CSL 0-1' (benzoic acid, benzyl alcohol), SQS 2-8' (PCBs); SC-49b: 9-10' SQS (hexachlorobutadiene, only analyzed for some contaminants); DU9002XX: 0-7' SQS (PCB)	SC-49	Below SQS	Increase	—	—	—	1	
Area 39	3.75 - 3.8 W	Upstream of Terminal 117 EAA	0.6	Yes	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	Only small portions of this area (in the navigation channel) have high-flow scour deeper than 10 cm. This area is assigned to VM because of one isolated, old (1998) SQS exceedance.

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint (continued)

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 40	3.9 - 3.95 W	Upstream of Terminal 117 EAA	0.4	No	No	Yes	No	No cores	—	—	—	—	—	—	—	3 (VM)	This area has evidence of vessel scour outside of a berthing area, but the other physical parameters support assignment to Category 3. Additionally, the area was delineated to encompass one, isolated SQS exceedance.
Area 41A	3.7 - 4.0 E	Near Central King County International Airport Source Control Area	5.1	Yes	No	No	No	(9) SC-50, SC-51, SC-52, DR220, AN-041, AN-042, AN-043, AN-044, SB-13	SC-50: CSL 0-2.8' (PCBs, As, BEHP); SC-51: CSL 0-2', SQS 2-3.8'; SC-52: CSL 0-1' (PCBs); DR220: SQS 0-2' (PCBs); AN-041: CSL 0-1' (PCBs); AN-042: CSL 0-2' (PCBs); AN-043: SQS 0-1' (PCBs, Butyl benzyl phthalate) CSL 1-2' (PCBs, 2,4 Dimethylphenol, Cd, Cr, Pb, Hg, Zn); AN-044: CSL 0-1' (PCBs) SQS 1-2' (PCBs); SB-13: SQS 0.33-0.69' (Dibenzo(a,h)anthracene).	SC-50, SC-51, SC-52, DR220, AN-041, AN-042, AN-043, AN-044	Increase, Decrease, Increase, Decrease, Increase, Equilibrium, Decrease, Increase	Increase, Mixed, Increase, Below SQS, No data, No data, Decrease, Increase	SS-115, SS-121, SS-123, AN-019, SS-119	Equilibrium, Decrease, Decrease, Increase, Equilibrium	Mixed, No data, No data, Below SQS, Decrease	2	High-flow scour is predicted near the navigation channel. This area is assigned to Recovery Category 2 because scour was not observed for most of the area (along the shore) and because the empirical data demonstrate mixed results.
Area 41B	3.75 - 3.8 navigation channel	Navigation Channel	0.6	Yes	Yes	No	No	(1) DU9121XX	SQS 0-4' (PCBs)	—	—	—	—	—	—	1	
Area 41C	3.95 navigation channel	Navigation Channel	0.4	Yes	No	No	No	(2) DU9001XX, DU9119XX	DU9001XX: SQS 0-5' (pentachlorophenol)	—	—	—	—	—	—	1	
Area 42A	4.1 E	Downstream of Slip 6	2.9	No	No	Yes	No	(12) SB-11, SB-12, SH-01 through SH-09, ST-21	SB-12: CSL 0.33-0.69' (Benzoic acid); SH-01: CSL 0.33-0.82' (Diethyl phthalate, Pentachlorophenol);SH-02: SQS 0.33-0.82' (PCBs, Dibenzo(a,h) anthracene, Di-n-octyl phthalate); SH-04: CSL 0.33-0.82 (PCBs, Pentachlorophenol, Dibenzo(a,h)anthracene); SH-07: CSL 0.33-0.82' (Benzoic acid); SH-08: SQS 0.33-0.82' (Dibenzo(a,h)anthracene)	SB-12, SH-03, SH-06, SH-09	Below SQS, Below SQS, Increase, Below SQS	Mixed, Mixed, Equilibrium, Below SQS	SS-126, B8b	Below SQS for both	Below SQS, No data	1	

Table D-1 Lines of Evidence for Assigning Recovery Categories by Area within AOPC 1 Footprint (continued)

								Core Exceedances and Risk Driver		Core Trends in Top Two Intervals			Trends at Resampled Surface Sediment Locations			Conclusion[f]	
Area within AOPC 1 Footprint	River Mile	Location/ Description	Approx. Size (Acres)	STM 100-yr Max High-Flow Scour Deeper than 10 cm (Y/N)	STM Net Sedimentation Rate <1 cm/yr (Y/N)	Observed Vessel Scour (Y/N)[a]	Berthing Area (Y/N)	(Number of Cores) and Core IDs	Depth of SQS and CSL Exceedances (at any depth; ft)[b]	Cores Evaluated[c]	Total PCBs	Other Detected SQS Exceedances	New Station Name[d]	Total PCBs	Other Detected SQS Exceedances	Recovery Category (1, 2, or 3)	Best Professional Judgment Category Notes
FS Figures where Data are Presented				Figures 2-9 and F-22	Figures 2-11 and F-2	Figures 2-10 and F-22	Figure 2-28			Figures 6-4b, F-13, and F-22			Figures 6-4b, F-8, and F-22			Figures 6-4a, F-8, F-13, and F-22	
Area 42B	Slip 6	Slip 6	4.9	No	No	Yes	Yes	(11) SC-53, DR246, SB-1, SB-2, SB-3, SB-4, SB-5, SB-6, SB-7, SB-8, SB-17.	SB-1: SQS 0.33-0.69'(Benzo(g,h,i) perylene, Bis(2-ethylhexyl)phthalate, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene); SB-2: SQS 0.33-0.69' (Dibenzo(a,h)anthracene); SB-3: CSL 0.33-0.69' (Benzoic acid, Phenol); SB-4: CSL 0.33-0.69' (Benzoic acid); SB-5: CSL 0.33-0.69' (Benzoic acid); SB-6: CSL 0.33-0.69' (Benzoic acid); SB-7: CSL 0.33-0.69' (Benzoic acid); SB-8: CSL 0.33-0.69' (Benzoic acid); SB-17: CSL 0.33-0.69' (Benzoic acid).	DR246, SB-1, SB-3, SB-4, SB-8	Lack of data density in all cores for total PCB trends	Below SQS, Equilibrium, Mixed, Mixed, Equilibrium	SS-127, SB-1, SS-129, SS-130	Below SQS for all	3 decreases, 1 increase	1 (whole area contains 1, 2, 3)	Slip 6 contains all three recovery categories, but this area is assigned to Category 1 because a large proportion of Slip 6 has observed vessel scour.
Area 43	4.25 - 4.3 W	Upstream of Delta Marine	0.4	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 44	4.35 E	Upstream of Slip 6	0.2	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 45	4.5 - 4.6 E	Northeast of Upper Turning Basin	0.6	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 46	4.7 W	Southwest corner of Upper Turning Basin	1.3	Yes	No	No bathymetry data	No	(1) SC-56	SC-56: SQS 0-2' (PCBs)	—	—	—	SS-148	Decrease	Decrease	1	This area overlaps Recovery Categories 1 and 3.
Area 47	4.7 - 4.8E	East of the Upper Turning Basin	0.9	No	No	No	No	No cores	—	—	—	—	—	—	—	3 (VM)	
Area 48	4.9 E	Norfolk EAA	1.0	Upstream of STM domain	Upstream of STM domain	Upstream of bathymetry data	No	(2) SC-55, NFK207	NFK207: 0-1' CSL (1,4-Dichlorobenzene)	SC-55, NFK207	Increase, Below SQS	Below SQS, Mixed	—	—	—	unassigned; upstream of STM domain[f]	Area will be considered to be like Recovery Category 2 during technology assignments.
Area 49	5.0 W	East of Norfolk EAA	0.2	Upstream of STM domain	Upstream of STM domain	Upstream of bathymetry data	No	No cores	—	—	—	—	—	—	—	unassigned; upstream of STM domain (VM)[f]	
Area 50	4.6 E	East of Upper Turning Basin	0.2	Yes	No	No	No	No cores	—	—	—	—	—	—	—	1	

Number of areas in recovery category:	1	29
	2	16
	3	43
	Unassigned (above RM 4.75)	2
Number of areas assigned to verification monitoring:		16

Notes:

— = no data or Lack of Data Density in cores for trends evaluation.

For empirical data, decreases and increases are ≥ 50% changes in concentration; equilibrium is a concentration change less than 50%; and mixed results indicate that not all SMS contaminants evaluated at a location have the same trends. Only detected contaminants exceeding the SQS were evaluated.

a. Observed vessel scour identified from sun-illuminated 2003 bathymetric data.

b. Only core sample intervals with detected SQS exceedances listed in this column; samples below the SQS and undetected are not listed. Exceedances in 0.5-ft interval samples are shown if they influence the mapping of the cores on Figures D-1 to D-5. For cores with similar exceedances in consecutive sampling intervals, the total depth across the exceedance is noted, as opposed to the depths of each sample; for example, SQS exceedances in the 0-1 ft, 1-2 ft, and 2-4 ft intervals are identified as 0-4 ft in this column. For samples with CSL exceedances, the risk drivers having SQS exceedances (but not CSL exceedances) are not listed, such that only the maximum exceedance status for each sample within a core is reported.

c. Only cores with appropriate vertical sample resolution were evaluated: 1-ft thick or shorter intervals, or a 0- to 2-ft interval with a co-located surface sediment location. See Appendix F for risk-driver data and trends.

Table D-2 Empirical Overrides of Recovery Category Assignments within AOPC 1 Footprint

Area	River Mile	Recovery Category[a] Based on Physical Considerations	Recovery Category Conclusion Based on Empirical Data: Final Recovery Category (1, 2, or 3)	Recovery Category Conclusion Based on Empirical Data: Best Professional Judgment Category Override Notes
Area 4A	0.1 - 0.2 W	2 or 3	2	Area 4A is Category 2 because of equilibrium and increasing empirical trends.[b]
Area 7A	0.5 - 0.6 W	3	1	Portion of Area 7A is outside of STM domain and includes increasing and mixed empirical trends.
Area 7D	0.6 W	3	2	Area 7D was changed from Category 3 to 2 because of equilibrium and increasing empirical trends.[b]
Area 8A	0.85 W	1	3	Although the net sedimentation rate is below 1 cm/yr, these areas are not subject to scour and have relatively low surface sediment concentrations.
Area 8B	0.7 - 0.85 W	1	3 (VM)	
Area 9A	0.8 - 0.9 navigation channel	3	2	Area 9A was changed from Category 3 to 2 because of a mixture of empirical trends. Additionally, this area is predicted to have high-flow scour deeper than 2 cm (but not deeper than 10 cm).
Area 10A	Slip 1	1	2	Combination of equilibrium and decreasing/mixed empirical trends override the scour potential.
Area 11A	0.95 - 1.0 W	1	2	Area 11A changed from Category 1 to 2 because of low risk-driver concentrations and total PCBs in equilibrium in a core.
Area 18C	1.65 - 1.7 E	2	3	Vessel scour was only identified in a small portion of this area. This area is behind a pier.
Area 19	Slip 2	2	3	Although vessel scour was observed at the mouth of Slip 2, sedimentation up to 3 cm/yr is expected, and empirical data demonstrate decreases in risk-driver concentrations over time. Therefore, this area is assigned to Category 3.
Area 25	Slip 3	1	2	Area 25 was changed from Category 1 to 2 because of decreasing total PCB concentrations.
Area 26	2.2 W	3	2	Trotsky Inlet was changed from Category 3 to 2 because of mixed empirical trends.
Area 27D	2.0 - 2.5 W	3	2	Area 27D is a marina (not considered a berthing area). Therefore, the physical considerations alone would suggest Category 3, but changed to Category 2 because of elevated total PCBs in the surface sediment. However, there are no empirical trend data in Area 27D.
Area 33A	Slip 4	1	3 (VM)	The mouth of Slip 4 has some vessel scour, but was assigned to Category 3 based on area-wide empirical trends that demonstrate recovery (no co-located data).
Area 34	3.0 W	1/2	3 (VM)	Although the net sedimentation rate is below 1 cm/yr, Area 34 is not subject to scour and has relatively low surface sediment concentrations. However, there are no empirical trend data in Area 34.

Table D-2 Empirical Overrides of Recovery Category Assignments within AOPC 1 Footprint

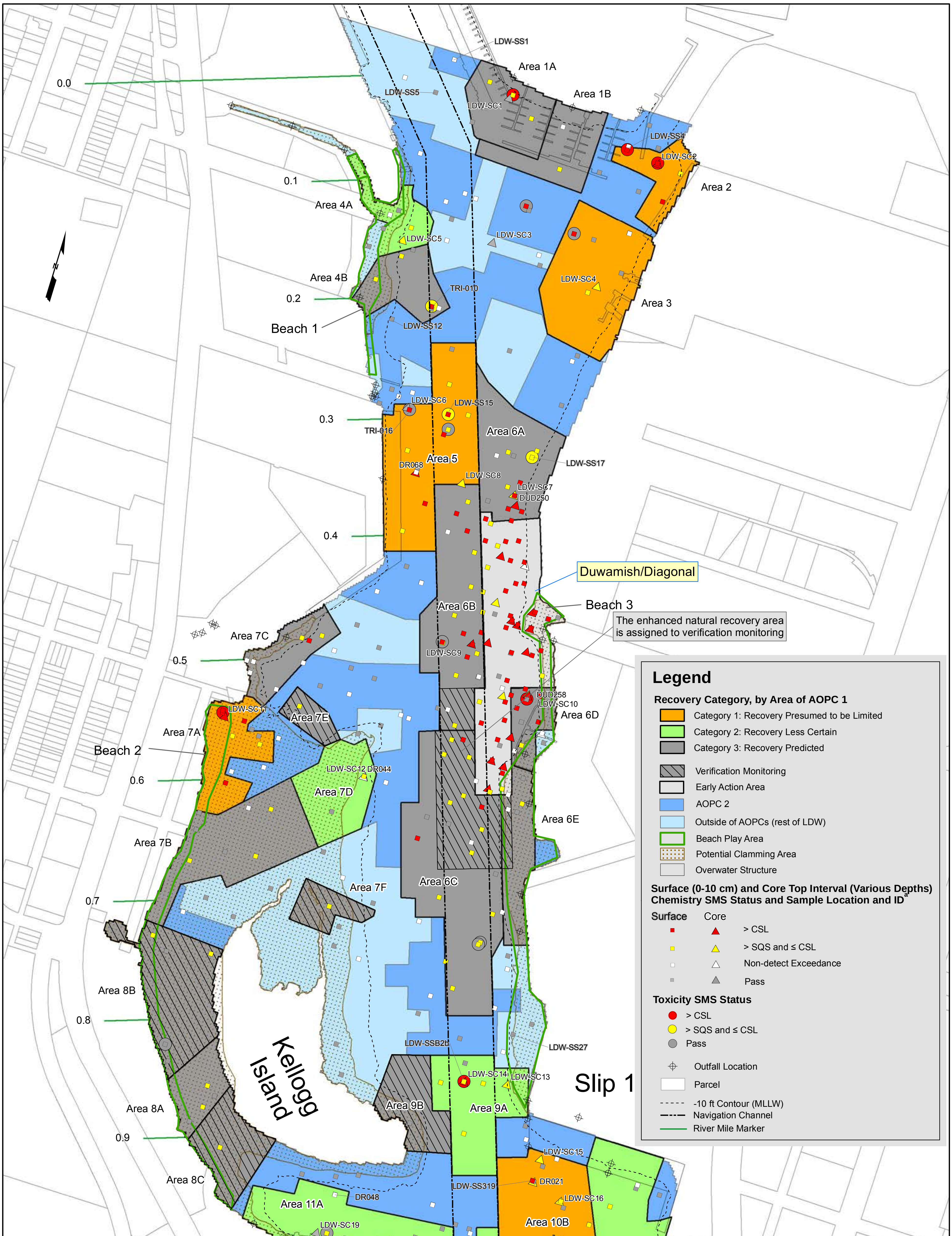
Area	River Mile	Recovery Category[a] Based on Physical Considerations	Recovery Category Conclusion Based on Empirical Data	
			Final Recovery Category (1, 2, or 3)	Best Professional Judgment Category Override Notes
Area 39	3.75 - 3.8 W	1	3 (VM)	Only small portions of this area (in the navigation channel) have high-flow scour deeper than 10 cm. This area is assigned to VM because of one isolated, old (1998) SQS exceedance.
Area 40	3.9 - 3.95 W	1	3 (VM)	This area has evidence of vessel scour outside of a berthing area, but the other physical parameters support assignment to Category 3. Additionally, the area was delineated to encompass one, isolated SQS exceedance.
Area 41A	3.7 - 4.0 E	1	2	High-flow scour is predicted near the navigation channel. This area was assigned to Category 2 because scour was not observed for most of the area and because the empirical data demonstrate mixed results.[b]

Notes:

a. Recovery categories are defined as follows: 1 - recovery is presumed to be limited; 2 - recovery is less certain; 3 - recovery is predicted.

b. Category designation outcome was determined from April 12 and 19, 2011 FS comment resolution meetings with U.S. Environmental Protection Agency (EPA)/Washington State Department of Ecology (Ecology).

AOPC = area of potential concern; cm/yr = centimeters per year; E = east; EPA = Environmental Protection Agency; FS = feasibility study; PCB = polychlorinated biphenyl; SQS = sediment quality standard; STM = sediment transport model; VM = verification monitoring; W = west.



Notes:
1. One recovery category was designated for each area; assignment was based on the category that overlapped the majority of that area. See Section 6 for description of recovery categories.
2. SMS status is assigned for any detected SMS contaminant within the FS baseline dataset.
3. Area numbers are not assigned to Duwamish/Diagonal, Slip 4, Boeing Plant 2/Jorgensen Forge, Terminal 117, or Norfolk Area early action areas.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.
a Surface sediment locations that were resampled are labeled with the newer station ID. See Appendix F for data. Other surface sediment locations are not labeled. All cores are labeled except for those in early action areas.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

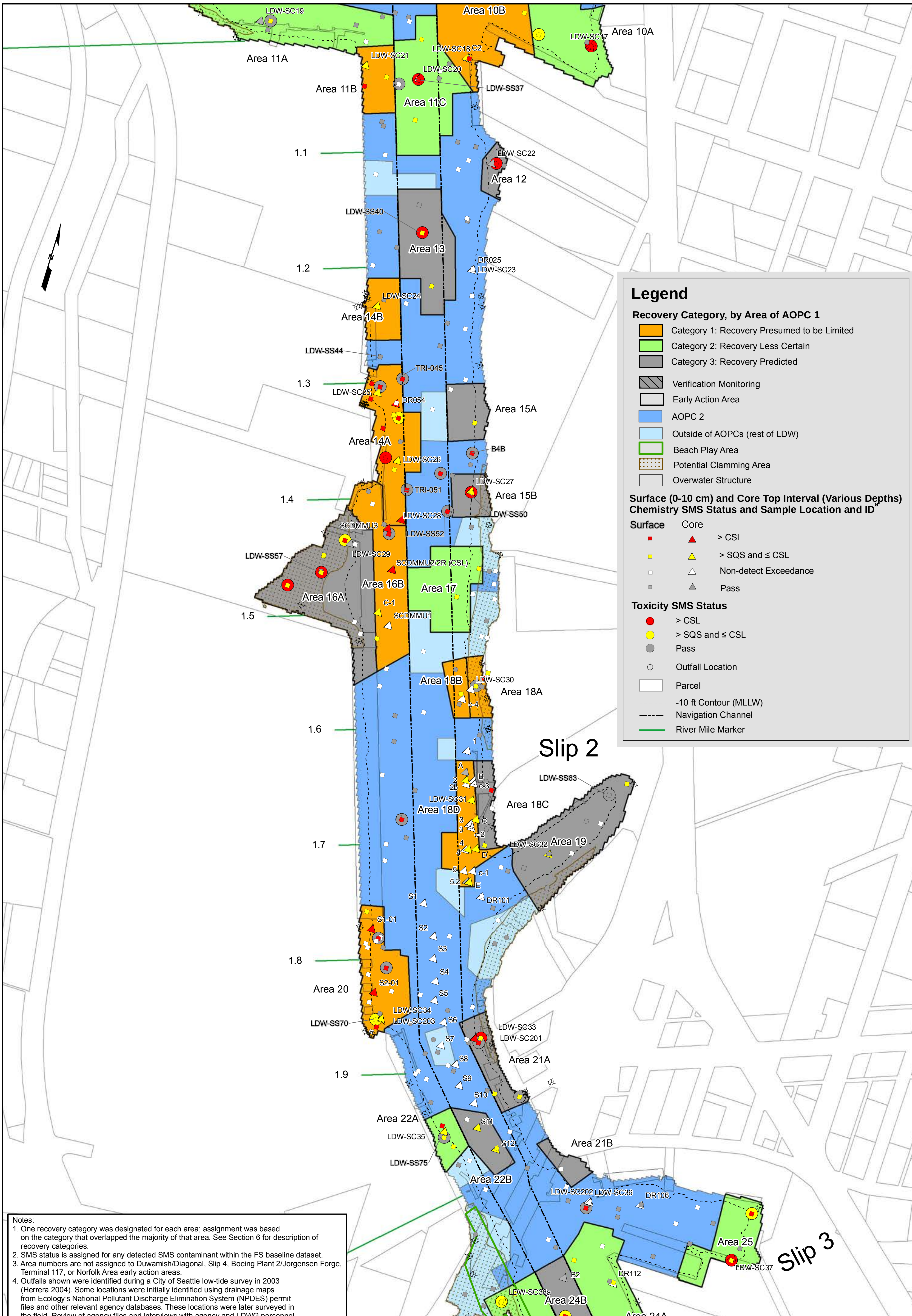
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Areas of AOPC 1 With Assigned Recovery Categories (RM 0.0 to 1.0)

DATE: 10/31/12 | DWRN:mvi/sea | Revision: 0

FIGURE D-1

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix D\FigureD-1_Areas of AOPC1_Rm0_1.mxd



Notes:
1. One recovery category was designated for each area; assignment was based on the category that overlapped the majority of that area. See Section 6 for description of recovery categories.
2. SMS status is assigned for any detected SMS contaminant within the FS baseline dataset.
3. Area numbers are not assigned to Duwamish/Diagonal, Slip 4, Boeing Plant 2/Jorgensen Forge, Terminal 117, or Norfolk Area early action areas.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.
a Surface sediment locations that were resampled are labeled with the newer station ID. See Appendix F for data. Other surface sediment locations are not labeled. All cores are labeled except for those in early action areas.

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix D\FigureD-2_Areas of AOPC1_Rm1_2.mxd

AECOM

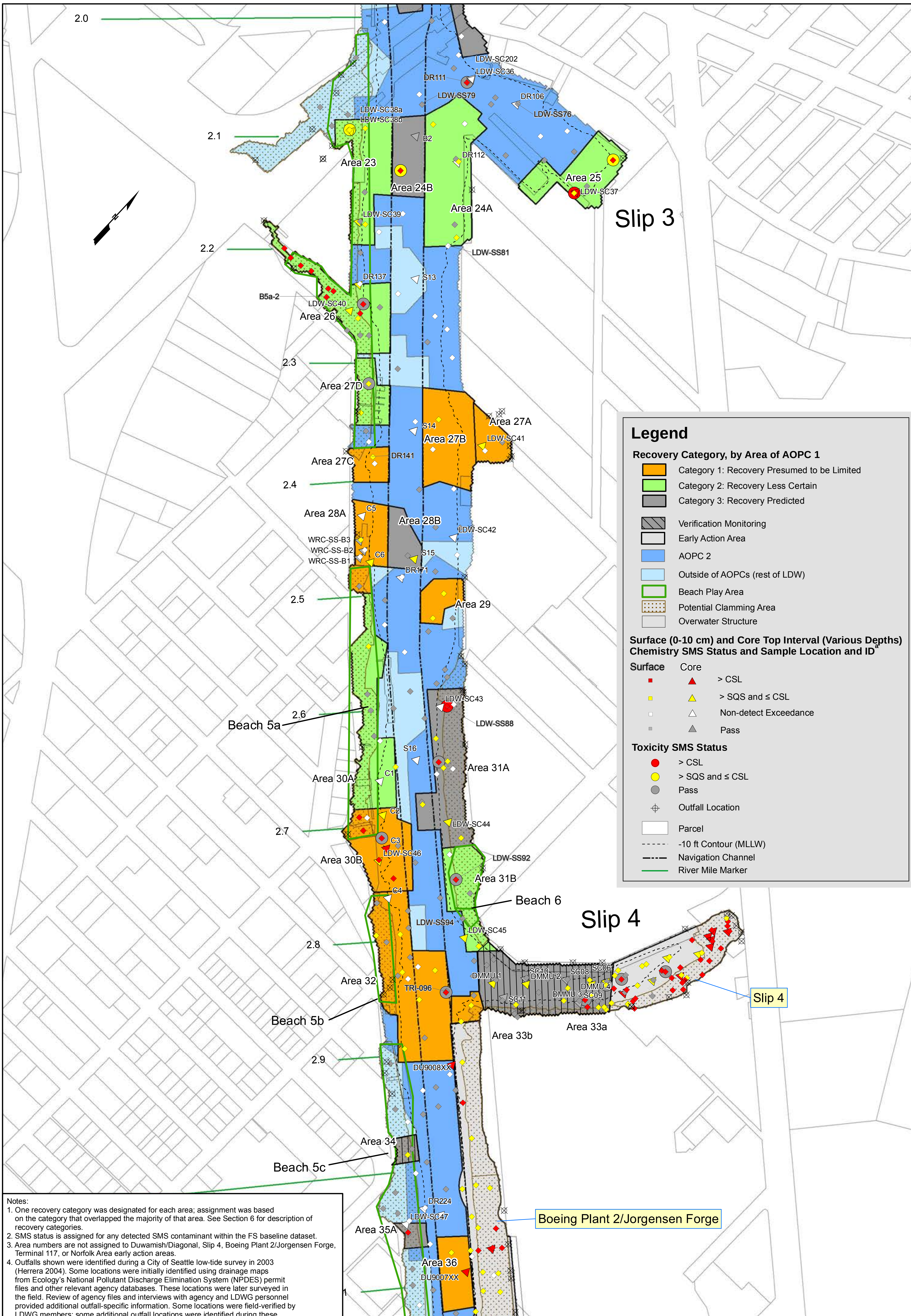
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Areas of AOPC 1 With Assigned Recovery Categories (RM 1.0 to 2.0)

DATE: 10/31/12 | DWRN:de/sea | Revision: 0

FIGURE D-2



Legend

Recovery Category, by Area of AOPC 1

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Recovery Predicted
- Verification Monitoring
- Early Action Area
- AOPC 2
- Outside of AOPCs (rest of LDW)
- Beach Play Area
- Potential Clamming Area
- Overwater Structure

Surface (0-10 cm) and Core Top Interval (Various Depths) Chemistry SMS Status and Sample Location and ID[a]

Surface	Core	
		> CSL
		> SQS and ≤ CSL
		Non-detect Exceedance
		Pass

Toxicity SMS Status

- > CSL
- > SQS and ≤ CSL
- Pass
- Outfall Location
- Parcel
- -10 ft Contour (MLLW)
- Navigation Channel
- River Mile Marker

Notes:
1. One recovery category was designated for each area; assignment was based on the category that overlapped the majority of that area. See Section 6 for description of recovery categories.
2. SMS status is assigned for any detected SMS contaminant within the FS baseline dataset.
3. Area numbers are not assigned to Duwamish/Diagonal, Slip 4, Boeing Plant 2/Jorgensen Forge, Terminal 117, or Norfolk Area early action areas.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

a Surface sediment locations that were resampled are labeled with the newer station ID. See Appendix F for data. Other surface sediment locations are not labeled. All cores are labeled except for those in early action areas.

0 200 400 800 Feet

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix D\FigureD-3_Areas of AOPC1_Rm2_3.mxd

AECOM

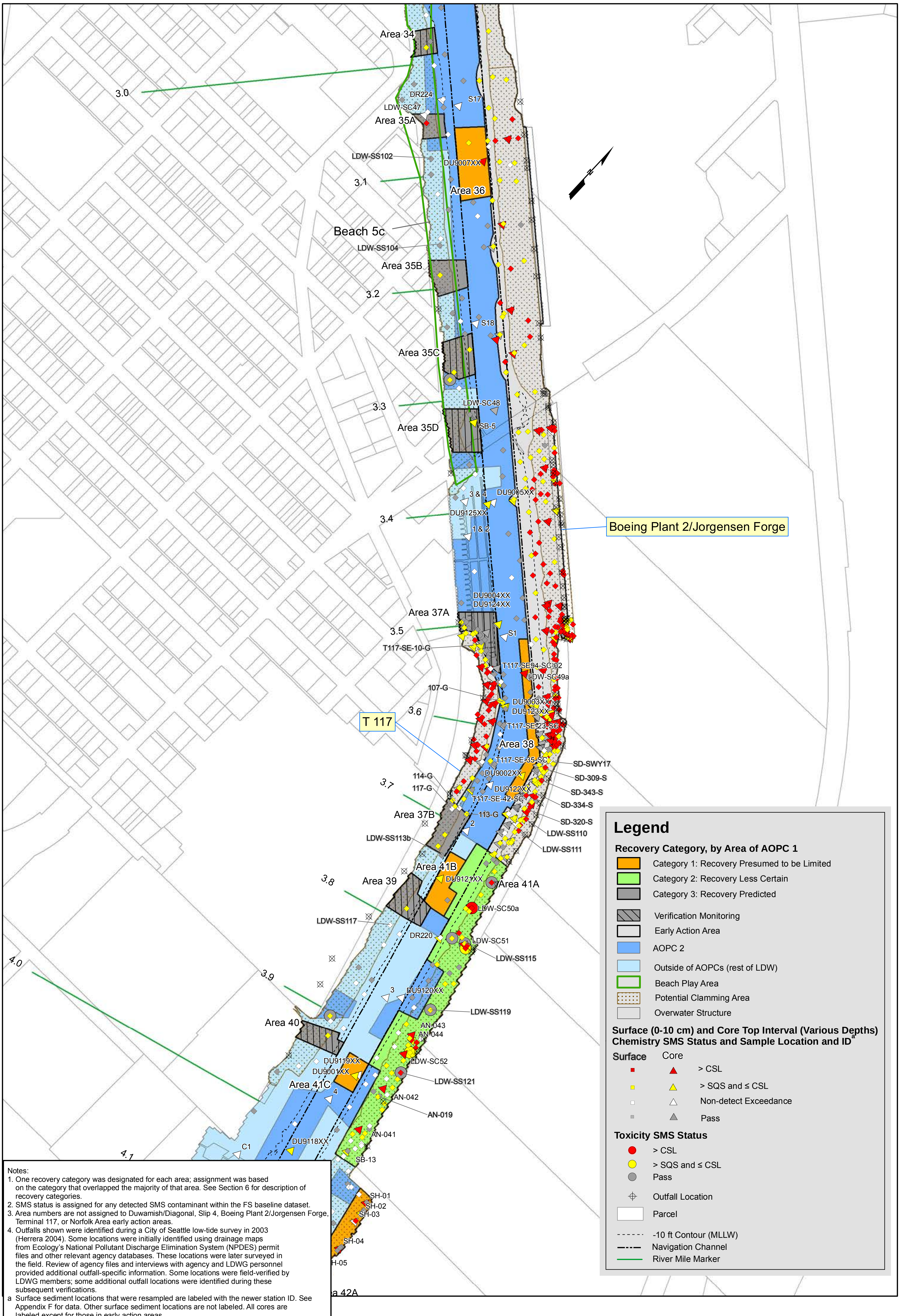
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Areas of AOPC 1 With Assigned Recovery Categories (RM 2.0 to 3.0)

DATE: 10/31/12 | DWRN:de/sea | Revision: 0

FIGURE D-3



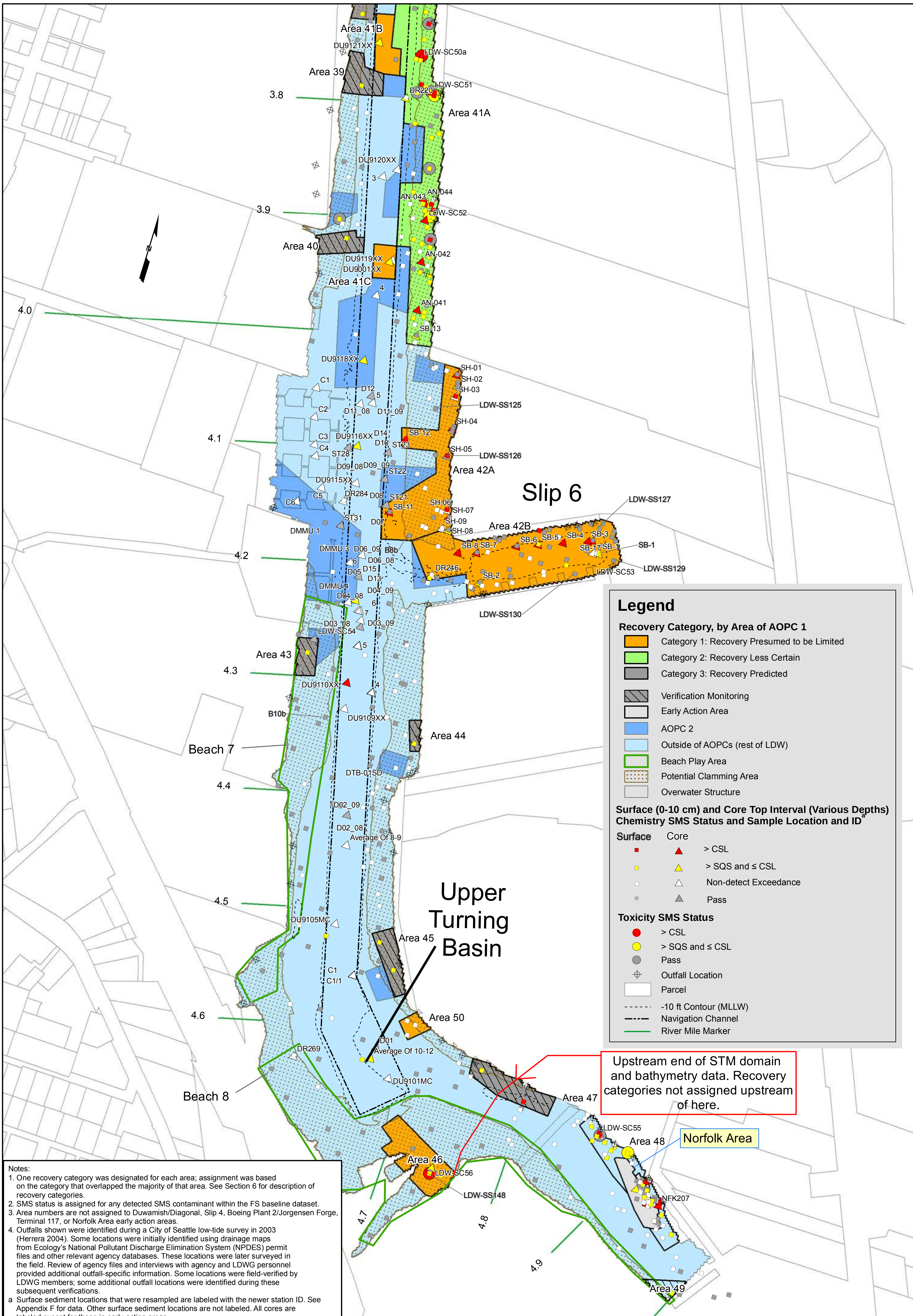
Notes:
1. One recovery category was designated for each area; assignment was based on the category that overlapped the majority of that area. See Section 6 for description of recovery categories.
2. SMS status is assigned for any detected SMS contaminant within the FS baseline dataset.
3. Area numbers are not assigned to Duwamish/Diagonal, Slip 4, Boeing Plant 2/Jorgensen Forge, Terminal 117, or Norfolk Area early action areas.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.
a Surface sediment locations that were resampled are labeled with the newer station ID. See Appendix F for data. Other surface sediment locations are not labeled. All cores are labeled except for those in early action areas.

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix D\FigureD-4_Areas of AOPC1_Rm3_4.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Areas of AOPC 1 With Assigned Recovery Categories (RM 3.0 to 4.0)
DATE: 10/31/12	DWRN:de/sea	Revision: 0	FIGURE D-4



Notes:

1. One recovery category was designated for each area; assignment was based on the category that overlapped the majority of that area. See Section 6 for description of recovery categories.
2. SMS status is assigned for any detected SMS contaminant within the FS baseline dataset.
3. Area numbers are not assigned to Duwamish/Diagonal, Slip 4, Boeing Plant 2/Jorgensen Forge, Terminal 117, or Norfolk Area early action areas.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

a Surface sediment locations that were resampled are labeled with the newer station ID. See Appendix F for data. Other surface sediment locations are not labeled. All cores are labeled except for those in early action areas.

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix D\FigureD-5_Areas of AOPC1_Rm4_5.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Areas of AOPC 1 With Assigned Recovery Categories (RM 4.0 to 5.0)

DATE: 10/31/12	DWRN:de/sea	Revision: 0	FIGURE D-5

Lower Duwamish Waterway Group

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

Appendix E
Methods for Calculating the Volume of Contaminated Sediments Potentially Requiring Remediation

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

List of Tables

List of Figures

E.1 Introduction

A key component in developing and evaluating remedial alternatives for the Lower Duwamish Waterway (LDW) is the estimation of the volume of contaminated sediment that will potentially require remediation. In particular, the volume of sediment to be removed and disposed of is a major factor in estimating the cost and construction time frame for all remedial alternatives.

Many different methods were explored for calculating contaminated sediment volumes (e.g., subsurface interpolation contours, average thickness, grids, triangulation projection or triangulated irregular network [TIN] terrain models[1], average-end-area[2] estimates). Ultimately, site-wide and area-based volumes were estimated as interpolated isopach thickness layers, developed from regularly spaced cross sections and a TIN terrain surface. Upland and in-water boring information with well-defined stratigraphic markers and good spatial coverage provided a foundation for site-wide geologic interpretations. Data from LDW cores were used to develop contaminant concentration profiles and were correlated with stratigraphy where sufficient subsurface sediment data were available. Together, this information created two geographic information system (GIS)-based mapping layers that were used to estimate contaminated sediment thicknesses.

The purpose of this effort was to create thickness layers for the entire LDW that are independent of the areas of potential concern (AOPCs) and dredge footprints, which may change as additional data become available. These isopach thickness layers are used for generating feasibility study (FS)-level estimates of contaminated sediment volumes.

This appendix discusses:

1) The methods used to develop site-wide isopach layers of contaminated sediment thickness and to estimate sediment volumes (Section E.2)
2) The thickness and distribution trends of contaminated sediments along the LDW and resulting estimates of sediment volumes for each remedial alternative (Sections E.2.5 and E.3)
3) Uncertainty in the data and methods (Section E.4).

---

1 A TIN is a series of triangles constructed from spatial coordinates (x, y, and z). This vector-based data structure is used to derive a surface, or terrain.

2 Average-end-area is a volume estimating tool commonly used in highway, road, railroad, and marine construction projects for design and payment purposes. This tool uses cross sections of the project surface area set at regularly spaced intervals. Elevation data are plotted in section view and the dredge area is determined by each cross section. Dredge volume is determined by the average area between two successive cross sections that is then projected along the distance, or spacing, between the cross sections.

The estimated contaminated sediment volumes presented in this FS are considered sufficient for calculating dredged material removal volumes and costs for remedial alternatives. Sufficient uncertainty has been factored into these volume estimates by calculating depth-to-alluvium (or native) volumes well beyond known contaminant depths. Volume estimates used for dredging design will require refinement based on further sampling and analyses during the remedial design phase conducted prior to any remedial action.

E.2 Methods

This section reviews methods used at various remediation sites, describes the method selected for use in the LDW FS based on this review, and describes the steps for estimating sediment volumes based on the selected method.

E.2.1 Review of Common Methods and Selection of Method for the LDW

The methods used to calculate contaminated sediment volumes at various contaminated sediment sites nationwide were reviewed. At the Whatcom Waterway site in Bellingham, Washington, a single contaminated sediment thickness was used because the sediment conditions were fairly uniform across the site (RETEC 2006). At the Lower Fox River and Green Bay Superfund site in Wisconsin, numerous subsurface sediment cores were available with enough spatial resolution to interpolate polychlorinated biphenyl (PCB) concentrations at 2-foot (ft) depth intervals (RETEC 2002). At the Chemical Recovery Systems (Black River) Superfund site in Ohio, contamination extended down to bedrock or dense, native alluvium; this stratigraphic contact was used to estimate the contaminated sediment volumes (IJC 1999). The Lower Passaic River Superfund site in New Jersey used regularly-spaced cross sections to derive average-end-area volume estimates. The two-dimensional (2-D) area of contamination estimated from one cross section was multiplied by the distance to the next cross section along these regularly-spaced intervals (Malcolm Pirnie 2007).

The FS prepared for the Hudson River Superfund site in New York incorporated some simplifications to account for a limited dataset (TAMS 2000). First, the Hudson River FS used only PCB data to delineate the depth of contamination and the volume estimates were keyed spatially to Thiessen polygon-based “target areas.” Next, a consistent contaminated sediment depth was applied to each target area. Measured from the deepest mudline elevation located in the area, and following the bathymetric contour of the river, a consistent sediment depth was established.

The method selected for calculating sediment volumes in the LDW is a combination of the basic methods described above. This combined method includes:

1) The lower (native) alluvium stratigraphic contact was identified as the maximum possible depth of contamination, similar to the Black River site in Ohio. Volumes estimated from the mudline to the alluvium are considered

to represent the upper-bound estimate of potential dredge volumes under any remedial alternative.

2) Even though the LDW dataset does not include enough spatial resolution to interpolate concentrations exceeding criteria at specific depth intervals, as was done for the Lower Fox River and Green Bay Superfund site, the available subsurface cores with chemistry and stratigraphy data from the LDW dataset were used to generate half-mile interval cross sections, similar to those generated for the Passaic River. The bottom of any core interval exhibiting a detected contaminant concentration above the sediment quality standards (SQS) or above concentrations of concern for other risk drivers, henceforth referred to collectively as SQS, was interpreted as the lower limit of contamination.[3] A TIN network was developed from cross sections and cores to approximate the thickness of contaminated sediment. The result was a variable thickness site-wide layer.

3) The target areas (or dredge footprints) define the surface requiring remediation, with variable contaminated sediment depths applied to these target areas based on the isopach surface.

This approach is considered the most effective and efficient, based on the available data, for determining contaminated sediment volumes in the LDW.

E.2.2 Method Used to Estimate Sediment Volumes

LDW-wide contaminated sediment volumes were generated using three major steps, which ultimately resulted in a GIS-generated isopach layer of contaminated sediment thickness. The three steps were:

1) **Generalized Cross Sections:** Cross sections were generated in a computer-aided drafting (CAD) program, generally at half-mile intervals along the LDW. In each cross section, three lines of elevation were digitized:

    - Elevation of mudline (or bathymetry)

[3] All risk drivers were used to develop the contaminated sediment volume. For simplicity, the term “SQS” is used to signify the lower limit of contamination. The lower limit of contamination includes sediment concentrations that exceed concentrations for total PCBs >240 micrograms per kilogram dry weight (µg/kg dw), carcinogenic polycyclic aromatic hydrocarbons (cPAHs) >1,000 µg toxic equivalent (TEQ)/kg dw, dioxins/furans >25 nanograms (ng) TEQ /kg dw, and Sediment Management Standards (SMS) chemicals >SQS. These concentrations define the AOPC 1 footprint (as described in Section 6) and Alternative 5 RALs for subtidal sediments (as described in Section 8). Because cPAH and dioxin/furan exceedances are typically shallower than the SQS exceedances, “SQS” is an appropriate term for discussing thickness of sediment contamination above these concentrations.

- Elevation of the bottom of contamination (lowest depth below the mudline at which detected concentrations of any Sediment Management Standards [SMS] contaminant exceeded the SQS)

- Elevation of the top of the native (lower) alluvium taken from the stratigraphic interface observed in sediment cores and nearby upland explorations (the lower alluvium and its significance are described in Section E.2.3.1).[4]

2) **LDW-wide Isopach Surfaces and Thickness Layers:** The three elevation lines described above were imported into the GIS program. The elevations of the bottom of contamination and the top of the lower alluvium were converted to x, y, z points and subtracted from the bathymetric elevations to represent depths from the mudline. Additional depths obtained from core data (i.e., depths of bottom of contamination and top of lower alluvium at specific x, y locations) were imported into GIS to provide spatial coverage between the half-mile cross sections. A TIN surface was generated using the points described above and in each of the datasets, described in Section E.2.3.2, to create a three-dimensional (3-D) representation of each depth-based surface within the LDW. A TIN applies a network of small triangles between all data points in the digitized data layers to form a 3-D surface.[5] The 3-D surface represents an approximation of the in situ conditions (natural location or position). The TIN application is explained in more detail in Section E.2.4. The TINs were then converted into 10-ft by 10-ft thickness grid cells, which were used to calculate the site-wide sediment volumes.

3) **Site-wide Sediment Volumes:** After the grids were generated, sediment volumes were estimated as the thickness of the grid cell multiplied by the surface area of an area of interest. Volumes were estimated for two layers: a thickness of contamination layer (i.e., mudline to the lower limit of SQS exceedances) and a thickness to lower alluvium layer (i.e., mudline to the

[4] The top of the lower alluvium is the assumed maximum possible depth of contamination for any remedial alternative. The lower alluvium is thoroughly defined and its significance is described in Section E.2.3.1.

[5] Three TIN surfaces were generated, the first being the bathymetry TIN based on the 2003 bathymetric survey (Windward and DEA 2004) and supplemented with mudline elevations from core data in areas where bathymetric data were not available because the presence of barges or overwater structures and/or low tides inhibited access by the sampling vessel during the bathymetric survey. The bathymetric data used to generate the TIN surface were the results of a high-resolution, multibeam survey with 1-meter (m) resolution capturing bank-to-bank bathymetry, where available. Two additional TINs include a thickness of contamination surface, and a thickness from the mudline to the top of the lower alluvium surface.

lower alluvium surface).[6] Section E.2.5 further discusses the sediment volume calculations and Section E.3 presents the resulting volume estimates. The horizontal extent of the contamination was assumed to be the top of the bank of the in-water study area, which is based on the bathymetric elevation of +11.3 ft mean lower low water (MLLW).

The three-step process used to generate sediment volumes is discussed in detail in the following sections. The sequential tools used to develop the volumes are listed below.

Attribute	Description
Line	An attribute that connects x, y, and z point data referenced to an elevation of interest
Isopach Surface	A two-dimensional surface contoured from lines and point data, expressed as elevation or depth
Layer	A three-dimensional volume of contamination extending below the mudline surface, expressed as thickness

These attribute terms are used throughout this appendix.

E.2.3 Step 1: Generalized Cross Sections

The process of generating sediment volume estimates began by developing a series of cross sections along the LDW, from river mile (RM) 0.0 to RM 4.8 at approximately half-mile increments (Figure E-1). The last cross section was set at RM 4.8, because bathymetric data were not available upstream of this point. Survey point data from sediment samples were used above RM 4.8 to RM 5.0 to estimate volumes in the remainder of the FS study area. Generally, cross sections were oriented perpendicular to the river flow direction, as illustrated in Figure E-1. The specific cross section locations were influenced by the amount, distribution, and type of subsurface data available. Additional cross sections were added to cover geographically unique areas like a bend in the waterway, the presence of Kellogg Island, or a slip. In particular, two cross sections (D-D′ at RM 1.0 W and E-E′ at RM 1.0 E) were added parallel to the navigation channel west of Slip 1 to estimate the thickness of contamination and the depth to the lower alluvium along the navigation channel. Cross section C-C′ at RM 0.5 to RM 0.6, and cross section I-I′ at RM 2.1 were oriented where data were available and adequate to capture the river cut around Kellogg Island and Slip 3. These cross sections were beneficial for estimating the volume of contaminated sediments in the areas of the LDW outside the navigation channel.

6 In Section 8 of the FS, additional volumes were added to these estimated volumes as a contingency to account for design considerations, dredging inaccuracies, and other contingencies typically encountered during construction (e.g., slope cut, debris).

Sixteen cross sections were generated manually. Each cross section used a combination of subsurface sediment chemistry and geology and upland geology where available. Core data collected during various studies, most of which are included in the remedial investigation (RI) project database, were used to populate the cross sections (described in Section E.2.3.2). These data points are illustrated on Figures E-2 through E-17.

When cores were projected onto cross sections such that mudline elevations for cores were different than the elevations of the bathymetric surface, the interpolated contamination and lower alluvium 2-D surfaces were drawn to a similar depth as the contacts in the cores, as opposed to the exact elevations of the contacts. The information from the hand-drawn cross sections was entered into CAD, and used to generate the cross sections shown on Figures E-2 through E-17. Two lines of elevation from each cross section were digitized into x, y, and z coordinates for export to GIS. These two lines, described in Section E.2.3.1, are the elevation of:

1) The bottom of the contaminated sediment layer (the lowest depth below the mudline with detected concentrations of any SMS contaminant greater than the SQS)
2) The top of the lower alluvium layer.

During the collection of the sediment cores, a common occurrence was that less than 100% of the sediment volume was retained. Recovery of sediment in the core is dependent on the nature and uniformity of the sediment, and frictional forces during driving (Windward and RETEC 2007). Some factors that prevent complete recovery of the driven sediment interval include: sediment loss during recovery of the core tube through the water column, compaction of sediment, and blockage during core advancement that prevented material from entering the core tube. As a result of these factors, the amount of sediment in the core tube during field processing (recovered depth) often does not reflect the actual depth below the mudline from which the sediment core was collected (referred to as the *in situ* depth) (Windward and RETEC 2007). The difference between the recovered depth and the drive depth was used to estimate the *in situ* depth over the entire core length. The *in situ* depths for the core data were used to generate the two layers and ensured that neither the depth to contamination nor the depth to the lower alluvium was underestimated.

E.2.3.1 Elevations of Interest

The bottom of contamination is defined as the lowest depth in each core where one or more detected contaminant concentrations exceed the SQS. First, the FS subsurface sediment database was queried to find the lowest depth in each core for which the SQS was exceeded for detected SMS contaminants. The bottom of the sample interval in a core was used for mapping. For example, if a detected SQS exceedance was found in the 4- to 6-ft sampling interval but the next interval (from 6- to 8-ft depth) was non-detect or below the SQS, then the core was assigned a contaminated sediment depth of 6 ft.

Second, other risk drivers were queried to determine if elevated contaminant concentrations (described in footnote 3) were present at lower depths. Collectively, these depths were used as the bottom of contamination in each core, which were then interpolated between cores in each cross section.

The lower alluvium is a native, predominantly dense, sandy stratigraphic unit that was deposited prior to the industrialization of the Duwamish watershed and the straightening of the Duwamish River into the LDW. Because of its depositional time frame, the lower alluvium has not been anthropogenically disturbed or contaminated by industrial activities in the area. It represents the pre-industrial strata, reflects pre-industrial contaminant conditions, and, therefore, should bound the lower extent of any contamination. Thus, the top of the lower alluvium was identified as the maximum possible depth of sediment contamination for any remedial alternative. Contaminant and stratigraphic data from the 2006 RI cores (Windward and RETEC 2007) confirm that SQS exceedances were not detected in the sandy lower alluvium unit.

The bathymetric data used for cross sections and TIN development were collected in 2003 during a LDW-wide survey for the RI (Windward and DEA 2004). In several areas, bathymetric data were not available. These data gaps occurred where barges, overwater structures, and low tides inhibited access by the sampling vessel during the bathymetric survey. Data for these areas (e.g., the Glacier Northwest embayment at RM 1.5 W) were extrapolated from the 2003 bathymetric survey and elevation data from core logs and borings.

Each cross section, except for cross sections C-C′, D-D′, and E-E′, was generated from at least two subsurface sediment cores, such as one deep geotechnical boring from either the east or west bench of the LDW, and at least one upland boring from each side of the adjacent upland area. Because the upland borings generally do not have chemistry data, the depth of contamination was interpolated from at least two in-water subsurface sediment cores in each cross section. This data requirement was set to ensure a higher degree of accuracy and confidence for estimating sediment volumes.

The upland boring logs were reviewed for physical information to confirm and map the depth to the lower alluvium surface. The lower alluvium was identified as a dense, typically medium-grained, non-silty sand to an interbedded silt and sand (with varying amounts of shell fragments located below interbedded silt and sand with abundant natural organic material) or fill units. The elevation of the top of the lower alluvium has been observed in several studies of the Puget Sound region, specifically the Duwamish Valley. From these studies, the elevation for the top of the lower alluvium is generally thought to be encountered at an elevation of about -30 to -50 ft below ground surface in the lower and central valley and between about -20 and 0 ft below ground surface in the upper valley (Booth and Herman 1998). The upland borings were used to confirm that the lower alluvium was reached in the LDW sediment cores (based on elevations).

E.2.3.2 Datasets

Four datasets were used to develop the cross sections along the LDW and to generate the TINs:

- Sediment cores collected for the RI in 2006 and published in a 2007 subsurface sediment data report (Windward and RETEC 2007).
- Other sediment cores collected from the LDW by various entities over the period between 1996 and 2009, now included in the FS subsurface sediment database (Striplin Environmental Associates, Inc. 1996, 1998, 2000; Weston 1999; Windward, DOF, and Onsite Enterprises 2005; USACE 2009a, 2009b; AMEC 2007; Geomatrix 2008; Anchor 2008a, 2008b; AMEC Geomatrix 2009a, 2009b, 2010).
- Upland and in-water boring logs available from the GeoMapNW on-line database (GeoMapNW 2008). These logs were typically generated for geotechnical investigations and are not accompanied by chemistry data.
- Radioisotope cores collected in 2004 for the Sediment Transport Analysis Report (STAR; Windward and QEA 2008).

It was necessary to combine these datasets to interpret both the thickness of contaminated sediments and the depth to the lower alluvium. The following subsections discuss each dataset.

E.2.3.2.1 2006 RI Sediment Cores

The primary data used to generate the cross sections were the cores collected in 2006 for the RI. These cores included both stratigraphic information and contaminant data reported at both recovered and *in situ* depths to about 12 ft below the mudline. These data were generally collected in continuous 1- to 2-ft depth intervals (low resolution) over the length of the core and analyzed for SMS contaminants. *In situ* depths were used where available, because they eliminated uncertainty introduced by core collection techniques and provided a more realistic approximation of actual conditions.

Data from within 400 ft of the transect line for any core were used to generate a cross section. Because stratigraphic and contaminant data can vary with distance, the 400-ft limit was established to ensure that data at greater distances from a given cross section were not applied to it. In general, the RI cores were located close to each transect, with 50% of those cores located within 100 ft of their respective transects, and 92% of those RI cores were located within 400 ft. It is noted that three RI cores (LDW-SC-26, LDW-SC-34, and LDW-SC-41) were located more than 400 ft from their corresponding transect. These cores were still used in this analysis because they provided information on the thickness of contaminated sediments in the navigation channel, where limited core data are available.

E.2.3.2.2 LDW Sediment Cores Collected by Other Entities

The next set of data used to generate the cross sections were the sediment cores collected from the LDW by other entities over the period between 1996 and 2009. These cores were primarily used in the cross sections to identify the thickness of recent sediment deposition, which generally correlated to the contamination layer. The dataset included cores from the following investigations: the Early Action Area (EAA) investigations for Terminal 117 and Boeing Plant 2/Jorgensen Forge (Windward, DOF, and Onsite Enterprises 2005; Geomatrix 2008; AMEC Geomatrix 2009a, 2009b, 2010), EPA's LDW-wide *Site Investigation* (SI; Weston 1999); the U.S. Army Corps of Engineers sampling events for dredged material characterization in the navigation channel (USACE 2009a and 2009b; Striplin Environmental Associates, Inc. 1996, 1998, and 2000); and two maintenance dredging characterizations (AMEC 2007; Anchor 2008a). The historical cores included both stratigraphic information and contaminant data in a mix of recovered and *in situ* depths, depending on the specific dataset. *In situ* depths were used, where available, and in many cases were calculated from the percent recovery and total drive depth information on the core logs.

As discussed above, data from cores within 400 ft of the transect line were used to generate a cross section. In general, the historical sediment cores were located close to each transect, with 80% of the cores located within 400 ft of their respective transects. It is noted, though, that two distant (>400 ft) historical cores, C1-PSDDA96 and Avg-8-9-PSDDA98, were included (N-N', Figure E-15) to provide information on the thickness of contaminated sediments in the navigation channel, where limited core data are available.

E.2.3.2.3 Upland and In-water Boring Logs from the GeoMapNW Online Database

The third set of data used to generate the cross sections were the upland and in-water boring logs from the GeoMapNW database (GeoMapNW 2008). This database is a compilation of sediment and soil borings collected throughout the state for various purposes, typically for civil engineering studies including utility corridors, bridge construction, other public works projects, and for private subsurface investigations. The GeoMapNW cores were generally advanced deeper than the cores from the other datasets, and these borings were used only to identify the top of the lower alluvium in each cross section.

The GeoMapNW cores included stratigraphic data but no chemistry data. A higher percentage of GeoMapNW cores was applied to cross sections with distances greater than 400 ft because these cores were used only to identify the elevation of the lower alluvium. Stratigraphic data can be interpolated over wider distances than contaminant data because stratigraphic data represent larger scale regional conditions, while subsurface sediment contaminant data are often more spatially heterogeneous.

One GeoMapNW boring log (ID 41911, A-A′ at RM 0.0) did not include the elevation of the top of the core. In this instance, the mudline elevation from the 2003 bathymetric survey (Windward and DEA 2004) was used as the elevation of the top of the core.

E.2.3.2.4 High Resolution Radioisotope Cores

The final set of data used to generate the cross sections were the high-resolution radioisotope cores that were collected to calculate net sedimentation rates (Windward and QEA 2008). Samples were collected at continuous 2-centimeter (cm) depth intervals over the upper 3 ft of these cores. These cores were used only to estimate the thickness of the recent sediment layer in cross sections at RM 1.45, RM 1.9, RM 3.5, and RM 4.3. It was important to interpolate the recent layer in the cross sections because it helps determine the top (upper limit) of the underlying layers. The radioisotope cores were not used to generate the TINs because they do not include chemistry data or lithology information beyond the recent soft sediment deposition layer.

E.2.3.3 Digitized Lines for Import into GIS

After the generalized cross sections were finalized in CAD, two lines of elevation were digitized from each cross section: the elevation of the bottom of contamination (>SQS), and the elevation of the top of the lower alluvium. This was accomplished by generating a point at every change in slope along each of the surfaces of interest (i.e., bottom of contamination [>SQS] and top of lower alluvium) established in the cross section generation process described in Section E.2.3. These points were then imported into GIS as x, y, and z coordinates.

E.2.4 Step 2: Site-wide Isopach Surfaces and the Creation of Thickness Layers

The digitized data from the 2003 bathymetric survey, the two digitized elevation lines from CAD, and additional x, y, and z coordinates from core data used for spatial coverage were imported into GIS to create three isopach surfaces:

- The mudline elevation (the sediment–water interface) from the RI bank-to-bank bathymetric survey (Windward and DEA 2004) extended shoreward to the top of the bank by the GeoMapNW cores
- The elevation of the bottom of contamination (one or more SMS contaminants at a detected concentration >SQS)
- The elevation of the top of the lower alluvium unit (native contact).

The latter two digitized lines are referred to as the lower limit of contamination and the top of the lower alluvium, respectively.

In GIS, the lower limit of contamination elevation and the top of lower alluvium elevation were subtracted from the mudline elevation to convert these elevation data to layers. In the upland portions of the cross sections, the elevation of the top of the lower alluvium was subtracted from the upland ground surface elevation to generate a depth to the top of the lower alluvium.[7]

Contaminant and stratigraphic data from all cores in the FS subsurface sediment dataset were used to fill in spatial data gaps between cross sections.

Near Kellogg Island, where there were relatively few cores, additional data points were generated to better match significant bathymetric features. The points included estimates of contamination thickness and depth to lower alluvium based on nearby cores, cross sections, and bathymetry (see data points around Kellogg Island; Figures E-1, E-5, E-6, and E-7). This resulted in thickness layers near Kellogg Island that are closer to the expected stratigraphy in this area.

E.2.4.1 Creation of Isopach Surfaces and Layers

Next, a TIN was used to interpolate a two-dimensional representation of the contamination and lower alluvium surfaces using the cross section lines of elevation and core data. A TIN of the mudline elevation was also generated by combining the bathymetric data (Windward and DEA 2004) with the mudline elevations from cores in areas where bathymetric data were not available because the presence of barges and overwater structures and/or low tides inhibited access of the sampling vessel during the bathymetric survey. A network of 10-ft by 10-ft grid cells was generated from the TIN surfaces to provide seamless coverage of the LDW.

Finally, the generation of TIN surfaces was used to produce digitally contoured three-dimensional figures, showing layer thicknesses (Figures E-18 and E-19) below mudline.

Some adjustments were made to these surfaces. For example, when the lower alluvium was not identified in a core log, the total depth of the core plus 1 ft was generally assumed to be the depth of the top of the lower alluvium. However, if nearby, deeper cores identified the top of the lower alluvium, only the cores that identified the top of the lower alluvium were used to generate the TIN (therefore, shallow cores that did not reach alluvium did not alter the TIN if they were contrary to other cores). A project geologist analyzed the core logs, locations, and preliminary TINs.

Analogous adjustments were made to the thickness of contamination layer. In the instances where the deepest sample in a core exceeded the SQS, 1 ft was added to the total depth of the core to represent the lower limit of contamination. However, if sample

[7] The ground surface elevations from the upland cores were not projected into the in-water portion of the cross sections, and thus did not affect the interpolated bathymetric contour. A sharp slope from the top of bank down to the mudline elevation can be seen on each side of each cross section (Figures E-2 through E-17).

data from nearby, deeper cores identified the lower limit of contamination, then only the cores that identified the lower limit of contamination were used to generate the TIN (therefore, shallow cores that did not reach the lower limit of contamination did not alter the TIN if they were contrary to other cores). In addition, if some sampling intervals were archived and not analyzed for chemistry, then lithology was considered when defining the lower limit of contamination. A project geologist analyzed the core sample intervals, contaminant concentrations, locations, and preliminary TINs.

A minimum contamination depth of 1 ft was assumed within AOPCs 1 and 2. This was necessary to ensure that a minimum contaminated volume was calculated for all dredge areas with detected surface exceedances of the SQS, regardless of whether a core had subsurface sediment contamination. Dredging to at least 1 ft would be required operationally in any area where dredging was the selected remedial action. Therefore, in locations with surface contamination and where the interpolated thickness to the lower limit of contamination was less than 1 ft, a minimum contamination depth of 1 ft was applied for volume estimation within the dredge footprints.

E.2.4.2 Trends in Contamination Thickness in the LDW

A general understanding of the thickness of contamination in various areas of the LDW can help site managers anticipate the volume of sediments to be managed under potential remedial alternatives.

The data compiled to calculate dredging volumes suggest that the depth of contamination (as defined by the SQS) in intertidal areas is generally less than 5 ft, and the average depth of contamination is 1 to 2 ft in intertidal areas. Figure E-20 presents summary statistics of contaminated sediment thickness within the total area of AOPC 1 and also grouped by mudline elevations.

Figure E-20 shows the depth of contamination (i.e. thickness of contaminated sediment) in AOPC 1 by mudline elevation. The figure indicates that higher elevations (e.g., intertidal) generally have thinner contaminated sediment and lower elevations (e.g., subtidal) generally have thicker contaminated sediment. This difference in contamination depths between subtidal and intertidal areas is in part explained by the conceptual site model, which indicates that subtidal areas experience greater net sedimentation rates than intertidal areas, such that contaminated sediments are buried and, therefore, found in deeper and thicker intervals in the subtidal areas.

The maximum depth of contamination observed in any core in the FS dataset was about 27 ft (core SD-DUW433[8]) after datasets from two studies (Terminal 105 and South Park Bridge) were excluded. Among the excluded datasets, the average maximum depth of

---

[8] Measured depth in core was 0 to 20 ft, but expanded to 27 ft to represent *in situ* conditions (77% core recovery).

contamination was about 21 ft in those cores. Both of these datasets included historical SQS exceedances at depth, but the chemistry data were excluded from consideration because of the sampling methods. The cores were collected with a hollow stem auger, which can vertically draw down and cross-contaminate deeper sediment as the augers are advanced with depth, obscuring contacts. For this reason, these datasets were not used in determining the depth of contamination, although they were retained for determining the depth to the top of the lower alluvium. The thickness to the top of the lower alluvium reached up to 70 ft in some places, which is an unrealistic depth for remedial design; therefore, the maximum depth to the top of the lower alluvium was bound to a reasonable depth below mudline in any given area. The maximum thickness for the lower alluvium was limited to no more than 27 ft from the mudline. The decision to bound the top of the lower alluvium to no more than 27 ft from mudline ensures that all possible contamination above the SQS is accounted for in the estimated sediment volumes. This approach also prevented the maximum extent of the depth of contamination, as represented by the top of the lower alluvium, from being overestimated in the GIS program and resulting TINs.

Regarding the thickness to the top of the lower alluvium, the average thickness in areas with mudline elevations above 0 ft MLLW is 3.5 ft thick. In the shallow subtidal areas and deep intertidal benches (between 0 and -10 ft MLLW), the average thickness to the top of the lower alluvium is about 10 ft, presumably from historical fill material along the banks of the LDW.

E.2.5 Step 3: Calculation of Sediment Neat-line Volumes

The next step was to calculate a neat-line volume[9] for each 10-ft by 10-ft grid cell in the LDW. The neat-line volume associated with each grid cell was calculated by multiplying each layer (thickness) by the area of the grid cell (100 ft^2). Dredge footprint sediment volumes were calculated by summing the volumes in each grid cell within a particular area.

It is noted that each dredge area may have variable depths of contamination. These variable depths are factored into sediment volumes by summing the neat-line volumes associated with each grid cell within the dredge footprint.[10]

For Alternatives 2 through 5, the neat-line volume to the maximum depth of SQS exceedances (SQS isopach) was used as the basis for calculating the volume of contaminated sediment. It was assumed that dredging would occur vertically to the

---

9 The “neat-line volume” is the calculated volume of sediments within a dredge area straight down to the bottom of contamination. Neat-line volumes do not take into account the design of constructible dredge prisms (i.e., side-slopes and box cuts), overdredging, or additional contingencies such as additional sediment characterization.

10 Engineering constraints used to delineate dredge footprints are discussed in Section 8 of the FS.

maximum depth of SQS exceedances. Dredging for Alternative 6 would be deeper and would occur vertically to the maximum depth of Alternative 6 remedial action level (RAL) exceedances, some of which are below the SQS (deeper than the SQS isopach). Therefore, the neat-line volume would be greater for Alternative 6 than the neat-line volume estimated for the other remedial alternatives. To account for this difference in Alternative 6, the neat-line volume was multiplied by an additional factor of 1.34. The factor of 1.34 was developed by comparing the maximum depth of Alternative 5 RAL exceedances (i.e., "SQS") and the maximum depth of Alternative 6 RAL exceedances for the 62 cores collected for the LDW RI. On average, the maximum depth of the Alternative 6 RAL exceedances was approximately 1.4 ft deeper (or approximately 34% deeper) than the maximum depth of Alternative 5 RAL exceedances (see Tables E-1 and E-2).

The extent of potential contamination was assumed to be limited vertically by the stratigraphic contact at the top of the lower alluvium (native sediment). Therefore, the neat-line volume to the top of the lower alluvium was used for the high sensitivity volume estimate, as discussed in the following section.

During remedial design, sediment volumes described in this appendix will be adjusted to consider common engineering and operational factors in dredging projects. This will be conducted by the collection and analysis of additional sediment cores in all dredge footprints to refine the sediment volume estimates, as described in Section 8.

E.3 Volume Estimates for Remedial Alternatives

Neat-line volumes underrepresent the amount of material that will be removed under actual field conditions. Therefore, these volumes were adjusted by considering the following specific allowance factors:

- An overdredging allowance over the neat-line depth, which is a common contracting approach that accounts for operational characteristics and limitations of dredging equipment.
- An allowance to account for additional sediment characterization (e.g., presence of contaminants below the presently estimated depth of contamination).
- An allowance to account for cleanup passes for residuals management within the dredge-cut prism.
- Additional volumes required for constructability of dredge-cut prisms, such as stable side slopes, box cuts,[11] the spatial resolution of dredge equipment, and the slumping of sediments around the dredge-cut prism.

[11] A box cut is a typical excavation method utilized by the dredge along the side slopes. In this method, the width of the dredge cut is sufficient to allow slope material to slough off to the natural underwater repose of that material.

E.3.1 Best-Estimate Dredge-Cut Prism Volume

To account for the multiple allowances listed above, the neat-line volumes were increased by 50%. This adjustment is consistent with literature evaluations of previous FS volume estimates and actual removal volumes for large sediment remediation sites (Palermo 2009).[12]

Palermo (2009) compared predredging volume estimates with actual dredge-cut prism volumes and computed the average volume allowance (63%) for all the sites reviewed. For Phase 1 of the Hudson River cleanup, when comparing the predredging estimates (neat-line estimate from their FS) with the post-dredging estimates (pay volume that included the box cuts and overdredging, etc.), the volume allowance was determined to be approximately 90% (Arcadis 2010). Table E-3 compares predredging estimates and post-dredging estimates for 19 representative sites as presented in Palermo (2009). The Sitcum Waterway, WA project was excluded because the post-dredging volume was inflated as a result of additional maintenance dredging, and data from Phase 1 of the Hudson River cleanup were included although they were not in the Palermo (2009) report. The table also includes each site's volume allowance and an average volume allowance for all the sites.

Table E-4 presents the best-estimate dredge-cut prism volume estimates for each remedial alternative, along with the low and high sensitivity estimates, which are discussed in the following section.

E.3.2 Dredge-Cut Prism Volumes Used for Sensitivity Analysis

EPA's 1988 RI/FS Guidance states that: "Use of sensitivity analyses should be considered for the factors that can significantly change overall costs of an alternative with only small changes in their values, especially if the factors have a high degree of uncertainty associated with them." For the LDW cleanup, dredge-cut prism volume is a cost-sensitive parameter (see Appendix I). Therefore, low and high volumes were developed to bound the best-estimate dredge-cut prism volume for each remedial alternative.

---

[12] "Volume creep" is the term applied to the additional dredge-cut prism volume required as a result of the allowance factors listed above in the introduction of Section E.3 (Palermo 2009). As cited in the paper, "volume creep" also applies to the additional dredge-cut prism volume required as a result of high siltation rates, slumping of the sediments around the dredge-cut prism, and incomplete site characterization. Possible causes of volume creep include changes in remedy approach, cleanup level, or project objectives; expansion of the area of concern or depth of dredging as a result of refinements in site or sediment characterization, sedimentation or erosion occurring between site characterization and active remediation; development of dredge-cut prisms that account for methods of dredge operation, inability to fully remove sediments to the desired depth, overdredging allowances; and redredging required to achieve a cleanup level. (Palermo 2009).

The lower bound dredge-cut prism volume estimate used the same neat-line volume estimates assumed for the best-estimate dredge-cut prism volume. However, instead of a 50% allowance factor, a 25% factor was used to account for overdredging, additional characterization, constructability, and the other allowance factors listed earlier.

The higher bound dredge-cut prism volume estimate used the top of the lower alluvium as the basis for the maximum depth of sediment contamination. No additional allowance was used because the neat-line volume to the top of the lower alluvium was considered to be the reasonable maximum possible dredged volume. For reference, the neat-line volume to the top of the lower alluvium is approximately equal to the neat-line volume to the maximum depth of SQS exceedances plus an additional 100%.

E.4 Sources of Uncertainty

Common sources of uncertainty in volume estimates include: data interpolations, areas with missing bathymetric data, cores without reported mudline elevations, limited core depths, and variability in the quality of data collected caused by different sampling techniques. The areas and depths chosen to represent volumes are also a source of uncertainty. Each of these sources of uncertainty is discussed below.

A level of uncertainty exists when interpolating data and when using data collected over various periods. Over the past 20 years, numerous investigations have been conducted in the LDW to determine the nature and extent of sediment contamination.

A portion of the uncertainty is related to analytical reporting limits that exceed the screening criteria, especially in older data. To account for this uncertainty, the vertical extent of contamination was delineated using only exceedances of the SQS for detected contaminants. As a result, there may be non-detect exceedances of the SQS below the maximum depth of detected SQS exceedances. In approximately 20% of all cores, non-detect exceedances occurred in the deepest sample interval of the core, as depicted in Appendix G. In general, these core samples were either: 1) collected for dredge material characterization (and therefore represent material that has subsequently been dredged), or 2) samples where the primary risk drivers (PCBs, arsenic, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), dioxins/furans) were well below the SQS or RALs, but the low organic carbon content of the samples resulted in higher organic carbon-normalized reporting limits that exceeded the SQS. Typically, the non-detected exceedances are due to reporting limit exceedances of the SQS for one or two SMS contaminants, and not exceedances of the SQS or RALs for the primary risk drivers (PCBs, cPAHs, arsenic, and dioxins/furans). This uncertainty is captured in the 50% volume allowance, which accounts for additional characterization during remedial design.

The RI subsurface sampling events in 2006 collected 10- to 12-ft sediment cores, and in most cases, the bottom samples reached "native sediments" (i.e., the lower alluvium) and were below the SQS. On a generalized scale, the vertical extent of contamination (>SQS) has been quantified in most areas, and the lower alluvium contact can be used as a conservative estimate of the maximum depth of contamination for this FS. Uncertainty regarding the spatial coverage of the RI cores was addressed by using multiple datasets and cores collected by different parties. However, many of the historical cores neither determined the maximum vertical extent of contamination nor reached the lower alluvium. This source of uncertainty was managed by interpolation between cores with adequate data. The use of additional upland data from areas adjacent to the LDW further minimized the level of uncertainty in the interpolated data surface for the depth to the lower alluvium by corroborating the thickness of geologic units. These thickness estimates will need to be refined during remedial design for individual areas.

The generation of assumed bathymetric and elevation data discussed in Section E.2.4 is also a source of uncertainty. Not all of the historical sediment core logs reported mudline elevations. For these cores, the 2003 bathymetric data were used to represent the top of the core. Boring elevations reported from the GeoMapNW database and boring logs were used in the analysis of the upland cores when available; however, there was no way to verify the accuracy of those reported data.

The top of bank, or top of shoreline, defined as the bathymetric elevation +11.3 ft MLLW, is the interface between the upland and in-water areas and is well-defined on GIS maps from the RI (Windward 2010). However, there is some uncertainty regarding the slope and elevation of the intertidal and high intertidal areas surrounding the top of bank demarcation. This area was hand-interpolated using the 2003 bathymetric data (Windward and DEA 2004), upland cores, and aerial photographs to better understand these shoreline areas. Historical filling in the shoreline area may contribute to the uncertainty of contaminated sediment volumes and the noticeable differences between the elevations based on the lower limit of SQS exceedances and the top of the lower alluvium.

Another source of uncertainty includes sediment cores with detected SQS exceedances in the lowest sample interval analyzed. Most core samples were collected in 2-ft to 4-ft depth composites (low resolution) and do not have finer resolution of contaminant data. Exceedances of the SQS in a 2-ft or 4-ft composite could be caused by high concentrations in the upper part of the interval even though there are lower concentrations (below the SQS) in the lower part of the interval; however, compositing obscures this distinction. Therefore, the precise depth of the bottom of contamination is unknown.

An overall assumption of this analysis is that the lower alluvium layer is "clean," meaning that this unit represents natural background contaminant concentrations with no SQS exceedances. This assumption is consistent with the LDW conceptual site model of contaminant and geology trends. However, seven historical cores with SQS exceedances were documented in the lower alluvium unit. All seven exceedances have been screened out on a case-by-case basis. Four cores with SQS exceedances at depths presumably within the lower alluvium were advanced by hollow stem auger drilling techniques (Terminal 105 and South Park Bridge cores). This method of sampling commonly produces draw-down of contaminants and contaminated sediment from the contaminated intervals of the boring to lower depths within a boring unless special care is taken during drilling. The samples from these four borings were collected via Shelby tube, split spoon, and Dames & Moore sampling methods. The four exceedances were determined to be false positives at a depth within the lower alluvium from smearing or draw-down of contaminated sediment from shallower intervals. Therefore, these four cores were excluded from the analysis related to depth of contamination; however, the geological interpretations from these cores were used in the depth-to-alluvium calculations. The three remaining cores with SQS exceedances at depths presumably within the lower alluvium were located within the EAAs (Terminal 117 and Duwamish/Diagonal) where possible localized disturbance of the lower alluvium unit may have occurred based on the historical industrial activities in such areas. Cleanup actions in the EAAs either already have been conducted or will be conducted independently of the FS process. The FS does not include volume calculations for the EAAs.

The rest of the samples located completely within the lower alluvium either had detected contaminant concentrations that were below the SQS or they were non-detect. All 35 lower alluvium samples analyzed for total PCBs (outside of EAAs) were non-detect, with reporting limits ranging from 1.9 microgram per kilogram dry weight (µg/kg dw) to 79 µg/kg dw. Of 30 lower alluvium samples analyzed for arsenic, 17 were non-detect and 13 were detect, with a maximum detected concentration of 21 mg/kg dw.

Uncertainty in the volume estimates is also based on variables related to horizontal accuracy, such as horizontal positioning, density of sampling points, terrain uniformity, and the computation method used. This type of spatial uncertainty should be resolved during remedial design.

E.5 Conclusions

The process of estimating contaminated sediment volumes for the LDW remedial alternatives combined approaches from several methods, including subsurface interpolation, a maximum vertical depth constraint, and target areas within the AOPCs to define surfaces requiring remediation with variable contaminated sediment depths. These methods have all been used at other contaminated sediment sites. By using this combined method to calculate the estimated contaminated sediment volumes potentially requiring removal and disposal, results were tailored to site-specific remedial alternatives and design constraints in the LDW. The volume estimates for each remedial alternative are presented in Table E-4 and are considered to be as accurate as can be achieved in the FS without further investigation, which will be conducted as part of remedial design. Sediment volumes potentially requiring removal were estimated by following the process for determining *in situ* sediment volumes as described in this appendix, and accounting for known engineering constraints, volume creep, and residuals management. The specific volume approaches used and their associated cost estimates can be found in Section 8 and Appendix I, respectively. Of the approaches available, one approach was ultimately selected for each remedial alternative.

Combined, all of the data and analyses presented in this appendix can be used to estimate dredge-cut prism volumes for remedial alternatives in the LDW with sufficient confidence for FS-level evaluations and subsequent remedial decision-making.

The estimated volumes, and associated uncertainties in those volumes, affect the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation of the remedial alternatives and the Model Toxics Control Act (MTCA) disproportionate cost analysis (Sections 9 and 11 of this FS) in the following ways:

- **Short-term effectiveness:** The volumes to be dredged affect the duration of the construction; associated short-term effects on workers, the community, and the environment; and the overall time to achieve the cleanup objectives.
- **Cost:** The volumes to be dredged and disposed of in an upland landfill (or treated) have a roughly linear effect on estimated project cost.
- **Overall protection of human health and the environment:** The short-term effectiveness factors above are a significant consideration in evaluating overall protection.

Finally, it is reiterated that the uncertainties in the volume estimates of the *in situ* contaminated sediments are most important to the dredging portion of each remedial alternative. The scoping and evaluation of other remedial approaches (capping, enhanced natural recovery, and monitored natural recovery) are driven by the area of contamination, which can be estimated with greater confidence than the *in situ* volume.

E.6 References

AMEC 2007. *Sediment Characterization Investigation Delta Marine PSDDA Sediment Sampling*. Seattle, Washington. Prepared for: Delta Marine Industries, Inc. Prepared by: AMEC Earth & Environmental, Inc. AMEC Project No. 7-915-13483-A. September 20, 2007

AMEC Geomatrix 2009a. *Building 2-41 Complex Under-Building Investigation Data Report. Boeing Plant 2 Duwamish Sediment Other Area and Southwest Bank Interim Measure.* Submitted to: The Boeing Company. Prepared by: AMEC Geomatrix, Inc., Lynnwood, WA. Project 12351.002. October 2009.

AMEC Geomatrix 2009b. *Additional Characterization Data Report. Boeing Plant 2 Duwamish Sediment Other Area.* Submitted to: The Boeing Company. Prepared by: AMEC Geomatrix, Inc., Lynnwood, WA. Project 13133.002 October 2009

AMEC Geomatrix 2010. 2*009 Additional Characterization Data Report. Boeing Plant 2 Duwamish Sediment Other Area.* Submitted to: The Boeing Company. Prepared by: AMEC Geomatrix, Inc., Lynnwood, WA. Project 13133.004. April 2010.

Anchor 2008a. *Port of Seattle Terminal 115 Sediment Characterization Report.* Prepared for Port of Seattle. Prepared by Anchor Environmental, L.L.C. June 2008.

Anchor 2008b. Draft Technical Memorandum. *8801 East Marginal Way South – Phase 2 SEWP Surface and Subsurface Sediment Results*. Submitted to Washington State Department of Ecology. Prepared for PACCAR. May 12, 2008.

Arcadis 2010. *Phase 1 Evaluation Report, Hudson River PCBs Superfund Site*. Prepared for General Electric Company, Albany, NY. March 2010.

Booth D., and L. Herman 1998. *Duwamish Coalition: Duwamish Basin Groundwater Pathways Conceptual Model Report.* City of Seattle Office of Economic Development and King Country Office of Budget and Strategic Planning, Seattle, WA.

EPA 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA,* EPA/540/G-89/004. United States Environmental Protection Agency, Washington, D.C. 1988.

GeoMapNW 2008. Pacific Northwest Center for Geologic Mapping Studies. Website address: http://geomapnw.ess.washington.edu/. Upland boring logs from the Duwamish watershed downloaded March to November, 2008.

Geomatrix 2008. *Data Report. Boeing Plant 2 Duwamish Sediment Other Area. Western Boundary and Navigation Channel Sample Collection.* Prepared for the Boeing Company. Prepared by Geomatrix. Project Number 013133.002. April 2008.

IJC 1999. International Joint Commission Great Lakes Water Quality Board. Website. http://www.ijc.org/boards/wqb/index.html.

Malcolm Pirnie 2007. *Draft Source Control Early Action Focused Feasibility Study*. Lower Passaic River Restoration Project. Prepared for the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, and the New Jersey Department of Transportation. June 2007.

Palermo 2009. *In Situ Volume Creep for Environmental Dredging Remedies.* Fifth International Conference on Remediation of Contaminated Sediments, D3. Jacksonville, Florida. February 4, 2009.

RETEC 2002. *Final Feasibility study for Lower Fox River and Green Bay, Wisconsin Remedial Investigation and Feasibility Study.* Prepared for Wisconsin Department of Natural Resources, 101 S. Webster Street, Madison, Wisconsin. December 2002.

RETEC 2006. *Draft Supplemental Remedial Investigation and Feasibility Volume 2: FS Report, Whatcom Waterway Site, Bellingham Washington.* Prepared for the Port of Bellingham, for submittal to the Washington State Department of Ecology, Bellevue, Washington. October 10, 2006.

Striplin Environmental Associates, Inc. 1996. *PSDDA Chemical Characterization of Duwamish Waterway and Upper Turning Basin, FY97 Operations and Maintenance Dredging, Seattle, Washington.* Prepared for the U.S. Army Corps of Engineers, Seattle District, Seattle, Washington. December 18, 1996.

Striplin Environmental Associates, Inc. 1998. *PSDDA Chemical Characterization of Duwamish Waterway and Turning Basin FY99 Operations and Maintenance Dredging, Seattle, Washington*. Prepared for the U.S. Army Corps of Engineers, Seattle District, Seattle, Washington. December 1, 1998.

Striplin Environmental Associates, Inc. 2000. *PSDDA Chemical Characterization of Duwamish River Navigation Channel FY2000 Operations and Maintenance Dredging Data Report.* Prepared for the U.S. Army Corps of Engineers, Seattle District, Seattle, Washington. January 2000.

TAMS Consultants 2000. *Hudson River PCBs Reassessment RI/FS Phase 3 Report: Feasibility Study. Appendix B Volume Computation for Sediment Removal.* Prepared for the U.S. Environmental Protection Agency Region 2 and the U.S. Army Corps of Engineers Kansas City Region. December 2000.

USACE 2009a. *Dredged Material Characterization for Duwamish River Navigation Channel, Seattle, WA*. Data Report Final. Prepared for USACE. Prepared by SAIC. October 7, 2009.

USACE 2009b. *Duwamish River Federal Navigation Channel Dredged Material Characterization, Seattle, WA*. Data Report Addendum Final. November 20, 2009

Weston 1999. *Site inspection report, Lower Duwamish River (RK 2.5-11.5), Seattle, Washington. Vol 1-Report and appendices.* Prepared for U.S. Environmental Protection Agency, Region 10. Roy F. Weston, Inc., Seattle, Washington. 1999.

Windward and DEA, Inc. 2004. *Lower Duwamish Waterway Bathymetric Survey 2003*. Final. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington State Department of Ecology, Bellevue, WA. Windward Environmental LLC, Seattle, WA, and David Evans and Associates, Seattle, WA.

Windward, DOF, and Onsite Enterprises 2005. *Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 sediment, soil and water field sampling, cruise and data report. Final.* Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward Environmental, LLC and QEA 2008. *Lower Duwamish Waterway Sediment Transport Analysis Report.* Prepared for Lower Duwamish Waterway Group. Quantitative Environmental Analysis, LLC, Montvale, NJ. Final. January 8, 2008.

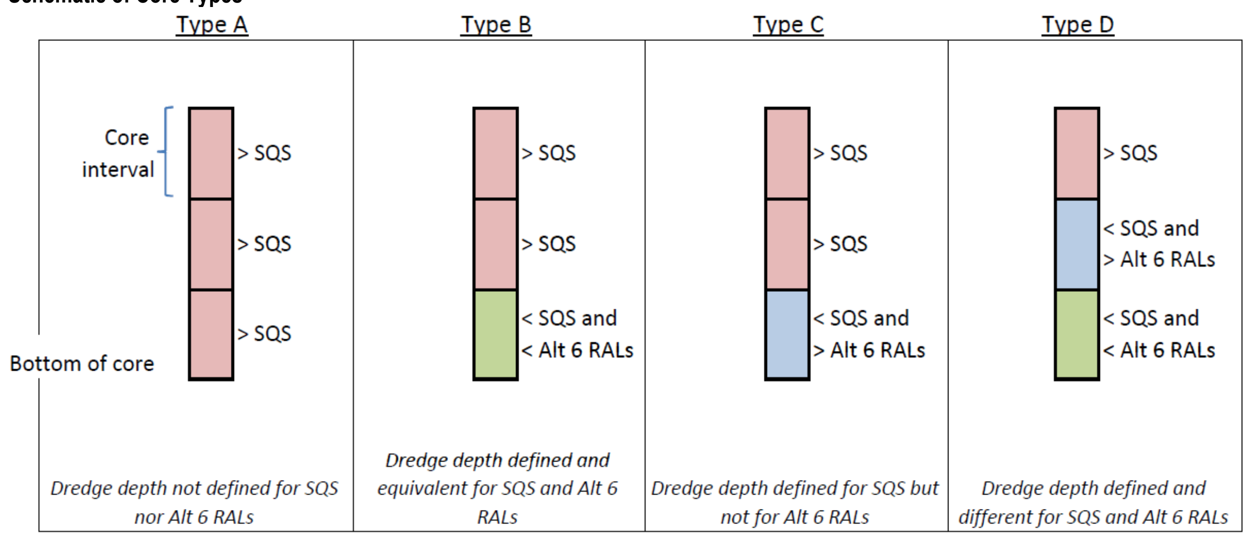
Windward Environmental, LLC and RETEC 2007. Lower Duwamish Waterway remedial investigation. *Data Report: Subsurface sediment sampling for chemical analyses*. Prepared for Lower Duwamish Waterway Group for submittal to the U.S. Environmental Protection Agency Region 10, Seattle, Washington and the Washington State Department of Ecology Northwest Regional Office, Bellevue, Washington. January 29, 2007.

Windward Environmental, LLC 2010. *Final Remedial Investigation Report, Lower Duwamish Waterway*. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, Washington and Washington State Department of Ecology, Bellevue, Washington. July 2010.

Table E-1 Summary of Dredge Depth Differences between SQS and Alternative 6 RALs for LDW RI Cores

Core Type	Count	Does the Bottom of Core (or Deepest Sample) Reach the Maximum Depth of Contamination?	Average Difference between SQS and Alt 6 RALs (ft *in situ*)	Notes
A	6	Not reached for both SQS and Alt 6 RALs	n/a	Not used in the analysis.
B	36	Reached for both, same depth for SQS and Alt 6 RALs	0.1	Depth difference generally 0 ft, but assume a minimum 1-ft dredge depth for Alt 6 in AOPC 2.
C	14	Reached for SQS, not reached for Alt 6 RALs	4.5	Assume Alt 6 dredge depth is 1 ft below the base of the core or deepest core sample.
D	3	Reached for both, deeper for Alt 6 RALs than SQS	1.9	The maximum depth of contamination is defined for both SQS and Alt 6 based on core data.
Total	59	Average of B, C, and D cores (n = 53):	1.4	Values converted from recovered depths to *in situ* core depths.

Schematic of Core Types



Scaling factor calculation

Average neat volume dredge depth to SQS	4	ft *in situ*
Average increase in dredge depth to achieve Alt 6 RALs	1.4	ft *in situ*
Average neat volume dredge depth to Alt 6 RALs	5.4	ft *in situ*
Average increase in neat volume from SQS to Alt 6 RALs (vertically)	34%	

Notes:

AOPC= area of potential concern; ft = foot; n = number of cores; n/a - not applicable; RAL = remedial action level; RI = remedial investigation; SQS = sediment quality standards

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores

Core Type	Core	AOPC	Sample Depth (ft)[a]		Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a]		Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
			Upper Depth	Lower Depth				Alt 5 Depth[d]	Alt 6 Depth[c]		
A (bottom sample > SQS)	LDW-SC10	1	0	1	260	8	x	> core depth	> core depth	0	n/a
			1	2	290	19	x				
			2	4	1,120	21	x				
			4	5	410		x				
			6	8	350		x				
	LDW-SC17	1	0	1	1,220	110	x	> core depth	> core depth	0	n/a
			1	2	1,040	170	x				
			2	4	9,800	60	x				
			6	8.6	1,900	76	x				
	LDW-SC26	1	0	1	280	40	x	> core depth	> core depth	0	n/a
			1	2	226	36	o				
			2	4	310	67	x				
			6	8	2,300	1,890	x				
			11.1	12.1	140	3	x				
	LDW-SC28	1	0	1	440	114	x	> core depth	> core depth	0	n/a
			1	2	360	18	x				
			2	4	290	30	o				
			5.5	7.5	3,200	760	x				
			12	12.6	540	17	x				
	LDW-SC41	1	0	1	370	20	x	> core depth	> core depth	0	n/a
			1	2	256	16	o				
			2	4	270	16	o				
			4	6	510		x				
			6	7.9	190		x				

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a] Upper Depth	Sample Depth (ft)[a] Lower Depth	Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a] Alt 5 Depth[d]	Dredge Depths (ft)[a] Alt 6 Depth[c]	Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
A (bottom sample > SQS)	LDW-SC8	1	0	1	290	19	x	> core depth	> core depth	0	n/a
			1	2	1,030	20	x				
			2	4	2,900	40	x				
			4	6	5,500	62	x				
			6	8	3,800		x				
			8	10	540	21	x				
B (bottom sample < SQS and < Alt 6 RALs)	LDW-SC1	1	0	0.5	85		o	4	4	0	n/a
			0.5	1	350		x				
			1	1.5	6,700		x				
			0	2	3,400	22	x				
			1.5	2	4,300		x				
			2	4	440	10	x				
			4	6	1.9		o				
	LDW-SC11	1	0	0.8	3,000	28	x	0.8	0.8	0	n/a
			0.8	2	1.95	9	o				
			2	3.4	1.95	7	o				
			3.4	4.1	2	9	o				
			4.1	5							
	LDW-SC12	1	0	0.5	64		o	6.6	6.6	0	n/a
			0.5	1	106		o				
			1	1.5	134		o				
			0	2	350	20	x				
			1.5	2	320		x				
			2	2.5	2,000		x				
			2.5	3	630		x				

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a] Upper Depth	Sample Depth (ft)[a] Lower Depth	Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a] Alt 5 Depth[d]	Dredge Depths (ft)[a] Alt 6 Depth[c]	Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
B (bottom sample < SQS and < Alt 6 RALs) (continued)	**LDW-SC12** *(continued)*	1	3	3.5	138		o				
			2	4	2,500	19	x				
			3.5	4	790		x				
			4	6.6	420		x				
			6.6	8.7	1.95		o				
	LDW-SC14	1	0	1.4	4,500	24	x	10	10	0	n/a
			1.4	2	2,060	22	x				
			2	4.1	1,550	22	x				
			4.1	6	420		x				
			6	8.7	70		x				
			10	11	1.95		o				
	LDW-SC15	1	0	1	360	30	x	8	8	0	n/a
			1	2	340	20	x				
			2	4	510	25	x				
			4	6	1,950		x				
			8	10	2		o				
	LDW-SC16	1	0	2	330	21	x	8	8	0	n/a
			2	4	5,400	20	x				
			4	6	3,400	20	x				
			8	10	18	14	o				
			10	10.8							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a]		Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a]		Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
			Upper Depth	Lower Depth				Alt 5 Depth[d]	Alt 6 Depth[c]		
B (bottom sample < SQS and < Alt 6 RALs)	LDW-SC18	1	0	1	182	11	o	1	1	0	n/a
			1	2	19.6	3	o				
			2	4	1.95	3	o				
			8	10.7							
	LDW-SC19	1	0	1	280[b]	20	o	9	9	0	n/a
			1	2	233	20	x				
			2	4	250	24	x				
			4	6	440		x				
			6	7	2,400		x				
			9	11.9	1.95		o				
	LDW-SC2	1	0	2	1,380	190	x	10.7	10.7	0	n/a
			2	4	2,900	210	x				
			4	6	209	270	x				
			8	10	237		x				
			10.7	12	1.9	3	o				
			12	13							
	LDW-SC20	1	0	2	3,200	20	x	8	8	0	n/a
			2	4	600	17	x				
			4	6	400		x				
			8	10	95		o				
	LDW-SC201	1	0	1.5	1,450	19	x	8	8	0	n/a
			1.5	4	530	13	x				
			4	6	340		x				
			8	10	1.95		o				
			10	11.8							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a] Upper Depth	Sample Depth (ft)[a] Lower Depth	Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a] Alt 5 Depth[d]	Dredge Depths (ft)[a] Alt 6 Depth[c]	Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
B (bottom sample < SQS and < Alt 6 RALs)	LDW-SC202	2	0	1	30	13	o	0	1	1	n/a
			1	2	1.9	12	o				
			2	4	1.95	9	o				
	LDW-SC21	1	0	1	250	20	x	6.2	6.2	0	n/a
			1	2	145	19	o				
			2	4	380	34	x				
			4	6.2	1,680		x				
			6.2	8	2		o				
			10	11.3	1.95		o				
	LDW-SC22	1	0	1.1	56	12	o	1	1	0	n/a
			1.1	2	26	8	o				
			2	4	7.8	7	o				
			6	7.7							
	LDW-SC23	2	0	2	177	18	o	8	8	0	n/a
			2	4	219	20	x				
			4	6	880		x				
			6	8	400		x				
			8	10.2	41		o				
	LDW-SC24	1	0	1	280	30	x	1	1	0	n/a
			1	2	36	11	o				
			2	4	1.95	3.5	o				
			8	10							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a] Upper Depth	Sample Depth (ft)[a] Lower Depth	Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a] Alt 5 Depth[d]	Dredge Depths (ft)[a] Alt 6 Depth[c]	Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
B (bottom sample < SQS and < Alt 6 RALs)	LDW-SC25	1	0	1	310	50	x	8	8	0	n/a
			1	2	360	91	x				
			2	4	430	170	x				
			4	6	800	250	x				
			8	9.1	1.95	8	o				
	LDW-SC29	1	0	1	33	14	o	1	1	0	n/a
			1	2	1.95	11	o				
			2	3.6	1.95	3	o				
	LDW-SC3	outside AOPC	0	2	2	3	o	0	0	0	n/a
			2	4	1.95	3.5	o				
			6	8							
	LDW-SC30	1	0	2.5	12.9	3	o	1	1	0	n/a
			2.5	4	1.95	3.5	o				
			4	5.9							
	LDW-SC31	1	0	1	370	20	x	2.8	2.8	0	n/a
			1	2.8	330	17	x				
			2.8	4	2.7	3	o				
			4	5.9							
	LDW-SC32	1	0	1	1,010	20	x	5.2	5.2	0	n/a
			1	2	1,720	40	x				
			2	4	2,450	30	x				
			5.2	8	1.9		o				
			10	11							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a]		Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a]		Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
			Upper Depth	Lower Depth				Alt 5 Depth[d]	Alt 6 Depth[c]		
B (bottom sample < SQS and < Alt 6 RALs)	LDW-SC33	1	0	0.5	490		x	8	8	0	n/a
			0.5	1	790		x				
			1	1.5	4,700		x				
			0	2	3,100	56	x				
			1.5	2	2,500		x				
			2	2.5	210		x				
			2.5	3	940		x				
			2	4	420	13	x				
			4	6	280	14	x				
			8	10	1.95		o				
			9.5	10							
	LDW-SC36	2	0	1	75	12	o	0	1	1	n/a
			1	2	2	11	o				
			2	4	1.9	10	o				
			8	10							
	LDW-SC38a/b	1	0	1	450	11	x	3	3	0	n/a
			1	2	710	10	x				
			2	3	3,400	13	x				
			3	3.3	14	3.5	o				
	LDW-SC4	1	0	1	143	18	x	4	4	0	n/a
			1	2	490	63	x				
			2	4	600	14	x				
			4	6	1.95		o				
			6	6.7							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a]		Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a]		Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
			Upper Depth	Lower Depth				Alt 5 Depth[d]	Alt 6 Depth[c]		
B (bottom sample < SQS and < Alt 6 RALs)	LDW-SC40	1	0	1.3	160	7	x	1.3	1.3	0	n/a
			1.3	2	2	3	o				
			2	4	1.95	3	o				
			4	6							
	LDW-SC43	1	0	2	2	3.5	o	1	1	0	n/a
			2	4	1.95	3	o				
			9	9.8							
	LDW-SC44	1	0	0.5	260		x	3.2	3.2	0	n/a
			0.5	1	880		x				
			1	1.5	200		o				
			0	2	510	16	x				
			1.5	2	140		o				
			2	2.5	270		x				
			2.5	3	150		o				
			2	3.2	450	19	x				
			3	3.5	2		o				
			3.2	4	1.95	9	o				
			4	5.8							
	LDW-SC47	1	0	1	72	3	o	3	3	0	n/a
			1	2	2,000	12	x				
			2	3	490	8	x				
			3	4	2	3	o				
			8	10							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a] Upper Depth	Sample Depth (ft)[a] Lower Depth	Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a] Alt 5 Depth[d]	Dredge Depths (ft)[a] Alt 6 Depth[c]	Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
B (bottom sample < SQS and < Alt 6 RALs)	LDW-SC48	2	0	1	77	3	o	0	1	1	n/a
			1	2	1.9	3	o				
			2	4	1.95	3.5	o				
			4	5.8							
	LDW-SC5	1	0	1	510	17	x	2.2	2.2	0	n/a
			1	2.2	66	14	x				
			2.2	4	1.95	3	o				
			4	6							
	LDW-SC51	1	0	2	1,290	25	x	3.8	3.8	0	n/a
			2	3.8	700	55	x				
			3.8	5.8	1.95		o				
	LDW-SC55	1	0	1	13.5	10	o	1	1	0	n/a
			1	2	1.95	3	o				
			2	3	2	3	o				
			4	6							
	LDW-SC56	1	0	2	330	7	x	2	2	0	n/a
			2	4	1.95	6	o				
			4	5.6							
	LDW-SC7	1	0	1	1,300	17	x	1.7	1.7	0	n/a
			1	1.7	1,270	11	x				
			1.7	4	2.75	3	o				
			8	8.7							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a] Upper Depth	Sample Depth (ft)[a] Lower Depth	Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a] Alt 5 Depth[d]	Dredge Depths (ft)[a] Alt 6 Depth[c]	Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
C (bottom sample < SQS and > Alt 6 RALs)	LDW-SC203 (replicate of LDW-SC34)	1	0	1	250	20	x	4	> sample depth	3	PCB
			1	2	110	20	x				
			2	4	174	15	x				
			4	6	181		o				
			8	8.8							
	LDW-SC27	1	0	0.5	250		x	3	> sample depth	2.5	As
			0.5	1	2,000		x				
			1	1.5	3,200		x				
			0	2	3,300	19	x				
			1.5	2	1,510		x				
			2	2.5	840		x				
			2.5	3	290		x				
			2	4.5	250	17	x				
			3	3.5	60		o				
			3.5	4	1.95		o				
			4	4.5	1.95		o				
			7.8	9.5							
	LDW-SC34 (gravel/glass at 8.7 ft; suspect non-native to bottom)	1	0	1	210	20	x	2	> sample depth	7	PCB/As
			1	2	280	20	x				
			2	4	250[b]	15	o				
			8	9.4							
	LDW-SC35 (pieces of concrete at 5.9 ft)	1	0	2	370	18	x	2	> sample depth	4	PCB/As
			2	4	150	16	o				
			6	8							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a] Upper Depth	Sample Depth (ft)[a] Lower Depth	Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a] Alt 5 Depth[d]	Dredge Depths (ft)[a] Alt 6 Depth[c]	Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
C (bottom sample < SQS and > Alt 6 RALs)	**LDW-SC37**	1	0	1	450	150	x	5.3	> core depth	2.6	As
			1	2	950	121	x				
			2	4	550	2,000	x				
			5.3	6.9	1.95	21	o				
	LDW-SC39 (alluvium at 8.5 ft)	1	0	1	208	9	x	4	> sample depth	4.5	PCB
			1	2	440	7	x				
			2	4	220	14	x				
			4	6	150		o				
			8.5	9.2							
	LDW-SC45	1	0	1	230	15	x	5	> core depth	2	PCB
			1	2	270	13	x				
			2	4	570	25	x				
			5	6	122		o				
	LDW-SC46	1	0	1	214	16	x	4	> sample depth	3.8	PCB
			1	2	185	13	x				
			2	4	270	18	x				
			4	6.8	195		o				
			10	11.2							
	LDW-SC49a (core did not reach alluvium)	1	0	1	75	10	x	8	> core depth	4	PCB
			1	2	150	10	o				
			2	4	420	11	x				
			4	6	780		x				
			6	8	810		x				
			8	10	130		o				

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a]		Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a]		Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
			Upper Depth	Lower Depth				Alt 5 Depth[d]	Alt 6 Depth[c]		
C (bottom sample < SQS and > Alt 6 RALs)	**LDW-SC50a** (non-silt sand below 2.8 ft)	1	0	1	510	707	x	2.8	> sample depth	2.2	As
			1	2	780	281	x				
			2	2.8	75	161	x				
			2.8	4	1.9	21	o				
			8	9.8							
	LDW-SC53 (head of Slip 6)	1	0	2	68	20	o	1	> sample depth	4	As
			2	4	77	20	o				
			8	10							
	LDW-SC54 (alluvium at 5.5')	2	0	2	109	12	o	0	> sample depth	5.5	PCB
			2	4	111	11	o				
			8	10							
	LDW-SC6	1	0	0.5	167		o	6	> sample depth	3	As
			0.5	1	97		o				
			1	1.5	101		o				
			0	2	172	21	o				
			1.5	2	94		o				
			2	2.5	176		o				
			2.5	3	350		x				
			3	3.5	490		x				
			3.5	4	1,590		x				
			2	4.5	1,640	41	x				
			4	4.5	2,600		x				
			6	8	4.5	20	o				
			8	8.5							

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Core Type	Core	AOPC	Sample Depth (ft)[a]		Total PCBs (µg/kg dw)[b,c]	Arsenic (mg/kg dw)[b,c]	SMS (x = > SQS) (o = < SQS)[c,d]	Dredge Depths (ft)[a]		Assumed Difference in Depth between SQS and Alt 6 RALs (ft)	Contaminant Driving the Increased Alt 6 Dredge Depth
			Upper Depth	Lower Depth				Alt 5 Depth[d]	Alt 6 Depth[c]		
C (bottom sample < SQS and > Alt 6 RALs)	LDW-SC9	1	0	1	3,600	17	x	2.6	> sample depth	2.4	As
			1	2.6	2,700	30	x				
			2.6	4	67	16	o				
			6.4	8.5							
D (bottom sample < Alt 6 RALs; plus at least one intermediate sample between SQS and Alt 6 RALs)	TLDW-SC13	1	0	0.5	460		x	1	2.5	1.5	PCB
			0.5	1	470		x				
			1	1.5	280		o				
			0	2	480	16	x				
			1.5	2	360[b]		o				
			2	2.5	120		o				
			2.5	3	1.95		o				
			3	3.5	1.9		o				
			2	4	53	13	o				
			8	9.5							
	LDW-SC42	2	0	1	107	10	o	0	2	2	PCB
			1	2	163	13	o				
			2	4	88	13	o				
			10	12							
	LDW-SC52	1	0	1	3,000	17	x	1	2	1	As
			1	2	65	28	o				
			2	4	2	3	o				
			4	5							

Average thickness from base of SQS to the base of Alternative 6 RALs for cores types B, C, and D (n=53) = 1.1 ft

Average *in situ* thickness assuming 80% recovery = 1.4 ft

Table E-2 Dredge Depth Differences between SQS and Alternative 6 RALs for the LDW RI Cores (continued)

Notes:

a. Depths are expressed as recovered depths, not *in situ* depths

b. PCBs were shaded pink based on dry-weight concentration (>240 µg/kg dw). However, the SMS exceedance status and Alternative 5 dredge depth were based on carbon-normalized concentrations for total PCBs (12 mg/kg oc). This results in some apparent discrepancies for samples >240 µg/kg dw and <12 mg/kg oc.

c. Alternative 6 RALs are 100 µg/kg dw for PCBs and 15 mg/kg for arsenic, and SQS for other SMS contaminants.

d. Based on all SMS contaminants

1. Blank cell indicates sample was not analyzed.

2. This analysis used the RI cores because they constitute a consistent dataset, they have sample intervals with relatively fine resolution, and they often have samples below the maximum depth of contamination. This analysis assumes that the average trends in the RI cores are representative of the average trends across the LDW.

3. Table E-1 provides the key for the color coding used in this table.

4. The Alt. 6 RAL for dioxins/furans was lower than the Alt. 5 RAL, however, there were no instances where consideration of dioxins/furans in cores would have resulted in a lower dredge depth, so a column for dioxins/furans is not included.

5. The Alt. 6 RAL for cPAHs and SMS was the same as the Alt. 5 RAL, so there was no need for considering cPAHs.

> core depth: indicates the dredge depth could not be defined by the core data because the deepest sample exceeded the RAL

Alt = remedial alternative; AOPC = area of potential concern; cPAH = carcinogenic polycyclic aromatic hydrocarbons; dw = dry weight; ft = feet; kg = kilogram; LDW = Lower Duwamish Waterway; µg = microgram; mg = milligram; n = number of cores; n/a = not applicable; oc = organic carbon; PCB = polychlorinated biphenyl; RAL = remedial action level; RI = remedial investigation; SMS = Sediment Management Standards; SQS = sediment quality standard

Table E-3 Comparison of Predredging and Post-dredging Volume Estimate at Representative Sites

Site	Predredging Estimated Volume (cy)	Post-dredging Estimated Volume (cy)	Volume Allowance Factor
Ashtabula River, OH	500,000	497,000	0.99
Bayou Bonfouca, LA	150,000	170,000	1.13
Black Lagoon, MI	90,000	115,000	1.28
Cumberland Bay, NY	93,000	195,000	2.10
Duwamish Diagonal, WA	70,000	68,000	0.97
Fox River OU1, WI	406,000	370,000	0.91
Fox River Phase 1, WI	138,000	132,000	0.96
Grand Calumet River, IN	750,000	786,000	1.05
Harbor Island Lockheed Shipyard, WA	55,000	70,000	1.27
Harbor Island Todd Shipyard, WA	116,000	220,000	1.90
Head of Hylebos, WA	217,000	404,000	1.86
Hudson River – Phase 1, NY*	133,000	256,000	1.92
Manistique Harbor, MI	104,000	188,000	1.81
Marathon Battery, NY	56,000	82,000	1.46
Northwest Oil Drain, UT	40,000	51,000	1.28
Puget Sound Naval Shipyard, WA	200,000	226,000	1.13
Reynolds Metals, NY	52,000	86,000	1.65
United Heckathorn, CA	65,000	107,000	1.65
Waukegan Harbor, IL	47,000	50,000	1.06
Average Volume Allowance Factor (19 sites)			**1.38**

References:

Palermo 2009. *In Situ Volume Creep for Environmental Dredging Remedies*. Fifth International Conference on Remediation of Contaminated Sediments, D3. Jacksonville, Florida. February 4, 2009.

*Arcadis 2010. *Phase 1 Evaluation Report, Hudson River PCBs Superfund Site*. Prepared for General Electric Company, Albany, NY. March 2010.

Note:

The Sitcum Waterway, WA project was excluded because the post-dredging volume was inflated as a result of additional maintenance dredging.

cy = cubic yards

Table E-4 Comparison of Dredge-cut Prism Volumes for Each Remedial Alternative

Remedial Alternative	Neat-line Volume to Lower Limit of Contamination[a]	Dredge-cut Prism Volume		
		Best-estimate	Low sensitivity	High sensitivity
		Neat-line Volume to Lower Limit of Contamination+ 50%[b]	Neat-line Volume to Lower Limit of Contamination+ 25%[b]	Neat-line Volume to Lower Alluvium[c]
	In situ Volume (cy), Rounded			
2 Removal	250,000	370,000	310,000	430,000
2 Removal with CAD	250,000	370,000	310,000	430,000
3 Removal	390,000	590,000	490,000	770,000
3 Combined Technology	200,000	300,000	250,000	430,000
4 Removal	700,000	1,000,000	870,000	1,400,000
4 Combined Technology	370,000	560,000	470,000	730,000
5 Removal	1,100,000	1,600,000	1,300,000	2,200,000
5 Removal with treatment	1,100,000	1,600,000	1,300,000	2,200,000
5 Combined Technology	430,000	640,000	540,000	850,000
6 Removal	2,600,000	3,900,000	3,300 ,000	4,300,000
6 Combined Technology	1,000,000	1,500,000	1,200,000	1,700,000

Notes:

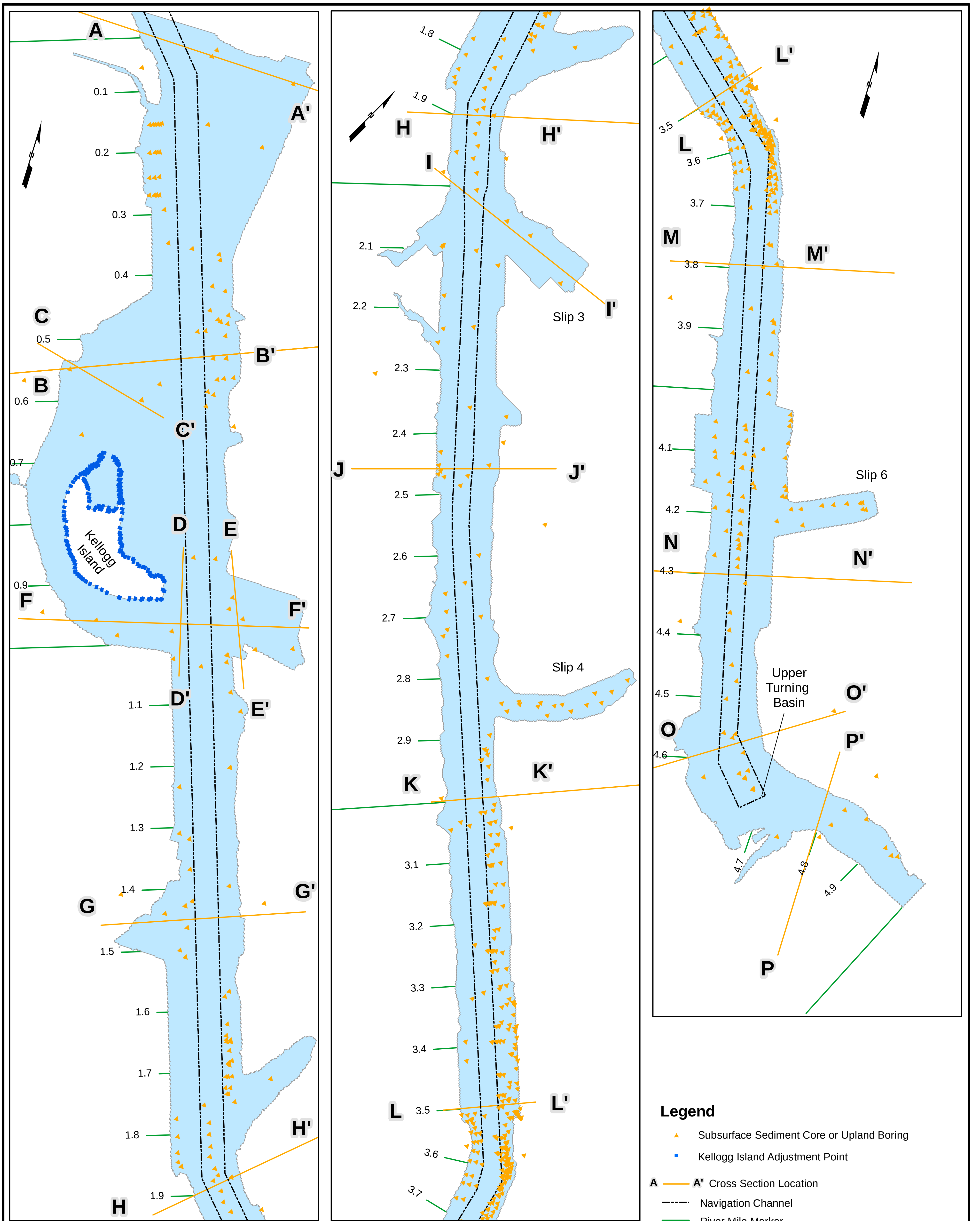
1. Volumes are shown rounded to two significant figures. Volumes are calculated prior to rounding; therefore, hand-calculated values may appear slightly different than those shown.

a. Neat-line volume to the lower limit of contamination (>SQS) is the *in situ* removal volume without incorporating side-slopes, box-cuts, overdredging, or contingencies. The neat-line volumes for Alternatives 2 through 5 are assumed to be to the maximum depth of SQS exceedances, and the neat-line volume for Alternative 6 is assumed to be to the maximum depth of Alternative 6 RALs, which is approximately the neat-line volume to the maximum depth of SQS exceedances +34%.

b. The additional allowance accounts for the method of dredge operation, allowable dredging overdepth, box cuts for slopes, and layback slopes for deeper excavations (Palermo 2009).

c. Neat-line volume to lower alluvium is assumed to be the maximum removal volume, including side-slopes, box-cuts, overdredging, and contingencies.

CAD = contained aquatic disposal; cy = cubic yards; RALs = remedial action level; SQS = sediment quality standard



Notes:
1. See Figures E-2 through E-17 for cross sections.
2. Kellogg Island adjustment points were used to constrain the contamination thickness and provide a more realistic interpolation near Kellogg Island.

Feet
0 200 400 800

L:\Lower Duwamish FS\IFS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix E\FigureE-1Transects.mxd

AECOM

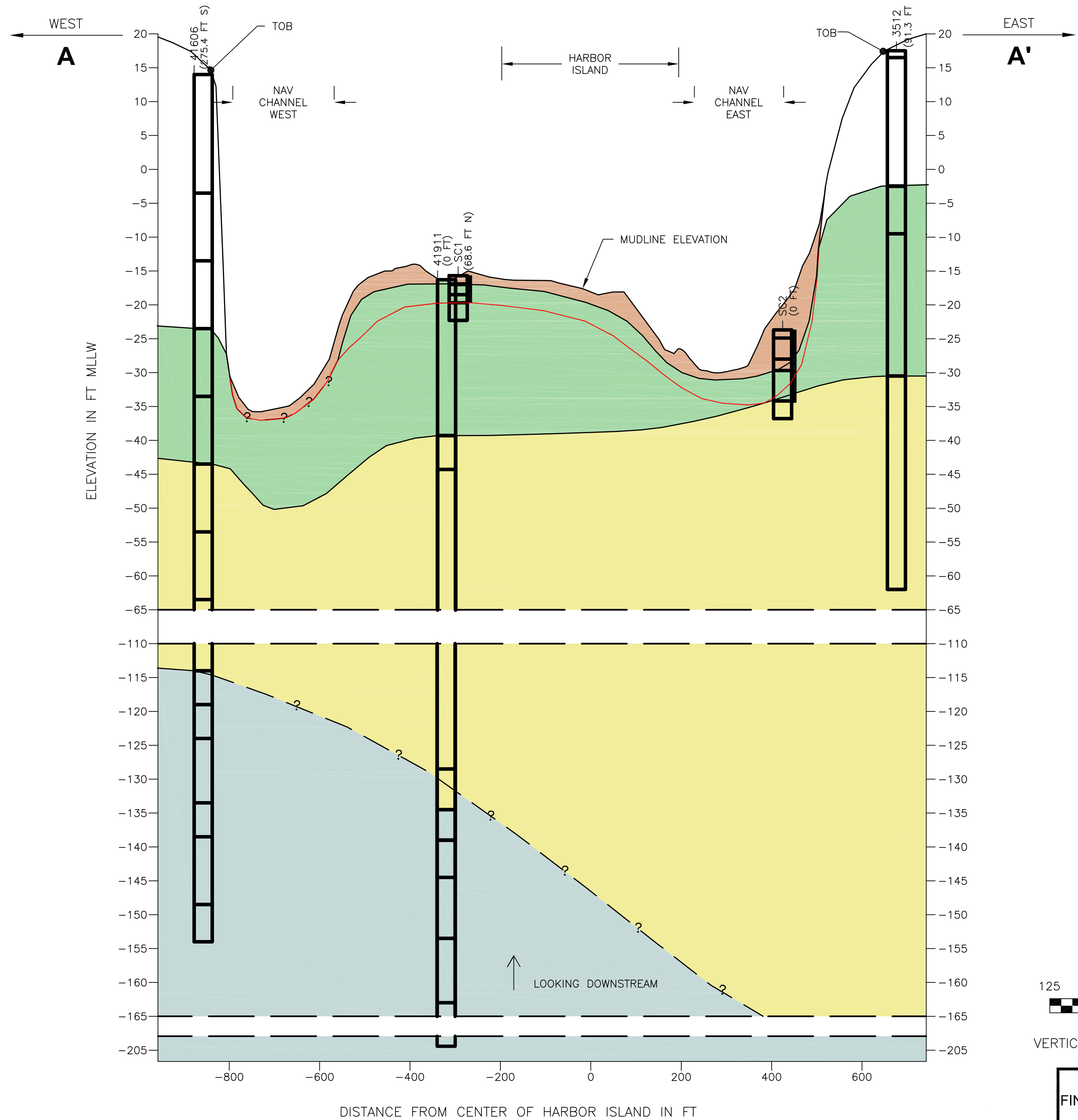
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

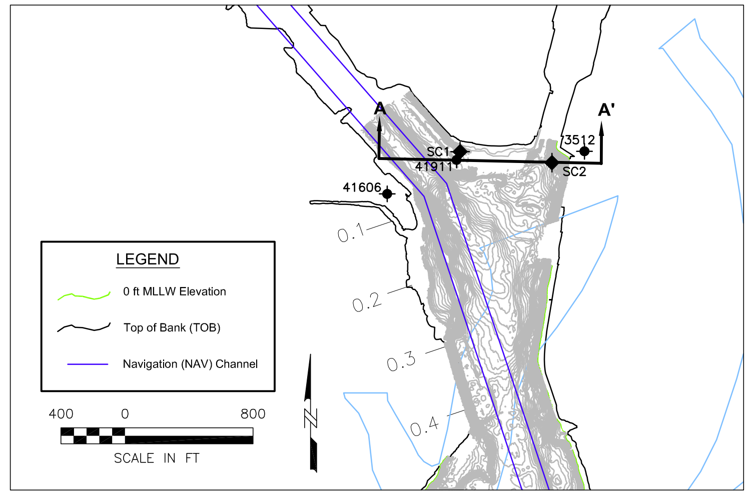
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Locations of Cross Sections and Cores Used to Estimate Sediment Volumes

FIGURE E-1





LEGEND

- 0 ft MLLW Elevation
- Top of Bank (TOB)
- Navigation (NAV) Channel

400 0 800
SCALE IN FT

STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT) — Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances. Where intervals immediately below intervals with SQS exceedances were not analyzed, the intervals not analyzed were assumed to also have SQS exceedances.
5. GeoMapNW core 41911 was assumed to start at mudline due to lack of elevation data.
6. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).
7. The core SC2 sample at 8-10 ft was analyzed after the RI dataset was finalized. Although the data for this sample are not in the RI dataset, they are used in this cross section.

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

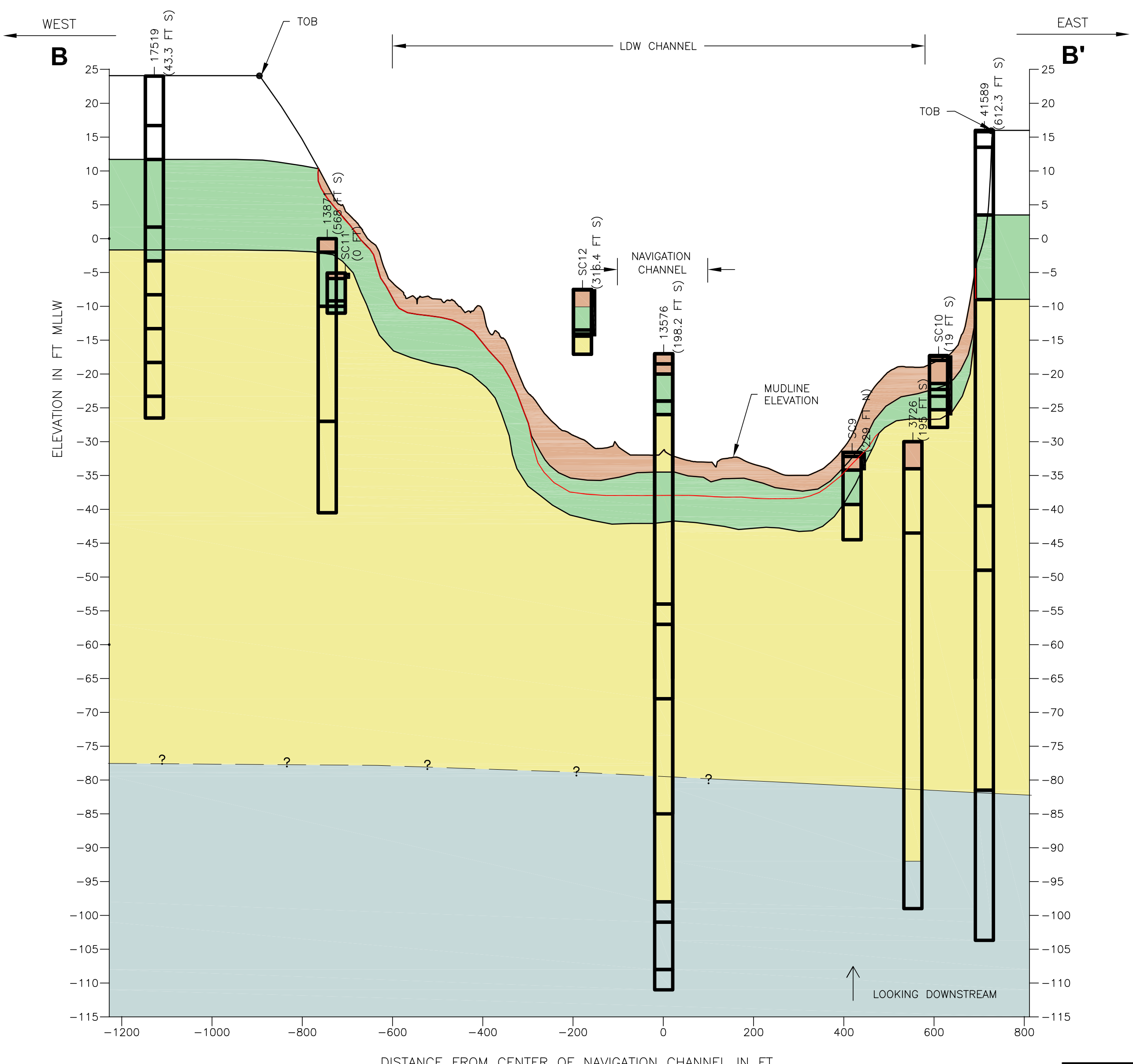
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

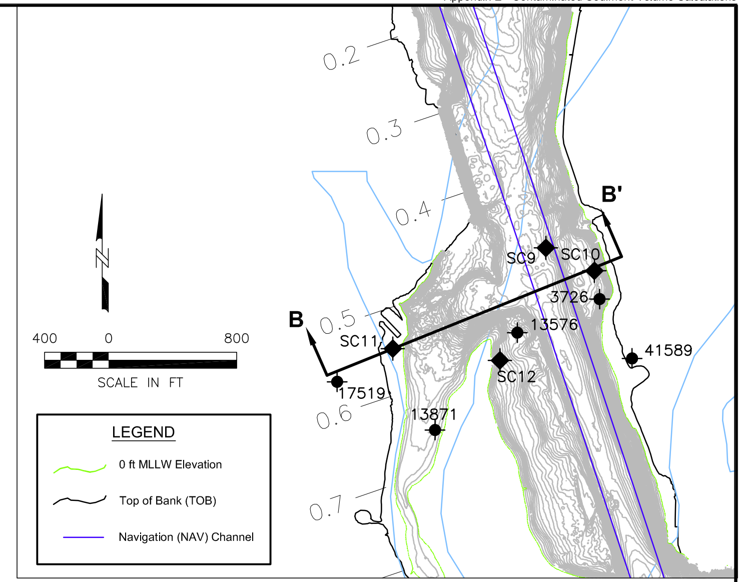
CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 0.0

DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

FIGURE E-2

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\rm0.0.dwg Layout: FIGURE E-2 User: oliveriam Plotted: Nov 06, 2012 - 11:27am Xref's:





LEGEND

- 0 ft MLLW Elevation
- Top of Bank (TOB)
- Navigation (NAV) Channel

STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

- SC19 (214 FT) – Core Name – (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

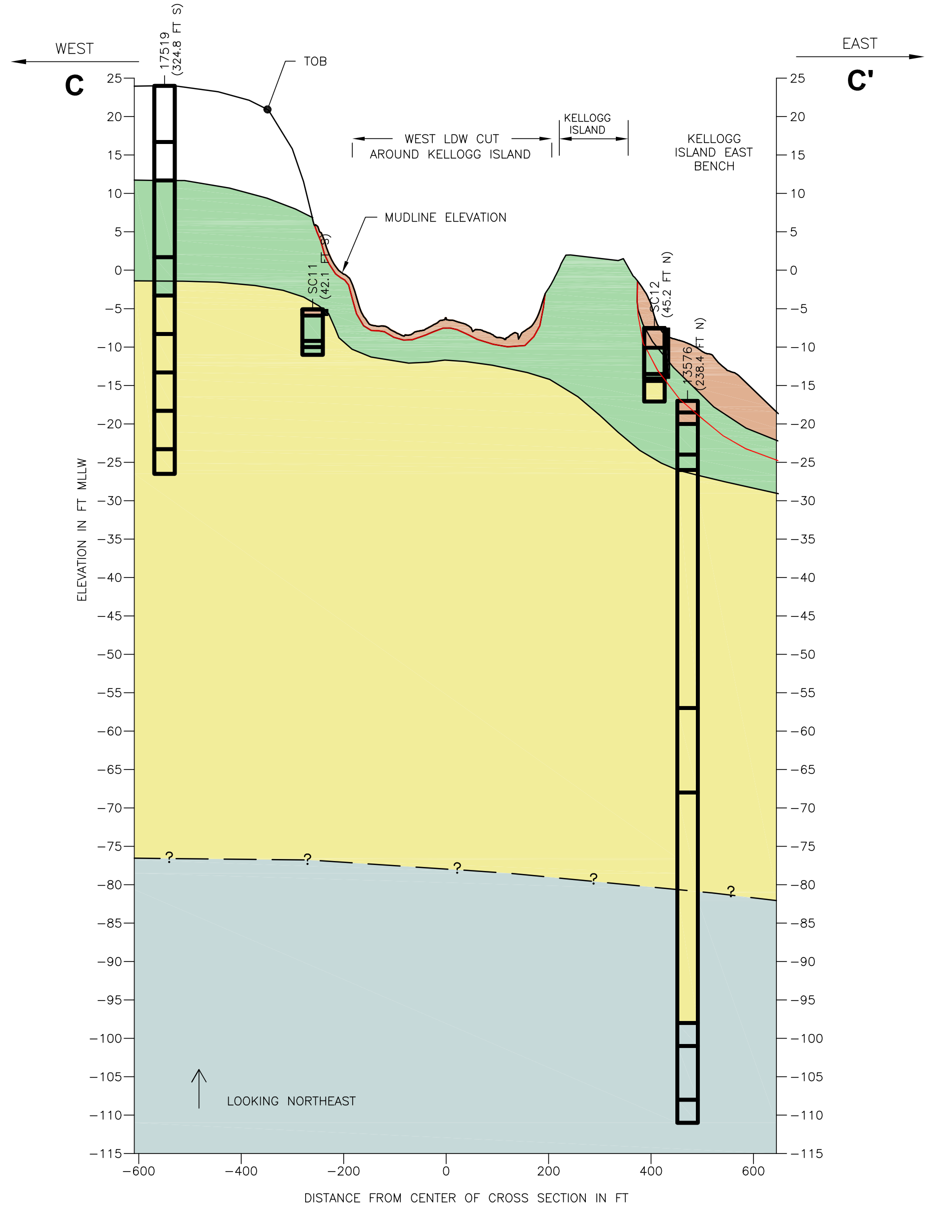
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

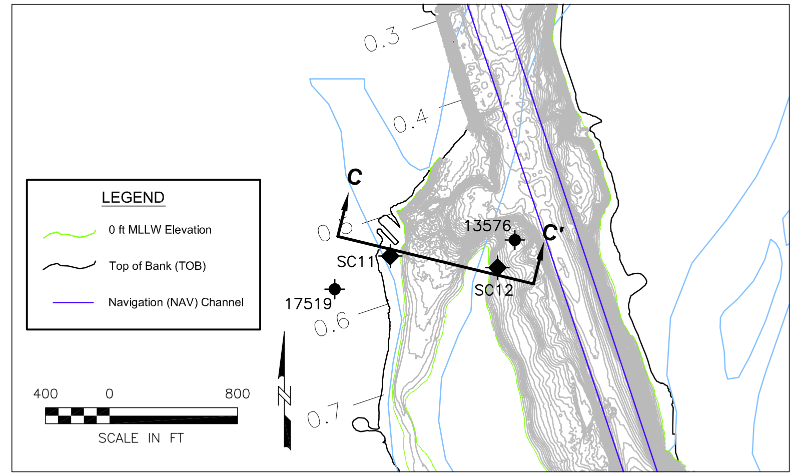
CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 0.5

DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

FIGURE E-3

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\rm0.5.dwg Layout: FIGURE E-3 User: oliveriam Plotted: Nov 06, 2012 – 11:57am Xref's:





LEGEND

- 0 ft MLLW Elevation
- Top of Bank (TOB)
- Navigation (NAV) Channel

400 0 800
SCALE IN FT

STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT)
- Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMap core
- RI/historical core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

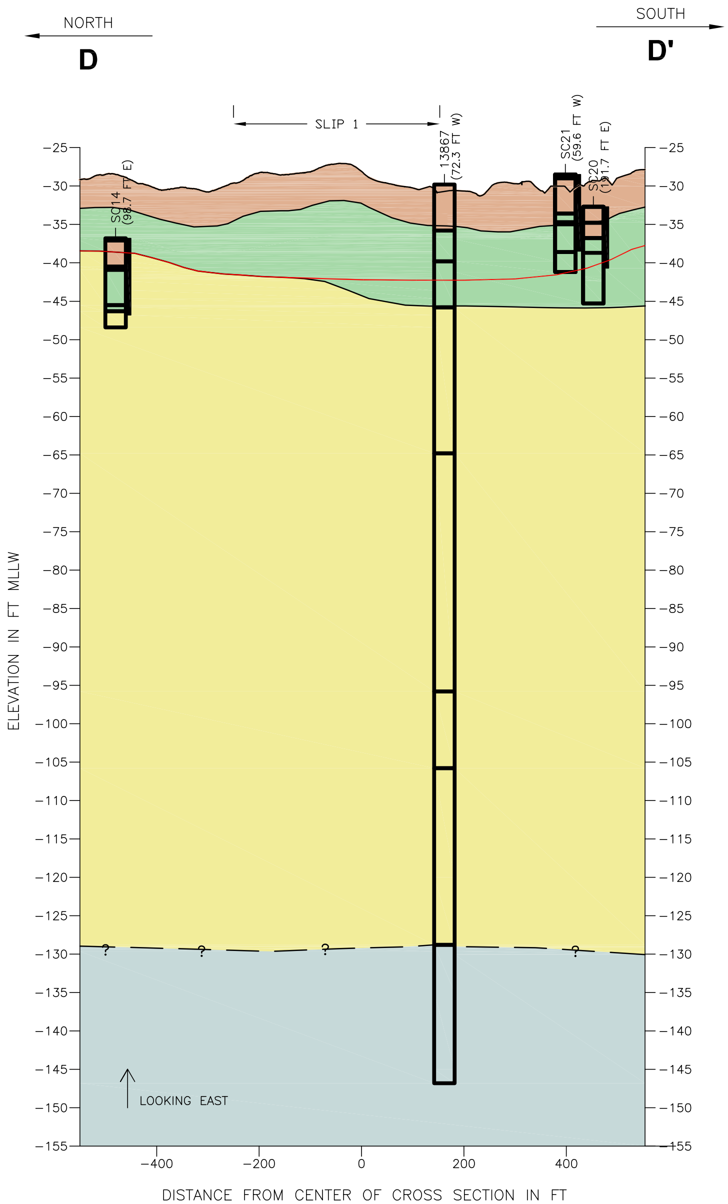
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

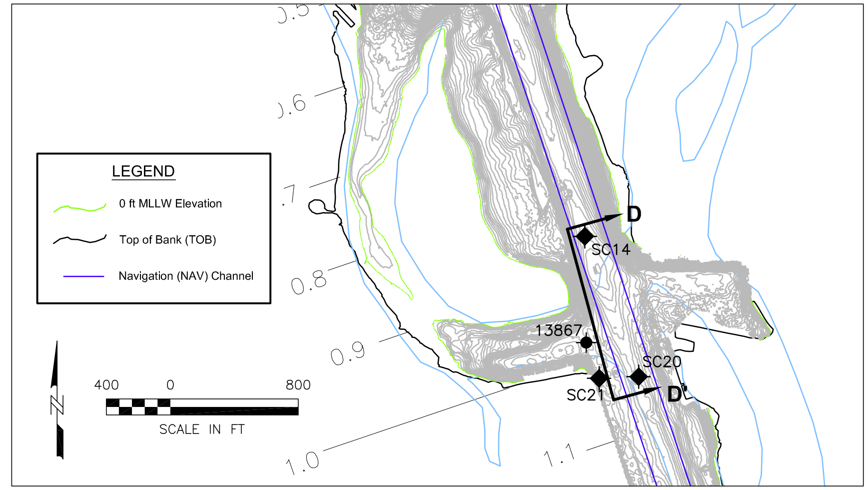
DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 0.5 TO 0.6

FIGURE E-4

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\rm0.5A.dwg Layout: FIGURE E-4 User: oliveriam Plotted: Nov 06, 2012 - 12:30pm Xref's:





LEGEND

- 0 ft MLLW Elevation
- Top of Bank (TOB)
- Navigation (NAV) Channel

STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

- SC19 (214 FT) — Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB — Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances. Where intervals immediately below intervals with SQS exceedances were not analyzed, the intervals not analyzed were assumed to also have SQS exceedances.
5. The core SC21 sample at 6.2-8 ft was analyzed after the RI dataset was finalized. Although the data for this sample are not in the RI dataset, they are used in this cross section.
6. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

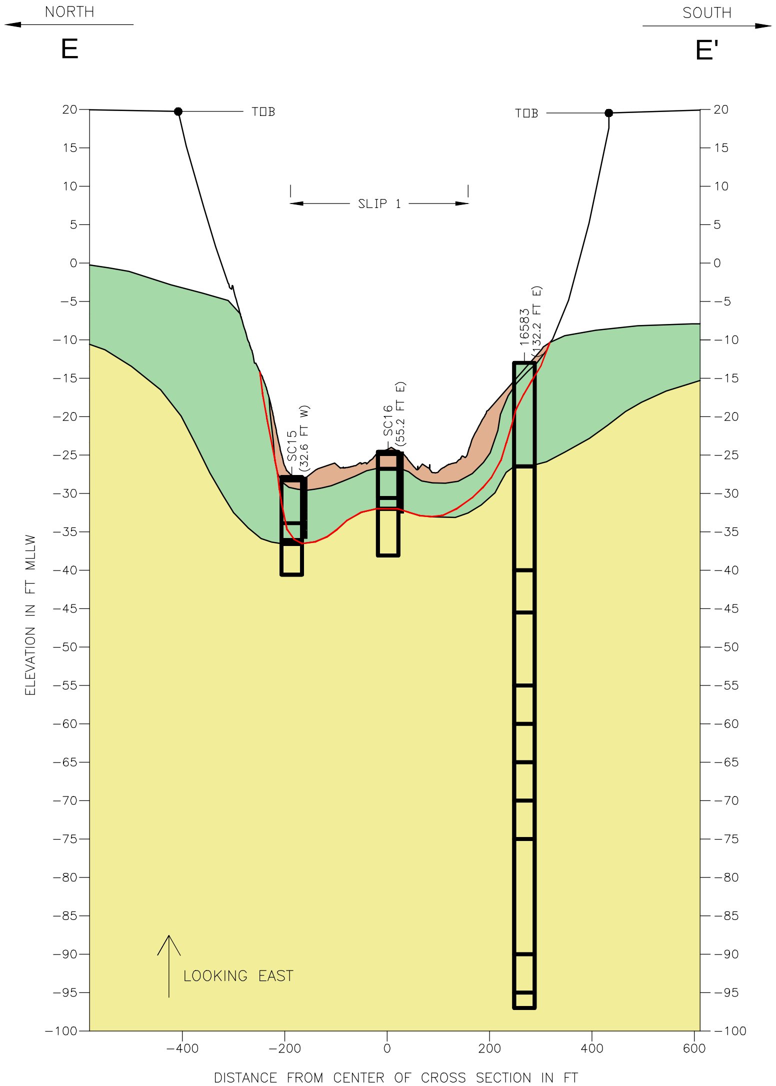
* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

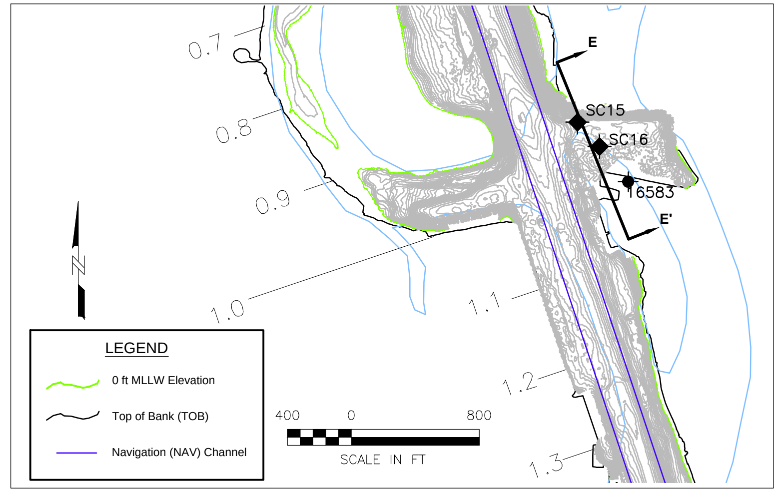
125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS 60150279-14.18	CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 1.0 WEST
DATE: 10/31/12 DRWN: E.M./SEA REV: 0	FIGURE E-5





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT) — Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances. Where intervals immediately below intervals with SQS exceedances were not analyzed, the intervals not analyzed were assumed to also have SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

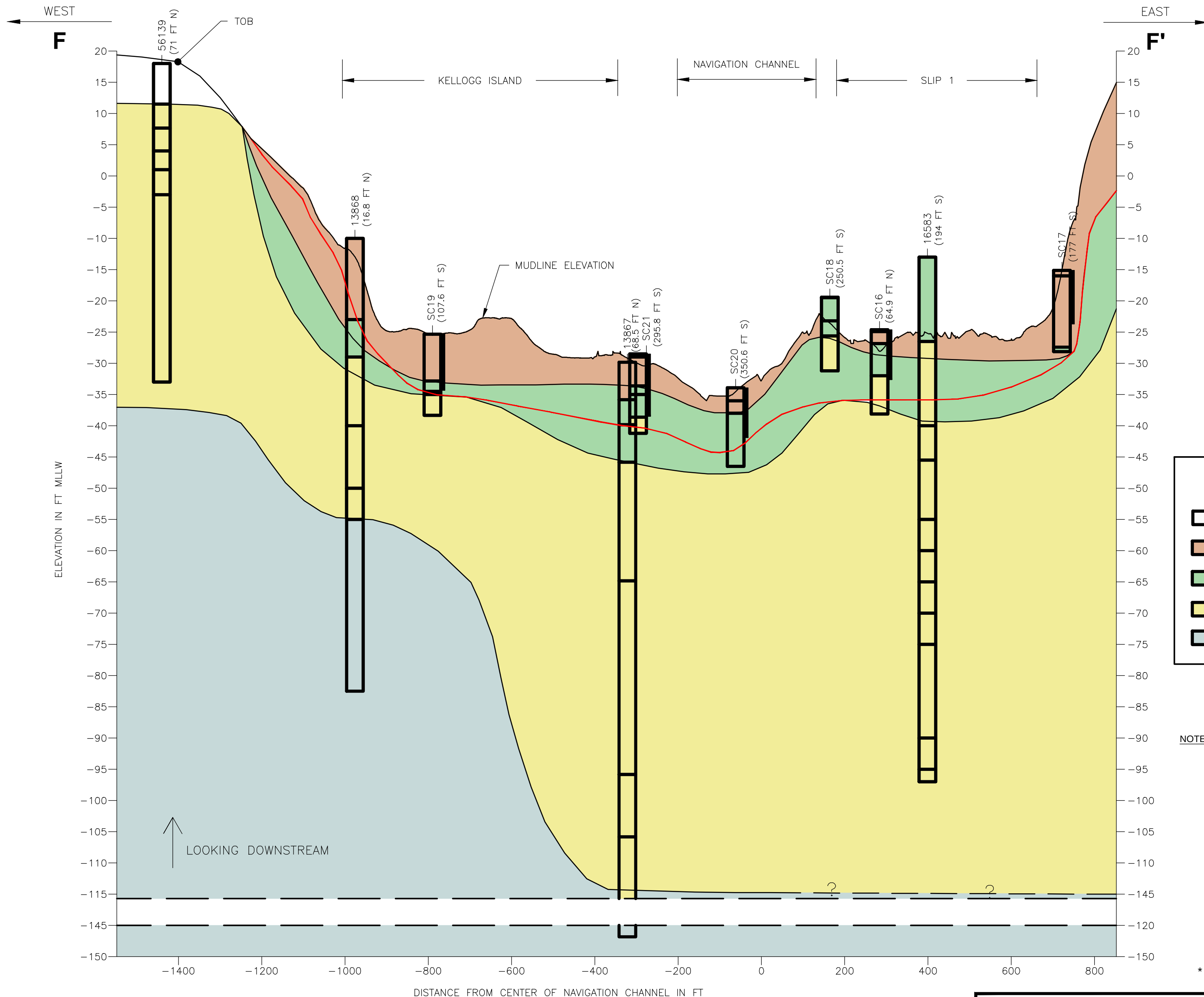
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

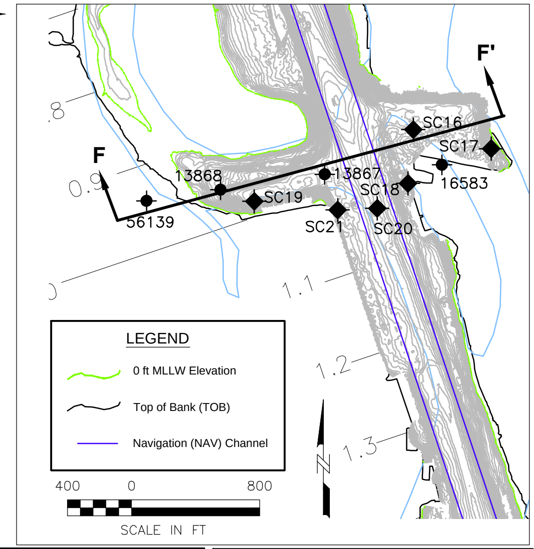
DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 1.0 EAST

FIGURE E-6

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\rm1.0_east.dwg Layout: FIGURE E-6 User: oliveriam Plotted: Nov 06, 2012 - 12:38pm Xref's:





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

- SC19 (214 FT) — Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- Radioisotope core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances. Where intervals immediately below intervals with SQS exceedances were not analyzed, the intervals not analyzed were assumed to also have SQS exceedances.
5. The core SC21 sample at 6.2-8 ft was analyzed after the RI dataset was finalized. Although the data for this sample are not in the RI dataset, they are used in this cross section.
6. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

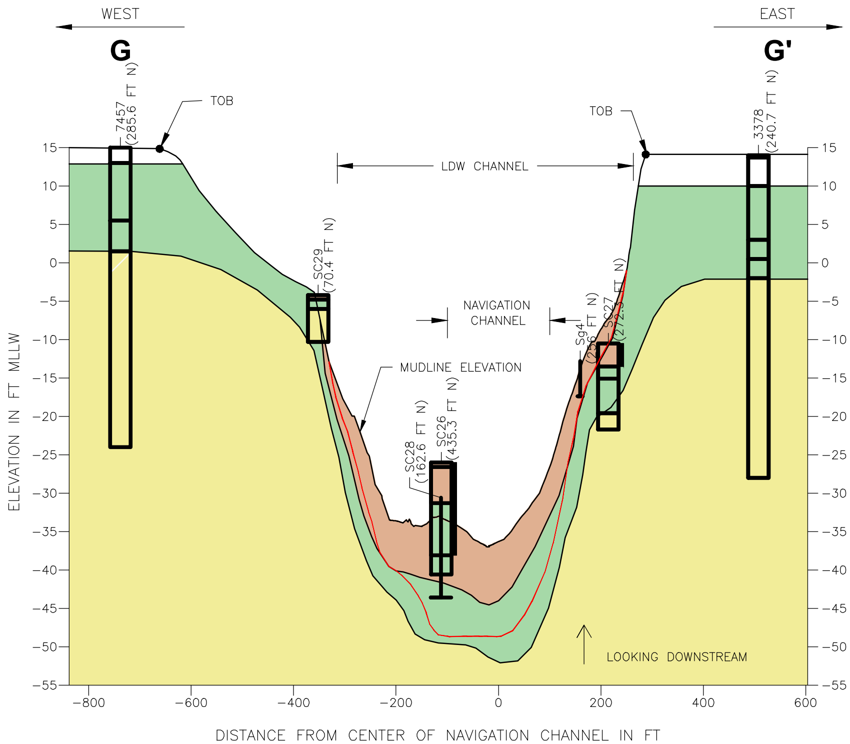
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

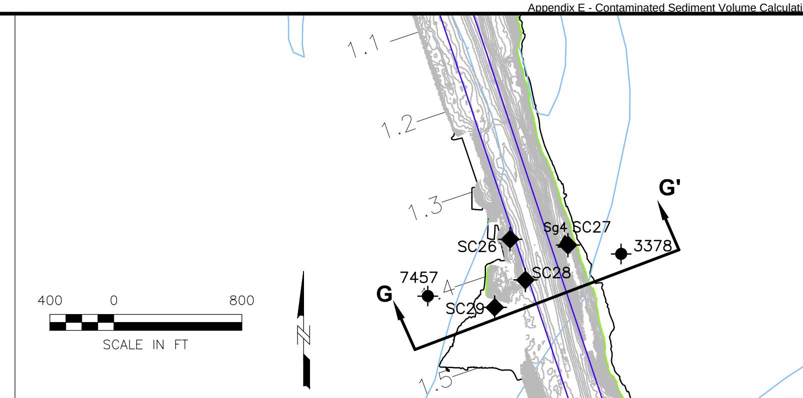
CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 1.0

DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

FIGURE E-7

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\rm1.0.dwg Layout: FIGURE E-7 User: oliveriam Plotted: Nov 06, 2012 - 12:40pm Xref's:





LEGEND

- 0 ft MLLW Elevation
- Top of Bank (TOB)
- Navigation (NAV) Channel

STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT)

- Core Name
- (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- Radioisotope core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances.
5. SC26 was chosen to be illustrated over SC28 because the core log for SC26 shows (at depth) the transition interface from recent sediment to the lower alluvium. SC28, at depth, does not indicate the interface between recent sediment and lower alluvium.
6. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250

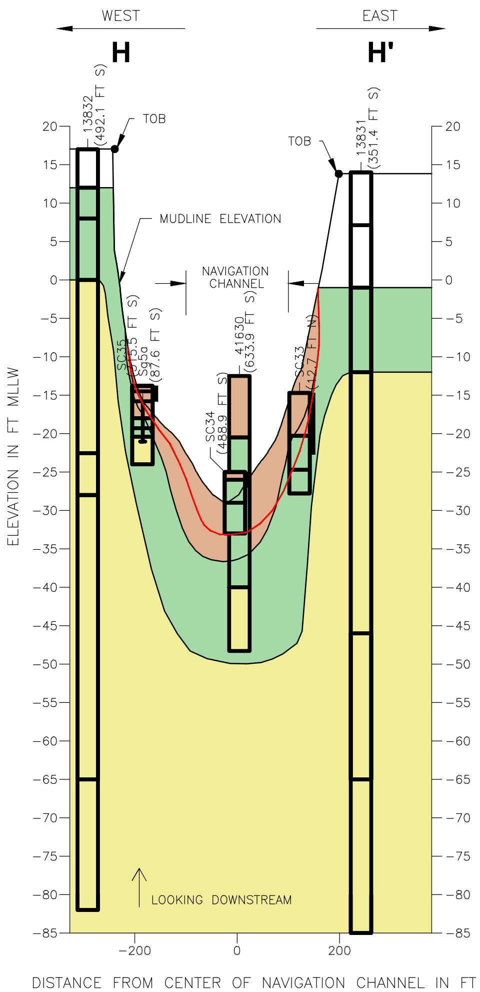
SCALE IN FT

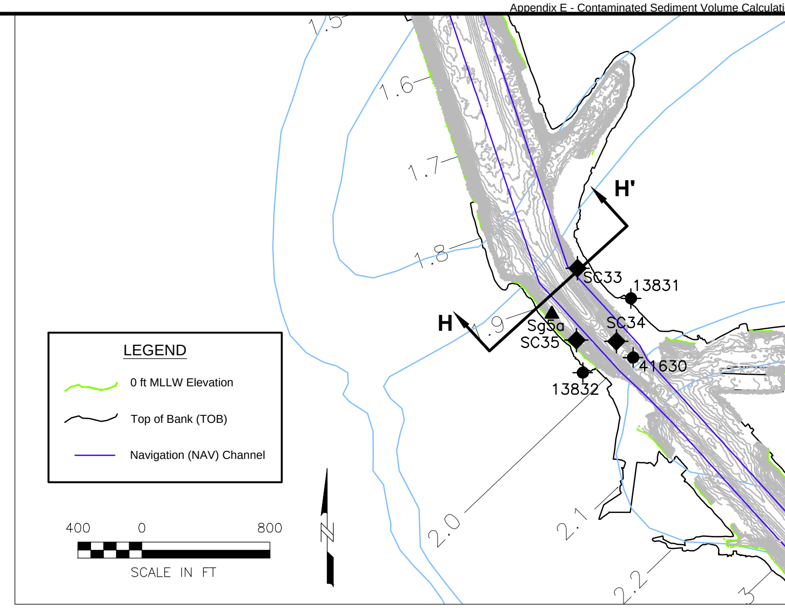
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS 60150279-14.18	**CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 1.45**
DATE: 10/31/12 DRWN: E.M./SEA REV: 0	**FIGURE E-8**





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT)
- Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- Radioisotope core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances. Where intervals immediately below intervals with SQS exceedances were not analyzed, the intervals not analyzed were assumed to also have SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

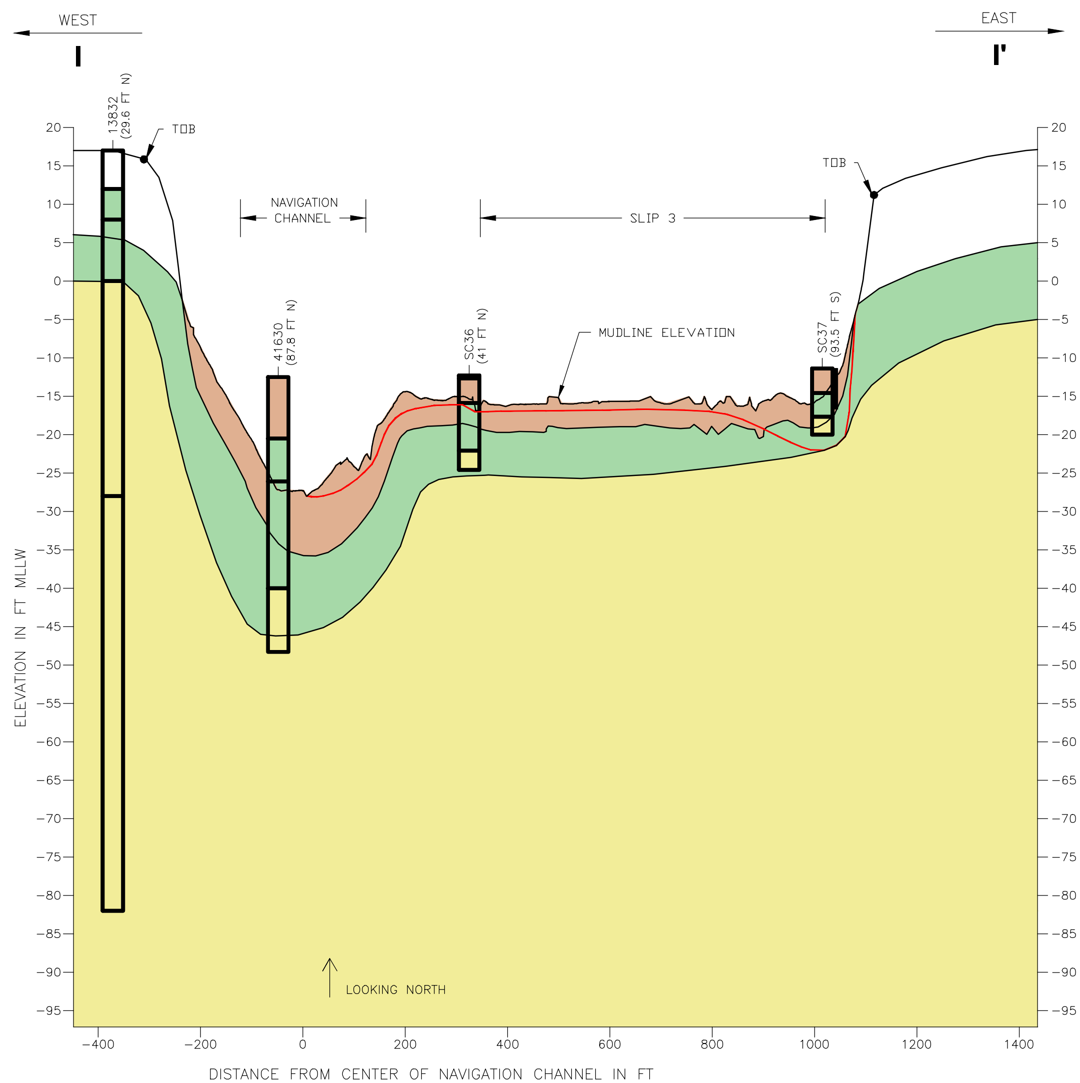
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

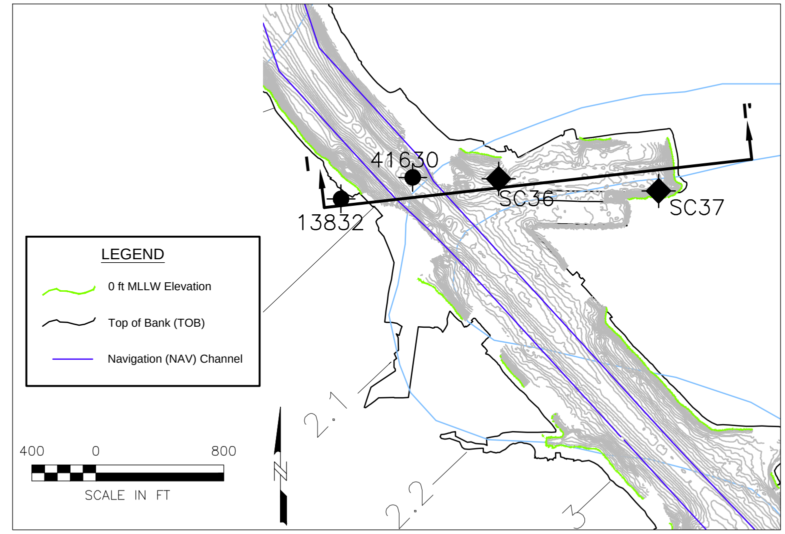
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 1.90

FIGURE E-9





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

- SC19 (214 FT) — Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances. Where intervals immediately below intervals with SQS exceedances were not analyzed, the intervals not analyzed were assumed to also have SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

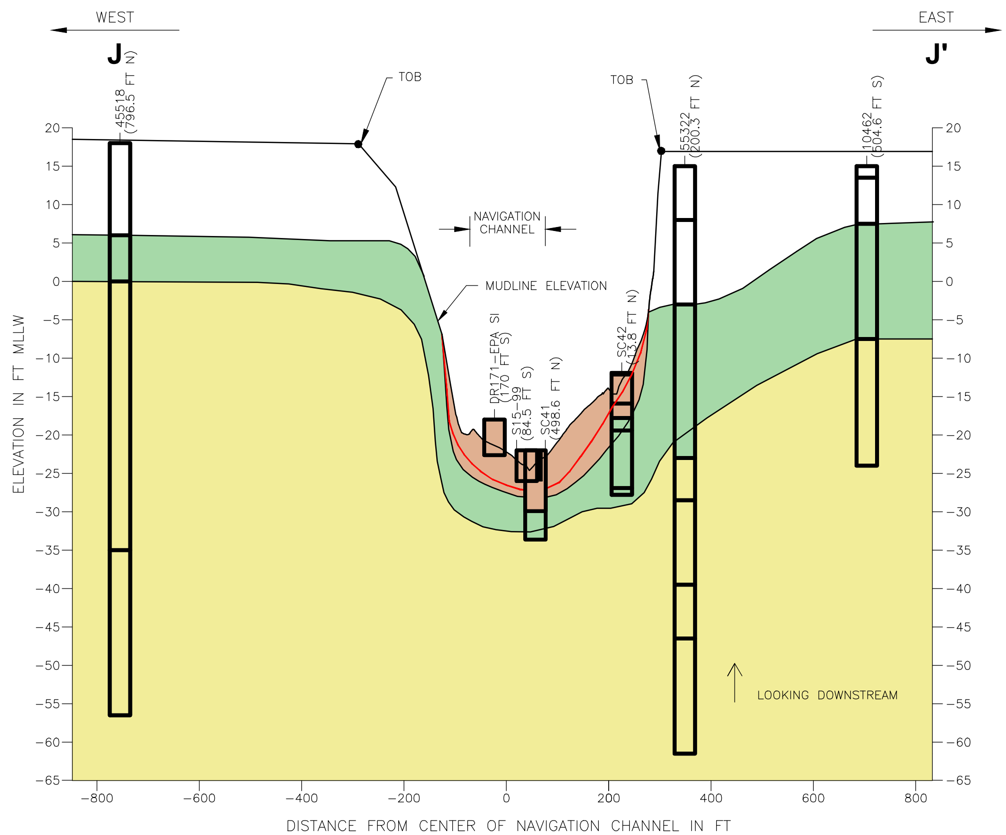
125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

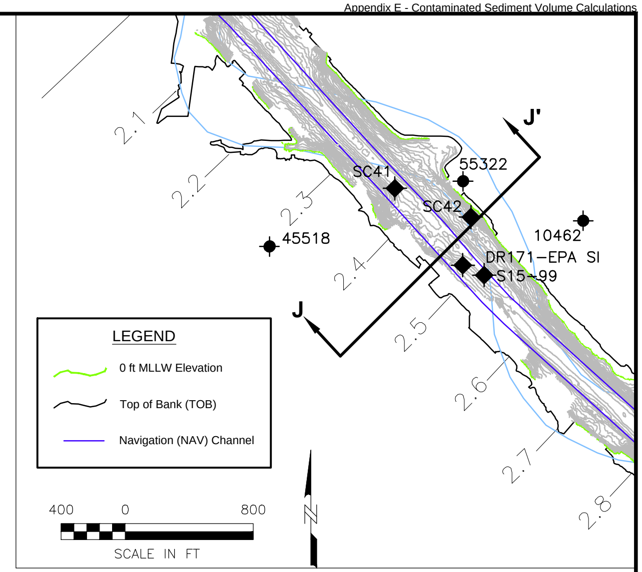
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\rm2.1.dwg Layout: FIGURE E-10 User: oliveriom Plotted: Nov 06, 2012 - 12:49pm Xref's:

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS 60150279-14.18			**CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 2.10**
DATE: 10/31/12	DRWN: E.M./SEA	REV: 0	**FIGURE E-10**





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT)
- Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

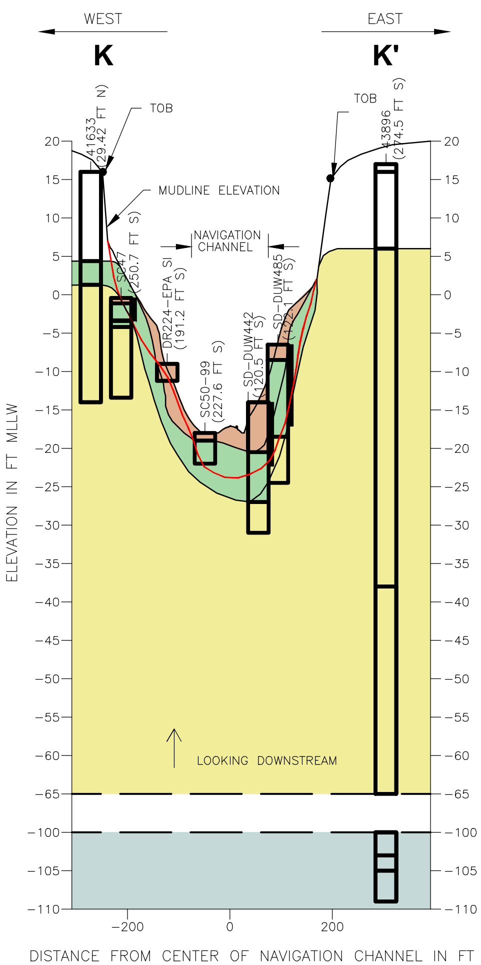
* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

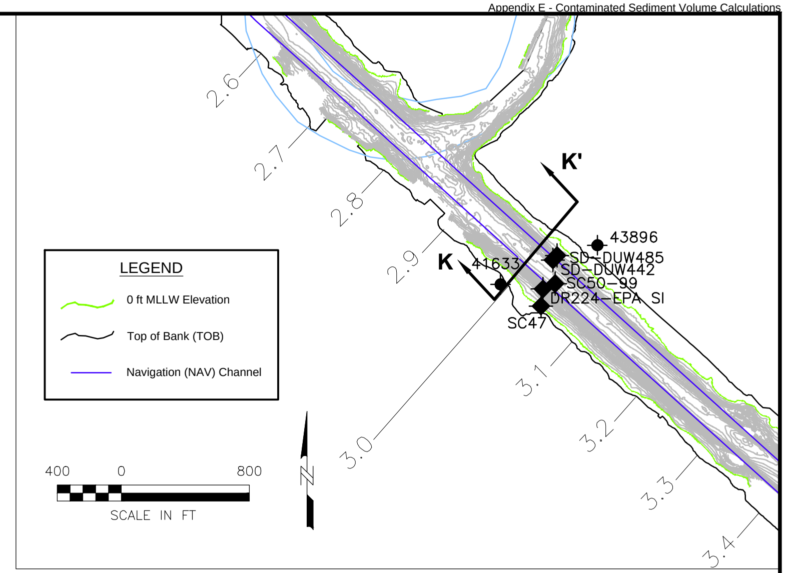
125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS 60150279-14.18	CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 2.45
DATE: 10/31/12 DRWN: E.M./SEA REV: 0	FIGURE E-11





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT) – Core Name (Dist. from cross section to core in ft)
– Top of Core
– Bottom of contamination, analyzed (>SQS)
– Bottom of Core
Bottom of contamination, interpolated (>SQS)
GeoMapNW core
RI/historical core
TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

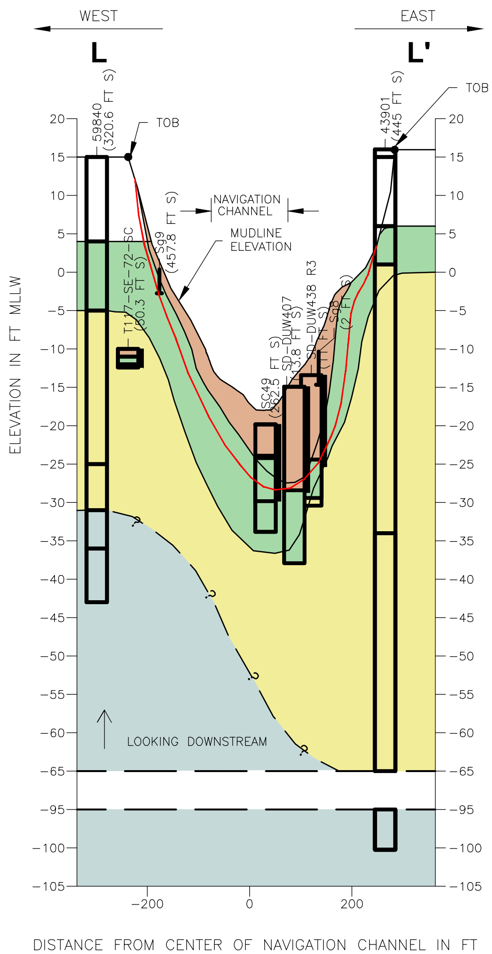
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

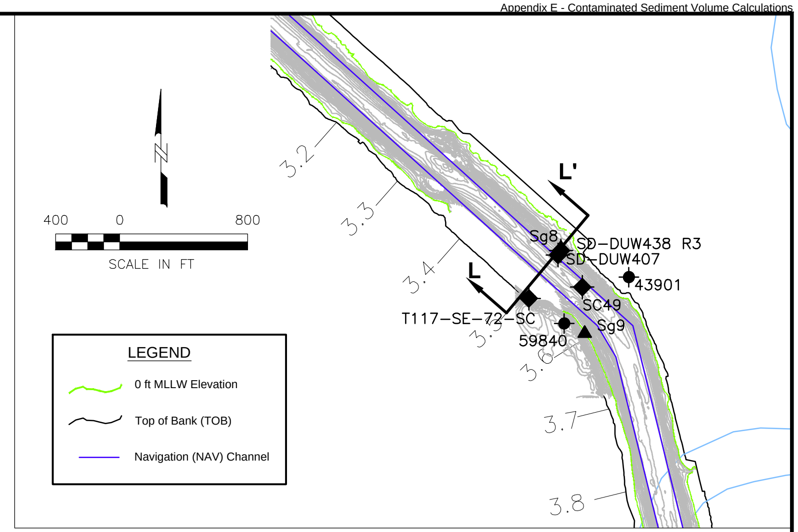
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 3.0

FIGURE E-12





LEGEND

- 0 ft MLLW Elevation
- Top of Bank (TOB)
- Navigation (NAV) Channel

STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

- SC19 (214 FT) — Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- Radioisotope core
- TOB — Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

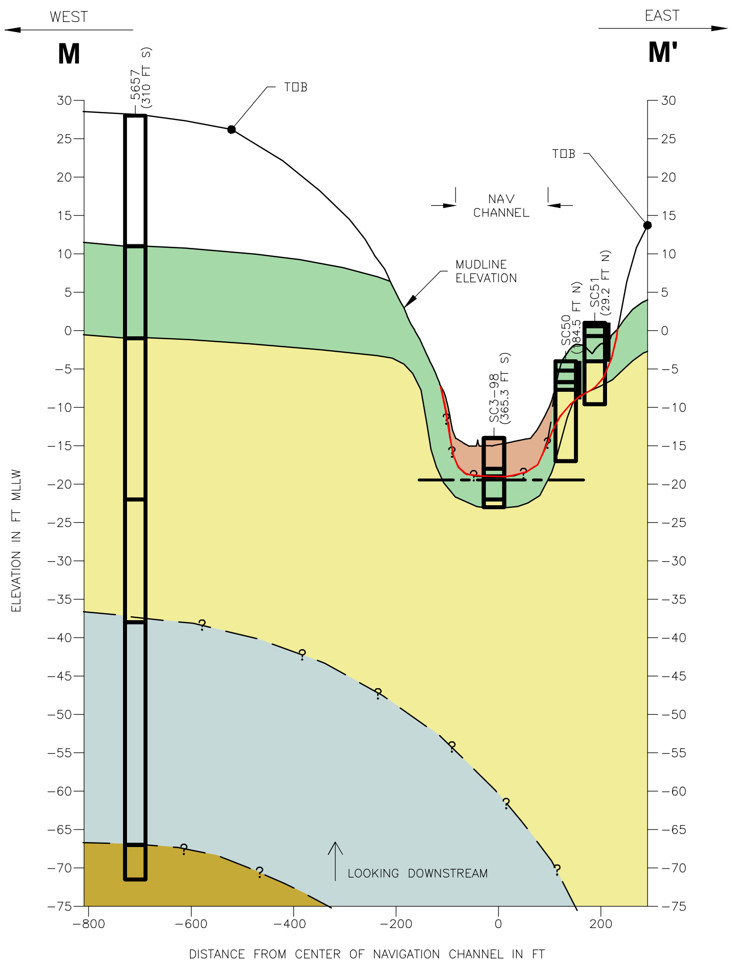
125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

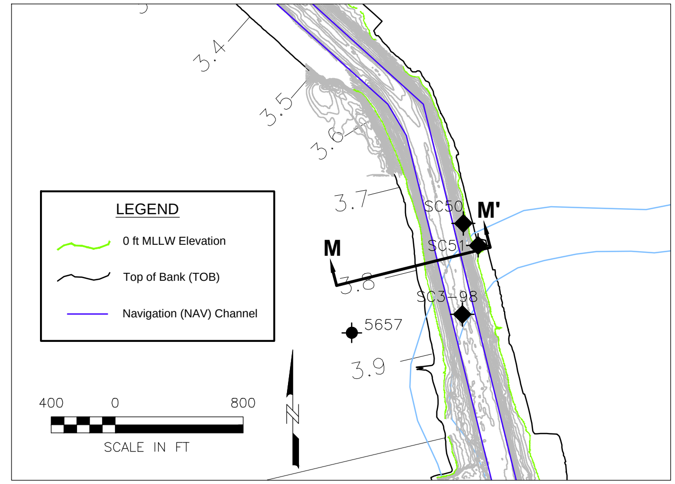
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS 60150279-14.18			CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 3.5
DATE: 10/31/12	DRWN: E.M./SEA	REV: 0	FIGURE E-13

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\July 2010 revisions\rm3.5.dwg Layout: FIGURE E-13 User: oliveriam Plotted: Nov 06, 2012 - 12:52pm Xref's:





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit
- Bedrock

KEY

SC19 (214 FT)
- Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Depth of 1999 dredge event to -15/-16 ft + 2 ft overdredge
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. Contamination layer = mudline to maximum depth of detected SQS exceedances.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

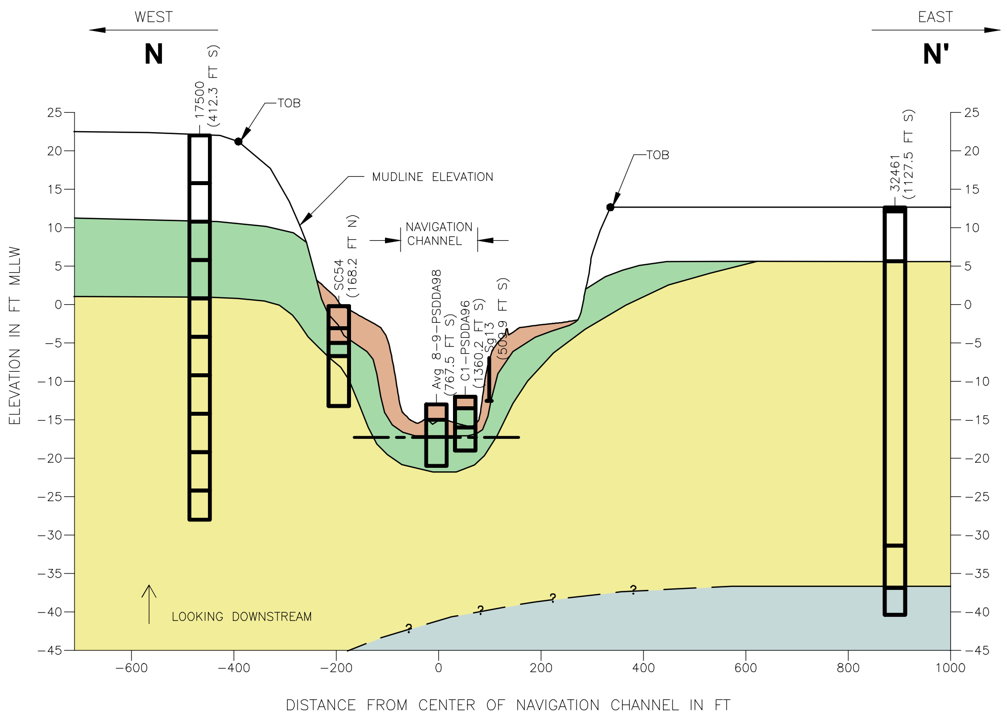
* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

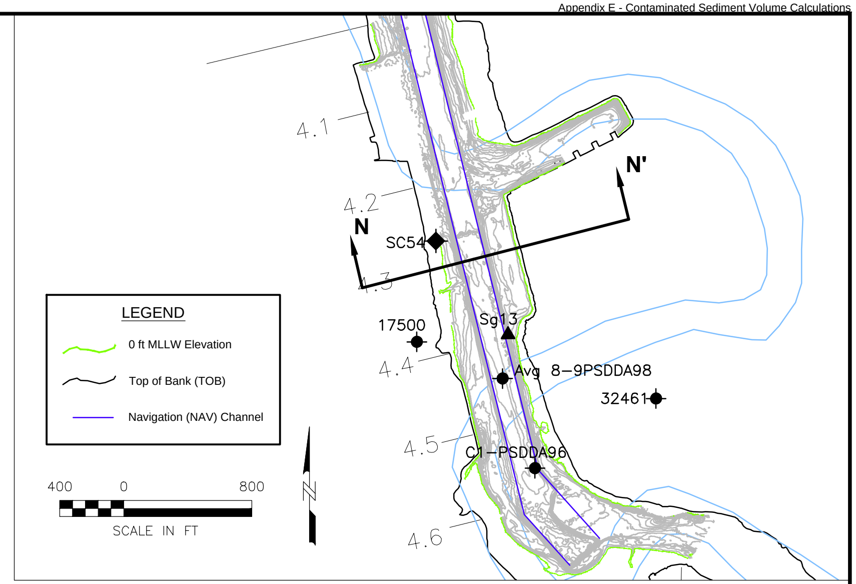
125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS 60150279-14.18	**CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 3.8**
DATE: 10/31/12 DRWN: E.M./SEA REV: 0	**FIGURE E-14**





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

- SC19 (214 FT) — Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Depth of 12/07-1/08 dredge event to -15/-16 ft + 2 ft overdredge
- GeoMapNW core
- RI/historical core
- Radioisotope core
- TOB — Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. No contamination > SQS for the in-water cores.
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

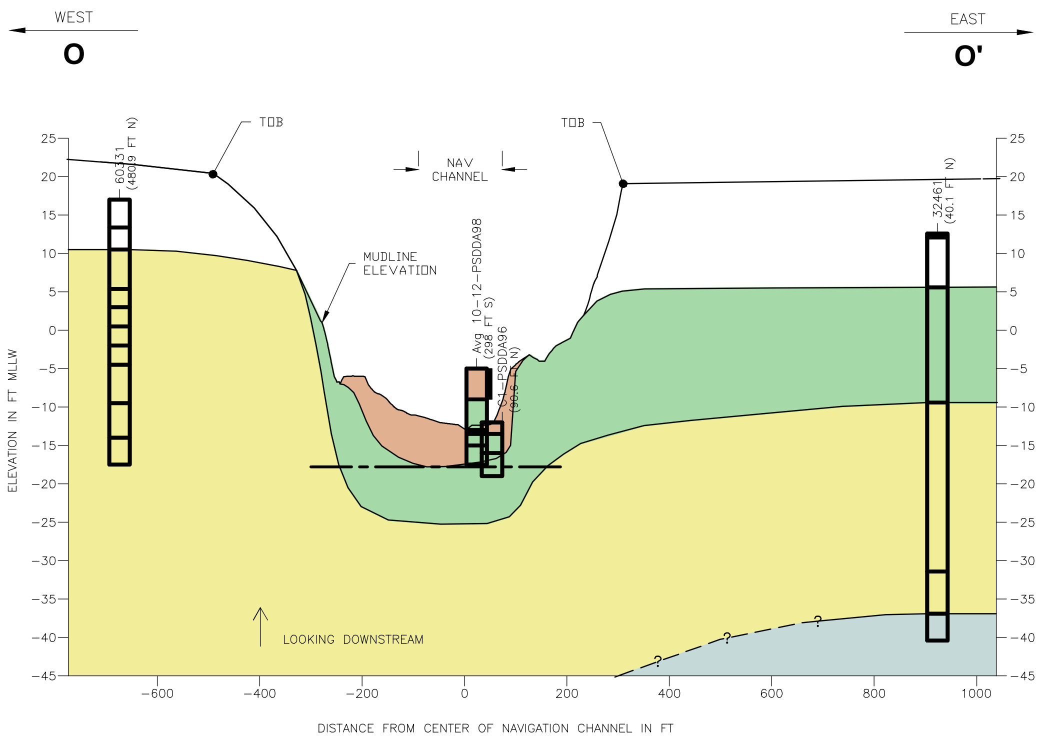
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

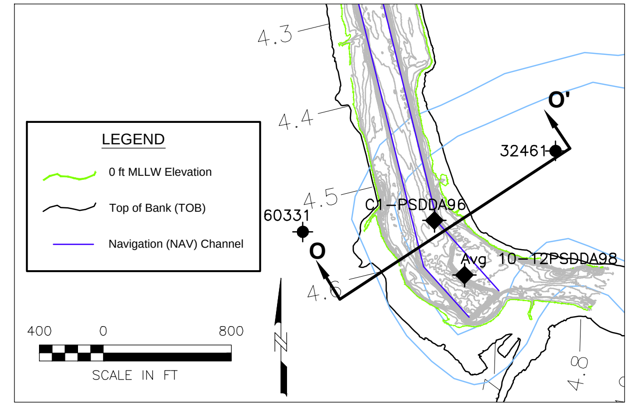
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 4.3

FIGURE E-15





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

SC19 (214 FT)
- Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Depth of 12/07-1/08 dredge event to -15/-16 ft + 2 ft overdredge
- GeoMapNW core
- RI/historical core

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. No interpolated contamination on cross section because of recent dredge event (12/07 - 1/08)
5. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

125 0 250
SCALE IN FT
VERTICAL EXAGGERATION = 15:1

AECOM

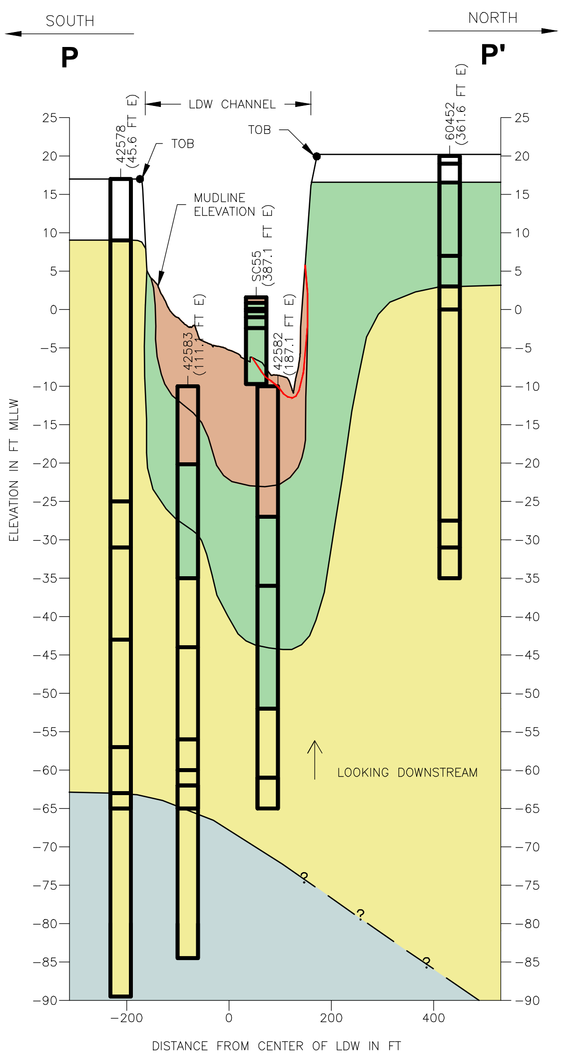
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

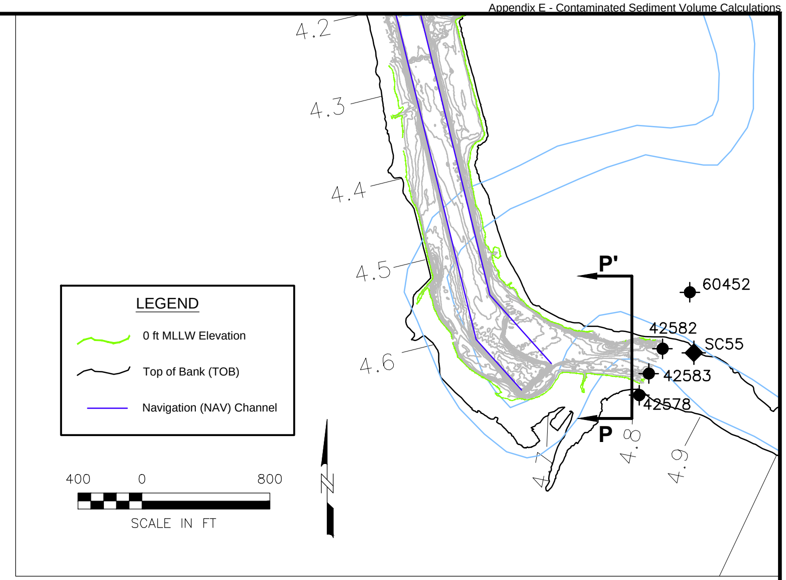
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 4.6

DATE: 10/31/12	DRWN: E.M./SEA	REV: 0	**FIGURE E-16**

File: G:\PROJECTS\CADD\Lower Duwamish\2009 FS Cross Sections\rm4.6.dwg Layout: FIGURE E-16 User: oliveriom Plotted: Nov 06, 2012 - 12:57pm Xref's:





STRATIGRAPHY*

- Upland Fill
- Recent Sediment
- Upper Alluvium/Transition
- Lower Alluvium
- Dense Post-Glacial and Glacial Unit

KEY

- SC19 (214 FT) – Core Name (Dist. from cross section to core in ft)
- Top of Core
- Bottom of contamination, analyzed (>SQS)
- Bottom of Core
- Bottom of contamination, interpolated (>SQS)
- GeoMapNW core
- RI/historical core
- TOB – Top of Bank

NOTES

1. GeoMapNW core stratigraphy presented in recovered depths. RI chemical data and stratigraphy presented in *in situ* depths. Historical core chemical data and stratigraphy presented in *in situ* depths where percent recovery available; otherwise presented in recovered depths. Actual contacts may vary.
2. GeoMapNW cores from Pacific Northwest Center for Geologic Mapping Studies. http://geomapnw.ess.Washington.edu/index.php
3. Top of bank is estimated based on elevation of upland cores.
4. No contamination > SQS for the in-water cores.
5. Surficial contamination confirmed to 1 ft below mudline on east bench.
6. Mudline elevation source based on bathymetric survey by David Evans & Associates, Inc. (Windward & DEA 2004).

* Stratigraphy terminology is used in subsurface data report (Windward Environmental, LLC and RETEC 2007) and sediment transport analysis report (Windward Environmental, LLC and QEA 2008).

AECOM

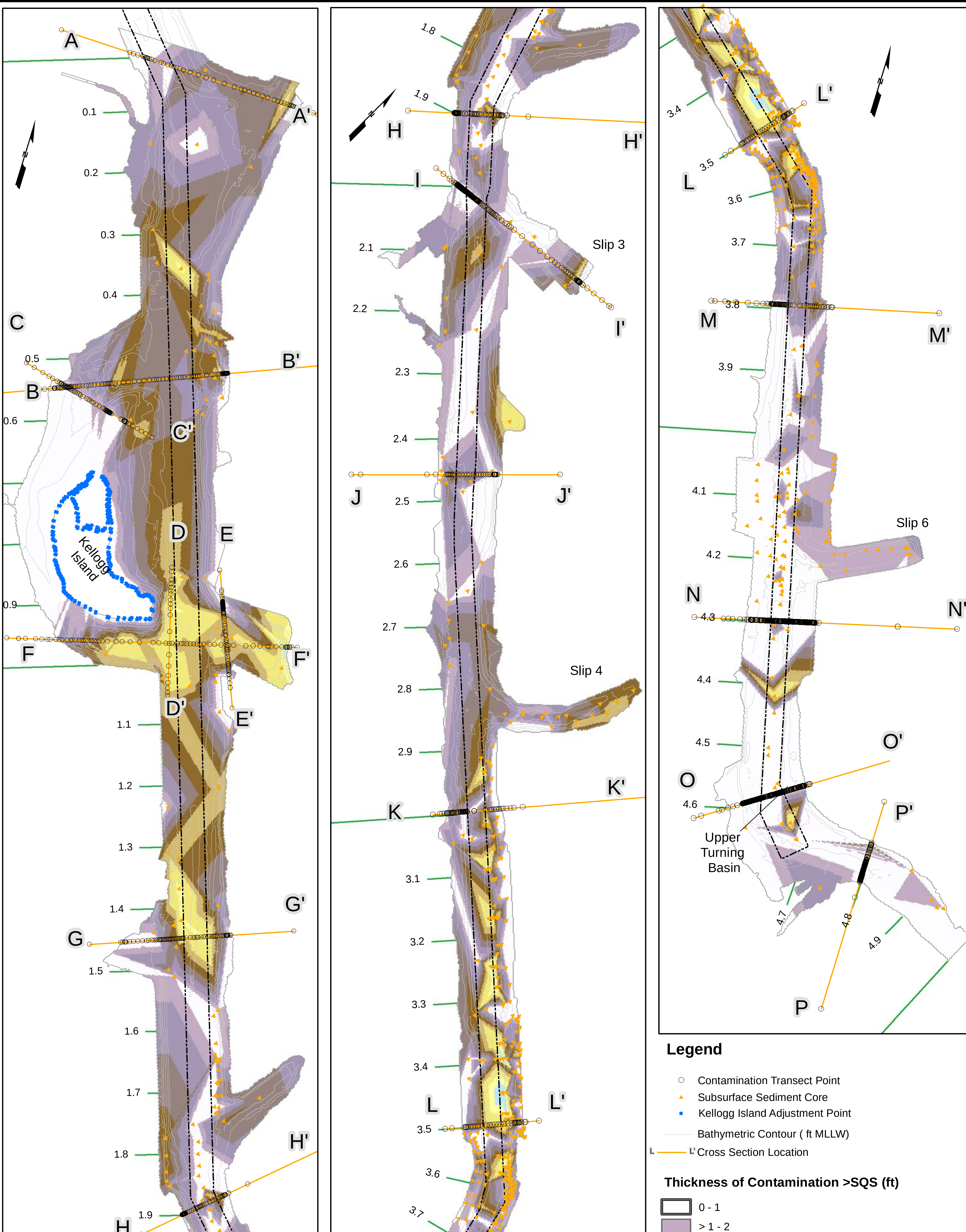
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY - VOLUME CALCULATIONS
60150279-14.18

DATE: 10/31/12 | DRWN: E.M./SEA | REV: 0

CROSS SECTION OF DEPTH OF CONTAMINATION AND LOWER ALLUVIUM RIVER MILE 4.8

FIGURE E-17



Legend

- Contamination Transect Point
- Subsurface Sediment Core
- Kellogg Island Adjustment Point
- Bathymetric Contour (ft MLLW)
- L L' Cross Section Location

Thickness of Contamination >SQS (ft)

- 0 - 1
- > 1 - 2
- > 2 - 4
- > 4 - 6
- > 6 - 8
- > 8 - 10
- > 10 - 14
- > 14 - 18
- > 18 - 23

- Navigation Channel
- River Mile Marker

Notes:
1. The elevations from the transect points and the elevations from the cores and borings were subtracted from the mudline elevations from the cross sections or cores, respectively. These thickness data were interpolated to generate a thickness TIN.
2. The resulting TIN was converted to a grid to provide seamless coverage for the study area.
3. For grid cells within the RAL exceedance area, a minimum 1-ft thickness was assigned.
4. To display interpolated elevation data, the thickness grid was subtracted from the bathymetry grid. The bathymetry grid is a combination of the 2003 David Evans bathymetry (Windward and DEA 2004) and the mudline elevations of the cores.
5. There are no upland borings on this figure because the upland borings did not include chemistry data.
6. Transect points on this figure represent vertices along the interpolated contamination lines from the CAD generated cross sections. They are not the same points as those on Figure E-19.
7. CAD = computer-aided design, RAL = remedial action level, TIN = triangulated irregular network.

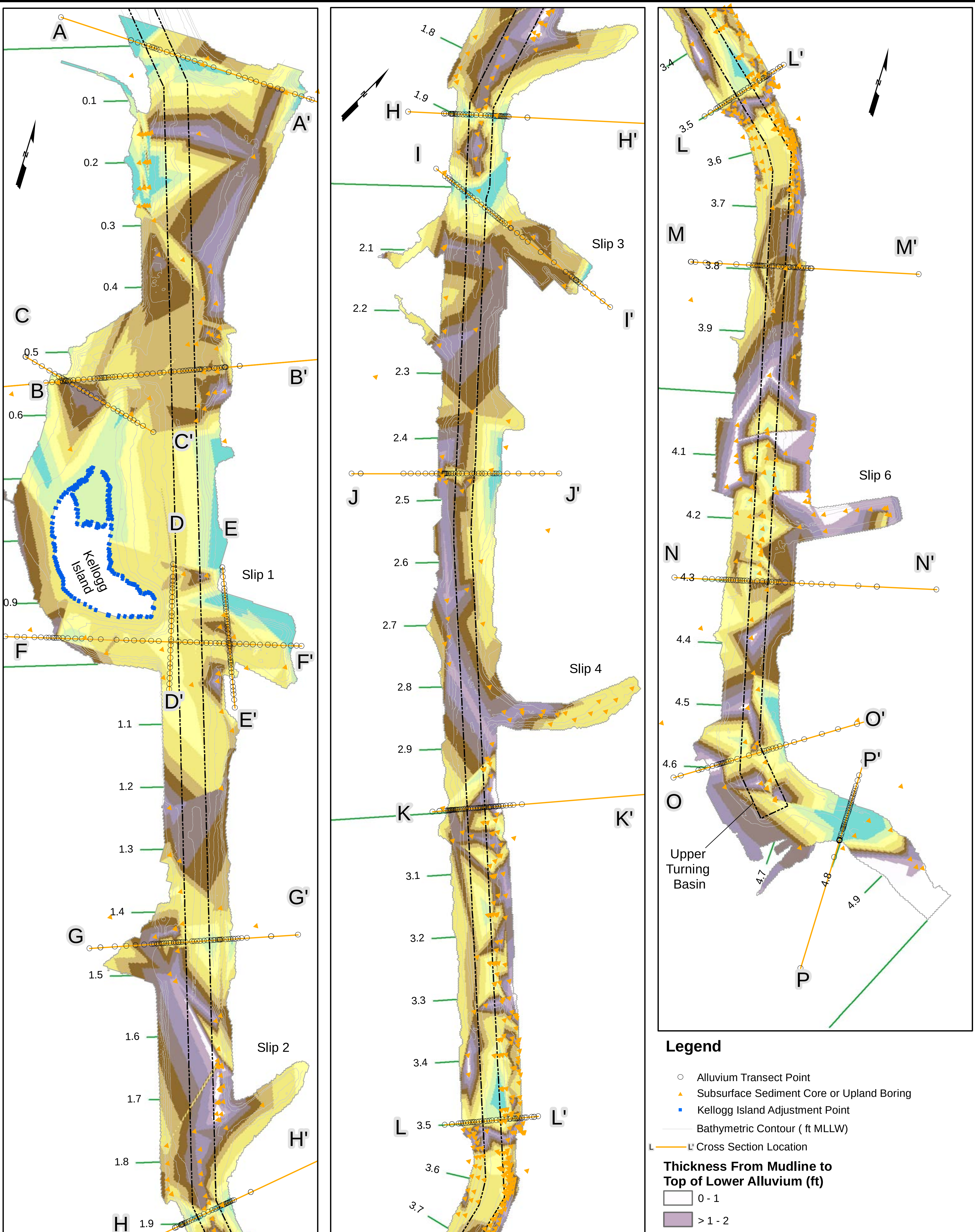
Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct12\FS_GIS_MXDs_Oct12\Appendix E\FigureE-18ContamThick.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Interpolated Thickness of Contaminated Sediment Layer from Mudline to Maximum Depth of SQS Exceedances
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE E-18



Legend

- Alluvium Transect Point
- Subsurface Sediment Core or Upland Boring
- Kellogg Island Adjustment Point
- Bathymetric Contour (ft MLLW)
- L — L' Cross Section Location

Thickness From Mudline to Top of Lower Alluvium (ft)

- 0 - 1
- > 1 - 2
- > 2 - 4
- > 4 - 6
- > 6 - 8
- > 8 - 10
- > 10 - 14
- > 14 - 18
- > 18 - 22
- > 22 - 23

- Navigation Channel
- River Mile Marker

Notes:
1. The elevations from the transect points and the elevations from the cores and borings were subtracted from the mudline elevations from the cross sections or cores, respectively. These thickness data were interpolated to generate a thickness TIN.
2. The resulting TIN was converted to a grid to provide seamless coverage for the study area.
3. For grid cells with thickness from mudline to top of lower alluvium greater than 27 ft, the maximum thickness was set to 27 ft.
4. To display interpolated elevation data, the thickness from mudline to top of lower alluvium grid was subtracted from the bathymetry grid. The bathymetry grid is a combination of the 2003 David Evans bathymetry (Windward and DEA 2004) and the mudline elevations of the cores.
5. Transect points on this figure represent verticies along the interpolated lower alluvium lines from the CAD generated cross sections. They are not the same points as those on Figure E-18.
6. CAD = computer-aided design, TIN = triangulated irregular network.

Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix E\FigureE-19AlluvThick.mxd

AECOM

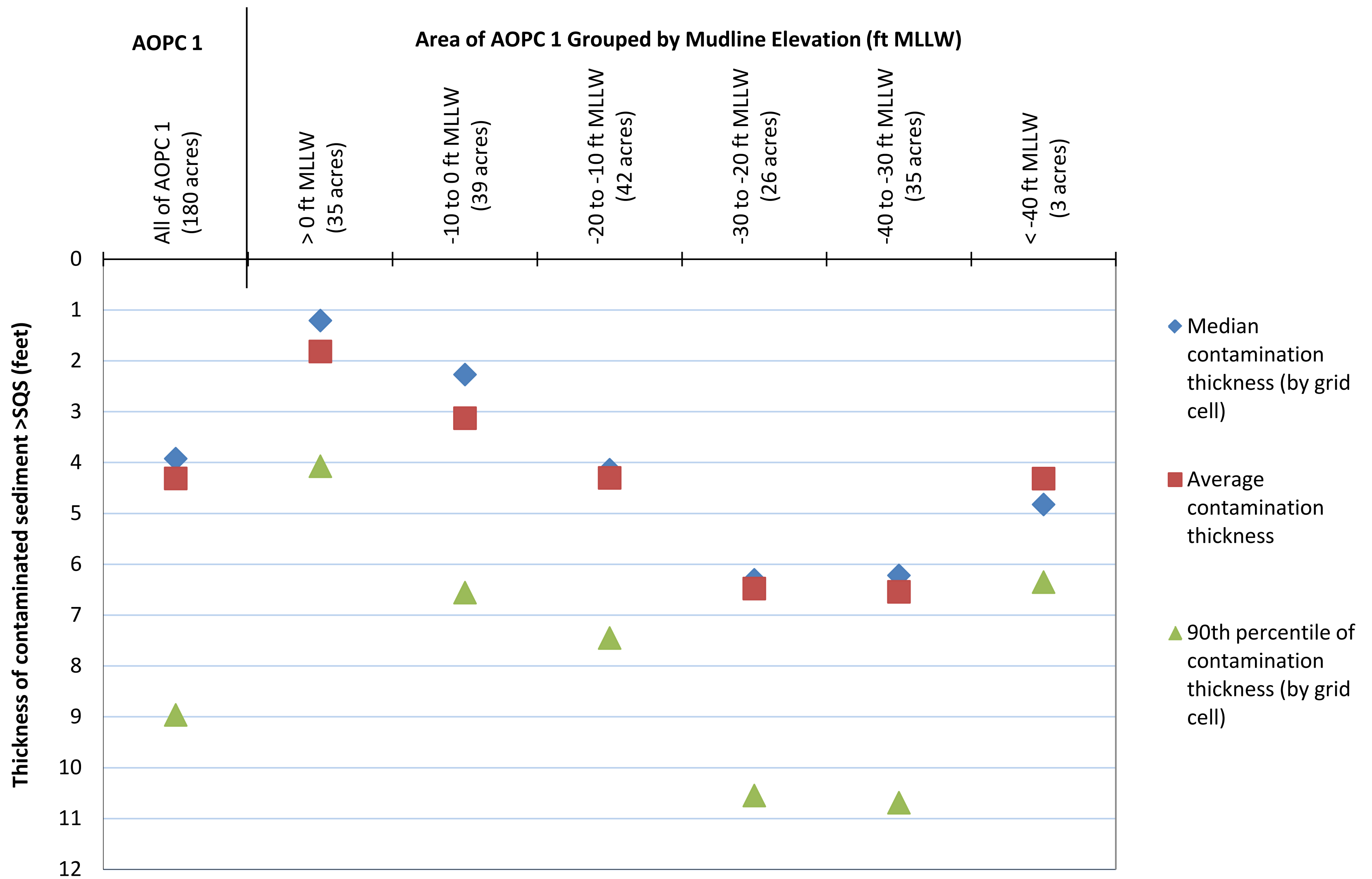
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Interpolated Thickness of Sediment Layer From Mudline to Lower Alluvium

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE E-19**

Figure E-20 Estimated Thickness of Contaminated Sediment in AOPC 1 vs. Mudline Elevation



Lower Duwamish Waterway Group

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

Appendix F
Evaluation of Natural Recovery, Empirical Trends, and Model Predictions

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

Table of Contents

List of Tables

List of Figures

List of Figures

F.1 Introduction

This appendix evaluates the potential for natural recovery in the Lower Duwamish Waterway (LDW). It employs a weight-of-evidence approach to investigate the viability of natural recovery at broad spatial scales, and in specific locations, within the LDW based on available technical information, empirical data, and predictive models (see Section 5). The results of this analysis were used in two ways: 1) to evaluate whether monitored natural recovery (MNR) is a viable remedial technology applicable to the LDW, and 2) to inform the assignment of remedial technologies in developing remedial alternatives discussed in Section 8 of this feasibility study (FS).

In this appendix, the conceptual site model (CSM) of recovery potential in the LDW is presented first. Next, chemical and biological trend information is presented and compared to modeled recovery predictions. Following the discussion of trends, this appendix presents the data limitations and associated uncertainties. Last, this natural recovery evaluation is summarized according to the weight-of-evidence approach discussed in Section F.1.2 (Davis et al. 2004; NRC 2001; EPA 2005). Collectively, these assessments show that natural recovery is occurring at broad scales and in many localized areas in the LDW. Areas that are not recovering have been prioritized for remedial actions in this FS.

F.1.1 Natural Recovery and Monitored Natural Recovery

Natural recovery is used to some extent for remediating almost all contaminated sediment sites because natural attenuation processes are occurring whether an active cleanup is ongoing or not. Attenuation processes that are potentially applicable to the natural recovery of contaminants in sediment include:

- Deposition of cleaner sediment on top of existing sediment, burying contaminated sediment
- Mixing of cleaner deposited sediment with existing sediment
- Dispersion, dilution, sorption and desorption, volatilization, and diffusion
- Biodegradation and abiotic degradation/transformation.

The cumulative effect of all or some of these processes can be a reduction in contaminant concentrations in the biologically active zone, thus potentially reducing exposure and ultimately risks in all pathways that include surface sediments or benthic organisms.

MNR, as a component of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Model Toxics Control Act (MTCA) remedial actions, is different from natural recovery (discussed in this appendix) in that it includes the establishment of cleanup levels and long-term goals, the assignment of a particular time frame for achieving those goals, the use of a monitoring program to track success, and a decision framework for implementing contingency actions if needed (adaptive management; EPA 2005).

MNR as a remedial technology is discussed in Section 7 of this FS. MNR is often combined with other remedial technologies when addressing complex sediment sites. Its benefits and limitations must be balanced against those of active remedial technologies. Section 8 of this FS identifies a range of alternatives that employ MNR to varying degrees, in combination with active technologies.

This is an FS-level assessment, and further information may be required during remedial design to verify the FS conclusions regarding natural recovery potential in individual areas. It should be noted that in most of the FS, the term "recovery" refers to sediment concentrations, either on a point-basis or on an area-weighted average basis, decreasing to below particular thresholds. In this appendix, "recovery," when used in the term "natural recovery," refers to decreases in surface sediment concentrations over time and is not tied to a threshold.

F.1.2 Weight-of-Evidence Approach

A weight-of-evidence approach for evaluating natural recovery was formalized by the Remediation Technologies Development Forum (RTDF) (Davis et al. 2004). The RTDF identified five general considerations for demonstrating a site's ability to recover naturally and for MNR to be considered an effective remedial action:

- Assessment of ongoing sources, although important, is only briefly discussed in this appendix. Source control efforts are described in Section 2, and ongoing sources related to recontamination potential are discussed in Appendix J. Historical source control efforts are discussed in Section F.2.
- An understanding of the fate and transport mechanisms at the site is discussed in Section F.3 in the context of the physical CSM.
- A review of the historical record of contamination in terms of empirical chemical trends is discussed in Section F.4.
- A consideration of biological trends is discussed in Section F.5.
- The use of predictive tools (e.g., models) is discussed in Section F.6.

Each of these weight-of–evidence considerations identified by the RTDF is discussed in this appendix as it applies to the LDW, followed by an uncertainty section (F.7) and summary (F.8). Reviewing site data and using models are components of the guiding principles described in the U.S. Environmental Protection Agency (EPA) sediment guidance (EPA 2005).

F.1.3 Common Tools for Assessing Recovery

MNR has been evaluated and implemented at large and small sites over the past 10 years, with various hydrologic conditions, contaminants of concern (COCs), ongoing and historical sources, risk drivers, natural recovery processes, and remedial strategies (NRC 2001 and 2007). EPA has selected MNR as a part of the remedy for at least 15 CERCLA sediment sites nationally (EPA 2010a and 2010b, Magar et al. 2009; see Table F-1). MNR has also been selected by the Washington State Department of Ecology (Ecology) as part of the remedy for the Whatcom Waterway, Bellingham Bay, WA (Anchor QEA 2010).

Common tools used to guide the selection of MNR as a remedial technology include qualitative assessments of natural recovery processes, assessment of empirical data trends, and predictive modeling. Qualitative assessments may include identifying areas of deposition and scour and routes of sediment transport. Empirical investigations of site conditions often include collecting chemical data to estimate rates of concentration reduction in sediment and in the tissues of ecological receptors, and measuring or estimating sedimentation rates at the site, particularly where physical isolation (burial) is a key recovery process. Bathymetric soundings, radioisotope analysis, and sediment traps are tools often employed to estimate current or historical sediment deposition rates.

At most sites where MNR is evaluated, empirical data collection is often followed by modeling to interpret the data and predict future conditions. Measured sediment deposition rates are used during calibration and verification of various mechanistic sediment deposition models that are then used to predict future surface sediment concentrations. Typically, model predictions were supported by empirical time trends depicting either decreasing surface sediment concentrations over time or sediment coring data with lower concentrations in surface sediments than in subsurface sediments.

These tools have been used to develop a CSM for potential recovery trends in the LDW and to predict future contaminant concentrations. The two types of sediment chemistry data used for assessing recovery potential in the LDW are:

- Contaminant concentrations in surface sediment representative of approximately the same area sampled at different times (typically separated by several years)
- Contaminant concentration trends with depth (and therefore time) in sediment cores.

The fact that the LDW has been studied over many years offers the opportunity to assess surface sediment concentration changes over time. The use of sediment cores to evaluate chemical profiles and calculate net sedimentation rates in the LDW was documented in Appendix F of the *Sediment Transport Analysis Report* (STAR; Windward and QEA 2008). The use of core profiles to assess natural recovery is well documented at other sediment sites (e.g., Fox River, Hudson River, Passaic River, and Bellingham Bay).

Empirical sediment chemistry data for total polychlorinated biphenyls (PCBs), arsenic, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), bis(2-ethylhexyl)phthalate (BEHP), and other Washington State Sediment Management Standards (SMS) contaminants (the risk drivers) are used in the discussion of natural recovery in this appendix. Far fewer dioxin/furan data are available in the LDW, and thus this risk driver is only briefly discussed. Much of the discussion of empirical data in this appendix focuses on total PCB trends because PCBs are man-made, have a clear history of industrial use and release via a range of pathways to the LDW, were phased out of manufacture and use in the U.S. during the late 1970s, and are consistently present in the LDW. These special circumstances allow relative dating of sediments and identification of associated trends in sediment chemistry. Further, PCB trends mirror the decreasing contributions from industrial sources (and improvements in source control) within the LDW drainage basin.

Arsenic, dioxins/furans, phthalates, and cPAHs are prevalent in urban watersheds, with the latter three still being produced and released to the environment by various mechanisms. Temporal trend information associated with these contaminants is pertinent in the context of recontamination potential (evaluated in Appendix J), as well as natural recovery. The evaluation of BEHP trends, in particular, can help identify areas where ongoing sources on a broader scale have an effect on LDW sediment chemistry. These areas would need more extensive source control before goals can be achieved. Trends for these contaminants, where available, are discussed in this appendix. However, the discussion focuses on PCBs because they are expected to have identifiable trends and can be associated with particular time markers in sediment. A summary of the empirical lines of evidence discussed in this appendix is provided in Table F-2.

The final tool used to evaluate natural recovery in the LDW is a predictive contaminant model, the bed composition model (BCM; see Section F.6). The BCM predicts contaminant recovery over time in surface sediments using output from the sediment transport model (STM; see Section 5).

F.1.4 Relevant Guidance

The use of MNR as a remedial technology is described by federal and state guidance, as presented below.

F.1.4.1 Federal Guidance

EPA has issued guidance on the evaluation and use of MNR as a remedial technology at sediment sites (EPA 2005). When EPA published *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA 2005), MNR had been selected as a component of the remedial action at approximately one dozen CERCLA sediment sites (see Table F-1).

The EPA guidance states that there should not necessarily be a presumption that removal of contaminated sediments from a water body will be more effective or permanent than MNR and recommends that an evaluation of MNR as a potential remedy or remedy component should, at a minimum, generally focus on the following questions:

- Is there evidence that the system is recovering?
- Why is the system recovering or not recovering?
- What is the pattern of recovery or non-recovery expected in the future?

The EPA guidance recommends that MNR evaluations be supported by various site-specific characterization data, often with modeling, and suggests that a weight-of-evidence approach can provide a general framework for evaluating recovery potential (Section F.1.2).

EPA's Office of Research and Development has developed two technical documents related to MNR in sediments. Specifically, these documents address the determination of rates and extent of dechlorination in PCB-contaminated sediments during natural recovery (EPA 2008a) and the use of sediment core profiling in assessing the effectiveness of MNR (EPA 2008b). EPA's Office of Superfund Remediation and Technology cites eleven guiding principles when evaluating sediment sites for remedial technologies, and includes MNR as a part of combined remedies. These principles include using CSMs, managing uncertainty (e.g., with model predictions), focusing data collection, setting realistic cleanup goals, and considering interim remedies (Ells 2010).

The U.S. Department of Defense, Environmental Security Technology Certification Program (ESTCP) has also published guidance for MNR, with the issuance of *Technical Guide – Monitored Natural Recovery at Contaminated Sites* (Magar et al. 2009). This guide provides the state of the science on MNR, and describes several case studies on the use of MNR (see Table F-1).

In addition, members of the joint industry-EPA Sediments Remediation Action Team of the RTDF have developed a series of working papers on MNR (Davis et al. 2004, Dekker et al. 2004, Erickson et al. 2004, Magar et al. 2004, Patmont et al. 2003). These papers provide a recommended framework for evaluating MNR, which is used in this appendix.

Finally, the EPA National Risk Management Research Laboratory is documenting the use of effective, inexpensive remediation strategies, including MNR, for managing contaminated sediment sites. The laboratory has documented its review of the success of MNR for PCBs and for polycyclic aromatic hydrocarbons (PAHs) in two recent case studies: Wyckoff/Eagle Harbor East Superfund Site near Bainbridge Island in Puget Sound, WA, and the Sangamo-Weston/Twelvemile Creek/Lake Hartwell Superfund Site in Pickens County, SC (EPA 2008b).

F.1.4.2 State Guidance

Ecology has issued the *Sediment Cleanup Standards User Manual* (Ecology 1991). This manual indicates that one of the major elements of a sediment cleanup action is natural recovery through chemical degradation and deposition of clean sediment for areas of a site that have relatively low surface sediment contaminant concentrations. The manual also states that estimated sedimentation rates are one indicator of the potential for contaminated sediments within an area to recover naturally. Thus, in this appendix, sedimentation rates, estimated using empirical evidence and predicted with the STM, are discussed.

Ecology's manual notes that the rate of natural recovery will also be affected by the rate that ongoing sources, such as storm drains, introduce contaminants into the environment. The manual also discusses using models to predict chemical decay and burial. Burial is incorporated into the FS predictive model, described in this appendix as one of the five weight-of-evidence considerations. Appendix J discusses ongoing sources and recontamination potential.

Finally, the SMS require that natural recovery processes be considered when evaluating the restoration time frame for completing the cleanup action (Washington Administrative Code [WAC] 173-204-580(3)(vii).

F.1.5 Examples of Sites That Have Used MNR

Precedent for applying MNR as a remedial technology is supported by its use at other sites. MNR has been selected as a remedy or a remedy component for at least 15 CERCLA sediment sites nationwide (Table F-1; EPA 2010a and 2010b, Magar et al. 2009, Brenner et al. 2004, NYSDEC and EPA 2005, USACE 2007).

As noted above, the ESTCP published guidance in May 2009, which includes case studies of MNR at several contaminated sediment sites. Since issuance of this document, MNR has been selected or proposed as part of the remedy at two additional sites: the Palos Verdes Shelf and the Nyanza Chemical Waste Dump (EPA 2010b). A Record of Decision (ROD) was recently released for the Palos Verdes Shelf Superfund Site in Los Angeles County, CA (EPA 2010a).

The sites listed in Table F-1 are in various stages of monitoring, and the data show varying degrees of success. The majority of sites, where enough data have been collected to examine trends, demonstrate that they have achieved or are on trajectory to achieve cleanup goals. Although some sites exhibit fish tissue contaminant concentrations above targets, this is not different from most sediment cleanup sites that have relied on active remedies (e.g., dredging, capping). In addition, a number of other site- and remedy-related factors (such as dredging residuals and ongoing sources) can cause fish tissue contaminant concentrations to be above targets following remediation.

F.2 Source Control

Like other remedial technologies (e.g., dredging, capping, enhanced natural recovery [ENR]), the viability of natural recovery is dependent in part on the nature and magnitude of ongoing sources that may exist upon implementation of the remedy. Source control is a complex assessment, however, and should be considered in both a location-specific and site-wide context, as described in this appendix and in Appendix J.

The types of potential contaminant sources (loading) are cataloged in the remedial investigation (RI; Windward 2010) and summarized in Section 2 of the FS. This FS assumes that source control efforts, best management practices (BMPs), or the remediation itself will sufficiently address many of the potential sources of recontamination to the LDW sediment to the extent practicable. Recontamination potential based on model estimates and empirical trends within the LDW is discussed in Appendix J.

A generalized schematic of historical LDW-wide events, historical chemical uses, and source control activities, as evidenced through chemical trends and stratigraphic units in cores, is shown in Figure F-1. General conditions of the LDW related to historical pollutant sources and control efforts and ongoing source control efforts are discussed below. The section below discusses contamination from various sources that may have contributed to environmental degradation in the LDW. It also discusses how these sources have been addressed over the past 30 years. The effects of these efforts are preserved in the sediment record and provide context for the shift in common practices, BMPs, system upgrades, and other control efforts that influence the recovery of the LDW.

F.2.1 Historical Source Control Efforts in the LDW

Several reports from the 1950s through the 1970s have documented the poor condition of surface water and fish health in the LDW during this period. Historical source control efforts in the LDW have included the development of a sewer system and subsequent upgrades to this system, along with efforts to reduce contaminant inputs to the receiving water body. Although these historical source control efforts are not necessarily specifically related to LDW risk drivers or COCs, they provide context for the changes in common business and waste management practices over time. They are indicators of improvements in practices and associated reductions in contaminant releases. These actions are discussed in this section.

Prior to 1965, raw and partially treated sewage, as well as wastes from manufacturing and food processing plants, were discharged directly to the LDW (Santos and Stoner 1972). In 1935, the East Marginal trunk was constructed, diverting several raw sewage outfalls along the east shoreline of the LDW to the Diagonal Way Sewage Treatment Plant (STP), which discharged primary treated effluent to the LDW at river mile (RM) 0.55E. The STP captured combined sewer flows from most of the eastern half of the LDW drainage basin, although significant overflows occurred regularly at the old raw sewer outfall locations as the system was over capacity by World War II. In the late 1950s, the Washington State Pollution Control Commission (a predecessor of Ecology) attempted to route all untreated direct discharges from the eastern side of the LDW to the East Marginal Way sewer line, which flowed to the Diagonal Way STP. In 1958, the biological oxygen demand in the LDW and Green/Duwamish River was estimated to be 26,000 pounds (lbs) per day. Three thousand pounds of this load were discharged between Auburn and Tukwila, with the remainder being discharged within the LDW (Brown and Caldwell 1958).

Beginning in 1965, portions of the effluent to the Green/Duwamish River and LDW (not already being diverted to the Diagonal Way STP) were diverted to the Renton wastewater treatment plant (WWTP), which discharged secondary treated effluent and was located approximately 13.5 miles upstream of the LDW (Santos and Stoner 1972). In 1966, the Renton WWTP operated at 9% of its capacity, but continued to increase over time as more sewer lines were diverted to it. A 1978 report from Ecology cited a 33 million gallon per day discharge from the Renton WWTP. In 1987, an upgrade to the Renton WWTP diverted the discharge of secondary treated effluent from the Green River to a deep outfall in Puget Sound.

In 1969 and early 1970, an interceptor sewer was constructed to collect combined sewer flow that had previously gone to the Diagonal Way STP (RM 0.55 E). The interceptor sent the flow to the West Point WWTP (northwest of Elliott Bay), diverting it from the LDW (Ecology 1978). Transfer of this flow to the higher capacity system also dramatically decreased the frequency and volume of combined sewer overflow (CSO) discharges into the LDW along the eastern shoreline and eliminated several raw sewer outfalls on the western shoreline (replaced by CSOs).

These two regional "upgrades" are important source control efforts that were initiated in the 1970s and 1980s. Prior to 1987, concentrations of coliform bacteria, indicators of raw sewage, typically measured more than 1,000 colony forming units (CFUs) per 100 milliliters (mL) at the King County long-term surface water monitoring station at RM 3.4 (Mickelson 2009). Since 1987, coliform bacteria counts have declined (although data are not directly comparable), with newer data ranging from 1 to 830 CFUs/100 mL (with one outlier at 4,000 CFUs/100 mL).[1] Phytoplankton blooms were frequently reported in the LDW in the 1960s (Welch 1969); currently (in the 2000s), blooms are absent, indicating an improvement in water quality, an increase in dissolved oxygen concentrations, a reduction in nutrient loading, and better source controls. Although coliform bacteria are not considered COCs, reductions in their levels indicate successful source controls that likely also reduce levels of other constituents (i.e., they are indicators of improving conditions).

The development of the Municipality of Metropolitan Seattle (Metro) regional sewer system has reduced the flow of untreated or poorly treated wastewater flowing to the Duwamish River and the LDW by 23,000 million gallons per year since its founding in 1958. The remaining CSO flows have been reduced by 77% since 1990 to an average of 180 million gallons per year.

In addition to the sewer system development and upgrades, many significant source control efforts have been undertaken in the LDW and in the broader Puget Sound region to reduce inputs of contaminants to receiving water bodies. The effectiveness of those efforts has been demonstrated by decreasing sediment concentrations. Some of the more concerted efforts over the last 50 years include the following:

- In the late 1950s, the Pollution Control Commission conducted an investigation of pollution in the Green/Duwamish River (PCC 1955) and subsequently required all direct discharges into the LDW from the eastern shore upstream of RM 0.5 to hook up to the local East Marginal Way sewer that flowed to the Diagonal Way STP. This included much of the heavy industry along the LDW at the time.
- Metro conducted a series of efforts to identify and control sources in the LDW from the late 1970s to the mid 1980s. Documents covering this work include: *Toxicants of Urban Runoff* (Galvin and Moore 1982), *Water Quality Assessment of Duwamish Estuary* (Harper-Owes 1982), and the *Toxicant Pretreatment Planning Study* (TPPS; Metro 1983a). These studies led to the *Duwamish Clean Water Plan* (Metro 1983b) and the *Duwamish Industrial Non-point Source Investigation* (Metro 1985).
- The Puget Sound Estuary Program conducted the Urban Bays Studies, which produced the Elliott Bay Toxics Action Program, including an *Evaluation of Potential Contaminant Sources* (PTI Environmental Services and Tetra Tech 1988) and the *Elliott Bay Action Plan* (PTI Environmental Services 1988).

[1] Per the Washington State Department of Health, Office of Shellfish and Water Protection, the water quality standard for shellfish growing is less than 14 organisms per 100 mL (geometric mean). The 90th percentile is less than 43 organisms per 100 mL (WDOH 2009).

- Quemetco Inc.'s former lead smelter on Harbor Island adjacent to the LDW began secondary lead smelting operations in 1937. The smelter, which reclaimed lead from automobile and industrial batteries, ceased operations in April 1984. During its time in operation, Quemetco was a source of fugitive dust emissions and groundwater contamination. The state established air quality standards for lead in 1978. Source control upgrades were implemented in 1980. Soil sampling conducted in parking areas near Quemetco in 1979 and again in 1982 by the Puget Sound Air Pollution Control Agency (PSAPCA) found a 60% decrease in soil lead content between the two sampling events (PSAPCA and Ecology 1983).
- Ecology developed stormwater regulations in the early 1990s that gave authority to local jurisdictions to make the introduction of pollutants to surface waters illegal and required stormwater BMPs to be implemented for all pollutant-generating activities. The regulations also required new developments to include stormwater treatment. Ecology continues to update the National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit requirements, which have increasingly led to advances in monitoring, BMPs, operation and maintenance, and treatment studies. Stormwater pollution prevention plans are developed by permittees to implement these requirements.
- The Port of Seattle and the Puget Sound Clean Air Agency developed the "Scrappage and Retrofits for Air in Puget Sound" program in November 2009. Through the end of 2010, 276 trucks were retired through the program. Through the buy-back efforts and by also retrofitting exhaust systems of newer trucks, tailpipe emissions (including diesel particulate matter) from trucks visiting Seattle ports have been greatly reduced (Port of Seattle 2010a; Takasaki, personal communication, 2011).
- In 2004, the Port of Seattle, Ecology, and the Northwest Cruise Ship Association signed a Memorandum of Understanding (MOU) setting strong standards for the treatment of waste discharges from cruise ships operating in Washington waters. This voluntary agreement exceeds the federal requirements that ordinarily apply to cruise ships. The MOU prohibits discharges of untreated wastewater within Washington waters. The MOU also prohibits discharges of treated black water and treated gray water unless it is from an Advanced Wastewater Treatment System (Port of Seattle 2010b).
- In 2005, the Port of Seattle berth for cruise ships at Terminal 30, just north of the LDW, was retrofitted with shore power. In 2009, when use of Terminal 30 as a cruise terminal was ceased, shore power was moved to Terminal

90/91. Shore power allows ships to turn off their internal power systems while berthed, reducing emissions by an estimated 30%. Those emissions could affect the LDW and Elliott Bay through atmospheric deposition onto the drainage basins (Port of Seattle 2005; Takasaki, personal communication, 2011).

- Ships at the Port of Seattle have reduced emissions of sulfur dioxide by at least 80% and diesel particulate matter by 60% through an innovative program called At-Berth Clean Fuels. Vessels participating in the program agree to use low sulfur fuel (0.5% or less) in their auxiliary engines while docked in Seattle. In exchange, the Puget Sound Clean Air Agency helps defray the cost of the more expensive low sulfur fuel by providing participating vessels with $1,500 for each port call (Port of Seattle 2009).

F.2.2 Ongoing Source Control Efforts in the LDW

Potential ongoing sources to the LDW are discussed in Section 2 and are evaluated as recontamination potential in Appendix J. A representation of lateral sources (watershed runoff, outfall discharges, and atmospheric deposition on drainage area land) is included in modeling estimates of lateral loads used in the BCM. The chemical input parameters used in the BCM for lateral sources were derived from samples collected over the past ten years by the City of Seattle, King County, and The Boeing Company. These data include whole-water samples collected from outfalls and sediment samples collected from storm drains (in-line sediment traps and grab samples) and catch basins. These values, as used in the BCM modeling process, are discussed in Section 5 and Appendix C.

Ecology is the lead entity for implementing source controls in the LDW and works in cooperation with local jurisdictions and EPA to create and implement source control strategy and action plans and to prioritize upland cleanup efforts in the LDW. The LDW source control strategy (Ecology 2004) describes how recontamination of LDW sediments will be controlled to the maximum extent practicable. The goal is to limit sediment recontamination that exceeds site-specific standards, where feasible. The LDW source control efforts are designed to identify and manage sources of contaminants to waterway sediments in coordination with sediment cleanups. Section 2.4 describes the scope, goals, and schedule for the source control work in the LDW and other regional source control efforts.

F.2.3 Historical Trends in Puget Sound

Contaminant trends in surface sediments (over time) and in sediment cores (by depth) at sites outside of the LDW provide evidence of regional or global trends in contaminant use, transport, and natural recovery. Additionally, the methods used at other locations establish precedence for the methods employed in the LDW.

Natural recovery is evident in Puget Sound sediments that are not being affected by new inputs from localized sources. Production of PCBs was banned in 1979 in the United States, and subsurface sediment contaminant trends by depth in Puget Sound mirror the PCB use pattern. Other contaminants related to industrial processes exhibit similar trends that are related to regulations requiring source control measures that have been put in place since the 1980s, such as good housekeeping practices, waste disposal, and wastewater treatment (Figure F-1).

Researchers from Battelle (Brandenberger et al. 2008) have collected sediment cores in Puget Sound during three events (1982, 1991, and 2005) and compared the depths of stratigraphic markers within these cores. A regression of the depth of this stratigraphic marker versus elapsed time (between sample events) indicated that cleaner sediments are burying historically more contaminated sediment at a rate of approximately 1.3 ± 0.1 centimeters per year (cm/yr) in a set of cores collected in Puget Sound near Tacoma (PS-1 core set). These rates were comparable to rates derived from the radioisotope (lead-210) profile in the 2005 core alone and confirmed the validity of this widely used radioisotope technique (Brandenberger et al. 2008). Radioisotope cores were thus used as one line of evidence to estimate net sedimentation rates in the LDW (Appendix F of the STAR; Windward and QEA 2008).

The data from the Battelle coring studies were also used to predict simplistic natural recovery rates for the 20th and 21st centuries using a regression that estimated surface sediment chemistry over time (based on trends from core data). This regression method has revealed that 21st century recovery rates are non-linear and have slowed from the 20th century rates. This provides a basis for calculating separate 21st century recovery rates, which predict lead recovery to pre-industrial levels near Seattle (PS-4) by 2050 ±20 years and copper by 2020 ±10 years. The identification of two different recovery rates supports the use of two different trend analyses in cores in this appendix: historical trends evaluated throughout the entire depth of the core, and 21st century rates found through trends in the top two intervals.

An exception to this is arsenic. Arsenic has already shown recovery in the Elliott Bay core set (PS-4) as a result of removing a known point source in Ruston, the ASARCO smelter, whose aerial plume is known to have contaminated a broad downwind area. Arsenic concentrations in sediment cores increased above background beginning around 1900, peaked around 1960, and decreased significantly following the smelter closure in 1986 (Brandenberger et al. 2008).

The Battelle coring studies tracked recovery rates of metals above the natural background versus estimating an absolute natural recovery rate (which cannot be estimated because arsenic, for example, occurs naturally in sediment). The study indicated that the natural background concentration of arsenic in Puget Sound sediments is 8.57 ±1.5 milligrams per kilogram dry weight (mg/kg dw). The arsenic recovery rates in the Battelle study are consistent with the arsenic recovery rates in the

LDW. These recovery rates are not as pronounced as PCB recovery rates, because arsenic concentrations cannot fall below natural background.

F.3 Physical Conceptual Site Model of Natural Recovery Mechanisms in the LDW

This section describes the CSM-based physical site conditions and how they relate to natural recovery potential in the LDW. The CSM for natural recovery in the LDW assumes that burial of contaminated sediment by cleaner sediment (transported from the Green/Duwamish River), combined with active vertical mixing in the biologically active zone (upper 10 cm) are the primary recovery mechanisms.[2] Deposition of cleaner material over existing contaminated surface and subsurface sediment limits the contaminated material from coming into contact with the water column (by burial, which decreases diffusion and advection of contaminants to the water column) and thereby eventually reduces exposure of human and ecological receptors to contaminants. In general, burial is more rapid in areas with moderate to high net sedimentation rates and slower in areas with either low net sedimentation rates or with the potential for significant scour.

For the CSM, the LDW is divided into three reaches (QEA 2008), each of which has distinct physical properties and recovery potentials (Figures 2-8a through 2-8c show the features of these reaches).

- **Reach 1** is downstream (north) of RM 2.2. A saltwater wedge (which can protect the sediment bed from significant erosion) is located in this reach during all flow and tidal conditions. Overall, this reach is net depositional. Both model and empirical data show that net sedimentation rates in this reach range from relatively low, on the order of 0.5 cm/yr in intertidal areas, to moderate on the order of 1 to 2 cm/yr in subtidal areas. This reach would not likely be subject to scour during the most aggressive high-flow event (the 100-year, spring-tide, high-flow) except perhaps in a few localized areas. While vessel traffic is common in this reach, maintenance dredging rarely occurs in the authorized navigation channel or berthing areas because depths are sufficient for navigation.

- **Reach 2** extends from RM 2.2 to RM 4.0 and includes the toe of the saltwater wedge during high-flow events; the saltwater wedge extends even farther upstream during average-flow conditions. The toe of the saltwater wedge is pushed downstream of this reach (to roughly around RM 1.8) only during extreme flow events (100-year high-flow event and greater). Reach 2 is

[2] The STM can be used to predict these mixing and burial processes. The BCM (see Section 5 of the FS) estimates changes in the contaminant composition of surface sediment (upper 10 cm) over time. Mechanics of the BCM are described in Appendix A.

narrower than Reach 1, and portions are subject to some scour during high-flow events, but this reach is net depositional on an annual basis. The deepest estimated scour depth (22 cm) during the 100-year high-flow event is at RM 3.1. Berthing areas are periodically dredged in this reach.

- **Reach 3** is upstream of RM 4.0. Flow in portions of this reach is characteristic of a freshwater tidal river during high-flow events. This reach is occupied by the saltwater wedge only during low- and average-flow conditions. This reach is also net depositional on an annual basis. Both model and empirical data indicate that the navigation channel and Upper Turning Basin located in Reach 3 have higher net sedimentation rates than other areas of the LDW. This is also supported by the need for frequent dredging events (every two to four years) conducted in this reach by the United States Army Corps of Engineers (USACE) to maintain authorized navigation depths. This dredging creates a disequilibrium that results in a net depositional environment.

The CSM also includes the assumption that the human health risk drivers (total PCBs, arsenic, cPAHs, and dioxins/furans) are not subject to significant degradation by natural biotic or abiotic chemical reaction processes and do not readily desorb into the water column or volatilize. Therefore, in the absence of active remediation, burial of surface sediments containing these contaminants is the primary mechanism for risk reduction. Arsenic is a metal and is therefore not subject to degradation. cPAHs may degrade slowly, but can continue to enter the LDW from nonpoint sources. Organochlorine compounds, such as PCBs and dioxins/furans, degrade only very slowly in the sediment environment (see Section 5). The desorption of PCBs from sediment particles is limited by their low solubility and high hydrophobicity and by the organic carbon content and type of sediment.

Because burial by clean sediments is the primary mechanism for risk reduction, the CSM acknowledges that both the rate and extent of natural recovery in the LDW are influenced by existing and future sources of contaminants and the extent to which sources are controlled. Source control is important to the success of natural recovery and to the success of all remedial technologies contemplated for the LDW.[3]

Finally, bed stability is of central importance to natural recovery in the LDW and is an important element of the CSM. In the absence of navigational uses of the LDW and assuming effective source control, rates of natural recovery in the LDW would be tied predominately to sedimentation rates and to erosion potential during high-flow events. Under current and foreseeable future use conditions, both natural erosional events and scour from ship propellers are expected to have some localized effects on recovery. This stems from the simple notion that sources of scour, if sufficiently energetic, can make

3 It is one of the five key lines of evidence discussed in this appendix (see Table F-2).

subsurface sediment available to receptors on at least a localized and temporally limited basis. The location and magnitude of predicted scour are important considerations in determining where risks of recontamination may be unacceptably high, and are therefore factored into the remedial alternatives developed and presented in Section 8.

F.3.1 Sedimentation

Net sedimentation is the net effect of sediment deposition and erosion, expressed as a rate of cm/yr. Estimates of net sedimentation are important for understanding and gauging natural recovery potential.

F.3.1.1 Net Sedimentation Rates Estimated from Sediment Cores

Empirical evidence of net sedimentation over time is contained in the signatures of chemical and physical markers found in sediment cores collected throughout the LDW. Trends in the chemical and physical properties in sediment cores were evaluated as a function of time, where the sampled depth intervals could be assigned a time frame during which the particular sediment was deposited. The amount of sediment that accumulated above the base time-calibrated depth of each viable core was used to estimate a net sedimentation rate (Windward and QEA 2008).

The empirically derived net sedimentation rates are based on numerous lines of evidence observed in cores, including:

- Stratigraphic units
- Radioisotope analyses (cesium-137, lead-210)
- Chemical profiling.

Of the 62 cores evaluated in the STAR and used to calibrate the model (Windward and QEA 2008[4]), net sedimentation rates could be estimated for 55 cores, and those rates ranged from 0.7 cm/yr to >3 cm/yr (see Table F-3 and Figure F-2). The other 7 cores did not have discernible markers from which rates could be calculated. This lack of markers indicates possible mixing of sediment or contributions from ongoing sources. Overall, the 55 cores with markers demonstrate that sedimentation is occurring in the LDW. These trends alone do not indicate natural recovery is necessarily occurring because the sediments responsible for burial may have high contaminant concentrations. Further, empirical chemical data and BCM predictions (discussed in Sections F.4 and F.6, respectively) must also be evaluated to estimate natural recovery potential, because mixing mechanisms (e.g., bioturbation) can also play a role in natural recovery by causing recently deposited material to commingle with older underlying contaminated material.

[4] Approval of the STAR by the EPA was documented in a January 25, 2008 letter.

An additional set of 19 cores (beyond the 62 mentioned above), collected as part of the early action area (EAA) investigations, was also evaluated for net sedimentation rates (Table F-3 and Figure F-2). The estimated net sedimentation rates from these core data were generally >1 cm/yr, which demonstrates that sedimentation occurs in the EAAs. However, in these particular areas, active remediation may be necessary to remove or isolate sediments with high contaminant concentrations, because the net sedimentation rate may not be sufficient for natural recovery to occur within a desired time frame.

Other observations of the evaluated cores lend additional qualitative support to the marker-based sedimentation rate calculations. Man-made debris, fill material, and sheen were often observed approximately 1 ft or more below the mudline. This is indicative of burial by soft, recent sediments over older debris-impacted sediments. Twelve of the 56 cores collected in 2006 by LDWG for the RI contained multiple (or scattered) pieces of debris (see Section 2). The shallowest debris in 9 of these 12 cores was at least 1 ft deep. Some debris was found as deep as 13 ft. These observations indicate that burial has occurred in the past and is likely still occurring.

Further, accumulations of soft sediment were frequently observed, an indication of quiescent and/or relatively stable environments where lower energy flow regimes allow deposition of finer-grained sediment. Thicknesses of "recent" soft sediment varied from 0.1 ft (SC-2 at RM 0.2) to 13 ft (SC-17 at the head of Slip 1).

F.3.1.2 Net Sedimentation Rates Estimated by the STM Compared to Rates Estimated by Cores

The STM estimates net sedimentation rates in the LDW based on grain sizes, sediment loading from lateral and upstream sources, and the historical flow regime of the Green/Duwamish River (QEA 2008). The net sedimentation rates estimated by the STM are shown in Figure F-2.

The net sedimentation rates estimated by the STM were compared to those derived from the empirical data. In general, the empirically derived net sedimentation rates shown in Table F-3 were consistent with those of the STM. Net sedimentation rates were evaluated for 62 cores (56 RI cores and 6 historical cores), with 55 of these cores having identifiable markers. The net sedimentation rates estimated for 45 of these 55 cores match or exceed the net sedimentation rates estimated by the STM. The middle value in the range of net sedimentation rates calculated for each core was compared to the STM-estimated net sedimentation rate in a one-to-one comparison. Figure F-2 shows the locations of all cores for which net sedimentation rates were calculated, along with the STM-estimated net sedimentation rates. Figure F-2 also provides information on the nine[5] cores with rates lower than those estimated by the STM and the one core outside of the model domain. These inconsistencies are typically associated with physical

[5] Figure F-2 contains text boxes for 10 cores. Nine cores have estimated net sedimentation rates lower than those estimated by the STM. One core, LDW-SC11, is outside of the model domain.

features and/or events not accounted for in the model (e.g., dredging events, bridge structures, pilings or other overwater structures, and localized scour events from vessel traffic). Overall, the good match between cores and STM estimates adds confidence to the understanding of the physical mechanisms of the LDW and the utility of the STM to track the fate and transport of sediment particles throughout the LDW.

Net sedimentation rates estimated from the radioisotope cores shown in Figure F-2 also have generally good agreement with the rates estimated from the STM (QEA 2008). The methods of collecting and evaluating these cores are described in the STAR (Windward and QEA 2008).

In summary, because net sedimentation rates from the STM generally agree with empirical data, STM-derived sedimentation rates are used in conjunction with the BCM to predict future concentrations. Areas where discrepancies are noted (as shown in Figure F-2) are tracked and managed in assigning recovery categories (Section 6 and Section F.3.2) and assigning remedial technologies (Section 8).

F.3.2 Recovery Categories

Physical conditions were used as lines of evidence to identify areas where natural recovery is predicted, less certain, or presumed limited. A recovery category represents areas of the LDW that share similar characteristics (i.e., net sedimentation rates, scour potential, berthing areas, plus empirical trends) that could affect the extent to which recovery can occur. The three recovery categories as defined for this FS are:

- **Category 1** includes areas where recovery is presumed to be limited. It includes areas with observed and predicted scour, net scour, and empirical data demonstrating increasing concentrations over time.
- **Category 2** includes areas where recovery is less certain. It includes areas with net sedimentation and mixed empirical contaminant trends.
- **Category 3** includes areas where recovery is predicted. It includes areas with minimal to no scour potential, net sedimentation, and empirical trends of decreasing concentrations.

Section 6 provides a detailed discussion of recovery categories, including the methods and criteria for delineating these categories using the lines of evidence discussed in this section. Section 8 uses these recovery categories when assigning remedial technologies.

F.4 Natural Recovery Potential in the LDW Based on Empirical Contaminant Concentration Trends

Empirical information obtained from the LDW is discussed in this section as it relates to ongoing natural recovery. This information demonstrates that sedimentation is occurring and that, in general, total PCBs and other contaminants in the surface sediment are decreasing on an LDW-wide basis. Empirical lines of evidence are summarized in Table F-2 and discussed below. Total PCB and other SMS contaminant trends in resampled surface sediment locations and in the top two intervals of cores were used on a case-by-case basis to adjust recovery category delineations based on physical criteria (Table 6-3). As noted above, areas with decreasing trends were assigned to Recovery Category 3; areas with mixed results were assigned to Recovery Category 2; and areas with increasing trends were assigned to Recovery Category 1.[6]

F.4.1 Changes in Surface Sediment Contaminant Concentrations

Changes in surface sediment contaminant concentrations over time provide a strong indication of natural recovery potential. These changes can be observed in unremediated/undisturbed locations that have been sampled at different times. Surface sediment data presented in this section include:

- Population and location-by-location chemical trends of resampled surface sediment locations site-wide (see Section F.4.1.1)
- Results from established monitoring locations around the perimeter of the Duwamish/Diagonal EAA that have been sampled from 2003 to 2009 (see Section F.4.1.2)
- General temporal trends in surface sediment data collected in and around the Slip 4 EAA (see Section F.4.1.3).

In this analysis, it is important to consider the analytical accuracy and precision when comparing surface sediment contaminant concentrations between locations. Analytical variability between locations can commonly be as high as 25%, even between two analyses of the same sample. Field replicate variability reported in the RI ranged from 8% (arsenic) to 48% (cPAHs).[7] Thus, location-specific conclusions when comparing sample results from one location that were collected at different times, and potentially with different sampling or analysis methods, must be used cautiously. In contrast, comparing populations of resampled data is a more statistically powerful analysis; however, this analysis (evaluation of the entire LDW-wide population) can only lead to conclusions regarding large spatial areas. Therefore, this appendix evaluates recovery at two scales: site-wide trends and location-by-location trends.

[6] These criteria were generally used to assign recovery categories, but best professional judgment was used in some of these assignments, for example when ongoing sources may have been contributing to mixed chemical trends. Category 3 can also include empirical trends demonstrating a mixture of decreasing contaminant concentrations and equilibrium. Predictions of future sediment conditions based on the BCM were not used in the assignment of recovery categories.

[7] Field replicate variability for total PCBs was 39% and for BEHP was 18%. These findings are reported in Section 4.2 of the Final RI (Windward 2010).

F.4.1.1 Analysis of Resampled Surface Sediment Locations

Evidence of natural recovery was based on surface sediment locations that have been resampled (newer stations needed to be within 10 ft of the original sampling location). Seventy locations have been resampled at various times for PCBs. Older data at each location were collected in 1991 through 2006, while the newer data were collected in 1998 through 2008, with an average time interval of seven years between samples at any location. Locations resampled for arsenic, cPAHs, and BEHP are also discussed herein; however, fewer locations were compared for these COCs (n = 56, 53, and 53, respectively) because some of the older samples were analyzed only for PCBs.

F.4.1.1.1 Analysis of Population Trends for Resampled Locations

Generally, observations of increasing or decreasing concentrations (i.e., trends) at resampled locations vary by COC and location (see box plot Figures F-3a and F-3b and Table F-4a).

Of the 70 locations where resampled data are available for total PCBs, summary statistics were generated for 67 locations,[8] with the older data being summarized separately from the newer data at each location. Comparison of the total PCB summary statistics of the newer data to the older data (for the 67-location dataset) revealed a 62% decrease in the mean total PCB concentration. As shown in Table F-4a, the 25th and 90th percentiles of these datasets also decreased by more than 30% and 60%, respectively. These data show that, on average, areas with both high and low initial PCB concentrations are experiencing recovery.

Summary statistics were also developed for 53 to 56 locations for arsenic, cPAHs, and BEHP. For arsenic, these data show that concentrations remain relatively unchanged, while concentrations of cPAHs and BEHP exhibit decreases at resampled locations, especially at stations with higher initial concentrations. The means for the cPAH and BEHP datasets decreased by 72% and 63%, respectively (Table F-4a).

These datasets were also evaluated for significant differences between the older and newer populations of data through a Wilcoxon-Mann-Whitney test (Table F-4b). The test found that the older datasets for total PCBs (70 locations) and arsenic were not significantly different from the newer datasets for these two risk drivers. However, when three total PCB samples at RM 3.7E were excluded,[9] and the populations were compared in a hypothesis test that assumes the samples are paired (related), a significant difference was identified for total PCBs. The box plot (Figure F-3a) illustrates lower concentrations in the newer data as compared to the older data for both data

[8] Three outlier samples at RM 3.7E were removed from the dataset because the statistical software ProUCL identified them as outliers (using the Rosner test). Statistics were run with and without the outlier data points.

[9] Maximum value of newer data when all locations were included was 13,000 µg/kg dw. When the three outliers are excluded, the maximum value of the newer data was 5,100 µg/kg dw.

treatments (i.e., one dataset with all samples included [n = 70] and one dataset with the three outliers removed [n = 67]).

The differences between the older and newer populations of cPAH and BEHP data are significant (Table F-4b). Although, on a population basis, these COCs display significant decreases, they have fewer individual locations that exhibit decreases (≥50%) compared to the total PCB trends (as discussed in the following section). This is likely due to localized effects from ongoing sources.

Resampled surface sediment locations with total PCB data were also evaluated on a reach-by-reach basis (Figure F-3b). Within each reach, the population of data is trending toward lower concentrations, with the greatest decrease in concentrations observed in Reach 3.

F.4.1.1.2 Location-by-Location Comparisons at Resampled Locations

In areas where net sedimentation is occurring, it is expected that historically-elevated concentrations will decrease over time, unless a nearby ongoing source is identified or the surface has been disturbed. Further, in areas where the older concentrations were comparatively low, either little or no change in concentrations is expected. Figure F-4 and Table F-5a show changes in total PCB concentrations at resampled surface sediment locations. Locations were also evaluated for temporal changes in arsenic, cPAH, and BEHP concentrations (Figures F-5 through F-7, respectively, and Tables F-5b through F-5d, respectively). Trends were evaluated at each resampled location for any SMS contaminant (other than total PCBs, arsenic, or BEHP) with a detected sediment quality standard (SQS) exceedance in either the older or newer sample (Tables F-5e and F-5f, respectively).

Defining a Percent Change for Sample-to-Sample Results

If concentration changes for the resampled locations are small, it can be difficult to discern if the change is significant. These locations may be in equilibrium; slight increases or decreases may result from site heterogeneity, analytical variability, or ongoing sources. In Tables F-5a through F-5f, which display concentration changes on a location-by-location basis, concentration changes must be greater than 50% for the location to be considered as exhibiting a decrease or increase. The location is described as being in equilibrium when concentration changes are less than 50%.

Among samples with numerous SMS exceedances, concentrations were categorized as decreasing if all SMS contaminants with detected SQS exceedances had concentration decreases of 50% or more. This degree of change is an indication that natural recovery might be occurring in the sample area. Locations with concentration changes of less than 50% and those with mixed results by SMS contaminant were identified as "equilibrium/mixed." See Section F.7.1 for a discussion of uncertainty in distinguishing trends between paired samples.

Total PCBs

For the total PCB dataset (a total of 70 resampled locations), 60 of the locations include data collected 5 or more years apart (Table F-5a). For locations where total PCB concentrations exceeded 1,300 micrograms (µg)/kg dw in the initial sample (11 locations with 5 or more years between samples), recovery trends for 10 of the locations are pronounced (decreases ranged from 56% to 98%). For locations where the original total PCB concentration was between 240 and 1,300 µg/kg dw (17 locations with 5 or more years between samples), 7 show recovery trends (greater than 50% decrease), 6 show minimal change, and 4 show concentration increases (by at least 90%).[10]

For locations where the original total PCB concentration was below 240 µg/kg dw, most locations are in equilibrium or have concentration increases. When initial concentrations are lower, recovery is less evident because:

- A 50% concentration change relative to a low initial concentration, especially at concentrations below 100 µg/kg dw, may be within the range of analytical variability. Detection at low concentrations may be beyond the precision of some analytical techniques (i.e., some techniques are not able to accurately quantify concentrations this low).
- Concentrations of newly deposited sediment are similar to existing bed sediment. Because recovery is largely based on burial by cleaner sediment, when the difference in concentration between the initial bed sediment and the incoming deposited sediments is low, the decrease in bed sediment concentration from deposition of this incoming sediment will not be substantial. At low concentrations, an area may be considered "in equilibrium" with surrounding sediment concentrations.

When PCB trends are reviewed on a reach-by-reach basis, it is clear that the greatest rate of recovery is observed in Reach 3, and the lowest rate of recovery is observed in Reach 2 (Table F-5a; Figure F-3b). However, all three reaches show increases and decreases in concentrations at individual locations. Reach 3 has the highest percent reduction in total PCB concentrations (90% decrease in average initial concentration compared to newer concentration). Reach 2 has a higher percentage of sample locations with no significant change compared to other reaches (only 29% decrease in the average PCB concentration); this area exhibits the most net erosion and the greatest number of hot-spot areas. These observations align with the CSM, which identifies Reach 3 as having both high net sedimentation rates and as receiving sediment sourced from upstream, and Reach 2 as experiencing both significant high-flow scour and lower sedimentation. However, locations in all recovery categories, even in areas subject to

[10] Only the surface sediment locations with SQS exceedances in either the older or newer sample were used in the delineation of recovery categories and shown in Figure F-8 and Figures F-22a through F-22c.

scour (Recovery Category 1), are showing decreasing concentrations in samples collected (on a location-by-location basis; Table F-5a).

Other Risk Drivers

Sample locations with higher initial concentrations showed the greatest concentration decreases, especially for historical industrial chemicals (e.g., PCBs). On the other hand, sample locations with mixed results (meaning some increasing concentrations and some decreasing concentrations) are generally observed for urban-related, non-point source contaminants, such as cPAHs and BEHP. At lower concentrations, it appears that a state of equilibrium is reached where concentrations change by less than 50% within sample pairs.

Table F-5b illustrates that arsenic samples are generally in equilibrium, with some decreases noted at higher concentrations, above the cleanup screening level (CSL) of 93 mg/kg dw. Table F-5c illustrates lower concentrations for cPAHs among new samples compared to older samples for concentrations above about 500 µg toxic equivalent (TEQ)/kg dw. Most cPAH samples below a starting concentration of 500 µg TEQ/kg dw are at equilibrium.[11] This equilibrium may change in the future as source control and sediment cleanup efforts continue. Table F-5d illustrates steadily decreasing BEHP concentrations at most locations that were above 460 µg/kg dw. Samples were also grouped by reach and by recovery category with similar results.

As shown in Table F-5e, most concentrations have decreased over time (at least 50% concentration change) in the resampled locations where the older samples had SQS exceedances. For locations having SQS exceedances in the newer sample, concentration changes were either increasing or in equilibrium. Many of the newer samples were analyzed for benthic toxicity and have passing results (Table F-5f). Of the 58 resampled surface sediment locations evaluated for trends in SMS contaminants other than total PCBs, 38 had an SQS exceedance in either the older or newer sample. Of those 38:

- Eighteen have decreasing trends (>50% decrease) for all SMS contaminants evaluated (i.e., all SMS contaminants, except total PCBs, with SQS exceedances).
- Eleven have increasing trends.
- Nine have either mixed results or are in equilibrium (Figure F-8). Of these nine locations, five have mixed results.[12] One location has benzyl alcohol decreasing and 2,4-dimethylphenol increasing.

---

[11] Most locations with starting concentrations below 500 µg TEQ/kg dw are coded white in Table F-5c either because the change in concentration is at equilibrium (less than 50% change) or because fewer than 5 years have elapsed between sampling events.

[12] At some locations, PAHs were decreasing while phthalates were in equilibrium; other locations showed the reverse.

Summary

Based on these results, recovery is expected to certain degrees for all of the contaminants evaluated. However, how much concentrations of certain contaminants can decrease is likely limited because some occur naturally in soils and sediment (e.g., arsenic); some are in watershed soils from atmospheric deposition of particulates from emissions (e.g., arsenic, dioxins/furans, and cPAHs); or some are released from nonpoint urban sources (e.g., cPAHs, dioxins/furans, and phthalates). Discussions of recontamination and potential recovery limits are presented in Appendix J.

Sample locations with concentration increases[13] are generally within areas with ongoing sources and/or exhibiting low sedimentation rates. These areas are also generally not predicted to recover based on BCM outputs. These areas are designated as Recovery Category 1 (Section 6) and are prioritized for active remediation in the remedial alternatives presented in this FS. Where increasing empirical trends are outside of Recovery Category 1, these trends are believed to be due to ongoing sources, not due to internal mechanisms, such as scour.

F.4.1.2 Duwamish/Diagonal Trends

Monitoring data collected around the Duwamish/Diagonal EAA cleanup action lend empirical support to natural recovery occurring in the LDW. This project involved a combination of dredging and capping in 2003 to 2004, and thin-layer sand placement (ENR) in 2005. Surface sediment chemistry is being monitored on and adjacent to the actively remediated areas of this EAA. This section presents surface sediment chemistry data collected peripheral to the actively remediated area (Figure F-9 and Table F-6).

These data suggest that contamination from resuspension and dispersal during the dredging operation may have been responsible for total PCB concentrations increasing for a year after dredging and then recovering to predredge concentrations. Overall, total PCB concentrations have declined by 50% or more at five of the eight perimeter locations, presumably as a result of natural recovery processes. Although four of the eight stations remained at or above the SQS (12 mg/kg organic carbon [oc]) for total PCBs in 2009, concentrations are decreasing over time (Table F-6). The average concentration of the perimeter stations graphed in Figure F-9 had already decreased (after 5 years) to below modeled predictions of recovery 10 years following remediation (Stern et al. 2009).

Location DUD_8C is notable because, although it has a 47% concentration reduction from 2003 to 2009, it had a considerable concentration increase in 2009 compared to other years post-ENR (2006 to 2008). This location has been used repeatedly for the collection of both parent and field replicate samples (10 double Van Veen grabs for each

[13] Figures F-4 through F-7 display resampled locations by the absolute concentration changes. Figure F-8 and Tables F-5a through F-5f display percent change in concentration (minimum of 50%) relative to the starting concentration.

monitoring period). A depression formed in this area may be due to the volume of sediment removed during these monitoring events. Other possible explanations for this depression include disturbances from tug traffic and from tidal action. A comparison of 2004 to 2009 bathymetry in the *Duwamish/Diagonal Sediment Remediation: 2009 ENR Physical Monitoring* Memorandum (Anchor QEA 2009; Appendix A of King County 2010) reveals a small area of deepening bathymetry in this general location. It is believed that data in this area represent contributions from older sediment that was below recently deposited sediments but has been exposed. Unpublished PCB data from 2010 sampling at this location indicate that the total PCB concentration had decreased by approximately 67% from that observed in 2009 (personal communication, D. Williston 2010) indicating the area is continuing to recover after the episode that exposed higher subsurface contamination.

Table F-6 also displays trends in the eight perimeter monitoring locations for arsenic, cPAHs, and BEHP. All samples collected in 2009 have arsenic concentrations that are below the SQS, and arsenic concentrations are decreasing over time at six of these locations (from 2003 to 2009). cPAH concentrations are decreasing over time at all locations. For BEHP, one of the eight perimeter stations exceeded the SQS in 2009. Seven of the eight perimeter stations have post-remediation BEHP concentration decreases (more than 50%) from 2003 to 2009, and five of the 2009 samples were undetected for BEHP. This overall trend is used to assign this area to Recovery Category 3.

F.4.1.3 Slip 4 Population Trends

Additional empirical data supportive of natural recovery occurring in the LDW are available from the Slip 4 surface sediment dataset, as shown in Figure F-10. This figure shows where surface sediment samples were collected and analyzed for total PCBs within Slip 4. These data were divided into two groups, representing conditions observed before 1999 and conditions observed in 2004. The two datasets were analyzed statistically and determined to be significantly different ($p<0.05$; Mann-Whitney two-sample test). The mean total PCB concentration in the 2004 dataset (1,400 µg/kg dw) is less than one-half the mean concentration of the pre-1999 dataset (3,300 µg/kg dw). Although the samples are not co-located, these two groups of samples reveal concentration decreases over time, and this trend is used to assign this area to Recovery Category 3.

F.4.2 Contaminant Concentration Trends with Depth

Profiles of contaminant concentration with depth (and therefore time) are an additional line of evidence for natural recovery. Empirical evidence of temporal trends in contaminant concentrations was evaluated as a separate line of evidence in two ways:

- In the sediment cores collected in 2006 for the RI, the peak concentration of total PCBs was identified, and a percent reduction was calculated for those cores having buried peaks. This evaluation provided evidence of long-term trends and reveals the history of contamination through the depth of the core. The depths corresponding to PCB introduction (1935), peak use (1960s and 1970s), and ban/source control (1980s and later) can be identified. They were used to identify chemical markers for estimating net sedimentation rates, discussed in Section F.3.1.2. This evaluation has limited use for predicting future chemical trends because the reduction from the time of peak use of PCBs (1960s and 1970s) was largely because of the PCB manufacturing ban in 1979 and nationwide regulations on the discharge of pollutants. Therefore, this particular evaluation (looking at deeper intervals) was not used to assign recovery categories, which are based on more recent recovery trends (since the 1980s).

- In all cores with adequate sampling resolution by depth, trends in the top two (shallowest) intervals were evaluated for total PCBs and for any SMS contaminants with detected SQS exceedances. The trends in the shallow sediment are assumed to continue into the future and were used to assign recovery categories. They represent a best estimate of changes in contaminant concentrations following the implementation of nationwide source control regulations and chemical bans (post 1980). These data were one criterion used in assigning recovery categories.

The rate and magnitude of concentration change may differ between the historical peak use time period (1960s through 1970s) and the more recent time period (post 1980s) because major source control efforts were implemented in the 1980s. Therefore, the first analysis was conducted to evaluate overall time trends, focusing on total PCBs, which have a distinct historical high use period prior to the production ban in 1979. The second analysis was conducted to evaluate recent time trends. It can be expected that trends observed in the shallowest two intervals of cores may continue into the future.

F.4.2.1 Percent Reduction of Total PCB Concentrations in Cores

PCB trends by depth in the sediment cores collected in 2006 for the RI were used to calculate percent reduction as evidence of long-term natural recovery trends and were used as chemical time markers for estimating net sedimentation rates (Section F.3.1.1). The maximum concentration within each core was found, regardless of depth. That maximum concentration must be at least twice the concentrations at shallower intervals, otherwise the core was considered to have no strong trend. Selected example profiles are shown in Figures F-11a through F-11c. These figures illustrate that core profiles can be a valuable visual tool to help understand natural recovery potential, and that multiple lines of evidence should be used to evaluate natural recovery potential. In this case, contaminant profiles, radioisotope profiles, and net sedimentation rate estimates are used collectively to inform the CSM. Where PCB peak concentrations occurred at depth in cores, the observed percent change was calculated by first subtracting the total

PCB concentration in the top interval from the peak concentration at depth and then dividing that difference by the peak concentration using Equation F-1:

$$PR_{core} = (C_{peak} - C_{top}) / C_{peak} \times 100 \qquad \textbf{Equation F-1}$$

Where:

PR_{core} = percent change in total PCB concentration (%)

C_{peak} = peak or maximum total PCB concentration in a core (µg/kg dw)

C_{top} = total PCB concentration in the top interval of the core (µg/kg dw)

Data were analyzed at 1- or 2-ft intervals (considered "low resolution" data) in all sediment cores collected in 2006 for the RI, and at 0.5-ft intervals (considered "high resolution" data) in a subset (of seven cores) with 2-ft data. In the sediment cores collected in 2006 for the RI, samples were collected either at 1-ft or 2-ft intervals. In those with 2-ft interval data, samples collected at 0.5-ft intervals were archived. The finer resolution data were generated for seven cores in a second round of analysis after the contaminant trends in the 2-ft sample intervals were evaluated. Cores with finer sampling intervals (0.5-ft) were used to refine the contaminant trends in the top 2 ft; trends were analyzed at the 0.5-ft scale in this appendix.[14] The Table F-7 series describe the cores for which:

- Total PCB recovery trends were discernible (subsurface PCB peaks) (Table F-7a).
- There were no strong trends (concentrations were low throughout the core) (Table F-7b).
- The highest concentrations were in the surface intervals (Table F-7c).

Sediment cores where decreasing total PCB trends by depth could be calculated (Table F-7a; a total of 24 cores) were typically located in areas where the STM predicted high percentages of Green/Duwamish River sediment and low percentages of bed sediment after 10 years (i.e., contaminated sediment was likely buried and/or surficially mixed). The highest total PCB concentrations were typically at depth (ranging from 2 to 8 ft below the mudline), with markedly lower concentrations in the surface interval (and in

[14] Sometimes, lower resolution data would indicate that the peak concentration was in the surface interval; however, when the high resolution data were considered, the peak was found to be below the surface. For example, 5 of 7 cores having both high and low resolution data had peaks in the subsurface using the 0.5-ft (high) resolution data, but the lower resolution data led to the conclusion that the peak was in the surface interval. The low resolution data (i.e., 1- to 2-foot intervals) were not fine enough to reveal the true depth of the peak.

other shallow intervals). For these cores, most of these empirically derived percent reductions ranged from 50% to approximately 95%.[15]

For those cores with no discernible trend (Table F-7b), most are in Recovery Category 3 and have contaminant concentrations in the top two intervals (total PCBs and other SMS contaminants) that are below the SQS or are in equilibrium. Although these cores do not exhibit decreasing concentrations, the areas represented by these cores are designated as Recovery Category 3 because of the absence of scour or other physical criteria that would preclude recovery (such as berthing areas). Empirical data for detected SMS contaminants exceeding the SQS were used on a case-by-case basis to override physical criteria that could suggest recovery was not occurring (for example moving an area from Recovery Category 1 to 2), but cores exhibiting equilibrium were not used to place areas in more restrictive recovery categories when scour or berthing areas were absent. Those cores without discernible trends that are in Recovery Category 1 are either actively remediated by Alternative 2 or have low enough surface sediment concentrations that they are not included in Area of Potential Concern 1 (AOPC 1) (i.e., not actively remediated until Alternative 6).

For those cores with the highest concentration in the surface interval, additional details are provided in Table F-7c, including whether scour is predicted or whether co-located surface sediment samples have lower concentrations. Often these cores are near EAAs, in potential scour areas, or in areas with low estimated net sedimentation rates. These cores are also often located in areas of the LDW not expected to recover naturally and are designated for active management under most remedial alternatives.

The F-7 table series also identifies the recovery category (Section 6), the remedial alternative when the core is first actively remediated (Section 8), and the trends for total PCBs and other SMS contaminants in the shallowest two intervals (see next section). Core data with subsurface peaks (Table F-7a) show that Recovery Category 1 assignments are fairly conservative (because active remediation is designated for some areas showing evidence of natural recovery) and that some recovery may be occurring over a longer period in some of the areas designated as priority cleanup areas.

In Table F-7c, the inverse is also true. Many of the higher surface concentrations are decreasing rapidly (at higher rates) and therefore have been assigned to Recovery Category 3, but are nevertheless prioritized for active remediation because of high concentrations. Figure F-12 shows decadal changes in total PCB concentrations based on net sedimentation rates estimated for the sediment cores collected in 2006 for the RI. These sediment cores typically span a period of about 90 years (~1916 to 2006), with the more recent trends targeted to represent the last 20 years (post 1980), generally observed in the upper 1 to 2 ft of the core. For this analysis, the subsurface peak total

[15] However, it is noted that a particular core must show at least a 50% change (i.e., concentration of the peak is twice that in the shallowest sample interval) to be placed in Table F-5a.

PCB concentration was set to 1960 (peak PCB use), and the core-specific net sedimentation rate was used to assign a period (year) to sample intervals above and below the interval with the peak concentration. Figure F-12 shows that, as expected, average total PCB concentrations increased from pre-industrial times to the 1950s to 1970s and then steadily decreased regardless of the recovery category. Although these decreases were observed in Recovery Category 1, there may be concerns with these areas achieving goals, due to other factors (such as scour), and thus MNR is not assigned in these areas when remedial action levels (RALs) are exceeded (Section 8). These results show general site-wide declines in total PCB concentrations since the 1960s and 1970s that correspond with sediment burial and deposition processes (see Section F.3 for physical results and radioisotope profiles).

F.4.2.2 Core Trends in the Top Two Intervals

To assess recent recovery trends, concentration changes were evaluated across the top two intervals within the upper 2 ft in cores (Table F-8). These trends are assumed to be indicative of contaminant conditions following the implementation of nationwide source control actions and chemical bans (targeted to represent 1980s and later) and are assumed to be more indicative of trends expected to occur in the future than trends based on longer time frames.

This analysis uses cores with 1-ft or shallower sampling intervals or with co-located surface sediment locations (167 cores in the FS baseline dataset). If a surface sediment sample was located within 10 ft of a core, that sample was used to represent the shallowest intervals, while the top interval of the core (either a 0- to 1-ft or a 0- to 2-ft interval) was used as the comparison (deeper) interval.[16]

When total PCBs were detected above the SQS in either interval, cores were analyzed for total PCB trends. If any of the other SMS contaminants were detected above the SQS in either interval, core trends were analyzed for those other SMS contaminants (as a group). The analysis was performed for total PCBs separately because PCBs have the potential to show a distinct natural recovery trend over time as the production of PCBs was phased out during the late 1970s, and because PCBs are not a by-product of urban activities (as PAHs are). However, PCBs can be discharged to the LDW through ongoing pathways from historically contaminated media and atmospheric deposition. Increasing PCB concentrations in cores can identify the need for source controls or identify areas subject to scour.

For the SMS contaminant analysis, only cores with detected SQS exceedances (for SMS contaminants other than total PCBs) in either sample interval were used. Those cores without detected SQS exceedances in these intervals are colored green in Figure F-13. The analysis identified the SMS contaminant(s) that exceeded the SQS in either of the

[16] If the core had 0.5-ft data, those samples were used in this analysis for both the shallow and deeper data; co-located surface sediment data were not used if 0.5-ft data were available.

two sample intervals. The percent change in concentration from the deeper interval to the shallower interval was calculated for each SMS contaminant identified using an equation similar to F-1. The concentrations were described as decreasing if all SMS contaminants with detected SQS exceedances had concentration decreases of 50% or more. This degree of change indicates that natural recovery might be occurring in this area. However, if the top interval had higher concentrations, and the percent increase within the core was 50% or more for each SMS contaminant evaluated, the core was classified as having an increasing trend. Concentration changes of less than 50% were identified as "equilibrium." If the SMS contaminants evaluated in a core did not all exhibit the same trend (e.g., some decreased, and others showed minimal change), the core was classified as having mixed results.

Of the 167 cores with the appropriate sampling density (i.e., 1- or 0.5-ft sample intervals or a co-located surface sample [that could be compared to a 0- to 2-ft sample]), 122 had at least 1 sample with total PCBs detected above the SQS. Of those 122 cores, 43 had a decreasing total PCB trend; 39 had increasing concentrations; and 40 showed no indication of total PCB trend with depth (i.e., the total PCB percent change was between -50% and +50% and the core is classified as being in equilibrium). Table F-8 includes all data evaluated (i.e., total PCBs in the top two intervals and detected SQS exceedances in the top two intervals). Tables F-7a through F-7c, which describe the total PCB profiles in the sediment cores collected in 2006 for the RI, also identify the trends from this analysis.

Trends for the other SMS contaminants were analyzed in the 165 cores; 57 of these cores had SQS exceedances. Sixty-five percent (108 of 165) of these cores did not have detected SQS exceedances in either interval evaluated, indicating that contamination is fairly localized (Table F-8). Of the 57 cores with SQS exceedances, 9 had a decreasing trend; 14 had an increasing trend; and 10 did not show any trend with depth (equilibrium). Twenty-four cores had a mixture of trends for the SMS contaminants evaluated, indicating a potential source control or recontamination issue for particular SMS contaminants. Of the 38 cores with either increasing or mixed trends, 7 are in EAAs. The most common SMS contaminant groups with increasing concentrations are PAHs and phthalates (Table F-9). Figure F-13 displays these core trends with the recovery categories, most of which are consistent with the CSM.

F.5 Biological Trends

Changes in contaminant concentrations in surface sediments provide empirical evidence of recovery; however, the health of the biota reflects the effects of all of the conditions in the environment. These include the mixture of contaminants present, the grain sizes, bioavailability, water quality, and other factors. Biological data provide holistic evidence of recovery, as opposed to trends for one contaminant, which describe only one component of sediment health. To evaluate biological trends for the LDW, historical trends of recovery (1970s) in fish health and fish tissue concentrations in the LDW were reviewed.

F.5.1 Biotic Health

The health conditions of biota reflect the cumulative effects of stressors in an estuary. Fish collected from the LDW in 1974 and 1975 exhibited high incidences of tumors, liver abnormalities, lesions, elevated concentrations of marker chemicals (potassium and cholesterol signaling cellular damage and liver malfunction, respectively), and fin erosion disease. Bacteria swabbed from the skin of fish collected in the LDW during this study were at concentrations (bacteria per square cm of fish surface area) 5- and 10-fold higher than those on fish collected from Alki Point and West Point, respectively (Miller et al. 1976, Miller et al. 1975). Although a comparable, quantitative study has not been conducted in the past 10 years, fish lesions and fin erosion were not visually observed or recorded during the RI tissue collection efforts in 2004 through 2007.

In another study, Harper-Owes (1982) documented decreases in biotic abnormalities, primarily incidences of fin erosion, over time. Observations of fin erosion on starry flounder were at 15.6% (i.e., the percentage of fish caught with observed abnormalities) in the 1966 to 1971 period, 10.3% in the 1974 to 1976 period, and 2.9% in the 1978 to 1980 period. Studies hypothesized that fin erosion disease was sediment-related because higher frequencies of fin erosion were observed on fishes' bottom fins (e.g., pelvic fins), which are in contact with sediment. Fins on the sides and top of the same fish, which are usually in contact with surface water (e.g., dorsal fins), had less observed erosion (Miller et al. 1976, Miller et al. 1975). As evidence of improvements in the LDW over time, fin erosion was not observed or documented during the RI tissue collection efforts. Some of the decline may be due to differences in sampling methods and different histological criteria; however, the data suggest a notable decline in disease, coincident with a reduction in pollutant inputs to the LDW (Harper-Owes 1982).

Tetra Tech (1988) cited cancerous liver tumors in 16% of English sole caught in "contaminated areas" of Elliott Bay and the LDW, whereas these lesions were absent in fish caught in relatively uncontaminated areas.

PAH-related liver disease in English sole has been monitored in Elliott Bay for more than 17 years (1989 to 2005) through the Puget Sound Ambient Monitoring Program. During this time, declining trends were observed in Elliott Bay, with the incidence of liver disease declining sharply from 1999 to 2005 (Puget Sound Action Team 2007). Although these studies do not document the same types of tests, species, or exact spatial areas, they describe the general improvement in the health of Elliott Bay related to control of pollutant sources, resulting in natural recovery of the sediments. This FS assumes that practices that improve the health of Elliott Bay may also be affecting the LDW, or that improvements in Elliott Bay could be indicative of improvements in the discharges from the LDW.

F.5.2 Tissue Concentrations

Harper-Owes (1982) also reported declines in total PCB concentrations for whole-body English sole, Pacific staghorn sculpin, and starry flounder collected from the LDW during the 1972 to 1979 period. Total PCB concentrations in English sole collected in the LDW from 1972 to 1975 averaged 1,700 µg/kg wet weight (ww), whereas total PCBs were undetected in those species collected from other estuaries during that time. Data from this period suggested a half-time (number of years required to reduce the concentration by 50%) in tissue concentrations of approximately 3.4 years (± 1.1 years). The long-term trend in the data suggests a drop in average concentrations in fillets from 1,760 µg/kg ww in the early 1970s to 350 µg/kg ww in 2007 (Figure F-14 and Table F-10). However, year-to-year comparisons of tissue data must be interpreted with caution because some historical data were collected in different portions of the LDW, in different seasons, for different size fish, and using different analytical methods.

It is noted that short-term PCB releases associated with more recent contaminated sediment dredging projects (e.g., Duwamish/Diagonal EAA, East Waterway, Lockheed, and Todd Shipyards) may have resulted in a temporary increase in fish tissue PCB concentrations in 2004. This temporary increase returned fish tissue PCB concentrations to historical concentrations, tissue concentrations then declined over the next several years (Stern 2007). Lipid-normalized monitoring data (Figure F-15) indicate that fish tissue total PCB concentrations declined from 1997 to 2007 and may not show a dredging-related 2004 spike. While this trend in the lipid-normalized data is obscured by the high variability in the 1997 lipid levels, the time series data still suggest that the dredge events may have had a short-term effect on the tissue concentration trends. This observation is consistent with fish tissue contaminant concentrations documented at other sites following dredging (NRC 2007).

F.6 Use of Predictive Tools – the BCM

Over most of the LDW, both empirical data and model estimates either provide evidence of, or are used to predict, natural recovery of legacy contaminants, primarily through deposition, vertical mixing, and burial.

While empirical data are valuable to use in determining past trends, they have limited use in predicting future conditions. Because of this, the BCM was developed as a tool to predict contaminant recovery as a function of location and time within the LDW. In this FS, the BCM predicts changes in surface sediment contaminant concentrations in specific areas and on a site-wide basis for the LDW. The STM is run continuously over a 30-year period to estimate scour potential, net sedimentation rates, and the future composition of surface sediment. Future surface sediment is represented by contributions from three sources: the LDW bed at the time the model period begins, lateral sources (storm drains, CSOs, and streams), and upstream from the Green/Duwamish River.

Using output from the STM at 5-year intervals, the BCM applies contaminant concentrations to these three sediment sources, as described in Section 5 and Appendix C. Model-predicted trends for total PCBs, arsenic, cPAHs, dioxins/furans, BEHP, and SMS contaminants are described below as a line of evidence for recovery potential. These trends are based primarily on sedimentation rates, scour potential, and incoming contaminant concentrations. These model predictions were used to assign remedial technologies for alternatives (Section 8). Predictions are applied at two spatial scales: 1) spatially-weighted average concentrations (SWACs) applied either site-wide or to specific areas, and 2) concentrations at discrete points for SMS contaminants (see Section F.6.1.5).

Similarly, predictive tools are being used to assess natural recovery at several other complex sediment sites including the Passaic River (NJ; EPA 2007), the Lower Fox River (WI; RETEC 2002), the Housatonic River (MA; Weston 2006), and the Portland Harbor Superfund Site (Lower Willamette River, OR; Anchor 2005). Predictive models are used to determine whether past reductions in contaminant concentrations (where sources have been controlled) can be expected to continue or may need to be augmented in the future with further source controls. The modeling efforts can range from extrapolation of historical trends into the future (where conditions are expected to be the same) to the use of computer models of varying complexity. Both empirical and predictive modeling tools are used in this FS, consistent with EPA guidance (EPA 2005) and the state-of-the-science being used at similar sites.

F.6.1 Model Predictions within 10 Years

As discussed in Section 5, the BCM is a spreadsheet-based tool that uses ranges of contaminant concentrations on upstream and lateral sediments to predict future surface sediment concentrations in 10 ft x 10 ft model grid cells at 5-year intervals. (Output is exported from the STM at 5-year intervals and used as input in the BCM. The BCM uses STM predictions of the sediment sources in each grid cell to predict future surface sediment concentrations for each 5-year interval [see Section 5].) These predictions are then converted into SWACs for the four human health risk drivers (total PCBs, arsenic, cPAHs, and dioxins/furans) to assess the ability of each remedial alternative to achieve the preliminary remediation goals (PRGs). The other SMS contaminants are spatially interpolated as Thiessen polygons, with the polygon being mapped, not by concentrations, but by one of three categories based on the maximum exceedance of the SQS for any SMS contaminant: pass, >SQS, and >CSL.

The results of this analysis, using the recommended (mid) input parameters 10 years after completion of Alternative 1 (the EAAs), are discussed below and shown in Figures F-16 through F-20 for total PCBs, arsenic, cPAHs, dioxins/furans, and SMS contaminants, respectively. Note that these results reflect no active remediation in areas outside of the EAAs; they are just a model prediction of what natural recovery could achieve for the LDW. In general, the model predicts recovery for the risk drivers. The

BCM does not account for potential recontamination of sediments adjacent to the EAAs by dredging residuals.

F.6.1.1 Total PCBs

Ten years following completion of Alternative 1, the total PCB SWAC is predicted to decrease by 60% (from 180 to 73 µg/kg dw; Figure F-16).[17] Total PCB percent reductions as high as 97% were predicted in some grid cells. Where little or no reduction was predicted, the starting grid cell (bed sediment) concentration was typically low, such that the total PCB concentrations associated with upstream-sourced sediments was not significantly lower. Alternatively, the BCM predicts concentration increases in some areas because the STM estimates the grid cell will receive a substantial amount of sediment from lateral sources or will retain a large proportion of the original bed sediment (net sedimentation less than 1 cm/yr) over the 10-year model time frame.

F.6.1.2 Arsenic

A similar analysis completed for arsenic predicted about a 30% reduction in the site-wide SWAC within 10 years (from 16 to 11 mg/kg dw) (Figure F-17). Most grid cells show minimal change in concentrations (equilibrium) because arsenic baseline (Year 0, the model starting point) concentrations are not elevated in most areas.

F.6.1.3 cPAHs

The site-wide reduction for cPAH SWAC is about 55% within 10 years (360 to 160 µg TEQ/kg dw) (Figure F-18). Although sedimentation is a strong factor governing natural recovery in the LDW, recovery is realized only when the depositing materials have lower concentrations of PAHs and the bed remains stable. With contaminants entering from diffuse urban watershed sources, recovery relies on practices that limit inputs from nonpoint sources. PAH contributions from urban sources were discussed in Section F.2.

F.6.1.4 Dioxins/Furans

For dioxins/furans, the BCM predicts that the average concentration in the LDW would decrease by almost 70% within 10 years (from 24 to 7.9 nanograms [ng] TEQ/kg dw) (Figure F-19).[18]

---

[17] Percent reductions in total PCBs over 10 years were determined by comparing concentrations predicted by the BCM starting at current conditions (Year 0) to conditions at the end of 10 years. These predictions were made assuming some level of source control, and assuming that the EAAs have been completed.

[18] The dioxin/furan concentrations displayed in Thiessen polygons were converted to spatial data simulating a 10′× 10′ raster so that these data could be evaluated in the BCM spreadsheet platform in the same manner as the other risk drivers. This is necessary because the STM grid cells don't align with the Thiessen polygons. The map of 10-year predictions (Figure F-19) thus looks similar to the inverse distance weighting interpolations shown for the other risk drivers whose BCM outputs have different predicted contaminant concentrations within the same Thiessen polygon in 10 years.

F.6.1.5 Other SMS Contaminants

The BCM can also be used to predict future SQS and CSL exceedances. Of the 224 stations outside of the EAAs with detected SQS exceedances (of any SMS contaminant[19]), the BCM predicts that 67 of the stations with exceedances would continue to exceed the SQS after 10 years (Figure F-20), and 34 of the stations would continue to exceed the SQS after 30 years. The BCM was run only for locations with detected baseline SQS exceedances based on chemistry and toxicity results (when available), i.e., locations that passed toxicity tests were not included. Specifically, a location with an SMS contaminant exceedance but a toxicity pass was not considered to have an SQS exceedance, and was not modeled by the BCM. Conversely, locations with SMS contaminant passes but toxicity exceedances are considered exceedances for this FS; however, predictions for these locations could not be modeled because the BCM predicts future surface sediment contaminant concentrations but cannot predict future toxicity test results.

F.6.2 Empirical Trends Compared to Model Predictions

Empirical trends for total PCBs and other SMS contaminants were compared to the BCM predictions to find areas where natural recovery predictions are uncertain (Figure F-21). In general, both the model predictions and the empirical data suggest that recovery is occurring. Most of the empirical data exhibited contaminant decreases at locations that coincided with model predictions of natural recovery. Locations with increasing contaminant trends were frequently coincident with locations that have STM-predicted high-flow scour deeper than 10 cm, low net sedimentation rates, or inputs from lateral sources. This is consistent with the expectation of limited recovery potential under those conditions.

The following factors may play a role in areas where the empirical trends and the BCM predictions do not match:

- The STM may not have adequate fine-scale resolution to account for small-scale processes, such as near-field effects near outfalls or around in-water structures.

- There is uncertainty in the contaminant concentrations associated with the BCM input parameters, which are not varied spatially (e.g., across outfalls, by deposition patterns, or by grain sizes of transported material) or temporally (e.g., for differing flow conditions, tidal stages, seasons, and over time as inputs could change).

[19] This evaluation includes total PCBs and arsenic, which are managed on a point basis for remedial action objective (RAO) 3 (for which they are benthic invertebrate risk drivers). These two contaminants are also human health risk drivers, and are managed on a spatially-weighted area-wide basis for the other RAOs.

- The STM can under- or overpredict sedimentation in areas containing overwater structures that the model does not account for or in areas with vessel scour.

Figures F-22a through F-22c illustrate the areas where scour is expected from high-flow events and maneuvering vessels (see Section 5). These figures also illustrate where berthing areas or overwater structures are located. These physical considerations are coupled with empirical recovery data to delineate the recovery categories (right panels in Figures F-22a through F-22c). Although the BCM predictions are not used to delineate recovery categories, most areas where both the empirical data and the BCM predictions match are in Recovery Category 3 and have moderate to high net sedimentation rates with relatively minimal influence from lateral sources.

Figure F-23 compares estimated recovery rates for resampled surface sediment locations to the recovery rates predicted by the BCM for the areas in which the empirical data are located. Estimated recovery rates from high resolution cores are also included. These data show that empirical data support the BCM predictions and that recovery is expected for most locations, based on both the BCM and the empirical data (Figure F-23). In areas where the empirical data and BCM predictions do not match, active remediation is typically called for and source control may be needed.

Natural recovery potential is generally expected to be limited in historically contaminated areas (EAAs, other hot spots) where physical obstructions hinder sedimentation (e.g., around bridge footings) and where high-flow events or vessel scour can cause erosion of the bed sediment. In areas where the BCM predicts recovery but the empirical data do not, vessel scour and physical structures (e.g., dolphins and piers) that are not considered by the model may be causing small-scale effects that impede recovery processes.

F.7 Limitations and Data Uncertainty

Uncertainty is an important consideration in evaluating natural recovery for the LDW, and therefore conclusions must be regarded with caution. A weight-of-evidence approach helps reduce uncertainty because it employs multiple types of information to draw conclusions. These uncertainties and how they are being managed in the FS are discussed in the following sections. Ultimately, long-term monitoring will be required to demonstrate that the LDW is recovering as predicted (EPA 2008b).

F.7.1 Uncertainty in Resampled Surface Sediment Trends

Analysis of resampled sediment locations introduced an element of uncertainty because data may not be truly co-located, but could be up to 10 ft apart.[20] Not all samples were

[20] Due to potential uncertainty in coordinates of historical data, co-located samples may actually be more than 10 ft apart.

collected by LDWG, and thus LDWG relied on the data reports prepared by others to provide accurate positional information. Errors can occur when different horizontal datums are used (because of conversion errors), during transcription into databases, and when positioning a boat over a static location because tidal flows and passing vessel wakes can move sampling equipment off position. The evaluation of these datasets at a population level helps to reduce these uncertainties, yielding conclusions that are useful on a site-wide basis (average condition across the whole site).

In addition, samples were not always analyzed using the same methods. Only data with sufficiently documented and appropriate quality control measures were used in the FS. However, among methods that are recognized as appropriate, variances of up to 25% in the results are not uncommon. These variances can also occur between two analyses of the same sample using the same method. This analytical uncertainty was taken into consideration by defining an increase or decrease as a change of >50% compared to the original concentration. Analytical variability has greater influence on results at lower concentrations. Therefore, empirical trends were only evaluated and mapped (dataset used for recovery categories) where either the initial or ending sample exceeded the SQS for at least one SMS contaminant.

Finally, the LDW surface sediments have a degree of spatial heterogeneity. The RI has shown that chemical gradients can be steep and that hot spots may be isolated and well contained, such that moving several feet off-station can yield different results, even during the same sampling event. These artifacts can mask actual recovery (or concentration increases) occurring in the LDW. This effect supports the use of population averages instead of evaluations of individual points. Population averages are also more relevant when evaluating reductions in the exposure of mobile biota with home ranges near the scale of the LDW; but population averages may not reflect potential effects to sessile biota or biota with small home ranges.

Therefore, the trend analyses are used to provide general evidence of recovery in the LDW. The trends are coupled with multiple lines of evidence, including STM outputs. Additional baseline and long-term sampling will be performed in any areas where MNR is selected as a remedial alternative.

F.7.2 Uncertainty in Core Profiles

The resolution with which net sedimentation rates (based on physical, chemical, and radioisotope time markers) and chemical trends can be discerned in cores is dependent upon the resolution used for collecting these data. Samples composited over 2 or more ft of depth lack spatial resolution when compared to cores with 0.5-ft or 1-ft depth composites. Only seven cores in the dataset have data at a 0.5-ft resolution, and data at this resolution were used when available. These finer resolution data refine the depths and the magnitudes of peak concentrations discerned from lower resolution data. For those cores initially identified as having total PCB peak concentrations in the uppermost sample interval (with low resolution sampling), sampling in 0.5-ft intervals often reveals that the peak is not really in the surface, but is buried by some depth (0.5 ft or more) of sediment having lower concentrations. However, this distinction could only be drawn on the seven cores with high resolution data.

Uncertainty in using the cores for estimating net sedimentation rates is diminished by the use of physical markers in cores and observations of anthropogenic impacts, such as debris, sheen, and odor. These observations are not limited by sampling resolution, because they are based on field observations independent of the resolution of contaminant sample collection. Therefore, the use of multiple lines of evidence to estimate net sedimentation rates (i.e., combining visual evidence with chemical trends and with co-located radioisotope trends) gives greater confidence to these empirical data and reduces uncertainty. Uncertainty is also introduced in core data (visual or chemical) by sample collection methods that result in poor substrate penetration or low sediment yield within the core. The depths at which sediment intervals are collected from or observed in core tubes are the recovered depths. These depths are adjusted to *in situ* depths, meant to describe the actual location of the sediment in the environment, using readings taken during sample collection. Using only recovered depths can either overestimate or underestimate trends from cores. This uncertainty is diminished for the sediment cores collected in 2006 for the RI, as field measurements were carefully recorded so that *in situ* depths could be accurately calculated with confidence. However, for historical cores collected by other parties, recorded *in situ* depths may be less precise or are completely absent.

Uncertainties in core trends can be diminished when co-located radioisotope cores or co-located surface sediment grab samples are available, or when other lines of evidence corroborate findings. In evaluating trends in the top two intervals of the cores for total PCBs and other SMS contaminants, co-located surface sediment locations were used to represent the shallowest interval, when available (if 0.5-ft interval data were available, the top 0.5 ft were used to represent the surface condition rather than a co-located surface sample). Of the cores evaluated in this appendix, 85 have co-located surface sediment data available. An example of co-located surface sediment data clarifying chemical trends can be seen in Figure F-11c where the cores shown in the profiles (SC-51 and SC-52) did not show total PCB concentration changes by depth. Therefore, these cores were placed in the "highest concentration at surface" category. However, when co-located surface sediment data are available, they can show that the top 10 cm have lower concentrations. These cores were therefore mapped as "decreases" using the trends in the top two intervals (with the surface sediment sample being the top interval). Additional lines of evidence are used whenever available to reduce uncertainties.

F.7.3 Scour Uncertainty

Some level of uncertainty exists in identifying areas potentially subject to scour in the LDW, stemming from both the STM and from the visual identification of vessel scour. The STM uses a myriad of input parameters (related to channel dynamics, sediment properties, solids loading, and river flow conditions) to model the movement of sediment in the LDW and the changes in the bed sediment. Various flow conditions and tidal stages can affect sedimentation and scour of the bed sediment. The STM was run with a combination of input parameters that most closely simulated real data. Adjusting any of these parameters could change the location and depth of scour estimated by the STM. The areas identified in Figures F-22a through F-22c are the best estimation from the model of where scour is expected to be deeper than 10 cm during a 30-year simulation based on high-flow conditions. Uncertainty was reduced by using a low-probability, worst–case scenario of high flows and highest tidal exchanges to estimate maximum scour potential in the STM bounding runs.

The potential vessel scour identified in Figures F-22a through F-22c represents observations made on bathymetric data collected during one survey in 2003. These bathymetric data represent a single time point, not an evaluation of changes in bathymetry over time. Further, the spatial coverage of the bathymetric data includes most, but not all, of the LDW. Obstructions such as moored vessels and overwater structures restricted collection of data in some parts of the LDW. Therefore, the areas where observations of ridges and depressions in the sediment bed were made are subject to some judgment and extrapolation outside the spatial extent of the data. These areas were typically extended to the shore (even in the absence of data) and believed to be centered around berthing areas. Further, these are simply observations of where ridges and depressions in the sediment bed existed based on the 2003 bathymetric data. They do not represent unequivocal evidence of scour.

F.7.4 BCM Uncertainties

The BCM was run using a range of concentrations for three input parameters: upstream inflow, lateral inflow, and post-remedy bed sediment replacement values. These data ranges are used to bracket the uncertainty in the long-term model-predicted concentrations. Recommended input parameters were generated by summary statistics from various datasets, discussed in Appendix C of this FS. Each dataset has some degree of uncertainty relating to aspects, such as the matrix from which the sample was collected, the location from which the sample was collected, the time (season, river flow) of sample collection, and other factors. By using several lines of evidence and a range of input parameters derived from these data, the uncertainty is diminished.

How the concentrations of these input parameters may change over time is also uncertain. For example, inputs from upstream and lateral sources could increase as a result of urbanization, or they could decrease as effective source control efforts continue. The ranges of lateral and upstream BCM input parameters were developed to account for future assumptions regarding increases in source control. Section 9 of the FS describes the effects of using ranges of values for input parameters on predictions of sediment recovery following active remediation.

Subsurface sediment could be exposed in the future as a result of construction, vessel scour, or earthquakes. These processes and their potential cumulative effects on the SWAC were not accounted for in the BCM, but Section 9 of the FS evaluated potential exposure of subsurface contamination by disturbances and the effects on PCB SWACs compared to long-term model-predicted concentrations and the time to achieve cleanup objectives.

Uncertainty also exists in locations where the STM resolution may be too coarse to model the effects of structures, like piers, on sediment deposition. Additionally, the STM did not cover the entire FS study area. The STM covers approximately 398 acres of the 441-acre site and ends at RM 4.75 (coverage is from RM 0.0 to RM 4.75). It also does not extend laterally to cover all inlets nor does it reach the shoreline (top of bank) in all places. The STM outputs were extrapolated in these locations to match the FS study area (up to RM 4.75 in the east to west extent). In these areas (where the STM is too coarse and where the STM output was extrapolated), the BCM may under- or over-predict future contaminant concentrations.

F.7.5 Uncertainty of Remedy Reliability

MNR can be a successful remedial technology at complex sediment sites (either alone or in combination with other technologies [Magar et al. 2009]). This evaluation has suggested that natural recovery is occurring in some parts of the LDW and thus MNR is considered with other technologies in this FS.

As discussed in Section 8, the effectiveness of MNR is a key uncertainty for Alternatives 2 through 4. MNR uncertainty was accounted for in this FS by limiting its assignment based on a set of assumptions (e.g., no MNR in Recovery Categories 1 or 2 when RALs are exceeded), and by assuming that a percent of the area assigned to MNR will actually be dredged as a result of remedial design investigations or as a contingency action if long-term monitoring shows that recovery is not occurring as expected. These adaptive management components are included in the cost estimates in Appendix I.

F.8 Summary of Natural Recovery Potential

Over most of the LDW, the five lines of evidence (Davis et al. 2004) suggest that the LDW has the ability to recover naturally in some areas. Both the empirical data and model outputs provide evidence of, or are used to predict, natural recovery of legacy contaminants, primarily through burial and source control. Overall, this appendix provides evaluations that help determine where active remediation is required (i.e., in those areas not expected to recover). The findings that address each of these five considerations (ongoing sources, fate and transport mechanisms, historical record of contamination, biological endpoints, and predictive tools/models) are summarized below for the LDW.

F.8.1 Assessment of Ongoing Sources

Consistent with historical trends observed in Puget Sound, historical point sources (primary sources) of contamination to the LDW have been largely controlled. Ongoing sources continue to a lesser extent due to general urbanization and nonpoint source pathways associated with historically impacted media (e.g., soils in the drainage basin affected by historical spills [secondary sources]).

Source control is imperative to the success of any remediation method, including natural recovery, and an LDW-wide source control program is underway. Where it is difficult to control sources, the effectiveness of remedial alternatives from MNR to dredging can be significantly impeded. The expectation is that source control efforts will be prioritized to match the sequencing of remedial actions so that, once completed, remediated areas will have minimal potential for recontamination (from lateral sources). The LDW source control strategy includes conducting field inspections, assessing sediment and contaminant loads to the LDW, tracing sources through sampling of drainage systems, cleaning out storm and sewer drains, and enforcing the use of BMPs (Ecology 2004). Ecology is also initiating agreed orders with several contaminated properties adjacent to the LDW to conduct RI/FS activities.

PCB contamination is predominantly from historical uses. PCBs are considered legacy contaminants in Puget Sound and the LDW, with peak PCB use occurring in the 1960s and 1970s. Total PCB concentrations have been decreasing site-wide following the federal ban on their production and significant source control upgrades in the 1970s and 1980s. Because primary sources have been controlled, the main focus of the remedial actions will be to address secondary sources and residual contamination in LDW sediments. Some regional sources of PCBs continue to exist, but additional source control efforts and cleanup of sediment and upland hot spots are expected to continue decreasing the surface sediment concentrations of total PCBs over time. However, global and regional atmospheric transport and deposition will continue, as well as low level non-point sources in urban areas. Therefore, PCBs cannot be completely eliminated from the LDW.

Arsenic concentrations are nearing equilibrium, and other risk drivers are derived from ongoing urban sources. Recovery may be less pronounced for contaminants other than PCBs because either they occur naturally in soils and sediment (arsenic and other metals), are in watershed soils from atmospheric deposition of particulates from emissions (arsenic, dioxins/furans, and PAHs), or are released from nonpoint urban sources (PAHs, dioxins/furans, and phthalates). For arsenic, approximately 99% of the LDW is already below the SQS of 57 mg/kg dw. Minimal changes in the average surface sediment concentrations of arsenic are predicted based on elevated concentrations in surrounding soils from historical smelting activities. For PAHs and phthalates, studies have shown that low level (or urban background) concentrations are expected to increase over time as a result of more urbanization. In localized areas, previously elevated concentrations of these contaminants are showing substantial decreases, but are still subject to continued inputs from lateral sources.

Elevated dioxin/furan concentrations are localized. The available data for dioxins/furans in the LDW show that high dioxin/furan concentrations are localized near discrete hot spots and that many other areas have concentrations within the range of upstream inputs. The five highest dioxin/furan sample concentrations are located at stations within the Duwamish/Diagonal EAA, in the embayment at Glacier Northwest (RM 1.4 – 1.5W), and in the Trotsky Inlet (Figures 2-16 and 2-17). Two of the 29 dioxin/furan cores have five-fold higher concentrations at depth (in the 4- to 8-ft depth interval) than in the surface interval (Figure 2-17). The other dioxin/furan cores have similar concentrations throughout their depths.

F.8.2 Physical CSM and Fate and Transport Mechanisms

The primary mechanism for natural recovery in the LDW is sedimentation, and sedimentation rates derived from the model generally correlate with empirically derived estimates. The physical conditions of the LDW are well understood as a result of a well-calibrated hydrodynamic and sediment transport model (QEA 2008). Scour and sedimentation processes are dominated by geomorphology, water depth, and the presence of a saltwater wedge in the downstream portions of the LDW. Over 83% of the LDW is net depositional, with net sedimentation rates greater than 1 cm/yr; the remaining areas are either in dynamic equilibrium or have net scour. Over 75% of the net sedimentation rates estimated from sediment chemistry and radioisotope cores (when rates could be derived) correlated with model predictions. Based on this validation, the STM is a reliable tool for predicting future conditions in the LDW, once contaminant concentrations have been assigned to the particles depositing in the LDW. Because the primary mechanism for natural recovery is burial by cleaner material, the contaminants in solids coming from upstream will likely dominate the level of sediment contamination with time, although lateral sources to the LDW also contribute to sediment concentrations.

Erosional processes are localized and limited to the upper 25 cm; recovery is presumed to be limited in these areas (Recovery Category 1). The effects of high-flow scour events and vessels navigating the LDW represent the principal forces affecting sediment stability. The STM report (QEA 2008) and this FS (Section 5) have identified localized areas with potential scour greater than the active mixing depth of 10 cm. In these areas, fine-grained sediments can be resuspended, mixed, and transported by high bottom velocities. The erosional forces vary with location, water depth, and particle size, but are generally limited in extent. Slightly more than 1 percent (or 5 acres) of the LDW has potential high-flow scour of more than 10 cm, with some subsurface

SQS exceedances subject to this potential scour. These areas, and areas with evidence of vessel scour, have been assigned to Recovery Category 1 and have been prioritized for consideration in the assembly of remedial alternatives. Even so, empirical data have shown that recovery can occur in potential scour areas[21] if net sedimentation rates are sufficient to bury the material of concern eventually (i.e., enough sedimentation occurs between the relatively infrequent high-flow conditions that more than compensates for the erosion that may occur during those infrequent episodic events). Other processes that may affect sediment stability (e.g., anchor drag, barge spudding, navigational dredging) will be managed via institutional controls. Evidence of erosion by vessels in berthing areas was used to assign these areas to Recovery Category 1. Berthing areas without evidence of vessel scour were assigned to Recovery Category 2.

Areas with limited recovery potential are managed by assignment of recovery categories. The physical, empirical, and model-predicted lines of evidence presented in this appendix were collectively evaluated to delineate three recovery categories. These categories represent a best estimate of where recovery is presumed to be limited, less certain, and predicted. Notable differences observed among the various lines of evidence highlight the need to consider multiple lines of evidence when evaluating natural recovery potential at a site, as was done in this FS. The level of effort and the recovery assignments presented in this appendix and in Section 6 are suitable for FS-level analyses. Site managers will use design-level sampling and analyses to clarify these recovery assignments and to select suitable remedial technologies on a small-scale basis before remedial actions occur in the LDW.

F.8.3 Historical Record of Contamination

Concentrations of most risk drivers in surface sediment are decreasing. Among resampled surface sediment locations, the more recent contaminant concentrations are 35 to 60% lower than the older data, depending on the statistic considered (e.g., mean, median, 90th percentile) and the contaminant. The populations of newer total PCB, cPAH, and BEHP data are significantly different (lower concentrations) than those of the older data, indicating overall site improvements. The same general trend is also observed among the sediment cores. In areas assigned to Recovery Categories 2 and 3, the average percent change in contaminant concentrations among resampled stations was greater than 50% (56 to 78% decrease) for total PCBs and cPAHs.[22] The average percent change in areas assigned to Recovery Category 1 was about 10% less than those in the other recovery categories. In EAAs, the average contaminant concentrations among newer samples slightly increased (1 to 20%). Arsenic concentrations in surface

[21] Empirical data demonstrating recovery may be used to assign an area with scour to Recovery Category 2 or 3, as described in Section 6.

[22] Recovery Category 1 = recovery presumed to be limited; Recovery Category 2 = recovery less certain; Recovery Category 3 = predicted to recover.

sediment, however, are in equilibrium. With the exception of small localized areas, minimal change has occurred in arsenic concentrations over time.

F.8.4 Biological Endpoints

Biological conditions have improved since the 1970s. Historical studies from the 1970s documented significant adverse effects in fish caught in the LDW, including lesions, tumors, and fin erosion. Bacterial concentrations were also high in the surface water from raw sewage being discharged directly into the Green/Duwamish River. Source control efforts from the 1980s through today have greatly improved the water quality and tissue contaminant concentrations in the LDW, although year-to-year comparisons of tissue data must be interpreted with caution because some historical data were collected in different portions of the LDW, in different seasons, for different size fish, and using different analytical methods. Elevated fish tissue contaminant concentrations have been recently documented in the LDW (relative to other years), likely caused by exposure to dredge residuals during removal operations (see Section 9). The state-of-the-art dredging operations have improved in recent years with regard to precision dredging and containment, but a small portion of resuspended, fine-grained material will always escape from the dredging operations (see Appendix M, Part 2). Therefore, although natural recovery is occurring, fish tissue concentrations may not always reflect these improvements during the construction period, because if the remedy also includes dredging, dredging residuals affect fish tissue over that period.

F.8.5 Predictive Tools and Models

Areas of the LDW that are not expected to recover naturally are being prioritized for active remediation. Those areas that are not showing recovery (decreasing concentrations) through model predictions, empirical trends, or physical considerations (such as vessel scour) have been assigned to Recovery Category 1. Areas where natural recovery is not expected are typically found in hot-spot areas with high COC concentrations, where physical obstructions can hinder sedimentation (e.g., around bridge footings), or where high-flow events or vessel scour can cause sediment erosion. This appendix supports using active remediation in the areas not expected to recover, and then allowing for natural recovery to achieve cleanup objectives over time.

Reasonably good agreement exists between the model predictions and empirical recovery estimates. The time trend data from resampled surface locations and shallow core trends show that most empirical data support the BCM predictions and that recovery is expected for many areas. The empirical data are typically more variable (greater percent changes in concentrations either higher or lower) than the base-case recommended model predictions.

F.8.6 Conclusions

Using the weight-of-evidence approach, all five considerations evaluated in this appendix independently demonstrate the potential for recovery to occur in many parts of the LDW, suggesting MNR is a viable remedial technology to be used when developing remedial alternatives. Empirical trends show risk-driver concentrations are decreasing in sediment in many areas of the LDW. In areas predicted to show recovery, concentrations are projected to decline to levels that contribute to achievement of cleanup objectives or are trending toward the long-term model-predicted concentrations within 10 to 20 years (when combined in an area-wide or site-wide SWAC with the reductions in other areas modeled to undergo active remediation). This depends upon initial sediment concentrations and other factors (such as net sedimentation rate). Improvements in natural recovery time frames for some contaminants depend largely on the effectiveness of source control efforts. However, as shown by the modeling and empirical data, not all areas of the LDW are expected to recover naturally.

Empirical recovery trends, the CSM, and modeled concentration changes all show reasonable agreement and support using the BCM to predict natural recovery in the LDW. Any recovery expectations will need to be confirmed during remedial design to account for localized physical and chemical conditions in the area being evaluated. Trends identified at particular locations in the LDW (e.g., on the Duwamish/Diagonal cap) may not be indicative of trends that would occur in other areas of the LDW. Areas that are not recovering, or are not predicted to recover, were prioritized for active remediation during development of remedial alternatives and assignment of recovery categories in the FS.

The combined empirical information and predictive tools are considered sufficient for FS assessments of natural recovery potential. However, considerable uncertainties are inherent in natural recovery predictions, particularly when assessing individual locations.

Area-specific natural recovery potential will need to be confirmed during remedial design when MNR is being considered. Periodic monitoring will be required to ensure that MNR is performing as anticipated, and these data should be used to adaptively manage the area through the recovery period. Should monitoring show that recovery is not occurring or is slower than required, contingency actions will be identified.

F.9 References

Anchor Environmental LLC 2005. *Portland Harbor RI/FS Draft Monitored Natural Recovery (MNR) Technical Memorandum – Step 2 Data Evaluation Methods*. Prepared for the Lower Willamette Group. April 2005.

Anchor Environmental LLC and King County 2007. Final *Data Report: Fish Tissue Sampling and Chemical Analysis in the Lower Duwamish Waterway*. Anchor Environmental, L.L.C. and King County Department of Natural Resources and Parks, Seattle, WA. July 2007.

Anchor QEA 2009. *Duwamish/Diagonal Sediment Remediation: 2009 ENR Physical Monitoring Memorandum*. Prepared for Jenée Colton, King County. Prepared by David Gillingham and Clay Patmont, Anchor QEA. Project Number 020067-01. September 3, 2009.

Anchor QEA 2010. *Pre-Remedial Design Investigation Data Report. Whatcom Waterway Site Cleanup*. Prepared for the Port of Bellingham. Prepared by Anchor QEA in association with KPFF Consulting Engineers, Coast & Harbor Engineering, Wilson Engineering, Blumen Consulting Group, and BST & Associates. August 2010.

Battelle 1996. *Final Report for the PCB Aroclor and Congener Analyses on Fish Tissue Samples from the Elliott Bay/Duwamish River Project*. Pacific Northwest Division, Battelle Marine Research Laboratory, Sequim, WA. February 7, 1996.

Brandenberger, J.M., E.A. Crecelius, and P. Louchouarn 2008. Historical Inputs and Natural Recovery Rates for Heavy Metals and Organic Biomarkers in Puget Sound during the 20th Century. In: *Environmental Science and Technology*. Volume 42. Number 18. pp 6786-6790. September 11, 2008.

Brenner, R.C., V.S. Magar, J.A. Ickes, E.A. Foote, J.E. Abbott, L.S. Bingler, and E.A. Crecelius 2004. Long-Term Recovery of PCB-Contaminated Surface Sediments at the Sangamo-Weston/Twelvemile Creek/Lake Hartwell Superfund Site. In: *Environmental Science and Technology.* Volume 38, Number 8, pp 2328-2337. March 10, 2004.

Brown and Caldwell 1958. Metropolitan Seattle Sewerage and Drainage Survey. 1956-1958. *A report for the City of Seattle, King County, and the State of Washington on the Collection, Treatment, and Disposal of Sewage and the Collection and Disposal of Storm Water in the Metropolitan Seattle Area*. March 1958.

Butler P.A. and R.L. Schutzmann 1978. Residues of Pesticides and PCBs in Estuarine Fish, 1972-76 -- National Pesticide Monitoring Program. In: *Pesticides Monitoring Journal* 12(2):51-59. September 1978.

Davis J.W., T. Dekker, M. Erikson, V. Magar, and C. Patmont, M. Swindoll 2004. *Framework for Evaluating the Effectiveness of Monitored Natural Recovery (MNR) as a Contaminated Sediment Management Option*. Working Draft. June 2004.

Dekker, T., J. Davis, V. Magar, C. Patmont, and M. Swindoll 2004. *Numerical Models as Tools to Allow Prediction of Monitored Natural Recovery (MNR).* Working Draft. June 2004.

Ecology 1978. *State of Washington Water Quality Assessment Report 1978.* Olympia, Washington; Washington State Department of Ecology. Publication 78-10. October 1978.

Ecology 1991. *Sediment Cleanup Standards User Manual.* First Edition. Olympia, Washington; Washington State Department of Ecology, Sediment Management Unit. December 1991.

Ecology 2004. *Lower Duwamish Waterway Source Control Strategy.* Prepared by Richard Huey, Washington Department of Ecology, Northwest Regional Office, Toxics Cleanup Program, Bellevue, WA. Publication No. 04-09-043. January 2004.

Ells, S.J. 2010. Thirteen Helpful Hints from Headquarters to Hasten Sediment Cleanups. Office of Superfund Remediation and Technology Innovation. *The Alpha and the Omega and the Points in Between Conference.* Sediment Management Work Group. Chicago, IL. April 13-14, 2010.

Environmental Protection Agency 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. EPA-540-R-05-012. OSWER 9355.0-85. December 2005.

Environmental Protection Agency 2007. Draft Focused Feasibility Study. *Appendix D Empirical Mass Balance Model*. Lower Passaic River Restoration Project. June 2007.

Environmental Protection Agency 2008a. Determination of Rates and Extent of Dechlorination in PCB-Contaminated Sediments during Monitored Natural Recovery. In: *Sediment Issue* EPA/600/S-18/012. August 2008.

Environmental Protection Agency 2008b. Use of Sediment Core Profiling in Assessing Effectiveness of Monitored Natural Recovery. In: *Sediment Issue* EPA/600/S-08/014. August 2008.

Environmental Protection Agency 2009. *Five-year Review Report. Sangamo-Weston, Inc./Twelve Mile Creek/Lake Hartwell PCB Contamination Superfund Site. Part 2. Operable Unit 2, Pickens, Pickens County, South Carolina.* November 2009.

Environmental Protection Agency 2010a. Palos Verdes Shelf Superfund Site. EPA Signs Interim Record of Decision – Remedial Work Begins. U.S. Environmental Protection Agency, Region 9, San Francisco, CA. News Brief. April 2010.

Environmental Protection Agency 2010b. Nyanza Chemical Waste Dump, Sudbury River, MA. Proposed Plan. Hazardous Waste Program at U.S. Environmental Protection Agency, New England. News Brief. June 2010.

Environmental Solutions Group (ESG) 1999. *Waterway Sediment Operable Unit, Harbor Island Superfund Site. Assessing Human Health Risks from the Consumption of Seafood: Human Health Risk Assessment Report.* Prepared for Port of Seattle, Todd Shipyards, and Lockheed-Martin for submittal to U.S. Environmental Protection Agency, Region 10, Seattle, WA. September 1999.

Erickson, M.J., J.W. Davis, T. Dekker, V. Magar, C. Patmont, and M. Swindoll 2004. *Sediment Stability Assessment to Evaluate Natural Recovery as a Viable Remedy for Contaminated Sediments*. May 2004.

EVS Consultants 1996. Harbor Island Sediment Operable Unit. Supplementary Remedial Investigation. Appendices, Vol. 2 of 2. Prepared for Harbor Island Sediment Work Group for submittal to U.S. Environmental Protection Agency, Region 10, Seattle, WA. Prepared by EVS Consultants, Seattle, WA. May 1996.

Galvin, D.V. and R.K. Moore 1982. *Toxicants in Urban Runoff. Metro Toxicant Program Report Number 2.* Prepared for the Municipality of Metropolitan Seattle Water Quality Division. December 1982.

Harper-Owes 1982. *Water Quality Assessment of the Duwamish Estuary, Washington*. Prepared for the Municipality of Metropolitan Seattle. October 1982.

Herrera 2004. Summary Report, Lower Duwamish Waterway Outfall Survey. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc. Seattle, WA. January 2004.

Integral 2009. *2007 Monitoring Report for Sediment Remediation in Ward Cove, Alaska.* Prepared for Ketchikan Pulp Company. April 24, 2009.

King County 1999. *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay.* Vol. 1 and Appendices B2, B3, and B4. King County Department of Natural Resources, Seattle, WA. February 1999.

King County 2010. *Duwamish/Diagonal Sediment Remediation Project 2008/2009 Monitoring Report*. Prepared for King County Department of Natural Resources and Parks and the Elliott Bay/Duwamish Restoration Program. Prepared by King County Department of Natural Resources and Parks. Panel Publication 42. May 2010.

Magar, V.S., J. Davis, T. Dekker, M. Erikson, D. Matey, C. Patmont, M. Swindoll, R. Brenner, and C. Zeller 2004. Characterization of Fate and Transport Processes: Comparing Contaminant Recovery with Biological Endpoint Trends. Working Draft June 2004.

Magar, V.S., D.B. Chadwick, T.S. Bridges, P.C. Fuchsman, J.M. Conder, T.J. Dekker, J.A. Steevens, K.E. Gustavson, and M.A. Mills 2009. Technical Guide – Monitored

Natural Recovery at Contaminated Sediment Sites. Environmental Security Technology Certification Program (ESTCP Project ER-0622), May 2009.

Malins, D.C., B.B. McCain, D.W. Brown, A.K. Sparks, H.O. Hodgins, and S-L. Chan 1982. *Chemical Contaminants and Abnormalities in Fish and Invertebrates from Puget Sound*. Environmental Conservation Division, National Marine Fisheries Service, Seattle, WA. NOAA Tech. Memo. OMPA 19, 168 p. 1982.

Metro 1983a. *Toxicant Pretreatment Planning Study*. Draft Task A.1 Report Treatment Plant Evaluation. The Municipality of Metropolitan Seattle, Seattle, WA. March 1983.

Metro 1983b. *Duwamish Clean Water Plan*. The Municipality of Metropolitan Seattle, Seattle, WA. 1983.

Metro 1985. *Duwamish Industrial Non-point Source Investigation*. The Municipality of Metropolitan Seattle, Seattle, WA. 1985.

Mickelson, S. 2009. Water Quality Data from 16th Avenue Bridge Station, January 1970 to December 2008. Provided to Nicole Ott, AECOM by Scott Mickelson, King County Department of Natural Resources and Park. Electronic format. March 10, 2009.

Miller, B.S., R.C. Wingert, and S.F. Borton 1975. *Ecological Survey of Demersal Fishes in the Duwamish River and at West Point*. One-Year Progress Report January – December 1974. Fisheries Research Institute, College of Fisheries, University of Washington. Prepared for the Municipality of Metropolitan Seattle. Contract #9684. August 8, 1975.

Miller, B.S., B.B. McCain, R.C. Wingert, S.F. Borton, and K.V. Pierce 1976. Puget Sound Interim Studies. *Ecological and Disease Studies of Demersal Fishes near Metro Operated Sewage Treatment Plants on Puget Sound and the Duwamish River.* One-Year Progress Report February – December 1975. Fisheries Research Institute, College of Fisheries, University of Washington. Prepared for the Municipality of Metropolitan Seattle. Contract #CR2231. June 14, 1976.

National Research Council (NRC) 2001. *A Risk-Management Strategy for PCB-Contaminated Sediments*. Committee on Remediation of PCB-contaminated Sediments. Board on Environmental Studies and Toxicology, Division of Life and Earth Studies. National Academy Press, Washington, D.C. 2001.

National Research Council (NRC) 2007. *Sediment Dredging at Superfund Megasites* – Assessing the Effectiveness. Committee on Sediment Dredging at Superfund Megasites. Board on Environmental Studies and Toxicology, Division of Life and Earth Studies. The National Academies Press 500 5th St, NW Washington D.C. 2007.

New York State Department of Environmental Conservation (NYSDEC) and EPA 2005. *Record of Decision. Onondaga Lake Bottom Subsite of the Onondaga Lake Superfund Site. Towns of Geddes and Salina, Villages of Solvay and Liverpool, and City of Syracuse, Onondaga County, New York*. Prepared by the NYSDEC and EPA Region 2. July 2005.

Patmont, C., J. Davis, T. Dekker, M. Erickson, V. Magar, and M. Swindoll 2003. Natural Recovery: Monitoring Declines in Sediment Chemical Concentrations and Biological Endpoints. In *Proceedings: 2nd International Conference on Remediation of Contaminated Sediments, Venice, Italy.* Columbus, Ohio: Battelle Press. September 20, 2003.

Pollution Control Commission (PCC) 1955. *An investigation of pollution in the Green-Duwamish River.* Technical Bulletin No. 20. Pollution Control Commission, State of Washington, Olympia, WA. 1955.

Port of Seattle 2005. News Release. Cruise Ships Plug In to Shore Power at Port of Seattle. July 23, 2005.

Port of Seattle 2009. News Release. Air Emissions from Ships Decline at Port of Seattle. ABC Fuels program reduces sulfur dioxide 80%, diesel particulate matter 60%. July 31, 2009.

Port of Seattle 2010a. News Release. Clean Air Program Takes 200th 'Dirty' Truck Off the Road. Port of Seattle and program partners welcome new trucks to replace older models. July 1, 2010.

Port of Seattle 2010b. Prohibiting Wastewater Discharge from Cruise Ships. In: *Protecting and Enhancing Water Quality At Seattle's Seaport*. 2010.

PTI Environmental Services 1988. *Elliott Bay Action Program. 1988 Action Plan*. Prepared for the Puget Sound Estuary Program, Office of Puget Sound, U.S. Environmental Protection Agency, Region 10, Seattle WA. September 1988.

PTI Environmental Services and Tetra Tech 1988. *Elliott Bay Action Program: Analysis of Toxic Problem Areas*. Prepared for Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Seattle, WA. July 1988.

Puget Sound Action Team 2007. *2007 Puget Sound Update: Ninth Report of the Puget Sound Assessment and Monitoring Program.* Publication No. PSAT 07-02. February 2007.

Puget Sound Air Pollution Control Agency (PSAPCA) and Washington State Department of Ecology (Ecology) 1983. *Attaining and Maintaining the Lead Standard in Washington State.* June 1983.

QEA 2008. *Lower Duwamish Waterway Final Sediment Transport Modeling Report*. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Bellevue, WA. Prepared by Quantitative Environmental Analysis, LLC, Montvale, NJ. October 2008.

RETEC 2002. Lower Fox River Feasibility Study. Appendix F. *Review of Natural PCB Degradation Processes in Sediments for the Lower Fox River and Green Bay, Wisconsin.* Prepared for the Wisconsin Department of Natural Resources. The RETEC Group, Inc. December 2002.

Santos, J.F. and J.D. Stoner 1972. *Physical, Chemical, and Biological Aspects of the Duwamish River Estuary, King County, Washington, 1963-1967*. Geological Survey Water-Supply Paper 1873-C. Prepared in cooperation with the Municipality of Metropolitan Seattle. 1972.

Stern, J. 2007. *Temporal effects of dredge-related releases on fish tissue concentrations: Implications to achieving net risk reduction*. SETAC North America 28th Annual Meeting and Conference, Nov. 2007, Milwaukee WI. SETAC Abstracts 28, p.59-60. Society of Environmental Toxicology and Chemistry, Pensacola, FL. November 2007.

Stern, J., J. Colton, and D. Williston 2009. Comparison of Enhanced and Monitored Natural Recovery Effectiveness. Duwamish/Diagonal Early Action Area. King County Department of Natural Resources and Parks. Remediation of Contaminated Sediments Conference. February 2009.

Takasaki, K. 2011. Personal communication between Kym Takasaki of the Port of Seattle and Nicole Ott of AECOM regarding the Port's shore power (cruise ships) and Scrappage (trucks) programs. July 19, 2011.

Tetra Tech, Inc. 1988. *Elliott Bay Action Program: Evaluation of Potential Contaminant Sources.* Technical Appendices. Prepared for the Puget Sound Estuary Program, Office of Puget Sound, U.S. Environmental Protection Agency, Region 10, Seattle WA. September 1988.

U.S. Army Corps of Engineers (USACE) 2007. *Second Five-Year Review Report for the Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington*. Prepared for the U.S. Environmental Protection Agency. Prepared by the U.S. Army Corps of Engineers, Seattle District. September 26, 2007.

Vita, C., P. Johanson, and D. Leisle 2011. Marine Sediment PCB Monitoring and Natural Recovery at the Bremerton Naval Complex. *Paper C-02*, in: *Remediation of Contaminated Sediments – 2011*. Sixth International Conference on Remediation of Contaminated Sediments. New Orleans, LA; February 7–10, 2011.

Washington State Department of Health 2009. *Annual Growing Area Review, Eld Inlet*. Office of Shellfish & Water Protection. December 31, 2009.

Welch, E.B. 1969. *Factors Initiating Phytoplankton Blooms and Resulting Effects on Dissolved Oxygen in Duwamish River Estuary, Seattle, Washington*. Geological Survey Water-Supply Paper 1873-A. Prepared in cooperation with the Municipality of Metropolitan Seattle. 1969.

West, J., S. O'Neill, G. Lippert, and S. Quinnell 2001. *Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington*. Results of the Puget Sound Ambient Monitoring Program Fish Component 1989-1999. Washington Department of Fish and Wildlife, Olympia, WA. August 2001.

Weston 2006. *Final Model Documentation Report: Modeling Study of PCB Contamination in the Housatonic River, Vol. 1.* Prepared for U.S. Army Corps of Engineers, New England District and U.S. Environmental Protection Agency, New England Region. Weston Solutions, Inc. November 2006.

Williston, D. 2010. Personal communication between Debra Williston of King County and Nicole Ott of AECOM regarding 2010 PCB surface sediment data collected from the Enhanced Natural Recovery area as part of the Duwamish/Diagonal Early Action Area post-remediation monitoring. August 26, 2010.

Windward Environmental, LLC 2010. *Final Remedial Investigation Report, Lower Duwamish Waterway.* Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, Washington, and Washington State Department of Ecology, Bellevue, Washington. Seattle, Washington: Windward Environmental, LLC, July 9, 2010.

Windward Environmental, LLC and QEA 2008. *Lower Duwamish Waterway Sediment Transport Analysis Report*. Prepared for Lower Duwamish Waterway Group. Prepared by Windward Environmental LLC and Quantitative Environmental Analysis, LLC. January 9, 2008.

Windward Environmental, LLC and RETEC 2007. *Lower Duwamish Waterway Remedial Investigation. Data Report. Subsurface Sediment Sampling for Chemical Analyses*. Final. January 29, 2007.

Table F-1 Example Sites that Have Used MNR as a Remedial Technology

Site Name	Portion of Cleanup Using MNR	Comments (Source: Magar et al. 2004, unless otherwise noted)
CERCLA Sites		
Commencement Bay, WA	Partial	Monitoring data show that mercury levels in surface sediments have decreased. Cleanup levels achieved in Sitcum Waterway. Monitoring of Thea Foss and Wheeler-Osgood Waterways ongoing.
Bremerton Naval Shipyard, WA	Partial	Monitoring data through 2010 and a trend analysis suggest that total PCB concentrations have a high probability of achieving the cleanup goal (3 mg/kg oc) by 2014 (Vita et al. 2011).
Elizabeth Mine, VT	Entire	Monitoring ongoing and/or data not yet available.
Hackensack River, NJ	Partial	Monitoring ongoing and/or data not yet available.
James River, MA	Entire	Continued low-level contamination in fish tissue, but concentrations are below action level.
Ketchikan Pulp Company, AK	Partial	Recovery is progressing in the natural recovery areas, such that all four areas have achieved the RAO for sediment toxicity, and three of the four areas have achieved healthy benthic communities with multiple taxonomic groups. The weight-of-evidence for the fourth natural recovery area indicates that, in addition to achieving the RAO for sediment toxicity, substantial and acceptable progress has been made toward achieving a healthy benthic community (Integral 2009).
Koppers Company, FL	Partial	Monitoring data show that sediment PAH concentrations have been decreasing.
Lavaca Bay, TX	Partial	Monitoring data show that mercury concentrations in surface sediment are below cleanup levels, but concentrations fluctuate and remain elevated in biota.
Lower Fox River/Green Bay: OU 2 and 5, WI	Partial	Monitoring ongoing and/or data not yet available.
Mississippi River Pool 15, IA	Entire	Although monitoring data are limited, available data indicate decreasing PCB levels in fish.
Sangamo/Twelve Mile Creek/Lake Hartwell, SC	Entire	Monitoring data show significant reductions in surface sediment total PCB concentrations, but total PCB concentrations in fish continue to exceed 2 mg/kg, thereby requiring other activities (EPA 2008b and 2009).
Wyckoff/Eagle Harbor, West and East Harbor OUs, WA	Partial	West Harbor monitoring data showed that surface sediment and biota levels were achieving remedial goals in capping and natural recovery areas. However, seeps were identified in intertidal areas and eelgrass beds in habitat restoration areas were not growing. East Harbor data indicate that contamination remains on the East Beach. Monitoring will continue to determine whether natural recovery aided by source control will achieve goals (USACE 2007, EPA 2008b).
Palos Verdes Shelf, CA	Partial	No monitoring data yet (EPA 2010a).
Nyanza Chemical Waste Dump, Sudbury River, MA	Partial	No monitoring data yet (EPA 2010b).
Onondaga Lake, NY	Partial	Monitoring ongoing, but data not yet available (NYSDEC and EPA 2005).
Washington MTCA Site		
Whatcom Waterway, Bellingham Bay, WA	Partial	Two natural recovery areas (3A and 5C) have surface sediment concentrations below the SQS and match model predictions (Anchor QEA 2010).

Notes:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; EPA = U.S. Environmental Protection Agency; kg = kilogram; mg = milligram; MNR = monitored natural recovery; MTCA = Model Toxics Control Act; NYSDEC = New York State Department of Environmental Conservation; oc = organic carbon; OU = operable unit; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; RAO = remedial action objective; SQS = sediment quality standards; USACE = U.S. Army Corps of Engineers

Table F-2 Summary of Empirical Lines of Evidence

Line of Evidence Used for Evaluating Natural Recovery	Count	Description	Where Presented	How Is This Line of Evidence Used in this FS?	How Is Recovery Defined?
Net Sedimentation Rates in Cores					
Cores Collected in 2006 for the RI	56	Various time markers were used to calculate net sedimentation rates in cores. Net sedimentation rates were used to assign years to intervals of cores collected in 2006 for the RI (for Figure F-12).	Figure F-2 and Figure F-12	Used to calibrate the STM net sedimentation rates	Net sedimentation of 1 cm/year or more
Historical Cores	25				
Resampled Surface Sediment Locations					
Total PCBs	70	Surface sediment samples located within 10 ft of one another sampled at different times	Tables F-4a, F-4b, and F-5a; Figures F-3a, F-3b, F-4, and F-8	Total PCBs and SMS contaminants (not cPAHs) are used for assigning recovery categories; population trends are used to discuss site-wide recovery.	Concentration decrease of 50% of more from older to newer sample
Arsenic	56		Tables F-4a, F-4b, and F-5b; Figures F-3a, F-5, and F-8		
cPAH	53		Tables F-4a, F-4b, and F-5c; Figures F-3a and F-6		
BEHP	53		Tables F-4a, F-4b, and F-5d; Figures F-3a, F-7, and F-8		
Other SMS Contaminants – old sample >SQS	23		Table F-5e and Figure F-8		
Other SMS Contaminants – new sample >SQS	24		Table F-5f and Figure F-8		
Surface Sediment Temporal Trends In and Around EAAs					
Duwamish/Diagonal Perimeter Monitoring Locations	8	Annual monitoring data from established monitoring stations sampled from 2003 to 2009	Table F-6 and Figure F-9	Data for total PCBs, arsenic, cPAHs, and BEHP used as general area recovery evidence for BPJ	Decreasing concentrations over time
Slip 4 Surface Sediment Data	60	Data collected from various events from 1997 to 2004; not co-located	Figure F-10	Data for total PCBs used as general area recovery evidence for BPJ	Decreasing concentrations over time
Trends at Depth in Cores Collected in 2006 for the RI					
Total PCBs	59	Identify depth of highest concentration either in the subsurface or surface, or no strong trend in core.	Tables F-7a, F-7b, and F-7c	Additional support for core trends in top two intervals, but not directly used in calculations	Cores with a buried peak demonstrate that recovery is occurring; those with the peak at the surface may be in areas subject to recontamination or with low recovery.
Trends in Top Two Intervals in Cores					
Total PCBs	165 total; 119 with detected total PCB SQS exceedances	Concentration changes for contaminants exceeding the SQS were evaluated in the two shallowest intervals in cores (representing the time since ~1980s). 1-ft intervals were used (or shorter) unless a co-located surface sediment sample was available.	Tables F-7a through F-8; Figures F-13 and F-22a through 22c	Used for assigning recovery categories	Concentration decrease of 50% of more from deeper to shallower interval
SMS Contaminants Other than Total PCBs	165 total; 57 with detected SQS exceedances				
Fish Tissue Trends					
Mean Total PCB Concentrations from English Sole Fillets Collected in the LDW by Year	61 samples	16 years of data spanning 1972 to 2007	Table F-10; Figures F-14 and F-15	Provides general information about recovery of the LDW and the impact of dredging residuals	Although historical data must be interpreted with caution, there is some indication of decreasing concentrations over time

Notes:

BEHP = bis(2-ethylhexyl)phthalate; BPJ = best professional judgment (when assigning remedial technologies); cPAHs = carcinogenic polycyclic aromatic hydrocarbons; EAA = early action area; FS = feasibility study; LDW = Lower Duwamish Waterway; PCBs = polychlorinated biphenyls; RI = remedial investigation; SMS = Sediment Management Standards; SQS = sediment quality standard

Table F-3 Net Sedimentation Rates in the LDW Estimated from Physical and Chemical Time Markers

Subsurface Core ID	Approx. River Mile	Net Sedimentation Rates (cm/year) Estimated from Time Markers and Event Horizons[a]								
		Physical[b]			Contaminant (1-ft, 2-ft Intervals)			Contaminant (6-in Intervals) from a Subset of 2006 Cores		
		Interface between Lower Alluvium and Upper Alluvium[c]	Interface between Upper Alluvium and Recent Sediments[d]	Dredge Horizon[e]	Lead/ PCB/ Phthalate Introduction	PCB Peak Usage/ Spill	Control Sources	PCB Introduction	PCB Peak Usage/ Spill	Control Sources
		1916	1961	Variable	1920/1935/ 1950	1960/ 1974	1980	1935	1960/ 1974	1980
RI 2006 Cores										
SC-1	0.0	0.9			1.7			1.1	0.9	0.9
SC-2	0.1									
SC-3	0.1	0.4								
SC-4	0.2	1.1			1.7		1.2			
SC-5	0.2	0.7	0.5		0.5, 0.9					
SC-6	0.3	2.6	3.0		2.3		2.3	2.6	2.3	2.7
SC-7	0.3				0.7					
SC-8	0.4					3.3	1.2			
SC-9	0.5		1.8	1.5						
SC-10	0.5	2.4	2.7	2.4		2.9				
SC-11	0.5		0.5		0.4					
SC-12	0.6	2.3	1.8		2.9	2.0	2.3, 1.2	2.6	2.0	2.1
SC-13	0.9				1.1			1.1 to 2.1		
SC-14	0.9	2.9			4.0					
SC-15	0.9	2.5	1.4		3.0	4.8				
SC-16	0.9	2.4			3.8	2.9	2.3, 1.2			
SC-17	1.0					2.9				
SC-18	1.0	1.9		1.5, 1.9	0.7, 0.9, 1.1					
SC-19	1.0	3.0	4.7		3.4	4.3				
SC-20	1.0									
SC-21	1.0	3.3	3.4		2.7	4.9	2.3			
SC-22	1.1									
SC-23	1.3		3.3		4.3	4.8	4.7	3.4	4.8	3.3
SC-24	1.2	1.1	0.7		0.7, 0.9					
SC-25	1.3	2.0 to 2.5			2.5, 3.0					
SC-26	1.4									
SC-27	1.4	1.5 to 2 .6						1.4	1.2	0.9
SC-28	1.4									
SC-29	1.4	0.6	0.4							
SC-30	1.6	1.1								
SC-31	1.7			12.2	1.0, 1.2, 1.5					
SC-32	1.7	1.7 to 2.4	1.9		2.0, 2.5					
SC-33	1.9	2.9			3.0, 3.8			2.6	0.8 to 1.7	0.9, 1.4
SC-34	1.9		2.2							
SC-35	2.0		3.5	2.8, 3.7						
SC-36	2.1	2.8	2.2							
SC-37	2.1	1.8	1.8		2.0, 2.6	1.0	2.3			

Table F-3 Net Sedimentation Rates in the LDW Estimated from Physical and Chemical Time Markers (continued)

		Net Sedimentation Rates (cm/year) Estimated from Time Markers and Event Horizons[a]								
		Physical[b]			Contaminant (1-ft, 2-ft Intervals)			Contaminant (6-in Intervals) from a Subset of 2006 Cores		
		Interface between Lower Alluvium and Upper Alluvium[c]	Interface between Upper Alluvium and Recent Sediments[d]	Dredge Horizon[e]	Lead/ PCB/ Phthalate Introduction	PCB Peak Usage/ Spill	Control Sources	PCB Introduction	PCB Peak Usage/ Spill	Control Sources
Subsurface Core ID	Approx. River Mile	1916	1961	Variable	1920/1935/ 1950	1960/ 1974	1980	1935	1960/ 1974	1980
RI 2006 Cores (continued)										
SC-38	2.1									
SC-39	2.2	2.9								
SC-40	2.2	0.7								
SC-41	2.4	2.6								
SC-42	2.5		2.7							
SC-43	2.6	3.0	0.5							
SC-44	2.7				1.4, 1.1			1.3	0.5	0.3
SC-45	2.8									
SC-46	2.7	2.3		7.6, 1.8						
SC-47	3.1	1.0			1.3, 1.4, 2.2	1.0	1.2			
SC-48	3.3				0.4 to 0.5					
SC-49	3.5		2.4		4.3					
SC-50	3.8	0.9			1.0, 1.2, 1.5					
SC-51	3.8									0.6
SC-52	3.9				0.5, 0.7, 0.9					
SC-53	4.2	3.1	3.3							
SC-54	4.3	1.8	2.7							
SC-55	4.9	1.0	0.3							
SC-56	4.7				0.8 to 1.0					
Historical Cores[f]										
B3 (T105 1985)[g]	0.2	4.9	5.1							
DUD006[g]	0.4								3.1, 1.9	2.7, 0.7
DR18 (PSDDA99)[g]	1.8	2.2	3.2							
DR39 (PSDDA99)[g]	2.2	1.5								
SC11 (Slip 4 2004)[g]	2.8	1.5	2.2							
S3 (PSDDA98)[g]	3.8	3.0	3.3							
SC04	2.8	2.7	1.6							
SC05	2.8	3.2			1.8					
SC06	2.8	2.0	2.3							
SC07	2.8	2.8								
SC09	2.8	2.7								
SL-4-5A	2.8	2.9	2.1							
SD-DUW06	3.2	3.0	7.0							
SD-DUW13D	3.5	2.9	1.5							

Table F-3 Net Sedimentation Rates in the LDW Estimated from Physical and Chemical Time Markers (continued)

		Net Sedimentation Rates (cm/year) Estimated from Time Markers and Event Horizons[a]								
		Physical[b]			Contaminant (1-ft, 2-ft Intervals)			Contaminant (6-in Intervals) from a Subset of 2006 Cores		
	Approx.	Interface between Lower Alluvium and Upper Alluvium[c]	Interface between Upper Alluvium and Recent Sediments[d]	Dredge Horizon[e]	Lead/ PCB/ Phthalate Introduction	PCB Peak Usage/ Spill	Control Sources	PCB Introduction	PCB Peak Usage/ Spill	Control Sources
Subsurface Core ID	River Mile	1916	1961	Variable	1920/1935/ 1950	1960/ 1974	1980	1935	1960/ 1974	1980
Historical Cores[f] (continued)										
SD-DUW-144	3.1	2.4	1.5		1.8					
SD-DUW-146	3.2	1.5			1.8					
SD-DUW-148	3.2	0.5								
SD-DUW-149	3.2	1.8			1.3					
SD-DUW-150D	3.2	1.4	0.5							
SD-208	3.6	2.7								
SD-214	3.7	2.9	1.4							
T117-SE-25-SC	3.6	2.8			3.6					
T117-SE-31-SC	3.6	3.3			0.9					
T117-SE-35-SC	3.6	3.2			3.6	2.1				
T117-SE-37-SC	3.6	0.7			0.4		3.6			

Notes:

= no strong markers in core; therefore no calculation of net sedimentation rates could be made for the core.

1. Blank cells indicate that markers were not present or core was not clearly indicative of a strong time marker.

a. All net sedimentation rate estimates are based on recovered core depths.

b. Sediments were grouped into three stratigraphic units identified for the LDW, primarily based on density, color, sediment type, texture, and marker bed horizons. The three sediment stratigraphy units were identified as follows: Recent, Upper Alluvium, Lower (Native) Alluvium.

c. Lower (Native) Alluvium is defined by top of dense sand unit. Assumed to be the marker at the time of LDW creation (1916).

d. This interface is defined by the presence of recent sediments (organic silt) above the interface and is assumed to be the marker at the time of completion of the Howard Hanson Dam (1961).

e. Dredging event rates show rate from dredging event to top of core and rate from stratigraphic marker to dredging effects marker.

f. Only the 25 cores where rates were calculated are presented in this section of the table.

g. These six historical cores were included in Appendix F of the Sediment Transport Analysis Report (STAR; Windward and QEA 2008) along with the 56 RI cores, for a total of 62 cores described in the STAR. Rates could be calculated for 55 of these 62 cores.

EAA = early action area; LDW = Lower Duwamish Waterway; PCBs = polychlorinated biphenyls; RI = remedial investigation; RM = river mile

See Subsurface Sediment Data Report (Windward and RETEC 2007) for core logs.

Table F-4a Change in Risk-Driver Concentrations in Resampled Surface Sediment Populations

Risk Driver and Metric	Older Data (1991–2006)	Newer (FS Baseline) Data (1998–2008)	Percent Change between Older and Newer Concentrations (%)
Total PCBs (µg/kg dw); N = 70			
Data Distribution	Non-parametric	Lognormal	n/a
Detection Frequency (%)	96	90	n/a
Minimum Detect	10	9.8	-2
25th Percentile	107	74	-31
Median	204	157	-23
Mean	1,057	688	-35
75th Percentile	928	473	-49
90th Percentile	2,363	961	-58
Maximum	9,400	13,000	38
Total PCBs (µg/kg dw); N = 67, excluding outliers			
Data Distribution	Non-parametric	Lognormal	n/a
Detection Frequency (%)	97	91	n/a
Minimum Detect	10	9.8	-2
25th Percentile	107	74	-31
Median	200	155	-23
Mean	939	354	-62
75th Percentile	561	415	-26
90th Percentile	2,141	776	-64
Maximum	9,400	5,100	-46
Arsenic (mg/kg dw); N = 56			
Data Distribution	Non-parametric	Non-parametric	n/a
Detection Frequency (%)	100	100	n/a
Minimum Detect	6.4	5.1	Minimal change; in equilibrium
25th Percentile	10	11	
Median	13	15	
Mean	40	35	
75th Percentile	17	19	
90th Percentile	41	40	
Maximum	1,130	807	

Table F-4a Change in Risk-Driver Concentrations in Resampled Surface Sediment Populations (continued)

Risk Driver and Metric	Older Data (1991–2006)	Newer (FS Baseline) Data (1998–2008)	Percent Change between Older and Newer Concentrations (%)
cPAHs (µg TEQ/kg dw); N = 53			
Data Distribution	Lognormal	Lognormal	n/a
Detection Frequency (%)	100	100	n/a
Minimum Detect	18	24	33
25th Percentile	200	145	-28
Median	505	265	-48
Mean	1,534	437	-72
75th Percentile	1,000	440	-56
90th Percentile	2,070	803	-61
Maximum	31,000	2,400	-92
BEHP (µg/kg dw); N = 53			
Data Distribution	Lognormal	Lognormal	n/a
Detection Frequency (%)	70	90	n/a
Minimum Detect	34	35	3
25th Percentile	230	92	-60
Median	505	160	-68
Mean	827	310	-63
75th Percentile	955	388	-59
90th Percentile	1,570	606	-61
Maximum	6,100	1,700	-72

Notes:

1. Newer data are co-located with older data (i.e., within 10 ft). Older data are not included in the FS baseline dataset.
2. Statistics calculated using ProUCL v.4.00.04.
3. Undetected data were set to the reporting limit.
4. Three PCB locations omitted in generating the n = 67 dataset: LDW-SS110/SD-323-S at 13,000 and 9,400 µg/kg dw; LDW-SS111/DR186 at 3,200 and 1,180 µg/kg dw; and SD-320-S/SD-DUW92 at 8,900 and 1,500 µg/kg dw. These are located within the Boeing Plant 2/Jorgensen Forge EAA. Outliers selected by Rosner test in ProUCL.

BEHP = bis(2-ethylhexyl)phthalate; cPAH = carcinogenic polycyclic aromatic hydrocarbon; µg/kg dw = microgram per kilogram dry weight; n/a = not applicable; p = probability; PCB = polychlorinated biphenyl; TEQ = toxic equivalent

Table F-4b Evaluation of Significant Differences in Resampled Surface Sediment Populations

Risk Driver	Number of Samples	Are Datasets Significantly Different?	Significance (p value)
Total PCBs – new vs. old	70	No	0.075
Total PCBs excluding outliers – new vs. old	67	Yes	0.023
Arsenic – new vs. old	56	No	0.474
cPAHs – new vs. old	53	Yes	0.002
BEHP – new vs. old	53	Yes	0.010

Notes:

1. Full datasets evaluated with 2-Tailed hypothesis testing using ProUCL v.4.00.04, two sample test (Wilcoxon-Mann-Whitney) with 95% confidence level (α=0.05).
2. Total PCB n=67 dataset evaluated with 2-Tailed hypothesis testing using SPSS v 13.0, two related sample test (Wilcoxon Signed Ranks Test) with 95% confidence level (α=0.05).
3. Three PCB locations omitted in generating the n=67 dataset: LDW-SS110/SD-323-S; LDW-SS111/DR186; and SD-320-S/SD-DUW92. These are located within the Boeing Plant 2/Jorgensen Forge EAA. Outliers selected by Rosner test in ProUCL.
4. Shaded cells indicate significantly different datasets.

BEHP = bis(2-ethylhexyl)phthalate; cPAH = carcinogenic polycyclic aromatic hydrocarbon; p = probability; PCB = polychlorinated biphenyl

Table F-5a Percent Change at Resampled Surface Sediment Locations — Total PCBs

River Mile	Older Total PCB Concentration Range (µg/kg dw)	Older Station			Newer Station			Change in Total PCB Concentration from Older Station to Newer Station				Recovery Category
		Station ID	Year Sampled	Total PCBs (µg/kg dw)	Station ID	Year Sampled	Total PCBs (µg/kg dw)	Years Elapsed	Concentration Change (µg/kg dw)	Percent Change[a]	Total PCB Concentration Change Rate (µg/kg dw/yr)	
3.7	>1,300	SD-323-S	2004	9,400	LDW-SS110	2005	13,000	1	3,600	38%	3600	EAA
4.7		DR271	1998	9,400	LDW-SS148	2005	520	7	-8,880	-94%	-1269	3
3.5		WST323	1997	7,900	T117-SE-10-G	2003	1,200	6	-6,700	-85%	-1117	EAA
3.6		SD-DUW90	1996	7,500	SD-343-S	2004	260	8	-7,240	-97%	-905	EAA
2.2		WIT280	1997	5,200	B5a-2	2004	1,730	7	-3,470	-67%	-496	2
1.4		DR030	1998	4,800	LDW-SS50	2005	590	7	-4,210	-88%	-601	3
0.8		EST219	1997	4,400	LDW-SS27	2005	97	8	-4,303	-98%	-538	3
3.9		EIT061	1997	2,400	LDW-SS121	2005	1,060	8	-1,340	-56%	-168	2
2.2		DR113	1998	2,030	LDW-SS81	2005	210	7	-1,820	-90%	-260	2
2.9		DR181	1998	1,670	DR-181	2006	460	8	-1,210	-72%	-151	3
3.7		SD-DUW92	1996	1,500	SD-320-S	2004	8,900	8	7,400	493%	925	EAA
3.9		EST144	1997	1,500	LDW-SS123	2005	149	8	-1,351	-90%	-169	2
3.9	>480 - 1,300	R30	1997	1,250	LDW-SS119	2005	880	8	-370	-30%	-46	2
2.0		R7	1997	1,200	LDW-SS75	2005	520	8	-680	-57%	-85	3
2.1		CH0023	1997	1,200	LDW-SS79	2005	68	8	-1,132	-94%	-142	3
3.7		DR186	1998	1,180	LDW-SS111	2005	3,200	7	2,020	171%	289	EAA
0.3		DUD042	1995	1,060	LDW-SS17	2005	120	10	-940	-89%	-94	3
1.2		DR088	1998	1,010	LDW-SS40	2005	510	7	-500	-50%	-71	3
1.5		DR123	1998	900	LDW-SS57	2005	750	7	-150	-17%	-21	3
1.0		DR087	1998	696	LDW-SS37	2005	5,100	7	4,404	633%	629	2
0.2		DR035	1998	516	LDW-SS12	2005	171	7	-345	-67%	-49	3
2.6	>240 - 480	EIT074	1997	450	LDW-SS88	2005	660	8	210	47%	26	3
0.9		DR085	1998	413	LDW-SSB2b	2005	790	7	377	91%	54	2
1.4		B4b	2004	400	B4B	2006	220	2	-180	-45%	-90	3
3.6		SD-SWY07	1995	320	SD-SWY17	2003	460	8	140	44%	18	EAA
0.3		LDW-SS16	2005	320	TRI-016	2006	190	1	-130	-41%	-130	1
2.1		DR111	1998	311	DR-111	2006	176	8	-135	-43%	-17	3
1.3		LDW-SS45	2005	290	TRI-045	2006	230	1	-60	-21%	-60	3
3.6		EST152	1997	290	SD-309-S	2004	570	7	280	97%	40	EAA
3.6		T117-SE-19-G	2003	270	107-G	2008	120	5	-150	-56%	-30	3
1.3		DR053	1998	260	LDW-SS44	2005	103	7	-157	-60%	-22	1
3.8		DR187	1998	246	LDW-SS115	2005	220	7	-26	-11%	-4	2
2.8	>100 - 240	EST180	1997	230	LDW-SS92	2005	970	8	740	322%	93	2
2.1		DR106	1998	227	LDW-SS76	2005	117	7	-110	-48%	-16	3
3.7		T117-SE-46-G	2003	210	117-G	2008	20	5	-190	-90%	-38	3
1.4		DR028	1998	207	B4b	2004	400	6	193	93%	32	3
0.0		K-11	1991	200	LDW-SS1	2005	161	14	-39	-20%	-3	3
3.7		R21	1997	200	LDW-SS113b	2005	18	8	-182	-91%	-23	3
3.7		R18	1997	200	114-G	2008	54	11	-146	-73%	-13	3
4.2		R42	1997	193	LDW-SS129	2005	10	8	-184	-95%	-23	1
3.7		R19	1997	190	113-G	2008	20	11	-170	-89%	-15	3
0.3		DR079	1998	187	LDW-SS15	2005	128	7	-59	-32%	-8	3
1.4		DR065	1998	185	LDW-SS52	2005	209	7	24	13%	3	2
1.0		DR020	1998	169	LDW-SS31	2005	96	7	-73	-43%	-10	2
1.0		DR019	1998	162	LDW-SS32	2005	122	7	-40	-25%	-6	2
1.4		LDW-SS51	2005	155	TRI-051	2006	132	1	-23	-15%	-23	3
3.6		EST154	1997	150	SD-334-S	2004	290	7	140	93%	20	EAA
3.9		LDW-SS123	2005	149	AN-019	2006	770	1	621	417%	621	2
0.9		DR021	1998	142	LDW-SS319	2006	350	8	208	146%	26	1
1.7		DR097	1998	126	LDW-SS63	2005	95	7	-31	-25%	-4	3
2.8		DR175	1998	120	LDW-SS94	2005	72	7	-48	-40%	-7	2
4.2		R40	1997	119	LDW-SS127	2005	58	8	-61	-51%	-8	3
1.4		DR160	1998	115	LDW-SS51	2005	155	7	40	35%	6	3
4.1		A11-05 avg	1994	109	LDW-SS126	2005	10	11	-99	-91%	-9	3
4.2		R45	1997	101	LDW-SS130	2005	26	8	-75	-74%	-9	1

Table F-5a Percent Change at Resampled Surface Sediment Locations — Total PCBs

River Mile	Older Total PCB Concentration Range (µg/kg dw)	Older Station: Station ID	Older Station: Year Sampled	Older Station: Total PCBs (µg/kg dw)	Newer Station: Station ID	Newer Station: Year Sampled	Newer Station: Total PCBs (µg/kg dw)	Change: Years Elapsed	Change: Concentration Change (µg/kg dw)	Change: Percent Change[a]	Change: Total PCB Concentration Change Rate (µg/kg dw/yr)	Recovery Category
3.2	≤100	DR202	1998	98	LDW-SS104	2005	75	7	-23	-23%	-3	3
1.9		DR131	1998	97	LDW-SS70	2005	96	7	-1	-1%	0	3
4.2		DR242	1998	93	SB-1	2004	170	6	77	83%	13	1
0.1		K-07	1991	87	LDW-SS4	2005	153	14	66	76%	5	2
3.1		DR198	1998	85	LDW-SS102	2005	74	7	-11	-13%	-2	3
0.2		K-05 avg	1991	83	LDW-SS10	2005	31	14	-52	-63%	-4	3
3.8		R24	1997	73	LDW-SS117	2005	79	8	6	8%	1	3
4.3		DR286	1998	54	B10b	2004	10	6	-44	-82%	-7	1
2.4		WST342	1997	38	DR141	1998	68	1	30	79%	30	1
0.2		LDW-SS10	2005	31	TRI-010	2006	159	1	128	413%	128	3
1.0		WST367	1997	29	DR048	1998	88	1	59	203%	59	3
2.8		LDW-SS96	2005	24	TRI-096	2006	220	1	196	817%	196	3
0.0		DR076	1998	20	LDW-SS5	2005	10	7	-10	-50%	-1	3
4.1		DR238	1998	20	LDW-SS125	2005	10	7	-11	-53%	-2	3
4.2		EST135	1997	10	B8b	2004	37	7	27	270%	4	1
								7	*Average Years Elapsed for All Locations*			

Concentration Averages by Reach - using locations with 5 or more years between sampling (n = 60)							
Reach 1 (RM 0 to 2.2; n = 28)		929		466		-50%	
Reach 2 (RM 2.2 to 4.0; n = 23)		1,219		861		-29%	
Reach 3 (RM 4.0 to 5.0; n = 9)		1,122		94		-92%	
Concentration Averages by Recovery Category (n=70)							
Category 1 (n= 9)		135		107		-20%	
Category 2 (n = 15)		989		835		-16%	
Category 3 (n = 38)		807		195		-76%	
EAAs (n = 8)		3,530		3,485		-1%	

Notes:

1. Resampled locations are those where older stations are within 10 ft of newer stations.
2. Recovery categories are as follows:
   Recovery Category 1 = recovery predicted to be limited; Recovery Category 2 = recovery less certain; Recovery Category 3 = predicted to recover.

a. Percent change = 100 x (Newer Concentration - Older Concentration)/Older Concentration

(red) Greater than or equal to 50% concentration increase, 5 or more years between events, and any data > 100 µg/kg dw.
(white) Minimal change (< 50% change in concentration), less than 5 years between events, or no concentrations > 100 µg/kg dw.
(blue) Greater than or equal to 50% concentration decrease, 5 or more years between events, and any data > 100 µg/kg dw.

EAA = early action area; µg/kg dw = micrograms per kilogram dry weight; PCBs = polychlorinated biphenyls; RM = river mile

Table F-5b Percent Change at Resampled Surface Sediment Locations — Arsenic

River Mile	Older Arsenic Concentration Range (mg/kg dw)[a]	Older Station: Station ID	Older Station: Year Sampled	Older Station: Arsenic (mg/kg dw)	Newer Station: Station ID	Newer Station: Year Sampled	Newer Station: Arsenic (mg/kg dw)	Change in Arsenic Concentration from Older Station to Newer Station: Years Elapsed	Concentration Change (mg/kg dw)	Percent Change[b]	Recovery Category
1.3	>93 (CSL)	SS-2	1993	1130	LDW-SS48	2005	807	12	-323	-29%	1
1.4		SS-4	1993	140	LDW-SS55	2005	17.2	12	-123	-88%	1
1		DR020	1998	99.3	LDW-SS31	2005	122	7	23	23%	2
1.4	>25 - 93	SS-3	1993	66	LDW-SS49	2005	171	12	105	159%	1
1.5		DR123	1998	52.4	LDW-SS57	2005	35.4	7	-17	-32%	3
3.8		DR187	1998	48.1	LDW-SS115	2005	44.4	7	-3.7	-8%	2
1.3		DR053	1998	35.4	LDW-SS44	2005	46.8	7	11	32%	1
3.7		SD-323-S	2004	32	LDW-SS110	2005	24.7	1	-7.3	-23%	EAA
1.3		LDW-SS45	2005	26.2	TRI-045	2006	52.1	1	26	99%	3
3.7	>15 - 25	DR186	1998	24.9	LDW-SS111	2005	31.7	7	6.8	27%	EAA
1		DR019	1998	21.1	LDW-SS32	2005	15.7	7	-5.4	-26%	2
4.2		R42	1997	21.1	LDW-SS129	2005	10.6	8	-11	-50%	1
4.2		DR242	1998	20	SB-1	2004	22	6	2.0	10%	1
4.2		R40	1997	18.4	LDW-SS127	2005	13.2	8	-5.2	-28%	3
1.4		LDW-SS51	2005	16.9	TRI-051	2006	18.7	1	1.8	11%	3
1		DR087	1998	16.8	LDW-SS37	2005	13.6	7	-3.2	-19%	2
0.2		DR035	1998	16.7	LDW-SS12	2005	13	7	-3.7	-22%	3
0.9		DR085	1998	16.5	LDW-SSB2b	2005	16.5	7	0.0	0%	2
2.1		DR111	1998	16.5	DR-111	2006	15.1	8	-1.4	-8%	3
1.2		DR088	1998	15.4	LDW-SS40	2005	16.7	7	1.3	8%	3
0.3		LDW-SS16	2005	15.2	TRI-016	2006	16.2	1	1.0	7%	1
0.9		DR021	1998	15.2	LDW-SS319	2006	14.8	8	-0.4	-3%	1
0.3		DR079	1998	15.1	LDW-SS15	2005	11.5	7	-3.6	-24%	3
0.3	≤15	DUD042	1995	15	LDW-SS17	2005	14.9	10	-0.1	-1%	3
1.7		DR097	1998	14.6	LDW-SS63	2005	10.2	7	-4.4	-30%	3
4.2		R45	1997	13.9	LDW-SS130	2005	15	8	1.1	8%	1
1.4		DR030	1998	13.6	LDW-SS50	2005	16.3	7	2.7	20%	3
2.2		DR113	1998	13.4	LDW-SS81	2005	18.1	7	4.7	35%	2
2.1		DR106	1998	12.7	LDW-SS76	2005	14.5	7	1.8	14%	3
2.8		LDW-SS96	2005	12.7	TRI-096	2006	10.3	1	-2.4	-19%	3
0		K-11	1991	12.6	LDW-SS1	2005	6.2	14	-6.4	-51%	3
0.2		LDW-SS10	2005	12.4	TRI-010	2006	12.2	1	-0.2	-2%	3
3.9		R30	1997	12.4	LDW-SS119	2005	10.9	8	-1.5	-12%	2
2.8		DR175	1998	12.2	LDW-SS94	2005	26.5	7	14	117%	2
2.9		DR181	1998	12.2	DR-181	2006	19.6	8	7.4	61%	3
3.7		SD-DUW92	1996	12	SD-320-S	2004	20	8	8.0	67%	EAA
0.1		K-07	1991	11.6	LDW-SS4	2005	21.2	14	10	83%	2
3.7		R21	1997	10.8	LDW-SS113b	2005	8.3	8	-2.5	-23%	3
4.3		DR286	1998	10.7	B10b	2004	5.1	6	-5.7	-53%	1
0		DR076	1998	10.6	LDW-SS5	2005	6.5	7	-4.1	-39%	3
1.4		DR065	1998	10.3	LDW-SS52	2005	15.5	7	5.2	50%	2
1.4		B4b	2004	10.3	B4B	2006	14	2	3.7	36%	3
3.8		R24	1997	10.2	LDW-SS117	2005	14.4	8	4.2	41%	3
0.2		K-05	1991	10	LDW-SS10	2005	12.4	14	2.4	24%	3
1.4		DR028	1998	9.9	B4b	2004	10.3	6	0.4	4%	3
1.4		DR160	1998	9.6	LDW-SS51	2005	16.9	7	7.3	76%	3
4.1		DR238	1998	8.9	LDW-SS125	2005	8.6	7	-0.3	-3%	3
1.9		DR131	1998	8.1	LDW-SS70	2005	14.8	7	6.7	83%	3
3.2		DR202	1998	8.1	LDW-SS104	2005	11.5	7	3.4	42%	3
4.1		06-intsed-2	1996	8	SH-04	2004	8.8	8	0.8	10%	3
2		R7	1997	7.9	LDW-SS75	2005	8.3	8	0.4	5%	3

Table F-5b Percent Change at Resampled Surface Sediment Locations — Arsenic

River Mile	Older Arsenic Concentration Range (mg/kg dw)[a]	Older Station: Station ID	Older Station: Year Sampled	Older Station: Arsenic (mg/kg dw)	Newer Station: Station ID	Newer Station: Year Sampled	Newer Station: Arsenic (mg/kg dw)	Change in Arsenic Concentration from Older Station to Newer Station: Years Elapsed	Concentration Change (mg/kg dw)	Percent Change[b]	Recovery Category
3.9	≤15	LDW-SS123	2005	7.4	AN-019	2006	8.6	1	1.2	16%	2
4		07-intsed-1	1996	7	SH-02	2004	11	8	4.0	57%	3
3.1		DR198	1998	6.7	LDW-SS102	2005	6.6	7	-0.1	-1%	3
4.1		A11-05	1994	6.5	LDW-SS126	2005	7.3	11	0.8	12%	3
4.7		DR271	1998	6.4	LDW-SS148	2005	15.6	7	9.2	144%	3
								7	*Average Years Elapsed for All Locations*		

	Older Arsenic (mg/kg dw)		Newer Arsenic (mg/kg dw)		Percent Change
Concentration Averages by Reach - using locations with 5 or more years more between sampling (n = 48)					
Reach 1 (RM 0 to 2.2; n = 28)	65		54		-17%
Reach 2 (RM 2.2 to 4.0; n = 10)	16		19		19%
Reach 3 (RM 4.0 to 5.0; n = 10)	12		12		0%
Concentration Averages by Recovery Category (n=56)					
Category 1 (n= 10)	147		113		-23%
Category 2 (n = 11)	24		28		16%
Category 3 (n = 32)	13		14		8%
EAAs (n = 3)	23		25		11%

Notes:

1. Resampled locations are those where older stations are within 10 ft of newer stations.
2. Recovery categories are as follows:
   Recovery Category 1 = recovery predicted to be limited; Recovery Category 2 = recovery less certain; Recovery Category 3 = predicted to recover.

a. Original concentrations are grouped by some of the remedial action levels discussed in Sections 6 and 8. There is no division for data between the SQS (57 mg/kg dw) and the CSL (93 mg/kg dw) because there would be only 1 sample in this group.

b. Percent change = 100 x (Newer Concentration - Older Concentration)/Older Concentration

Greater than or equal to 50% concentration increase, 5 or more years between events, and any data > 25 mg/kg dw.

Minimal change (< 50% change in concentration), less than 5 years between events, or no concentrations > 25 mg/kg dw.

Greater than or equal to 50% concentration decrease, 5 or more years between events, and any data > 25 mg/kg dw.

CSL = cleanup screening level; EAA = early action area; mg/kg dw = milligram per kilogram dry weight; RM = river mile; SQS = sediment quality standards

Table F-5c Percent Change at Resampled Surface Sediment Locations — cPAHs

River Mile	Older cPAH Concentration Range (µg TEQ/kg dw)[a]	Older/Resampled Station: Station ID	Older/Resampled Station: Year Sampled	Older/Resampled Station: cPAH (µg TEQ/kg dw)	Newer Station: Station ID	Newer Station: Year Sampled	Newer Station: cPAH (µg TEQ/kg dw)	Change in cPAH Concentration from Resampled Station to Newer Station: Years Elapsed	Change: Concentration Change (µg TEQ/kg dw)	Change: Percent Change[b]	Recovery Category
4.2	>1,000	R40	1997	31000	LDW-SS127	2005	640	8	-30,360	-98%	3
4.2		R42	1997	8600	LDW-SS129	2005	860	8	-7,740	-90%	1
3.8		DR187	1998	5600	LDW-SS115	2005	2400	7	-3,200	-57%	2
4.2		R45	1997	4800	LDW-SS130	2005	370	8	-4,430	-92%	1
1.3		SS-2	1993	2160	LDW-SS48	2005	1400	12	-760	-35%	1
1		DR019	1998	2100	LDW-SS32	2005	340	7	-1,760	-84%	2
2.8		DR175	1998	2000	LDW-SS94	2005	100	7	-1,900	-95%	2
1		DR020	1998	1900	LDW-SS31	2005	600	7	-1,300	-68%	2
1.3		DR053	1998	1700	LDW-SS44	2005	670	7	-1,030	-61%	1
1		DR087	1998	1200	LDW-SS37	2005	210	7	-990	-83%	2
3.7		DR186	1998	1200	LDW-SS111	2005	1900	7	700	58%	EAA
0.3		DUD042	1995	1080	LDW-SS17	2005	440	10	-640	-59%	3
1.4		SS-3	1993	1080	LDW-SS49	2005	400	12	-680	-63%	1
0.1	>500 - 1,000	K-07	1991	1000	LDW-SS4	2005	270	14	-730	-73%	2
1.7		DR097	1998	1000	LDW-SS63	2005	190	7	-810	-81%	3
0.2		DR035	1998	840	LDW-SS12	2005	200	7	-640	-76%	3
0.9		DR021	1998	830	LDW-SS319	2006	560	8	-270	-33%	1
0.2		K-05	1991	800	LDW-SS10	2005	480	14	-320	-40%	3
1.5		DR123	1998	770	LDW-SS57	2005	350	7	-420	-55%	3
1.4		DR065	1998	700	LDW-SS52	2005	160	7	-540	-77%	2
2.1		DR111	1998	670	DR-111	2006	270	8	-400	-60%	3
1.4		DR028	1998	600	B4b	2004	300	6	-300	-50%	3
3.7		SD-323-S	2004	590	LDW-SS110	2005	250	1	-340	-58%	EAA
1.4		SS-4	1993	559	LDW-SS55	2005	190	12	-369	-66%	1
1.4		DR160	1998	540	LDW-SS51	2005	170	7	-370	-69%	3
0		K-11	1991	530	LDW-SS1	2005	130	14	-400	-75%	3
2.1		DR106	1998	510	LDW-SS76	2005	110	7	-400	-78%	3
1.9		DR131	1998	500	LDW-SS70	2005	410	7	-90	-18%	3
2.9		DR181	1998	500	DR-181	2006	320	8	-180	-36%	3
0.3	>250 - 500	LDW-SS16	2005	490	TRI-016	2006	440	1	-50	-10%	1
0.2		LDW-SS10	2005	480	TRI-010	2006	670	1	190	40%	3
4.2		DR242	1998	470	SB-1	2004	2300	6	1,830	389%	1
0.3		DR079	1998	460	LDW-SS15	2005	140	7	-320	-70%	3
4.7		DR271	1998	430	LDW-SS148	2005	230	7	-200	-47%	3
3.9		R30	1997	420	LDW-SS119	2005	260	8	-160	-38%	2
1.4		DR030	1998	400	LDW-SS50	2005	410	7	10	3%	3
0.9		DR085	1998	390	LDW-SSB2b	2005	260	7	-130	-33%	2
1.3		LDW-SS45	2005	350	TRI-045	2006	1400	1	1,050	300%	3
1.4		B4b	2004	300	B4B	2006	470	2	170	57%	3

Table F-5c Percent Change at Resampled Surface Sediment Locations — cPAHs

		Older/Resampled Station			Newer Station			Change in cPAH Concentration from Resampled Station to Newer Station			
River Mile	Older cPAH Concentration Range (µg TEQ/kg dw)[a]	Station ID	Year Sampled	cPAH (µg TEQ/kg dw)	Station ID	Year Sampled	cPAH (µg TEQ/kg dw)	Years Elapsed	Concentration Change (µg TEQ/kg dw)	Percent Change[b]	Recovery Category
1.2	≤250	DR088	1998	230	LDW-SS40	2005	95	7	-135	-59%	3
3.7		R21	1997	190	LDW-SS113b	2005	190	8	0	0%	3
1.4		LDW-SS51	2005	170	TRI-051	2006	370	1	200	118%	3
2		R7	1997	170	LDW-SS75	2005	130	8	-40	-24%	3
4.1		DR238	1998	160	LDW-SS125	2005	170	7	10	6%	3
3.1		DR198	1998	150	LDW-SS102	2005	61	7	-89	-59%	3
2.2		DR113	1998	140	LDW-SS81	2005	270	7	130	93%	2
3.2		DR202	1998	130	LDW-SS104	2005	52	7	-78	-60%	3
4.1		A11-05	1994	130	LDW-SS126	2005	180	11	50	38%	3
3.8		R24	1997	100	LDW-SS117	2005	78	8	-22	-22%	3
4.3		DR286	1998	100	B10b	2004	24	6	-76	-76%	1
2.8		LDW-SS96	2005	62	TRI-096	2006	130	1	68	110%	3
3.9		LDW-SS123	2005	21	AN-019	2006	67	1	46	219%	2
0		DR076	1998	18	LDW-SS5	2005	89	7	71	394%	3
								7	*Average Years Elapsed for All Locations*		

Concentration Averages by Reach - using locations with 5 or more years more between sampling (n = 45)						
Reach 1 (RM 0 to 2.2; n = 28)		817		330		-60%
Reach 2 (RM 2.2 to 4.0; n = 9)		1,143		596		-48%
Reach 3 (RM 4.0 to 5.0; n = 8)		5,711		597		-90%
Concentration Averages by Recovery Category (n=53)						
Category 1 (n= 10)		2,079		721		-65%
Category 2 (n = 11)		1,406		449		-68%
Category 3 (n = 30)		1,442		296		-79%
EAAs (n = 2)		895		1,075		20%

Notes:

1. Resampled locations are those where older stations are within 10 ft of newer stations.
2. Recovery categories are as follows:
   Recovery Category 1 = recovery predicted to be limited; Recovery Category 2 = recovery less certain; Recovery Category 3 = predicted to recover.

a. Original concentrations grouped by multiples of 250 µg TEQ/kg dw because the lowest site-wide RAL is 1,000 µg TEQ/kg dw, and the majority of these data fall below this concentration; therefore, RAL-based divisions are not appropriate here.

b. Percent change = 100 x (Newer Concentration - Older Concentration)/Older Concentration

Greater than or equal to 50% concentration increase, 5 or more years between events, and any data > 250 µg TEQ/kg dw.
Minimal change (< 50% change in concentration), less than 5 years between events, or no concentrations > 250 µg TEQ/kg dw.
Greater than or equal to 50% concentration decrease, 5 or more years between events, and any data > 250 µg TEQ/kg dw.

cPAH = carcinogenic polycyclic aromatic hydrocarbon; EAA = early action area; µg TEQ/kg dw = microgram per kilogram toxic equivalent dry weight; RAL = remedial action level; RM = river mile

Table F-5d Percent Change at Resampled Surface Sediment Locations — Bis(2-ethylhexyl)phthalate

River Mile	Older BEHP Concentration Range (µg/kg dw)[a]	Older Station			Newer Station			Change in BEHP Concentration from Older Station to Newer Station			Recovery Category
		Station ID	Year Sampled	BEHP (µg/kg dw)	Station ID	Year Sampled	BEHP (µg/kg dw)	Years Elapsed	Concentration Change (µg/kg dw)	Percent Change[b]	
0	>2,100	DR076	1998	6100	LDW-SS5	2005	20	7	-6,080	-100%	3
1.3		DR053	1998	3800	LDW-SS44	2005	120	7	-3,680	-97%	1
1.4		SS-4	1993	2200	LDW-SS55	2005	98	12	-2,102	-96%	1
0.3	>460 - 2,100	DUD042	1995	2000	LDW-SS17	2005	1100	10	-900	-45%	3
1.4		DR160	1998	1900	LDW-SS51	2005	120	7	-1,780	-94%	3
1.3		SS-2	1993	1600	LDW-SS48	2005	770	12	-830	-52%	1
1.4		DR030	1998	1500	LDW-SS50	2005	560	7	-940	-63%	3
1.9		DR131	1998	1500	LDW-SS70	2005	1700	7	200	13%	3
3.8		DR187	1998	1500	LDW-SS115	2005	330	7	-1,170	-78%	2
4.2		R40	1997	1400	LDW-SS127	2005	140	8	-1,260	-90%	3
1.7		DR097	1998	1200	LDW-SS63	2005	150	7	-1,050	-88%	3
4.2		R45	1997	1200	LDW-SS130	2005	72	8	-1,128	-94%	1
0.3		DR079	1998	1100	LDW-SS15	2005	64	7	-1,036	-94%	3
1.4		SS-3	1993	960	LDW-SS49	2005	160	12	-800	-83%	1
3.8		R24	1997	940	LDW-SS117	2005	140	8	-800	-85%	3
4.2		R42	1997	930	LDW-SS129	2005	170	8	-760	-82%	1
2.2		DR113	1998	910	LDW-SS81	2005	190	7	-720	-79%	2
2.9		DR181	1998	790	DR-181	2006	584	8	-206	-26%	3
0.1		K-07	1991	740	LDW-SS4	2005	83	14	-657	-89%	2
0.2		DR035	1998	720	LDW-SS12	2005	180	7	-540	-75%	3
0.2		K-05	1991	710	LDW-SS10	2005	82	14	-628	-88%	3
0.9		DR021	1998	710	LDW-SS319	2006	520	8	-190	-27%	1
1		DR019	1998	710	LDW-SS32	2005	93	7	-617	-87%	2
4.2		DR242	1998	620	SB-1	2004	1600	6	980	158%	1
1		DR087	1998	570	LDW-SS37	2005	760	7	190	33%	2
1.5		DR123	1998	560	LDW-SS57	2005	290	7	-270	-48%	3
1		DR020	1998	550	LDW-SS31	2005	160	7	-390	-71%	2
2.1		DR106	1998	460	LDW-SS76	2005	59	7	-401	-87%	3
3.9		R30	1997	460	LDW-SS119	2005	280	8	-180	-39%	2
1.2	>210 - 460	DR088	1998	410	LDW-SS40	2005	270	7	-140	-34%	3
1.4		DR065	1998	410	LDW-SS52	2005	95	7	-315	-77%	2
2.1		DR111	1998	410	DR-111	2006	340	8	-70	-17%	3
3.7		SD-323-S	2004	410	LDW-SS110	2005	170	1	-240	-59%	EAA
1.4		DR028	1998	390	B4b	2004	140	6	-250	-64%	3
0.3		LDW-SS16	2005	360	TRI-016	2006	504	1	144	40%	1
0.9		DR085	1998	340	LDW-SSB2b	2005	350	7	10	3%	2
1.3		LDW-SS45	2005	300	TRI-045	2006	592	1	292	97%	3
0		K-11	1991	290	LDW-SS1	2005	67	14	-223	-77%	3
2.8		DR175	1998	270	LDW-SS94	2005	46	7	-224	-83%	2
4.7		DR271	1998	260	LDW-SS148	2005	160	7	-100	-38%	3
3.7		R21	1997	220	LDW-SS113b	2005	200	8	-20	-9%	3
3.7		DR186	1998	210	LDW-SS111	2005	580	7	370	176%	EAA

Table F-5d Percent Change at Resampled Surface Sediment Locations — Bis(2-ethylhexyl)phthalate

River Mile	Older BEHP Concentration Range (µg/kg dw)[a]	Older Station: Station ID	Older Station: Year Sampled	Older Station: BEHP (µg/kg dw)	Newer Station: Station ID	Newer Station: Year Sampled	Newer Station: BEHP (µg/kg dw)	Change: Years Elapsed	Change: Concentration Change (µg/kg dw)	Change: Percent Change[b]	Recovery Category
2	≤210	R7	1997	180	LDW-SS75	2005	74	8	-106	-59%	3
3.1		DR198	1998	150	LDW-SS102	2005	130	7	-20	-13%	3
4.3		DR286	1998	150	B10b	2004	35	6	-115	-77%	1
1.4		B4b	2004	140	B4B	2006	612	2	472	337%	3
4.1		DR238	1998	130	LDW-SS125	2005	97	7	-33	-25%	3
1.4		LDW-SS51	2005	120	TRI-051	2006	400	1	280	233%	3
0.2		LDW-SS10	2005	82	TRI-010	2006	508	1	426	520%	3
4.1		A11-05	1994	81	LDW-SS126	2005	92	11	11	14%	3
3.2		DR202	1998	80	LDW-SS104	2005	36	7	-44	-55%	3
2.8		LDW-SS96	2005	70	TRI-096	2006	243	1	173	247%	3
3.9		LDW-SS123	2005	34	AN-019	2006	86	1	52	153%	2
								7	*Average Years Elapsed for All Locations*		

Concentration Averages by Reach - using locations with 5 or more years more between sampling (n = 45)						
Reach 1 (RM 0 to 2.2; n = 28)		1,176		308		-74%
Reach 2 (RM 2.2 to 4.0; n = 9)		513		258		-50%
Reach 3 (RM 4.0 to 5.0; n = 8)		596		296		-50%
Concentration Averages by Recovery Category (n=53)						
Category 1 (n= 10)		1,253		405		-68%
Category 2 (n = 11)		590		225		-62%
Category 3 (n = 30)		806		305		-62%
EAAs (n = 2)		310		375		21%

Notes:
1. Resampled locations are those where older stations are within 10 ft of newer stations.

2. The SQS criteria for bis(2-ethylhexyl)phthalate is 47 mg/kg oc.

2. Recovery categories are as follows:
Recovery Category 1 = recovery predicted to be limited; Recovery Category 2 = recovery less certain; Recovery Category 3 = predicted to recover.

a. Original concentrations grouped by FS baseline dataset percentiles (95, 75, and 50) as presented in Section 2.

b. Percent change = 100 x (Newer Concentration - Older Concentration)/Older Concentration

Greater than or equal to 50% concentration increase, 5 or more years between events, and any data > 210 µg/kg dw.
Minimal change (< 50% change in concentration), less than 5 years between events, or no concentrations > 210 µg/kg dw.
Greater than or equal to 50% concentration decrease, 5 or more years between events, and any data > 210 µg/kg dw.

BEHP = bis(2-ethylhexyl)phthalate; EAA = early action area; FS = feasibility study; µg/kg dw = microgram per kilogram dry weight; mg/kg oc = milligram per kilogram organic carbon; RM = river mile; SQS = sediment quality standards

Table F-5e Percent Change at Resampled Surface Sediment Locations — SMS Contaminants: Pairs Where Older Data Have SQS Exceedances

SQS Exceedance Contaminant for Older Sample Location	Units	Older Station				Newer Station				Change in Concentration from Older Station to Newer Station		
		Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Years Elapsed	Concentration Change	Percent Change[a]
2,4-Dimethylphenol	µg/kg dw	B4b	2004	28	1.9	B4B	2006	65	2.2	2	38	136%
4-Methylphenol	µg/kg dw	DR053	1998	910	1.4	LDW-SS44	2005	29	0.1	7	-881	-97%
Acenaphthene	µg/kg dw	R40	1997	3,300	8.1	LDW-SS127	2005	24	0.0	8	-3,276	-99%
		R42	1997	520	1.4	LDW-SS129	2005	34	0.1	8	-486	-93%
		R45	1997	420	1.1	LDW-SS130	2005	10	0.0	8	-410	-98%
		DR019	1998	580	1.4	LDW-SS32	2005	23	0.1	7	-557	-96%
		DR087	1998	530	2	LDW-SS37	2005	10	0.1	7	-520	-98%
		DR053	1998	690	1.6	LDW-SS44	2005	29	0.2	7	-661	-96%
		DR065	1998	1,800	4.7	LDW-SS52	2005	10	0.1	7	-1,790	-99%
		DR175	1998	740	2.7	LDW-SS94	2005	10	0.1	7	-730	-99%
Anthracene	µg/kg dw	R40	1997	9,300	1.6	LDW-SS127	2005	60	0.0	8	-9,240	-99%
Benzo(a)anthracene	µg/kg dw	R40	1997	21,000	7.4	LDW-SS127	2005	400	0.1	8	-20,600	-98%
		R42	1997	5,000	1.9	LDW-SS129	2005	490	0.2	8	-4,510	-90%
		R45	1997	3,000	1.1	LDW-SS130	2005	220	0.1	8	-2,780	-93%
		DR175	1998	3,000	1.5	LDW-SS94	2005	95	0.0	7	-2,905	-97%
Benzo(a)pyrene	µg/kg dw	R40	1997	21,000	8.2	LDW-SS127	2005	450	0.1	8	-20,550	-98%
		R42	1997	5,700	2.4	LDW-SS129	2005	580	0.2	8	-5,120	-90%
		R45	1997	3,400	1.4	LDW-SS130	2005	260	0.1	8	-3,140	-92%
Benzo(g,h,i)perylene	µg/kg dw	R40	1997	14,000	17	LDW-SS127	2005	170	0.2	8	-13,830	-99%
		R42	1997	3,900	5.2	LDW-SS129	2005	300	0.4	8	-3,600	-92%
		R45	1997	1,300	1.7	LDW-SS130	2005	86	0.1	8	-1,214	-93%
Benzofluoranthenes (total-calc'd)	µg/kg dw	R40	1997	32,000	5.2	LDW-SS127	2005	1,150	0.2	8	-30,850	-96%
		R42	1997	11,200	2	LDW-SS129	2005	1,430	0.3	8	-9,770	-87%
Benzyl alcohol	µg/kg dw	B4b	2004	70	1.2	B4B	2006	10.5	0.2	2	-60	-85%
		DR238	1998	130	2.3	LDW-SS125	2005	16.5	0.6	7	-114	-87%
		DR019	1998	1,700	30	LDW-SS32	2005	10	0.4	7	-1,690	-99%
		DR106	1998	80	1.4	LDW-SS76	2005	10	0.4	7	-70	-88%
Butyl benzyl phthalate	µg/kg dw	R30	1997	290	4.9	LDW-SS119	2005	140	1.9	8	-150	-52%
		DR271	1998	300	2.2	LDW-SS148	2005	24	0.2	7	-276	-92%
		DUD042	1995	140	1.1	LDW-SS17	2005	54	0.6	10	-86	-61%
		DR131	1998	460	6.3	LDW-SS70	2005	90	1.2	7	-370	-80%

Table F-5e Percent Change at Resampled Surface Sediment Locations — SMS Contaminants: Pairs Where Older Data Have SQS Exceedances

SQS Exceedance Contaminant for Older Sample Location	Units	Older Station				Newer Station				Change in Concentration from Older Station to Newer Station		
		Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Years Elapsed	Concentration Change	Percent Change[a]
Cadmium	mg/kg dw	K-05	1991	7.3	1.4	LDW-SS10	2005	0.5	0.1	14	-6.8	-93%
Chrysene	µg/kg dw	R40	1997	21,000	7.4	LDW-SS127	2005	690	0.2	8	-20,310	-97%
		R42	1997	6,800	2.5	LDW-SS129	2005	910	0.3	8	-5,890	-87%
		DR187	1998	4,100	2.0	LDW-SS115	2005	2,500	1.2	7	-1600	-39%
		R45	1997	3,700	1.4	LDW-SS130	2005	400	0.1	8	-3,300	-89%
		DR175	1998	3,400	1.8	LDW-SS94	2005	120	0.1	7	-3,280	-96%
Dibenzo(a,h)anthracene	µg/kg dw	R40	1997	7,200	23	LDW-SS127	2005	28	0.1	8	-7,172	-100%
		R42	1997	2,000	6.9	LDW-SS129	2005	110	0.4	8	-1,890	-95%
		DR187	1998	950	4.2	LDW-SS115	2005	240	1.1	7	-710	-75%
		R45	1997	640	2.2	LDW-SS130	2005	10	0.1	8	-630	-98%
		DR087	1998	210	1.1	LDW-SS37	2005	49	0.4	7	-161	-77%
Dibenzofuran	µg/kg dw	R40	1997	2,300	5.9	LDW-SS127	2005	10	0.0	8	-2,290	-100%
		R42	1997	470	1.3	LDW-SS129	2005	10	0.1	8	-460	-98%
		DR019	1998	500	1.3	LDW-SS32	2005	10	0.1	7	-490	-98%
		DR053	1998	480	1.1	LDW-SS44	2005	29	0.3	7	-451	-94%
		DR065	1998	1,300	3.6	LDW-SS52	2005	10	0.1	7	-1,290	-99%
		DR175	1998	750	2.9	LDW-SS94	2005	10	0.1	7	-740	-99%
Fluoranthene	µg/kg dw	R40	1997	62,000	15	LDW-SS127	2005	1,100	0.2	8	-60,900	-98%
		R42	1997	17,000	4.4	LDW-SS129	2005	1,500	0.4	8	-15,500	-91%
		DR187	1998	8,800	2.9	LDW-SS115	2005	5,200	1.7	7	-3600	-41%
		R45	1997	8,200	2.1	LDW-SS130	2005	700	0.2	8	-7,500	-91%
		DR053	1998	5,500	1.3	LDW-SS44	2005	940	0.4	7	-4,560	-83%
		DR065	1998	4,200	1.1	LDW-SS52	2005	250	0.1	7	-3,950	-94%
		DR175	1998	18,000	6.3	LDW-SS94	2005	200	0.1	7	-17,800	-99%
Fluorene	µg/kg dw	R40	1997	4,400	7.4	LDW-SS127	2005	32	0.0	8	-4,368	-99%
		R42	1997	730	1.3	LDW-SS129	2005	42	0.1	8	-688	-94%
		R45	1997	440	0.78	LDW-SS130	2005	10	0.0	8	-430	-98%
		DR065	1998	2,100	3.8	LDW-SS52	2005	10	0.0	7	-2,090	-100%
		DR175	1998	1,700	4.3	LDW-SS94	2005	10	0.0	7	-1,690	-99%

Table F-5e Percent Change at Resampled Surface Sediment Locations — SMS Contaminants: Pairs Where Older Data Have SQS Exceedances

SQS Exceedance Contaminant for Older Sample Location	Units	Older Station				Newer Station				Change in Concentration from Older Station to Newer Station		
		Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Years Elapsed	Concentration Change	Percent Change[a]
Hexachlorobenzene	µg/kg dw	DR198	1998	690	120	LDW-SS102	2005	2	0.6	7	-688	-100%
Indeno(1,2,3-cd)pyrene	µg/kg dw	R40	1997	15,000	17	LDW-SS127	2005	200	0.2	8	-14,800	-99%
		R42	1997	4,300	5.3	LDW-SS129	2005	340	0.4	8	-3,960	-92%
		R45	1997	2,700	3.2	LDW-SS130	2005	100	0.1	8	-2,600	-96%
		DR019	1998	920	1	LDW-SS32	2005	49	0.1	7	-871	-95%
		DR087	1998	620	1.1	LDW-SS37	2005	80	0.1	7	-540	-87%
		DR175	1998	660	1.1	LDW-SS94	2005	20	0.0	7	-640	-97%
Lead	mg/kg dw	SD-323-S	2004	2,350	5.20	LDW-SS110	2005	870	1.9	1	-1,480	-63%
Mercury	mg/kg dw	DR035	1998	0.52	1.3	LDW-SS12	2005	0.24	0.6	7	-0.28	-54%
		DR020	1998	0.47	1.1	LDW-SS31	2005	0.33	0.8	7	-0.14	-30%
		DR087	1998	0.55	1.3	LDW-SS37	2005	0.69	1.7	7	0.14	25%
		DR030	1998	0.62	1.5	LDW-SS50	2005	0.41	1.0	7	-0.21	-34%
		DR123	1998	0.45	1.1	LDW-SS57	2005	0.31	0.8	7	-0.14	-31%
Phenanthrene	µg/kg dw	R40	1997	43,000	17	LDW-SS127	2005	530	0.2	8	-42,470	-99%
		R42	1997	8,300	3.5	LDW-SS129	2005	790	0.3	8	-7,510	-90%
		R45	1997	4,900	2	LDW-SS130	2005	280	0.1	8	-4,620	-94%
		DR019	1998	3,000	1.1	LDW-SS32	2005	180	0.1	7	-2,820	-94%
		DR187	1998	6,300	3.3	LDW-SS115	2005	2,400	1.3	7	-3900	-62%
		DR065	1998	8,900	3.7	LDW-SS52	2005	74	0.0	7	-8,826	-99%
		DR175	1998	16,000	9.2	LDW-SS94	2005	79	0.0	7	-15,921	-100%
Phenol	µg/kg dw	K-11	1991	1,200	2.9	LDW-SS1	2005	10	0.0	14	-1,191	-99%
		K-05	1991	2,000	4.8	LDW-SS10	2005	24	0.1	14	-1,976	-99%
		DR202	1998	1,400	3.3	LDW-SS104	2005	29	0.1	7	-1,371	-98%
		K-07	1991	3,600	8.6	LDW-SS4	2005	10	0.0	14	-3,590	-100%
		DR053	1998	570	1.4	LDW-SS44	2005	29	0.1	7	-541	-95%
		R40	1997	48,000	1.8	LDW-SS127	2005	910	0.0	8	-47,090	-98%

Table F-5e Percent Change at Resampled Surface Sediment Locations — SMS Contaminants: Pairs Where Older Data Have SQS Exceedances

SQS Exceedance Contaminant for Older Sample Location	Units	Older Station				Newer Station				Change in Concentration from Older Station to Newer Station		
		Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Years Elapsed	Concentration Change	Percent Change[a]
Total HPAH (calc'd)	µg/kg dw	R40	1997	241,000	9.7	LDW-SS127	2005	5,100	0.2	8	-235,900	-98%
		R42	1997	69,000	3	LDW-SS129	2005	6,800	0.3	8	-62,200	-90%
		R45	1997	34,000	1.5	LDW-SS130	2005	2,940	0.1	8	-31,060	-91%
		DR187	1998	45,000	2.5	LDW-SS115	2005	19,000	1.0	7	-26,000	-58%
		DR175	1998	41,000	2.5	LDW-SS94	2005	860	0.0	7	-40,140	-98%
		R40	1997	60,000	6.2	LDW-SS127	2005	650	0.1	8	-59,350	-99%
		R42	1997	10,800	1.2	LDW-SS129	2005	930	0.1	8	-9,870	-91%
		DR065	1998	14,800	1.7	LDW-SS52	2005	110	0.0	7	-14,690	-99%
		DR175	1998	20,000	3	LDW-SS94	2005	105	0.0	7	-19,895	-99%
Zinc	mg/kg dw	DR020	1998	1,060	2.6	LDW-SS31	2005	997	2.4	7	-63	-6%

Greater than or equal to 50% concentration increase and 5 or more years between events.
Minimal change (<50% change in concentration) or less than 5 years between events.
Greater than or equal to 50% concentration decrease and 5 or more years between events.

Notes:
1. Resampled locations are those where older stations are within 10 ft of newer stations.
2. All older samples with SQS exceedances shown in this table; if the location has an exceedance in the newer sample, it is also shown in Table F-5f.
3. Data for total PCBs, arsenic, and BEHP not shown because they are included in Tables F-5a, F-5b, and F-5c, respectively.

a. Percent change = 100 x (Newer Concentration - Older Concentration)/Older Concentration

BEHP = bis(2-ethylhexyl)phthalate; HPAH = high-molecular-weight polycyclic aromatic hydrocarbon; µg/kg dw = microgram per kilogram dry weight; mg/kg dw = milligram per kilogram dry weight; SMS = Sediment Management Standards; SQS = sediment quality standards; U = undetected value

Table F-5f Percent Change at Resampled Surface Sediment Locations — SMS Contaminants - Pairs Where Newer Data Have SQS Exceedances

SQS Exceedance Contaminant for Newer Sample Locations	Units	Older Station				Newer Station					Change in Concentration from Older Station to Newer Station		
		Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Station ID	Year Sampled	Concentration	SQS Exceedance Factor	Toxicity Exceedance Status	Years Elapsed	Concentration Change	Percent Change[a]
2,4-Dimethylphenol	µg/kg dw	B4b	2004	27.5	1.9	B4B	2006	65	2.2	pass	2	37.5	136%
		DR111	1998	10	0.69	DR-111	2006	54	1.9	pass	8	44	440%
		LDW-SS10	2005	7	0.48	TRI-010	2006	45	1.6	SQS	1	38	543%
		LDW-SS16	2005	3.3	0.23	TRI-016	2006	44	1.5	pass [b]	1	40.7	1233%
		LDW-SS45	2005	3.3	0.23	TRI-045	2006	45	1.6	pass	1	41.7	1264%
		LDW-SS51	2005	3.3	0.23	TRI-051	2006	46	1.6	pass	1	42.7	1294%
		LDW-SS96	2005	3.3	0.23	TRI-096	2006	52	1.8	pass	1	48.7	1476%
Benzo(g,h,i)perylene	µg/kg dw	DR242	1998	20 U	undetected	SB-1	2004	1,100	1.3	no data	6	1,090	10900%
Benzyl alcohol	µg/kg dw	DR028	1998	50	0.9	B4b	2004	70	1.2	pass	6	20	40%
		DR111	1998	25	0.88	DR-111	2006	74	1.3	pass	8	49	196%
		DR181	1998	25	0.88	DR-181	2006	70	1.2	pass	8	45	180%
		LDW-SS16	2005	16.5	0.58	TRI-016	2006	64	1.1	pass [b]	1	47.5	288%
Butyl benzyl phthalate	µg/kg dw	R30	1997	290	4.9	LDW-SS119	2005	140	1.9	pass	8	-150	-52%
Chromium	mg/kg dw	DR186	1998	180	0.69	LDW-SS111	2005	455	1.8	no data	7	275	153%
Chrysene	µg/kg dw	DR187	1998	4,100	2.0	LDW-SS115	2005	2,500	1.2	pass	7	-1,600	-39%
Dibenzo(a,h)anthracene	µg/kg dw	DR187	1998	950	4.2	LDW-SS115	2005	240	1.1	pass	7	-710	-75%
		DR242	1998	100	0.24	SB-1	2004	700	2.2	no data	6	600	600%
Fluoranthene	µg/kg dw	DR187	1998	8,800	2.9	LDW-SS115	2005	5,200	1.7	pass	7	-3,600	-41%
		DR242	1998	2,000	0.36	SB-1	2004	4,800	1.1	no data	6	2,800	140%
Fluorene	µg/kg dw	DR186	1998	300	0.65	LDW-SS111	2005	640	1.2	no data	7	340	113%
Indeno(1,2,3-cd)pyrene	µg/kg dw	DR242	1998	180	0.15	SB-1	2004	1,200	1.3	no data	6	1,020	567%
Lead	mg/kg dw	SD-323-S	2004	2,350	5.20	LDW-SS110	2005	870	1.9	no data	1	-1,480	-63%
		DR186	1998	152	0.34	LDW-SS111	2005	635	1.4	no data	7	483	318%
Mercury	mg/kg dw	DR079	1998	0.25	0.61	LDW-SS15	2005	0.6	1.5	SQS	7	0.35	140%
		DR021	1998	0.29	0.71	LDW-SS319	2006	0.88	2.1	no data	8	0.59	203%
		DR087	1998	0.55	1.3	LDW-SS37	2005	0.69	1.7	CSL	7	0.14	25%
Phenanthrene	µg/kg dw	DR186	1998	1,700	0.85	LDW-SS111	2005	3,200	1.4	no data	7	1,500	88%
		DR187	1998	6,300	3.3	LDW-SS115	2005	2,400	1.3	pass	7	-3,900	-62%
Phenol	µg/kg dw	LDW-SS16	2005	240	0.57	TRI-016	2006	573	1.4	pass [b]	1	333	139%
Total HPAH (calc'd)	µg/kg dw	DR187	1998	45,000	2.5	LDW-SS115	2005	19,000	1	pass	7	-26,000	-58%
Zinc	mg/kg dw	DR186	1998	240	0.59	LDW-SS111	2005	460	1.1	no data	7	220	92%
		DR020	1998	1,060	2.6	LDW-SS31	2005	997	2.4	CSL	7	-63	-6%
		DR019	1998	359	0.88	LDW-SS32	2005	414	1	SQS	7	55	15%

Notes:

1. Resampled locations are those where older stations are within 10 ft of newer stations.
2. All newer samples with SQS exceedances shown in this table; if the location has an exceedance in the older sample, it is also shown in Table F-5e.
3. Data for total PCBs, arsenic, and BEHP not shown because they are included in Tables F-5a, F-5b, and F-5c, respectively.

a. Percent change = 100 x (Newer Concentration - Older Concentration)/Older Concentration

b. Older station had an SQS exceedance for toxicity.

Legend:
- Red: Greater than or equal to 50% concentration increase, 5 or more years between events.
- White: Minimal change (<50% change in concentration) or less than 5 years between events.
- Blue: Greater than or equal to 50% concentration decrease, 5 or more years between events.

BEHP = bis(2-ethylhexyl)phthalate; HPAH = high-molecular-weight polycyclic aromatic hydrocarbon; µg/kg dw = microgram per kilogram dry weight; mg/kg dw = milligram per kilogram dry weight; PCBs = polychlorinated biphenyls; SMS = Sediment Management Standards; SQS = sediment quality standards; U = undetected value

Table F-6 Duwamish / Diagonal Perimeter Data – Total PCBs, Arsenic, cPAHs, and BEHP

Station ID	Total PCBs (µg/kg dw)								Total PCBs (mg/kg oc)							
	2003 (pre-cap)	2004 (post-cap)	Jan 2005 (post-cap)	2006 (post-cap and ENR)	2007 (post-cap and ENR)	2008 (post-cap and ENR)	2009 (post-cap and ENR)	Percent Change (2003 to 2009)[a]	2003 (pre-cap)	2004 (post-cap)	Jan 2005 (post-cap)	2006 (post-cap and ENR)	2007 (post-cap and ENR)	2008 (post-cap and ENR)	2009 (post-cap and ENR)	Percent Change (2003 to 2009)[a]
DUD_1C	621	241	196	605	147	263	95	-85%	18.5	35.4	15.8	30.3	6.27	9.1	4.27	-77%
DUD_2C	382	368	340	274	158	142	93	-76%	16.2	47.2	20.6	14	7.36	5.87	4.47	-72%
DUD_8C	4,610	1,902	774	316	435	290	2970	-36%	251	163	71.7	51.5	39.5	n/a	132	-47%
DUD_9C	103	734	945	269	311	282	167	62%	13.2	95	85.1	n/a	39.2	41.9	15.2	15%
DUD_10C	373	665	328	319	134	159	142	-62%	36.6	64.6	38.1	33.8	11.4	17.2	14.2	-61%
DUD_11C	378	12	18.8	40.2	110	60	66.9	-82%	27.8	n/a	n/a	6.84	9.09	8.98	6.03	-78%
DUD_12C	263	644	334	383	309	246	240	-9%	19.9	79.7	45	57.9	37.6	19.5	20.3	2%
DUD_13C	n/a	n/a	710	355	371	241	91.5	-87%	n/a	n/a	38	21.6	24.4	14.1	4.82	-87%

Station ID	Arsenic (mg/kg dw)							
	2003 (pre-cap)	2004 (post-cap)	Jan 2005 (post-cap)	2006 (post-cap and ENR)	2007 (post-cap and ENR)	2008 (post-cap and ENR)	2009 (post-cap and ENR)	Percent Change (2003 to 2009)[a]
DUD_1C	29	1.8	6.1	11	14	15.2	14	-52%
DUD_2C	28	1.85	7.5	13	13	14.6	12	-57%
DUD_8C	35.7	1.85	6.4	5.2	7.3	5.5	15.6	-56%
DUD_9C	14	1.75	7.9	5.1	6.9	6.2	7.4	-47%
DUD_10C	24.4	7.4	10	9.9	10	9.62	8.9	-64%
DUD_11C	23.9	1.65	1.5	4.4	8.7	5.5	7.4	-69%
DUD_12C	23.1	1.75	4.8	6.9	7.2	12	9.1	-61%
DUD_13C	n/a	n/a	10	12	11	9.9	11	10%

Table F-6 Duwamish / Diagonal Perimeter Data – Total PCBs, Arsenic, cPAHs, and BEHP

Station ID	cPAH (µg TEQ/kg dw) 2003 (pre-cap)	2004 (post-cap)	Jan 2005 (post-cap)	2006 (post-cap and ENR)	2007 (post-cap and ENR)	2008 (post-cap and ENR)	2009 (post-cap and ENR)	Percent Change (2003 to 2009)[a]
DUD_1C	1050	142	339	463	n/a	430	230	-78%
DUD_2C	1020	258	513	847	n/a	620	250	-75%
DUD_8C	275	228	215	131	n/a	84	100	-64%
DUD_9C	246	179	202	136	n/a	100	49	-80%
DUD_10C	337	264	249	271	n/a	160	120	-64%
DUD_11C	558	48.4	30.6	144	n/a	140	84	-85%
DUD_12C	478	266	206	183	n/a	290	65	-86%
DUD_13C	n/a	n/a	485	350	n/a	250	54	-89%

Station ID	BEHP (µg/kg dw) 2003 (pre-cap)	2004 (post-cap)	Jan 2005 (post-cap)	2006 (post-cap and ENR)	2007 (post-cap and ENR)	2008 (post-cap and ENR)	2009 (post-cap and ENR)	Percent Change (2003 to 2009)[a]	BEHP (mg/kg oc) 2003 (pre-cap)	2004 (post-cap)	Jan 2005 (post-cap)	2006 (post-cap and ENR)	2007 (post-cap and ENR)	2008 (post-cap and ENR)	2009 (post-cap and ENR)	Percent Change (2003 to 2009)[a]
DUD_1C	5,940	676	877	2,360	1,440	2,330	591 U	-95%	177	99.3	70.7	118	61.5	80.6	26.6 U	-92%
DUD_2C	2,700	896	1,040	1,770	805	1,580	482 U	-91%	114	115	63	90.3	37.6	65.6	23.1 U	-90%
DUD_8C	2,420	1,110	763	405	255	400a	948	-61%	132	94.9	70.6	66.1	23.2	n/a	42	-68%
DUD_9C	473	681	695	348	156	393	464 U	-51%	60.9	88.1	62.6	n/a	19.7	58.4	42.2 U	-65%
DUD_10C	463	540	301	450	249	329	305 U	-68%	45.4	52.4	35	47.7	21.3	35.5	30.5 U	-67%
DUD_11C	1,610	52	62	755	517	559	1,150	-29%	118	n/a	n/a	128	42.7	84.1	104	-12%
DUD_12C	988	770	441	668	468	958	466 U	-76%	74.8	95.3	59.4	101	56.9	76	39.4 U	-73%
DUD_13C	n/a	n/a	770	592	342	484	148	-81%	n/a	n/a	41	36.1	22.5	28.3	15.6	-62%

Notes:

1. Underlined oc-normalized data for total PCBs and BEHP exceed the sediment quality standards of 12 and 47 mg/kg oc, respectively.
2. Unpublished 2010 data show further decreases in risk driver concentrations, including those from location DUD_8C (Williston 2010, personal communication).

a. Percent change for locations DUD_12C and DUD_13C is from 2005 to 2009 because samples were not collected at these locations in 2003 or 2004.

Greater than or equal to 50% concentration increase, more than 5 years between events.

Minimal change (<50% change in concentration) or less than 5 years between events.

Greater than or equal to 50% concentration decrease, more than 5 years between events.

n/a = not applicable because total organic carbon was not within appropriate range for normalizing concentrations or because location was not sampled.

BEHP = bis(2-ethylhexyl)phthalate; cPAH = carcinogenic polycyclic aromatic hydrocarbon; ENR = enhanced natural recovery; LDW = Lower Duwamish Waterway; µg/kg dw = microgram per kilogram dry weight; mg/kg oc = milligram per kilogram organic carbon; PCBs = polychlorinated biphenyls; RM = river mile; TEQ = toxic equivalent quotient; U = undetected at reporting limit, one-half of this value was used in the percent change calculation

Table F-7a Subsurface Sediment Total PCB Trends — Trend Present with Subsurface Peak (N=24) – Low Resolution and High Resolution Data from 2006 LDW RI Cores

Subsurface Core ID	Location	Recovered Depth Interval (ft)	Total PCBs (µg/kg dw)	Concentration Change (µg/kg dw)[a]	Percent Change (µg/kg dw)[b]	Trends in Top Two Intervals: Total PCBs	Trends in Top Two Intervals: Other SMS Contaminants	Recovery Category	Remedial Alternative When First Active
LDW-SC1	RM 0.0, by marina	0–0.5	85	-6,615	-99%	Decrease	Mixed	3	3
		0.5–1	350						
		1–1.5	6,700						
		1.5–2	4,300						
LDW-SC4	RM 0.2 E	0–1	143	-457	-76%	Decrease	Mixed	1	4
		1–2	490						
		2–4	600						
		4–6	3.9 U						
LDW-SC6	RM 0.3 W	0–0.5	167	-2,433	-94%	Below SQS	Sample resolution too coarse	1	4
		0.5–1	97						
		1–1.5	101						
		1.5–2	94						
		2–2.5	176						
		2.5–3	350						
		3–3.5	490						
		3.5–4	1,590						
		4–4.5	2,600						
LDW-SC8	RM 0.35 in Navigation Channel	0–1	290	-5,210	-95%	Decrease	Mixed	3	5
		1–2	1,030						
		2–4	2,900						
		4–6	5,500						
		6–8	3,800						
		8–10	540						
LDW-SC10	RM 0.55 E	0–1	260	-860	-77%	Equilibrium	Decrease	3	3
		1–2	290						
		2–4	1,120						
		4–5	410						
		6–8	350						
LDW-SC12	RM 0.6 W	0–0.5	64	-1,936	-97%	Equilibrium	Increase	2	4
		0.5–1	106						
		1–1.5	134						
		1.5–2	320						
		2–2.5	2,000						
		2.5–3	630						
		3–3.5	138						
		3.5–4	790						
LDW-SC15	NW Corner of Slip 1	0–1	360	-1,590	-82%	Equilibrium	No contaminants other than PCBs exceed the SQS	2	3
		1–2	340 J						
		2–4	510						
		4–6	1,950						
		8–10	4.0 U						
LDW-SC16	Mouth of Slip 1	0–2	330	-5,070	-94%	Equilibrium	Decrease	1	4
		2–4	5,400						
		4–6	3,400						
		8–10	18 J						

Table F-7a Subsurface Sediment Total PCB Trends — Trend Present with Subsurface Peak (N=24) – Low Resolution and High Resolution Data from 2006 LDW RI Cores

Subsurface Core ID	Location	Recovered Depth Interval (ft)	Total PCBs (µg/kg dw)	Concentration Change (µg/kg dw)[a]	Percent Change (µg/kg dw)[b]	Trends in Top Two Intervals: Total PCBs	Trends in Top Two Intervals: Other SMS Contaminants	Recovery Category	Remedial Alternative When First Active
LDW-SC17	Head of Slip 1	0–1	1,220	-8,580	-88%	Decrease	Mixed	2	2
		1–2	1,040						
		2–4	9,800						
		6–8.2	1,900						
LDW-SC19	RM 1.0, South of Kellogg Island	0–1	280	-2,120	-88%	Equilibrium	No contaminants other than PCBs exceed the SQS	2	5
		1–2	233						
		2–4	250						
		4–6	440						
		6–7	2,400						
		9–11.9	3.9 U						
LDW-SC21	RM 1.0 W	0–1	250	-1,430	-85%	Increase	No contaminants other than PCBs exceed the SQS	1	2
		1–2	145						
		2–4	380 J						
		4–6.2	1,680						
		6.2-8	4U						
		10–11.3	3.9 U						
LDW-SC23	RM 1.2 E	0–2	177	-703	-80%	Sample resolution too coarse	No contaminants other than PCBs exceed the SQS	2	6
		2–4	219						
		4–6	880						
		6–8	400						
		8–10.2	41						
LDW-SC25	RM 1.3 W	0–1	310	-490	-61%	Equilibrium	Equilibrium	1	2
		1–2	360						
		2–4	430						
		4–6	800						
		8–9.1	3.9 U						
LDW-SC26	RM 1.35 W	0–1	280	-2,020	-88%	Equilibrium	No contaminants other than PCBs exceed the SQS	1	2
		1–2	226						
		2–4	310						
		6–8	2,300						
		11.1–12.1	140						
LDW-SC27	RM 1.4 E	0–0.5	250	-2,950	-92%	Decrease	Equilibrium	3	3
		0.5–1	2,000						
		1–1.5	3,200						
		1.5–2	1,510						
		2–2.5	840						
		2.5–3	290						
		3–3.5	60						
		3.5–4	3.9 U						
		4–4.5	3.9 U						
LDW-SC28	RM 1.4 W	0–1	440	-2,760	-86%	Equilibrium	Increase	1	2
		1–2	360 J						
		2–4	290						
		5.5–7.5	3,200						
		12–12.6	540						
LDW-SC32	Slip 2	0–1	1,010	-1,440	-59%	Decrease	Mixed	3	5
		1–2	1,720						
		2–4	2,450						
		5.2–8	3.8 U						

Table F-7a Subsurface Sediment Total PCB Trends — Trend Present with Subsurface Peak (N=24) – Low Resolution and High Resolution Data from 2006 LDW RI Cores

Subsurface Core ID	Location	Recovered Depth Interval (ft)	Total PCBs (µg/kg dw)	Concentration Change (µg/kg dw)[a]	Percent Change (µg/kg dw)[b]	Trends in Top Two Intervals: Total PCBs	Trends in Top Two Intervals: Other SMS Contaminants	Recovery Category	Remedial Alternative When First Active
LDW-SC33	RM 1.9 E	0–0.5	490	-4,210	-90%	Equilibrium	Sample resolution too coarse	3	3
		0.5–1	790						
		1–1.5	4,700						
		1.5–2	2,500						
		2–2.5	210						
		2.5–3	940						
LDW-SC37	SE Corner of Slip 3	0–1	450	-500	-53%	Decrease	Mixed	2	3
		1–2	950						
		2–4	550						
		5.3–6.9	3.9 U						
LDW-SC38	RM 2.1 W	0–1	450	-2,950	-87%	Equilibrium	No chemicals other than PCBs exceed the SQS	3	5
		1–2	710						
		2–3	3,400						
		3–3.3	14						
LDW-SC39	RM 2.15 W	0–1	208	-232	-53%	Equilibrium	No contaminants other than PCBs exceed the SQS	3	4
		1–2	440						
		2–4	220						
		4–6	150						
LDW-SC44	RM 2.7 E	0–0.5	260	-620	-70%	Decrease	Sample resolution too coarse	3	3
		0.5–1	880						
		1–1.5	200						
		1.5–2	140						
		2–2.5	270						
		2.5–3	150						
		3–3.5	4.0 U						
LDW-SC47	RM 3.05 W	0–1	72	-1,928	-96%	Decrease	No contaminants other than PCBs exceed the SQS	3	5
		1–2	2,000						
		2–3	490 J						
		3–4	4.0 UJ						
LDW-SC49a	RM 3.55 in Navigation Channel	0–1	75	-735	-91%	Below SQS	Increase	1	4
		1–2	150						
		2–4	420						
		4–6	780						
		6–8	810						
		8–10	130						

Notes:

1. Subsurface peak is defined where the maximum concentration is at least twice the concentration of that in the surface interval, and the peak exceeds 240 µg/kg dw.

2. Recovery categories are defined as:

Recovery Category 1 = recovery predicted to be limited; Recovery Category 2 = recovery less certain; Recovery Category 3 = predicted to recover.

3. See Table F-8 for trends for other SMS contaminants.

a. Concentration change = Peak concentration in subsurface - concentration in top interval.

b. Percent change = 100 * Concentration change / Peak concentration in subsurface.

(shaded) Peak concentration in subsurface used in percent change calculation.

E = east; EAA = early action area; J = qualified value; LDW = Lower Duwamish Waterway; µg/kg dw = microgram per kilogram dry weight; PCBs = polychlorinated biphenyls; RI = remedial investigation; RM = river mile; SMS = Sediment Management Standards; SQS = sediment quality standard; U = undetected value; W = west

Table F-7b Subsurface Sediment Total PCB Trends — No Strong Trend
(N=17, plus 1 replicate) - Low and High Resolution Data from 2006 LDW RI Cores

Subsurface Core ID	Location	Recovered Depth Interval (ft)	Total PCBs (µg/kg dw)	Trends in Top Two Intervals: Total PCBs	Trends in Top Two Intervals: Other SMS Contaminants	Recovery Category	Remedial Alternative When First Active
LDW-SC3	RM 0.1 E	0–2	4.0 U	Sample resolution too coarse	Sample resolution too coarse	3	Outside of AOPC
		2–4	3.9 U				
LDW-SC13	RM 0.85 E	0–0.5	460	Equilibrium	Sample resolution too coarse	3	5
		0.5–1	470				
		1–1.5	280				
		1.5–2	360				
		2–2.5	120				
		2.5–3	3.9 U				
		3–3.5	3.8 U				
LDW-SC18	RM 1.0 E	0–1	182	Increase, using a co-located surface sediment sample at 650 µg/kg dw	Increase	1	2
		1–2	19.6				
		2–4	3.9 U				
LDW-SC22	RM 1.1 E	0–1.1	56	Below SQS	Below SQS	3	3
		1.1–2	26 J				
		2–4	7.8 J				
LDW-SC29	RM 1.4 W	0–1	33 J	Below SQS	Equilibrium	3	2
		1–2	3.9 UJ				
		2–3.6	3.9 U				
LDW-SC30	RM 1.55 E	0–2.5	12.9	Sample resolution too coarse	Sample resolution too coarse	3	4
		2.5–4	3.9 U				
LDW-SC34	RM 1.85 W	0–1	210	Below SQS	Mixed	1	2
		1–2	280				
		2–4	250				
LDW-SC36	RM 2.1 E	0–1	75	Below SQS	Below SQS	3	6
		1–2	4.0 U				
		2–4	3.8 U				
LDW-SC202	RM 2.1 E, replicate of SC36	0–1	30	Below SQS	Mixed	3	6
		1–2	3.8 UJ				
		2–4	3.9 UJ				
LDW-SC40	RM 2.2 W	0–1.3	160 J (21 mg/kg oc)	Increase	No contaminants other than PCBs exceed the SQS	2	2
		1.3–2	4.0 UJ				
		2–4	3.9 UJ				
LDW-SC42	RM 2.4 W	0–1	107	Below SQS	Below SQS	1	6
		1–2	163 J				
		2–4	88 J				
LDW-SC43	RM 2.6 E	0–2	4.0 UJ	Sample resolution too coarse	Sample resolution too coarse	3	2
		2–4	3.9 UJ				

Table F-7b Subsurface Sediment Total PCB Trends — No Strong Trend (N=17, plus 1 replicate) - Low and High Resolution Data from 2006 LDW RI Cores

Subsurface Core ID	Location	Recovered Depth Interval (ft)	Total PCBs (µg/kg dw)	Trends in Top Two Intervals: Total PCBs	Trends in Top Two Intervals: Other SMS Contaminants	Recovery Category	Remedial Alternative When First Active
LDW-SC45[a]	RM 2.8 E	0–1	230 J	Equilibrium	No contaminants other than PCBs exceed the SQS	2	5
		1–2	270				
		2–4	570				
		5–6	122				
LDW-SC46	RM 2.7 W	0–1	214	Equilibrium	Mixed	1	2
		1–2	185 J				
		2–4	270				
		4–6.8	195				
LDW-SC48	RM 3.3 Navigation Channel	0–1	77	Below SQS	Below SQS	3	6
		1–2	3.8 U				
		2–4	3.9 U				
LDW-SC53	Head of Slip 6	0–2	68	Sample resolution too coarse	Sample resolution too coarse	1	2
		2–4	77				
LDW-SC54	RM 4.2 W	0–2	109	Sample resolution too coarse	Sample resolution too coarse	1	6
		2–4	111				
LDW-SC55	RM 4.85 E	0–1	13.5	Increase, using a co-located surface sediment sample at 2,700 µg/kg dw	Below SQS	Upstream of STM domain; no category assigned	2
		1–2	59 U				
		2–3	4.0 U				

Notes:

1. Cores with no strong trends have similar low level concentrations throughout the profile, or all concentrations are below 240 µg/kg dw.
2. Recovery categories are as follows:
   Recovery Category 1 = recovery predicted to be limited; Recovery Category 2 = recovery less certain;
   Recovery Category 3 = predicted to recover.
3. See Table F-8 for trends for other SMS contaminants.

a. The concentration in the 2- to 4-ft interval, 570 µg/kg dw, is two times that in the shallowest interval, 230 µg/kg dw; but the concentration of the interval in between suggests that there is no real strong "peak" in this core. The concentrations are more diffuse.

AOPC = area of potential concern; E = east; J = qualified value; LDW = Lower Duwamish Waterway; µg/kg dw = microgram per kilogram dry weight; PCBs = polychlorinated biphenyls; RI = Remedial Investigation; RM = river mile; SMS = Sediment Management Standards; SQS = sediment quality standards; STM = Sediment Transport Model; U = undetected value; W = west

Table F-7c Subsurface Sediment Total PCB Trends — High Concentration in Surface Interval (N=15, plus 2 replicates) - Low Resolution Data from 2006 LDW RI Cores

Subsurface Core ID	Location	Recovered Depth Interval (ft)	Total PCBs (µg/kg dw)	Potential Explanation for High Concentration in Surface	Trends in Top Two Intervals: Total PCBs	Trends in Top Two Intervals: Other SMS Contaminants	Recovery Category	Remedial Alternative When First Active
LDW-SC2	RM 0.0 E	surface - LDW-SS6	1,920	Low sedimentation rate; active berthing area; concentration increase with co-located surface	Equilibrium	Mixed	2	3
		0–2	1,380					
		2–4	2,900					
		4–6	209					
		8-10	237					
		10.7–12	3.8 U					
LDW-SC5	RM 0.15 W	0–1	510	Nearby outfalls (in tributary)	Increase	Equilibrium	2	4
		1–2.2	66					
		2.2–4	3.9 U					
LDW-SC7	RM 0.4 E	surface - DUD043	570	Co-located surface show concentration decrease	Decrease	Mixed	3	5
		0–1	1,300					
		1–1.7	1,270 J					
		1.7–4	5.5 U					
LDW-SC9	RM 0.5 in Navigation Channel, by D/D EAA cap	surface - DUD_8C (2009)[a]	2,970	Co-located surface show concentration decrease of 18% (equilibrium)	Equilibrium	Mixed	3	5
		0–1	3,600					
		1–2.6	2,700					
		2.6–4	67					
LDW-SC11	RM 0.55 W	0–0.8	3,000	Nearby outfalls (not modeled)	Increase	Mixed	1	2
		0.8–2	3.9 U					
		2–3.4	3.9 U					
		3.4–4.1	4.0 U					
LDW-SC14	RM 0.85 in Navigation Channel	surface - LDW-SSB2b	790	0-2 cm high-flow scour	Decrease	Decrease	2	3
		0–1.4	4,500					
		1.4–2	2,060					
		2–4.1	1,550					
		4.1–6	420					
		6–8.7	70					
		10–11	3.9 U					
LDW-SC20	RM 1.05 in Navigation Channel	surface - LDW-SS37	5,100	Area of elevated dioxins/furans	Increase	Equilibrium	2	2
		0–2	3,200					
		2–4	600					
		4–6	400					
		8–10	95					
LDW-SC24	RM 1.25 W	0–1	280	Evidence of vessel scour	Increase	No contaminants other than PCBs exceed the SQS	1	4
		1–2	36					
		2–4	3.9 U					
LDW-SC31	RM 1.65 E	0–1	370	Evidence of vessel scour; in maintenance dredging footprint where 3 of 5 DMMUs not suitable for open water disposal	Sample resolution too coarse	Sample resolution too coarse	1	4
		1–2.8	330					
		2.8–4	2.7 J					

Table F-7c Subsurface Sediment Total PCB Trends — High Concentration in Surface Interval (N=15, plus 2 replicates) - Low Resolution Data from 2006 LDW RI Cores

Subsurface Core ID	Location	Recovered Depth Interval (ft)	Total PCBs (µg/kg dw)	Potential Explanation for High Concentration in Surface	Trends in Top Two Intervals: Total PCBs	Trends in Top Two Intervals: Other SMS Contaminants	Recovery Category	Remedial Alternative When First Active
LDW-SC203	RM 1.85 W, replicate of SC-34	0–1	250	0-2 cm high flow scour; near modeled discharge location and near two maintenance dredging events; SC-34 (parent core) has similar concentration in top interval (210 µg/kg dw)	Below SQS	Mixed	1	2
		1–2	110					
		2–4	174					
		4–6	181					
LDW-SC201	RM 1.9 E, replicate of SC33	0–1.5	1,450	Downstream of modeled discharge location; berthing and cable area	Sample resolution too coarse	Sample resolution too coarse	3	3
		1.5–4	530 J					
		4–6	340					
		8–10	3.9 U					
LDW-SC35	RM 1.95 W	0–2	370 J	0-2 cm high-flow scour; upstream of maintenance dredging event	Sample resolution too coarse	Sample resolution too coarse	3	3
		2–4	150 J					
LDW-SC41	R 2.35 E	0–1	370 J	Nearby storm drains; evidence of vessel scour	Equilibrium	No contaminants other than PCBs exceed the SQS	1	4
		1–2	256					
		2–4	270					
		4–6	510					
		6–7.9	190					
LDW-SC50a	RM 3.75 E	surface - LDW-SS114	820	Near hot spot at RM 3.8 E	Increase	Increase	2	2
		0–1	510					
		1–2	780					
		2–2.8	75 J					
		2.8–4	3.8 UJ					
LDW-SC51	RM 3.8 E	surface - LDW-SS115	220	Near hot spot at RM 3.8 E; by modeled discharge location	Decrease	Mixed	2	2
		0–2	1,290					
		2–3.8	700					
		3.8–5.8	3.9 U					
LDW-SC52	RM 3.9 E	0–1	3,000 J	0-2 cm high-flow scour	Decrease	Increase	2	2
		1–2	65					
		2–4	4.0 U					
LDW-SC56	RM 4.75 W	0–2	330	Nearby resampled station for PCBs had 94% reduction, but newer sample still above SQS	Sample resolution too coarse	Sample resolution too coarse	1	3
		2–4	3.9 U					

Notes:

1. Table F-6 includes cores with highest concentration and total PCBs greater than 240 µg/kg dw in surface interval.
2. Recovery categories are as follows:
   Recovery Category 1 = recovery predicted to be limited; Recovery Category 2 = recovery less certain;
   Recovery Category 3 = predicted to recover.
3. Only low resolution sample intervals (1- to 2-ft) were available for these cores.
4. See Table F-8 for trends for other SMS contaminants.

a. Unpublished 2010 data show further decreases in total PCB concentrations (Williston 2010, personal communication).

D/D = Duwamish/Diagonal; E = east; EAA = early action area; DMMU = dredged material management unit; J = qualified value; LDW = Lower Duwamish Waterway; µg/kg dw = microgram per kilogram dry weight; PCBs = polychlorinated biphenyls; RI = remedial investigation; RM = river mile; SMS = Sediment Management Standards; SQS = sediment quality standards; U = undetected value; W = west

highest concentration in surface interval or top two intervals is approximately twice that in the deeper intervals, and is greater than 240 µg/kg dw.

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
LDW-SC1	LDW Subsurface Sediment 2006	0	2006	—	Bis(2-ethylhexyl) phthalate	0	0.5	700	µg/kg dw	No	0.68	No	0.41	0.5	1	400	µg/kg dw	No	0.43	No	0.26	75	Decrease	Mixed
						1	1.5	2400	µg/kg dw	Yes	2.6	Yes	1.5	1.5	2	1000	µg/kg dw	No	0.89	No	0.54	—		
					Butyl benzyl phthalate	0	0.5	46	µg/kg dw	No	0.43	No	0.033	0.5	1	38	µg/kg dw	No	0.39	No	0.03	21		
						1	1.5	98	µg/kg dw	Yes	1	No	0.078	1.5	2	93	µg/kg dw	No	0.8	No	0.061	—		
					Mercury	0	0.5	0.27	mg/kg dw	No	0.66	No	0.46	0.5	1	0.33	mg/kg dw	No	0.8	No	0.56	-18		
						1	1.5	1.27	mg/kg dw	Yes	3.1	Yes	2.2	1.5	2	1.22	mg/kg dw	Yes	3	Yes	2.1	—		
					PCBs (total calc'd)	0	0.5	85	µg/kg dw	No	0.33	No	0.06	0.5	1	350	µg/kg dw	Yes	1.5	No	0.28	-76		
						1	1.5	6700	µg/kg dw	Yes	28	Yes	5.2	1.5	2	4300	µg/kg dw	Yes	15	Yes	2.8	—		
LDW-SC2	LDW Subsurface Sediment 2006	0.1	2006	2005	Arsenic	Surface	—	82.9	mg/kg dw	Yes	1.5	No	0.89	0	2	190	mg/kg dw	Yes	3.3	Yes	2	-56	Equilibrium	Mixed
					Bis(2-ethylhexyl) phthalate	Surface	—	850	µg/kg dw	Yes	1.7	Yes	1	0	2	900	µg/kg dw	Yes	2.1	Yes	1.3	-6		
					Lead	Surface	—	573	mg/kg dw	Yes	1.3	Yes	1.1	0	2	569	mg/kg dw	Yes	1.3	Yes	1.1	1		
					N-Nitrosodi-phenylamine	Surface	—	24	µg/kg dw	No	0.21	No	0.21	0	2	135	µg/kg dw	Yes	2.7	Yes	2.7	-91		
					PCBs (total calc'd)	Surface	—	1920	µg/kg dw	Yes	15	Yes	2.8	0	2	1380	µg/kg dw	Yes	13	Yes	2.3	39		
					Total PAH (calc'd)	Surface	—	1400	µg/kg dw	—	—	—	—	0	2	1850	µg/kg dw	—	—	—	—	-24		
					Zinc	Surface	—	553	mg/kg dw	Yes	1.3	No	0.58	0	2	748	mg/kg dw	Yes	1.8	No	0.78	-26		
LDW-SC4	LDW Subsurface Sediment 2006	0.2	2006	—	Arsenic	0	1	18	mg/kg dw	No	0.32	No	0.19	1	2	63	mg/kg dw	Yes	1.1	No	0.68	-71	Decrease	Mixed
					Mercury	0	1	0.53	mg/kg dw	Yes	1.3	No	0.9	1	2	0.43	mg/kg dw	Yes	1	No	0.73	23		
					PCBs (total calc'd)	0	1	143	µg/kg dw	No	0.78	No	0.14	1	2	490	µg/kg dw	Yes	2.1	No	0.38	-71		
LDW-SC5	LDW Subsurface Sediment 2006	0.2	2006	—	Mercury	0	1	0.27	mg/kg dw	No	0.66	No	0.46	1	2.2	0.51	mg/kg dw	Yes	1.2	No	0.86	-47	Increase	Equilibrium
					PCBs (total calc'd)	0	1	510	µg/kg dw	Yes	2.5	No	0.46	1	2.2	66	µg/kg dw	No	0.14	No	0.026	673		
LDW-SC6	LDW Subsurface	0.3	2006	2005	Total PAH (calc'd)	Surface	—	4490	µg/kg dw	—	—	—	—	0	2	4360	µg/kg dw	—	—	—	—	3	Below SQS	Below SQS
DR068	EPA SI	0.3	1998	1998	PCBs (total calc'd)	Surface	—	93	µg/kg dw	No	0.33	No	0.06	0	2	2600	µg/kg dw	Yes	13	Yes	2.5	-96	Decrease	Below SQS
					Total PAH (calc'd)	Surface	—	4780	µg/kg dw	—	—	—	—	0	2	5900	µg/kg dw	—	—	—	—	-19		
LDW-SC7	LDW Subsurface Sediment 2006	0.4	2006	1995	1,2-Dichlorobenzene	Surface	—	1.6	µg/kg dw	No	0.033	No	0.033	0	1	10	µg/kg dw	No	0.43	No	0.43	-92	Decrease	Mixed
						1	1.7	10	µg/kg dw	Yes	1	Yes	1	—	—	—	—	—	—	—	—	—		
					Bis(2-ethylhexyl) phthalate	Surface	—	2600	µg/kg dw	Yes	2.6	Yes	1.5	0	1	1200	µg/kg dw	Yes	1.3	No	0.76	117		
						1	1.7	240	µg/kg dw	No	0.62	No	0.37	—	—	—	—	—	—	—	—	—		
					Butyl benzyl phthalate	Surface	—	130	µg/kg dw	Yes	1.3	No	0.097	0	1	73	µg/kg dw	No	0.73	No	0.056	78		
						1	1.7	18	µg/kg dw	No	0.45	No	0.034	—	—	—	—	—	—	—	—	—		
					Mercury	Surface	—	0.29	mg/kg dw	No	0.71	No	0.49	0	1	0.47	mg/kg dw	Yes	1.1	No	0.8	-38		
						1	1.7	0.17	mg/kg dw	No	0.41	No	0.29	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	570	µg/kg dw	Yes	2.3	No	0.42	0	1	1300	µg/kg dw	Yes	5.3	No	0.98	-56		
						1	1.7	1270	µg/kg dw	Yes	13	Yes	2.3	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	7100	µg/kg dw	—	—	—	—	0	1	3200	µg/kg dw	—	—	—	—	122		
						1	1.7	490	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
LDW-SC8	LDW Subsurface Sediment 2006	0.4	2006	—	Hexachloro-benzene	0	1	0.49	µg/kg dw	No	0.13	No	0.021	1	2	2.45	µg/kg dw	Yes	1.1	No	0.19	-80	Decrease	Mixed
					Mercury	0	1	0.32	mg/kg dw	No	0.78	No	0.54	1	2	0.48	mg/kg dw	Yes	1.2	No	0.81	-33		
					PCBs (total calc'd)	0	1	290	µg/kg dw	Yes	1.3	No	0.23	1	2	1030	µg/kg dw	Yes	7.5	Yes	1.4	-72		
LDW-SC9	LDW Subsurface Sediment 2006	0.5	2006	2009	1,2,4-Trichlorobenzene	Surface	—	0.08	µg/kg dw	No	0.0088	No	0.0039	0	1	18	µg/kg dw	Yes	1.4	No	0.61	-100	Equilibrium	Mixed
					Benzyl alcohol	Surface	—	1.6	µg/kg dw	No	0.056	No	0.044	0	1	140	µg/kg dw	Yes	2.5	Yes	1.9	-99		
					Bis(2-ethylhexyl) phthalate	Surface	—	948	µg/kg dw	No	0.89	No	0.54	0	1	1700	µg/kg dw	Yes	2.1	Yes	1.3	-44		
					Mercury	Surface	—	0.61	mg/kg dw	Yes		Yes		0	1	0.42	mg/kg dw	Yes	1	No	0.71	45		
					PCBs (total calc'd)	Surface	—	2970	µg/kg dw	Yes	11	Yes	2	0	1	3600	µg/kg dw	Yes	18	Yes	3.4	-18		
					Total PAH (calc'd)	Surface	—	1600	µg/kg dw	—	—	—	—	0	1	1730	µg/kg dw	—	—	—	—	-8		
LDW-SC10	LDW Subsurface Sediment 2006	0.5	2006	—	Bis(2-ethylhexyl) phthalate	0	1	1200	µg/kg dw	Yes	1.4	No	0.83	1	2	2800	µg/kg dw	Yes	2.8	Yes	1.7	-57	Equilibrium	Decrease
					Butyl benzyl phthalate	0	1	29	µg/kg dw	No	0.33	No	0.025	1	2	160	µg/kg dw	Yes	1.5	No	0.11	-82		
					PCBs (total calc'd)	0	1	260	µg/kg dw	Yes	1.2	No	0.22	1	2	290	µg/kg dw	Yes	1.1	No	0.2	-10		
LDW-SC11	LDW Subsurface Sediment 2006	0.5	2006	—	1,2,4-Trichlorobenzene	0	0.8	4.5	µg/kg dw	No	0.15	No	0.088	0.8	2	2.9	µg/kg dw	Yes	1.1	No	0.5	-22	Increase	Mixed
					Benzo(a) anthracene	0	0.8	3600	µg/kg dw	Yes	2.8	Yes	2.3	0.8	2	9.5	µg/kg dw	No	0.026	No	0.011	18847		
					Benzo(a)pyrene	0	0.8	3100	µg/kg dw	Yes	1.9	Yes	1	0.8	2	9.5	µg/kg dw	No	0.029	No	0.014	16216		
					Benzofluoranthenes (total-calc'd)	0	0.8	7600	µg/kg dw	Yes	2.4	Yes	2.1	0.8	2	9.5	µg/kg dw	No	0.013	No	0.0064	39900		
					Chrysene	0	0.8	4300	µg/kg dw	Yes	3.1	Yes	1.5	0.8	2	9.5	µg/kg dw	No	0.026	No	0.0063	22532		
					Fluoranthene	0	0.8	8100	µg/kg dw	Yes	4.8	Yes	3.2	0.8	2	9.5	µg/kg dw	No	0.018	No	0.0024	42532		
					Indeno(1,2,3-cd) pyrene	0	0.8	670	µg/kg dw	Yes	1.1	No	0.97	0.8	2	9.5	µg/kg dw	No	0.085	No	0.033	3426		
					Lead	0	0.8	639	mg/kg dw	Yes	1.4	Yes	1.2	0.8	2	3	mg/kg dw	No	0.0067	No	0.0057	21200		
					Mercury	0	0.8	0.64	mg/kg dw	Yes	1.6	Yes	1.1	0.8	2	0.03	mg/kg dw	No	0.15	No	0.1	967		
					PCBs (total calc'd)	0	0.8	3000	µg/kg dw	Yes	23	Yes	3	0.8	2	1.95	µg/kg dw	No	0.05	No	0.0092	76823		
					Pyrene	0	0.8	6700	µg/kg dw	Yes	2.6	Yes	2	0.8	2	13	µg/kg dw	No	0.002	No	0.0014	51438		
					Total HPAH (calc'd)	0	0.8	34700	µg/kg dw	Yes	2.9	Yes	2	0.8	2	13	µg/kg dw	No	0.0021	No	0.00038	266823		
					Zinc	0	0.8	482	mg/kg dw	Yes	1.2	No	0.5	0.8	2	26.2	mg/kg dw	No	0.064	No	0.027	1740		
DR008	EPA SI	0.5	1998	1998	1,2-Dichlorobenzene	Surface	—	520	µg/kg dw	Yes	15	Yes	10	0	2	10	µg/kg dw	No	0.24	No	0.24	2500	Equilibrium	Mixed
					Benzo(g,h,i) perylene	Surface	—	1000	µg/kg dw	Yes	1.5	Yes	1.4	0	2	580	µg/kg dw	No	0.52	No	0.21	72		
					Bis(2-ethylhexyl) phthalate	Surface	—	11000	µg/kg dw	Yes	8.5	Yes	5.8	0	2	6900	µg/kg dw	Yes	4	Yes	2.4	59		
					Butyl benzyl phthalate	Surface	—	940	µg/kg dw	Yes	15	Yes	1	0	2	550	µg/kg dw	Yes	3.1	No	0.23	71		
					Chrysene	Surface	—	1700	µg/kg dw	Yes	1.2	No	0.61	0	2	1400	µg/kg dw	No	0.35	No	0.085	21		
					Fluoranthene	Surface	—	3300	µg/kg dw	Yes	1.9	Yes	1.3	0	2	2400	µg/kg dw	No	0.42	No	0.056	38		
					Indeno(1,2,3-cd) pyrene	Surface	—	1000	µg/kg dw	Yes	1.7	Yes	1.4	0	2	630	µg/kg dw	No	0.53	No	0.2	59		
					Mercury	Surface	—	0.29	mg/kg dw	No	0.71	No	0.49	0	2	0.92	mg/kg dw	Yes	2.2	Yes	1.6	-68		
					PCBs (total calc'd)	Surface	—	430	µg/kg dw	Yes	3.3	No	0.43	0	2	750	µg/kg dw	Yes	1.8	No	0.32	-43		
					Pyrene	Surface	—	2700	µg/kg dw	Yes	1	No	0.82	0	2	3800	µg/kg dw	No	0.11	No	0.079	-29		
					Total HPAH (calc'd)	Surface	—	14500	µg/kg dw	Yes	1.2	No	0.85	0	2	13900	µg/kg dw	No	0.41	No	0.074	4		
					Total PAH (calc'd)	Surface	—	16200	µg/kg dw	—	—	—	—	0	2	16000	µg/kg dw	—	—	—	—	1		
					Zinc	Surface	—	360	mg/kg dw	No	0.88	No	0.38	0	2	420	mg/kg dw	Yes	1	No	0.44	-14		

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Shallow Sediment / Top Layer: Upper Depth (ft)	Shallow Sediment / Top Layer: Lower Depth (ft)	Shallow Sediment / Top Layer: Concen-tration or Half if Undetected	Shallow Sediment / Top Layer: Units	Shallow Sediment / Top Layer: Exceeds SQS?	Shallow Sediment / Top Layer: SQS Exceedance Factor	Shallow Sediment / Top Layer: Exceeds CSL?	Shallow Sediment / Top Layer: CSL Exceedance Factor	Deeper Sediment: Upper Depth (ft)	Deeper Sediment: Lower Depth (ft)	Deeper Sediment: Concen-tration or Half if Undetected	Deeper Sediment: Units	Deeper Sediment: Exceeds SQS?	Deeper Sediment: SQS Exceedance Factor	Deeper Sediment: Exceeds CSL?	Deeper Sediment: CSL Exceedance Factor	Percent Change for SMS Contaminant	Core Trend for: Total PCBs	Core Trend for: Other SMS Contaminants
DUD006	Duw/Diag-1	0.5	1994	1997	1,4-Dichlorobenzene	Surface	—	34	µg/kg dw	No	0.31	No	0.28	0.49	0.98	100	µg/kg dw	Yes	2.9	Yes	1	-66	Decrease	Mixed
						0.98	1.48	120	µg/kg dw	Yes	3.5	Yes	1.2	1.48	1.97	260	µg/kg dw	Yes	11	Yes	3.7	—		
						1.97	2.46	120	µg/kg dw	Yes	2.4	No	0.83	—	—	—	—	—	—	—	—	—		
					Bis(2-ethylhexyl) phthalate	Surface	—	6180	µg/kg dw	Yes	4.8	Yes	3.3	0.49	0.98	2200	µg/kg dw	Yes	4.3	Yes	2.6	181		
						0.98	1.48	1700	µg/kg dw	Yes	3.2	Yes	1.9	1.48	1.97	2400	µg/kg dw	Yes	6.4	Yes	3.8	—		
						1.97	2.46	2500	µg/kg dw	Yes	3.4	Yes	2.1	—	—	—	—	—	—	—	—	—		
					Butyl benzyl phthalate	Surface	—	263	µg/kg dw	Yes	4.2	No	0.29	0.49	0.98	62	µg/kg dw	Yes	1.1	No	0.088	324		
						0.98	1.48	44	µg/kg dw	No	0.82	No	0.063	1.48	1.97	49	µg/kg dw	Yes	1.2	No	0.095	—		
						1.97	2.46	1300	µg/kg dw	Yes	17	Yes	1.3	—	—	—	—	—	—	—	—	—		
					Cadmium	Surface	—	1.4	mg/kg dw	No	0.27	No	0.21	0.49	0.98	1.9	mg/kg dw	No	0.37	No	0.28	-26		
						0.98	1.48	3.7	mg/kg dw	No	0.73	No	0.55	1.48	1.97	7.9	mg/kg dw	Yes	1.5	Yes	1.2	—		
						1.97	2.46	13	mg/kg dw	Yes	2.5	Yes	1.9	—	—	—	—	—	—	—	—	—		
					Copper	Surface	—	75.6	mg/kg dw	No	0.19	No	0.19	0.49	0.98	420	mg/kg dw	Yes	1.1	Yes	1.1	-82		
						0.98	1.48	76	mg/kg dw	No	0.19	No	0.19	1.48	1.97	90	mg/kg dw	No	0.23	No	0.23	—		
						1.97	2.46	150	mg/kg dw	No	0.38	No	0.38	—	—	—	—	—	—	—	—	—		
					Lead	Surface	—	101	mg/kg dw	No	0.22	No	0.19	0.49	0.98	290	mg/kg dw	No	0.64	No	0.55	-65		
						0.98	1.48	370	mg/kg dw	No	0.82	No	0.7	1.48	1.97	870	mg/kg dw	Yes	1.9	Yes	1.6	—		
						1.97	2.46	910	mg/kg dw	Yes	2	Yes	1.7	—	—	—	—	—	—	—	—	—		
					Mercury	Surface	—	0.17	mg/kg dw	No	0.41	No	0.29	0.49	0.98	0.26	mg/kg dw	No	0.63	No	0.44	-35		
						0.98	1.48	0.42	mg/kg dw	Yes	1	No	0.71	1.48	1.97	0.68	mg/kg dw	Yes	1.7	Yes	1.2	—		
						1.97	2.46	1.1	mg/kg dw	Yes	2.7	Yes	1.9	—	—	—	—	—	—	—	—	—		
					N-Nitrosodiphenylamine	Surface	—	42	µg/kg dw	No	0.15	No	0.15	0.49	0.98	16.5	µg/kg dw	No	0.27	No	0.27	27		
						1.97	2.46	190	µg/kg dw	Yes	1.1	Yes	1.1	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	250	µg/kg dw	Yes	1.9	No	0.25	0.49	0.98	509	µg/kg dw	Yes	3.8	No	0.71	-51		
						0.98	1.48	820	µg/kg dw	Yes	6.3	Yes	1.2	1.48	1.97	238	µg/kg dw	Yes	2.5	No	0.46	—		
						1.97	2.46	730	µg/kg dw	Yes	3.8	No	0.71	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	6500	µg/kg dw	—	—	—	—	0.49	0.98	3580	µg/kg dw	—	—	—	—	82		
						0.98	1.48	2280	µg/kg dw	—	—	—	—	1.48	1.97	2950	µg/kg dw	—	—	—	—	—		
						1.97	2.46	6070	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
					Zinc	Surface	—	240	mg/kg dw	No	0.59	No	0.25	0.49	0.98	450	mg/kg dw	Yes	1.1	No	0.47	-47		
						0.98	1.48	240	mg/kg dw	No	0.59	No	0.25	1.48	1.97	310	mg/kg dw	No	0.76	No	0.32	—		
						1.97	2.46	350	mg/kg dw	No	0.85	No	0.36	—	—	—	—	—	—	—	—	—		
DUD020	Duw/Diag-1	0.5	1994	1994	Bis(2-ethylhexyl) phthalate	Surface	—	6200	µg/kg dw	Yes	3.8	Yes	2.3	0.49	0.98	11000	µg/kg dw	Yes	7.2	Yes	4.4	-44	Equilibrium	Mixed
						0.98	1.48	3900	µg/kg dw	Yes	3	Yes	2.1	1.48	1.97	3300	µg/kg dw	Yes	3.8	Yes	2.3	—		
						1.97	2.46	3800	µg/kg dw	Yes	3	Yes	1.8	—	—	—	—	—	—	—	—	—		
					Butyl benzyl phthalate	Surface	—	180	µg/kg dw	Yes	1.1	No	0.083	0.49	0.98	970	µg/kg dw	Yes	6.1	No	0.47	-81		
						0.98	1.48	80	µg/kg dw	Yes	1.3	No	0.089	1.48	1.97	63	µg/kg dw	No	0.71	No	0.055	—		
						1.97	2.46	72	µg/kg dw	No	0.53	No	0.041	—	—	—	—	—	—	—	—	—		
					Lead	Surface	—	110	mg/kg dw	No	0.24	No	0.21	0.49	0.98	230	mg/kg dw	No	0.51	No	0.43	-52		
						0.98	1.48	500	mg/kg dw	Yes	1.1	No	0.94	1.48	1.97	430	mg/kg dw	No	0.96	No	0.81	—		
						1.97	2.46	360	mg/kg dw	No	0.8	No	0.68	—	—	—	—	—	—	—	—	—		
					Mercury	Surface	—	0.23	mg/kg dw	No	0.56	No	0.39	0.49	0.98	1.2	mg/kg dw	Yes	2.9	Yes	2	-81		
						0.98	1.48	0.6	mg/kg dw	Yes	1.5	Yes	1	1.48	1.97	0.22	mg/kg dw	No	0.54	No	0.37	—		
						1.97	2.46	1.2	mg/kg dw	Yes	2.9	Yes	2	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	506	µg/kg dw	Yes	1.3	No	0.23	0.49	0.98	760	µg/kg dw	Yes	2	No	0.37	-33		
						0.98	1.48	158	µg/kg dw	Yes	1.2	No	0.16	1.48	1.97	441	µg/kg dw	Yes	2.1	No	0.38	—		
						1.97	2.46	3020	µg/kg dw	Yes	9.2	Yes	1.7	—	—	—	—	—	—	—	—	—		
					Phenol	Surface	—	870	µg/kg dw	Yes	2.1	No	0.73	0.49	0.98	390	µg/kg dw	No	0.93	No	0.33	123		
						0.98	1.48	85	µg/kg dw	No	0.4	No	0.14	1.48	1.97	110	µg/kg dw	No	0.52	No	0.18	—		
						1.97	2.46	85	µg/kg dw	No	0.4	No	0.14	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	9600	µg/kg dw	—	—	—	—	0.49	0.98	11100	µg/kg dw	—	—	—	—	-14		
						0.98	1.48	6400	µg/kg dw	—	—	—	—	1.48	1.97	2480	µg/kg dw	—	—	—	—	—		
						1.97	2.46	8300	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
DR044	EPA SI	0.6	1998	1998	Chrysene	Surface	—	4600	µg/kg dw	Yes	2	No	0.48	0	2	50	µg/kg dw	No	0.017	No	0.0041	9100	Lack of Data Density	Increase
					Fluoranthene	Surface	—	23000	µg/kg dw	Yes	6.9	No	0.92	0	2	120	µg/kg dw	No	0.028	No	0.0038	19067		
					Phenanthrene	Surface	—	3000	µg/kg dw	Yes	1.4	No	0.29	0	2	60	µg/kg dw	No	0.022	No	0.0046	4900		
					Total HPAH (calc'd)	Surface	—	51000	µg/kg dw	Yes	2.6	No	0.47	0	2	560	µg/kg dw	No	0.022	No	0.004	9007		
					Total PAH (calc'd)	Surface	—	55000	µg/kg dw	—	—	—	—	0	2	660	µg/kg dw	—	—	—	—	8233		
LDW-SC12	LDW Subsurface Sediment 2006	0.6	2006	1998	PCBs (total calc'd)	0.5	1	106	µg/kg dw	No	0.45	No	0.083	1	1.5	134	µg/kg dw	No	0.6	No	0.11	-21	Equilibrium	Increase
						1.5	2	320	µg/kg dw	Yes	1.3	No	0.25	2	2.5	2000	µg/kg dw	Yes	7.4	Yes	1.4	—		
					Chrysene	Surface	—	4600	µg/kg dw	Yes	2	No	0.48	0	2	210	µg/kg dw	No	0.1	No	0.024	2090		
					Fluoranthene	Surface	—	23000	µg/kg dw	Yes	6.9	No	0.92	0	2	350	µg/kg dw	No	0.11	No	0.015	6471		
					Phenanthrene	Surface	—	3000	µg/kg dw	Yes	1.4	No	0.29	0	2	100	µg/kg dw	No	0.052	No	0.011	2900		
					Total HPAH (calc'd)	Surface	—	51000	µg/kg dw	Yes	2.6	No	0.47	0	2	2090	µg/kg dw	No	0.11	No	0.021	2340		
					Total PAH (calc'd)	Surface	—	55000	µg/kg dw	—	—	—	—	0	2	2240	µg/kg dw	—	—	—	—	2355		
LDW-SC13	LDW Subsurface Sediment 2006	0.9	2006	—	PCBs (total calc'd)	0	0.5	460	µg/kg dw	Yes	2.5	No	0.46	0.5	1	470	µg/kg dw	Yes	1.2	No	0.22	-2	Equilibrium	Lack of Data Density
						1	1.5	280	µg/kg dw	No	0.92	No	0.17	1.5	2	360	µg/kg dw	No	0.92	No	0.17	—		
						2	2.5	120	µg/kg dw	No	0.29	No	0.054	—	—	—	—	—	—	—	—	—		
LDW-SC14	LDW Subsurface Sediment 2006	0.9	2006	2005	Bis(2-ethylhexyl) phthalate	Surface	—	350	µg/kg dw	No	0.45	No	0.27	0	1.4	1200	µg/kg dw	Yes	1.5	No	0.9	-71	Decrease	Decrease
						1.4	2	470	µg/kg dw	No	0.62	No	0.37	—	—	—	—	—	—	—	—	—		
					Butyl benzyl phthalate	Surface	—	21	µg/kg dw	No	0.47	No	0.036	0	1.4	100	µg/kg dw	Yes	1.2	No	0.091	-79		
						1.4	2	51	µg/kg dw	No	0.63	No	0.048	—	—	—	—	—	—	—	—	—		
					Mercury	Surface	—	0.26	mg/kg dw	No	0.63	No	0.44	0	1.4	0.71	mg/kg dw	Yes	1.7	Yes	1.2	-63		
						1.4	2	0.51	mg/kg dw	Yes	1.2	No	0.86	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	790	µg/kg dw	Yes	3.8	No	0.71	0	1.4	4500	µg/kg dw	Yes	22	Yes	4	-82		
						1.4	2	2060	µg/kg dw	Yes	11	Yes	2	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	1920	µg/kg dw	—	—	—	—	0	1.4	2310	µg/kg dw	—	—	—	—	-17		
						1.4	2	1000	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
LDW-SC15	LDW Subsurface Sediment 2006	0.9	2006	—	PCBs (total calc'd)	0	1	360	µg/kg dw	Yes	1.3	No	0.23	1	2	340	µg/kg dw	Yes	1.4	No	0.26	6	Equilibrium	Below SQS
DR021	EPA SI	0.9	1998	2006	Mercury	Surface	—	0.88	mg/kg dw	Yes	2.1	Yes	1.5	0	2	0.38	mg/kg dw	No	0.93	No	0.64	132	Equilibrium	Increase
					PCBs (total calc'd)	Surface	—	350	µg/kg dw	Yes	1.1	No	0.2	0	2	520	µg/kg dw	Yes	1.7	No	0.31	-33		
					Total PAH (calc'd)	Surface	—	4260	µg/kg dw	—	—	—	—	0	2	5600	µg/kg dw	—	—	—	—	-24		
LDW-SC16	LDW Subsurface Sediment 2006	1	2006	2006	Fluoranthene	Surface	—	860	µg/kg dw	No	0.28	No	0.038	0	2	4700	µg/kg dw	Yes	1.4	No	0.19	-82	Equilibrium	Decrease
					PCBs (total calc'd)	Surface	—	390	µg/kg dw	Yes	1.8	No	0.32	0	2	330	µg/kg dw	Yes	1.3	No	0.25	18		
					Total PAH (calc'd)	Surface	—	4910	µg/kg dw	—	—	—	—	0	2	12200	µg/kg dw	—	—	—	—	-60		
LDW-SC17	LDW Subsurface Sediment 2006	1	2006	2005	Arsenic	Surface	—	122	mg/kg dw	Yes	2.1	Yes	1.3	0	1	110	mg/kg dw	Yes	1.9	Yes	1.2	11	Decrease	Mixed
						1	2	170	mg/kg dw	Yes	3	Yes	1.8	—	—	—	—	—	—	—	—	—		
					Benzyl alcohol	0	1	140	µg/kg dw	Yes	2.5	Yes	1.9	1	2	38	µg/kg dw	No	0.67	No	0.52	268		
					Cadmium	Surface	—	3.2	mg/kg dw	No	0.63	No	0.48	0	1	4.5	mg/kg dw	No	0.88	No	0.67	-29		
						1	2	7.6	mg/kg dw	Yes	1.5	Yes	1.1	—	—	—	—	—	—	—	—	—		
					Fluoranthene	Surface	—	670	µg/kg dw	No	0.19	No	0.026	0	1	2000	µg/kg dw	No	0.41	No	0.054	-67		
						1	2	5600	µg/kg dw	Yes	1.1	No	0.14	—	—	—	—	—	—	—	—	—		
					Mercury	Surface	—	0.33	mg/kg dw	No	0.8	No	0.56	0	1	0.5	mg/kg dw	Yes	1.2	No	0.85	-34		
						1	2	0.6	mg/kg dw	Yes	1.5	Yes	1	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	96	µg/kg dw	No	0.37	No	0.068	0	1	1220	µg/kg dw	Yes	3.3	No	0.62	-92		
						1	2	1040	µg/kg dw	Yes	2.7	No	0.49	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	4480	µg/kg dw	—	—	—	—	0	1	14200	µg/kg dw	—	—	—	—	-68		
						1	2	22800	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
					Zinc	Surface	—	997	mg/kg dw	Yes	2.4	Yes	1	0	1	1260	mg/kg dw	Yes	3.1	Yes	1.3	-21		
						1	2	2050	mg/kg dw	Yes	5	Yes	2.1	—	—	—	—	—	—	—	—	—		
LDW-SC18	LDW Subsurface Sediment 2006	1	2006	2005	2-Methyl-naphthalene	Surface	—	3300	µg/kg dw	Yes	4.2	Yes	2.5	0	1	29.5	µg/kg dw	No	0.087	No	0.052	5493	Increase	Increase
						1	2	10	µg/kg dw	No	0.055	No	0.033	—	—	—	—	—	—	—	—	—		
					Acenaphthene	Surface	—	5200	µg/kg dw	Yes	16	Yes	4.6	0	1	48	µg/kg dw	No	0.17	No	0.047	10733		
						1	2	10	µg/kg dw	No	0.13	No	0.037	—	—	—	—	—	—	—	—	—		
					Benzo(a) anthracene	Surface	—	3200	µg/kg dw	Yes	1.5	No	0.59	0	1	490	µg/kg dw	No	0.25	No	0.1	553		
						1	2	16	µg/kg dw	No	0.015	No	0.0063	—	—	—	—	—	—	—	—	—		
					Benzo(a)pyrene	Surface	—	2000	µg/kg dw	Yes	1	No	0.48	0	1	340	µg/kg dw	No	0.19	No	0.09	488		
						1	2	27	µg/kg dw	No	0.028	No	0.013	—	—	—	—	—	—	—	—	—		
					Benzofluoranthenes (total-calc'd)	Surface	—	5100	µg/kg dw	Yes	1.1	No	0.56	0	1	970	µg/kg dw	No	0.24	No	0.12	426		
						1	2	70	µg/kg dw	No	0.032	No	0.016	—	—	—	—	—	—	—	—	—		
					Chrysene	Surface	—	3700	µg/kg dw	Yes	1.6	No	0.39	0	1	740	µg/kg dw	No	0.38	No	0.091	400		
						1	2	17	µg/kg dw	No	0.016	No	0.0039	—	—	—	—	—	—	—	—	—		
					Dibenzofuran	Surface	—	3500	µg/kg dw	Yes	11	Yes	2.9	0	1	29.5	µg/kg dw	No	0.22	No	0.057	5832		
						1	2	10	µg/kg dw	No	0.14	No	0.036	—	—	—	—	—	—	—	—	—		
					Fluoranthene	Surface	—	17000	µg/kg dw	Yes	5.3	No	0.71	0	1	2600	µg/kg dw	No	0.94	No	0.13	554		
						1	2	36	µg/kg dw	No	0.023	No	0.0031	—	—	—	—	—	—	—	—	—		
					Fluorene	Surface	—	4900	µg/kg dw	Yes	10	Yes	3	0	1	36	µg/kg dw	No	0.087	No	0.025	13511		
						1	2	10	µg/kg dw	No	0.091	No	0.027	—	—	—	—	—	—	—	—	—		
					Mercury	Surface	—	0.46	mg/kg dw	Yes	1.1	No	0.78	0	1	0.11	mg/kg dw	No	0.27	No	0.19	318		
						1	2	0.025	mg/kg dw	No	0.12	No	0.085	—	—	—	—	—	—	—	—	—		
					Naphthalene	Surface	—	5300	µg/kg dw	Yes	2.6	Yes	1.5	0	1	35	µg/kg dw	No	0.02	No	0.012	15043		
						1	2	10	µg/kg dw	No	0.021	No	0.012	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	650	µg/kg dw	Yes	2.7	No	0.49	0	1	182	µg/kg dw	No	0.83	No	0.15	257		
						1	2	19.6	µg/kg dw	No	0.17	No	0.031	—	—	—	—	—	—	—	—	—		
					Phenanthrene	Surface	—	15000	µg/kg dw	Yes	7.5	Yes	1.6	0	1	290	µg/kg dw	No	0.16	No	0.033	5072		
						1	2	10	µg/kg dw	No	0.021	No	0.0044	—	—	—	—	—	—	—	—	—		
					Total HPAH (calc'd)	Surface	—	42000	µg/kg dw	Yes	2.2	No	0.4	0	1	7000	µg/kg dw	No	0.42	No	0.075	500		
						1	2	242	µg/kg dw	No	0.026	No	0.0047	—	—	—	—	—	—	—	—	—		
					Total LPAH (calc'd)	Surface	—	34000	µg/kg dw	Yes	4.6	Yes	2.2	0	1	560	µg/kg dw	No	0.086	No	0.041	5971		
						1	2	10	µg/kg dw	No	0.0057	No	0.0027	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	76000	µg/kg dw	—	—	—	—	0	1	7600	µg/kg dw	—	—	—	—	900		
						1	2	242	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
LDW-SC19	LDW Subsurface Sediment 2006	1	2006	—	PCBs (total calc'd)	0	1	280	µg/kg dw	No	1	No	0.18	1	2	233	µg/kg dw	Yes	1.2	No	0.22	20	Equilibrium	Below SQS
LDW-SC20	LDW Subsurface Sediment 2006	1	2006	2005	Mercury	Surface	—	0.69	mg/kg dw	Yes	1.7	Yes	1.2	0	2	0.65	mg/kg dw	Yes	1.6	Yes	1.1	6	Increase	Equilibrium
					PCBs (total calc'd)	Surface	—	5100	µg/kg dw	Yes	18	Yes	3.4	0	2	3200	µg/kg dw	Yes	18	Yes	3.2	59		
					Total PAH (calc'd)	Surface	—	1300	µg/kg dw	—	—	—	—	0	2	1360	µg/kg dw	—	—	—	—	-4		
LDW-SC21	LDW Subsurface Sediment 2006	1	2006	—	PCBs (total calc'd)	0	1	250	µg/kg dw	Yes	1.1	No	0.2	1	2	145	µg/kg dw	No	0.81	No	0.15	72	Increase	Below SQS
LDW-SC22	LDW Subsurface Sediment 2006	1.1	2006	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
LDW-SC23	LDW Subsurface Sediment 2006	1.2	2006	—	Total PAH (calc'd)	0	0.5	5230	µg/kg dw	—	—	—	—	0.5	1	3560	µg/kg dw	—	—	—	—	47	Lack of Data Density	Below SQS
						1	1.5	4800	µg/kg dw	—	—	—	—	1.5	2	4800	µg/kg dw	—	—	—	—	—		
LDW-SC24	LDW Subsurface Sediment 2006	1.2	2006	—	PCBs (total calc'd)	0	1	280	µg/kg dw	Yes	1.2	No	0.22	1	2	36	µg/kg dw	No	0.28	No	0.036	678	Increase	Below SQS
DR025	EPA SI	1.2	1998	1998	Total PAH (calc'd)	Surface	—	5600	µg/kg dw	—	—	—	—	0	2	5000	µg/kg dw	—	—	—	—	12	Lack of Data Density	Below SQS
LDW-SC25	LDW Subsurface Sediment 2006	1.3	2006	—	Arsenic	0	1	50	mg/kg dw	No	0.88	No	0.54	1	2	91	mg/kg dw	Yes	1.6	No	0.98	-45	Equilibrium	Equilibrium
					PCBs (total calc'd)	0	1	310	µg/kg dw	Yes	1.3	No	0.25	1	2	360	µg/kg dw	Yes	2	No	0.37	-14		
					Zinc	0	1	263	mg/kg dw	No	0.64	No	0.27	1	2	503	mg/kg dw	Yes	1.2	No	0.52	-48		

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concentration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concentration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
DR054	EPA SI	1.3	1998	1998	Arsenic	Surface	—	24	mg/kg dw	No	0.42	No	0.26	0	2	280	mg/kg dw	Yes	4.9	Yes	3	-91	Decrease	Decrease
					Bis(2-ethylhexyl) phthalate	Surface	—	450	µg/kg dw	No	0.4	No	0.24	0	2	1200	µg/kg dw	Yes	1.3	No	0.77	-63		
					Copper	Surface	—	140	mg/kg dw	No	0.36	No	0.36	0	2	800	mg/kg dw	Yes	2.1	Yes	2.1	-83		
					PCBs (total calc'd)	Surface	—	97	µg/kg dw	No	0.34	No	0.063	0	2	250	µg/kg dw	Yes	1.1	No	0.2	-61		
					Total PAH (calc'd)	Surface	—	4210	µg/kg dw	—	—	—	—	0	2	9500	µg/kg dw	—	—	—	—	-56		
					Zinc	Surface	—	170	mg/kg dw	No	0.41	No	0.18	0	2	1600	mg/kg dw	Yes	3.9	Yes	1.7	-89		
LDW-SC26	LDW Subsurface Sediment 2006	1.4	2006	—	PCBs (total calc'd)	0	1	280	µg/kg dw	Yes	1.7	No	0.31	1	2	226	µg/kg dw	No	0.92	No	0.17	24	Equilibrium	Below SQS
LDW-SC27	LDW Subsurface Sediment 2006	1.4	2006	2005	Mercury	Surface	—	0.41	mg/kg dw	No	1	No	0.69	0	2	0.52	mg/kg dw	Yes	1.3	No	0.88	-21	Decrease	Equilibrium
					PCBs (total calc'd)	0	0.5	250	µg/kg dw	Yes	1.3	No	0.25	0.5	1	2000	µg/kg dw	Yes	9.2	Yes	1.7	-88		
						1	1.5	3200	µg/kg dw	Yes	22	Yes	4	1.5	2	1510	µg/kg dw	Yes	6.9	Yes	1.3	—		
					Total PAH (calc'd)	Surface	—	3410	µg/kg dw	—	—	—	—	0	2	2670	µg/kg dw	—	—	—	—	28		
LDW-SC28	LDW Subsurface Sediment 2006	1.4	2006	—	Arsenic	0	1	114	mg/kg dw	Yes	2	Yes	1.2	1	2	18	mg/kg dw	No	0.32	No	0.19	533	Equilibrium	Increase
					Benzyl alcohol	0	1	110	µg/kg dw	Yes	1.9	Yes	1.5	1	2	15	µg/kg dw	No	0.53	No	0.41	267		
					PCBs (total calc'd)	0	1	440	µg/kg dw	Yes	1.4	No	0.26	1	2	360	µg/kg dw	Yes	1.4	No	0.26	22		
LDW-SC29	LDW Subsurface Sediment 2006	1.4	2006	—	Hexachlorobenzene	0	1	5.9	µg/kg dw	No	0.87	No	0.14	1	2	2.95	µg/kg dw	Yes	1.5	No	0.24	0	Below SQS	Equilibrium
LDW-SC32	LDW Subsurface Sediment 2006	1.7	2006	2006	Acenaphthene	0	1	29	µg/kg dw	No	0.2	No	0.056	1	2	1400	µg/kg dw	Yes	7.5	Yes	2.1	-96	Decrease	Mixed
					Bis(2-ethylhexyl) phthalate	Surface	—	210	µg/kg dw	No	0.23	No	0.14	0	1	200	µg/kg dw	No	0.23	No	0.14	5		
						1	2	650	µg/kg dw	Yes	1.2	No	0.72	—	—	—	—	—	—	—	—	—		
					Dibenzofuran	0	1	29	µg/kg dw	No	0.21	No	0.055	1	2	1200	µg/kg dw	Yes	6.7	Yes	1.7	-95		
					Fluoranthene	Surface	—	240	µg/kg dw	No	0.081	No	0.011	0	1	210	µg/kg dw	No	0.075	No	0.01	14		
						1	2	2500	µg/kg dw	Yes	1.4	No	0.18	—	—	—	—	—	—	—	—	—		
					Fluorene	0	1	29	µg/kg dw	No	0.14	No	0.041	1	2	1900	µg/kg dw	Yes	7	Yes	2	-97		
					PCBs (total calc'd)	Surface	—	211	µg/kg dw	No	0.92	No	0.17	0	1	1010	µg/kg dw	Yes	4.7	No	0.86	-79		
						1	2	1720	µg/kg dw	Yes	13	Yes	2.3	—	—	—	—	—	—	—	—	—		
					Phenanthrene	Surface	—	78	µg/kg dw	No	0.042	No	0.0088	0	1	88	µg/kg dw	No	0.049	No	0.01	-11		
						1	2	3700	µg/kg dw	Yes	3.2	No	0.67	—	—	—	—	—	—	—	—	—		
					Total LPAH (calc'd)	Surface	—	117	µg/kg dw	No	0.017	No	0.0082	0	1	130	µg/kg dw	No	0.019	No	0.0092	-10		
						1	2	7500	µg/kg dw	Yes	1.8	No	0.83	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	1480	µg/kg dw	—	—	—	—	0	1	1700	µg/kg dw	—	—	—	—	-13		
						1	2	14900	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
DR101	EPA SI	1.7	1998	1998	Total PAH (calc'd)	Surface	—	4730	µg/kg dw	—	—	—	—	0	2	700	µg/kg dw	—	—	—	—	576	Lack of Data Density	Below SQS
LDW-SC33	LDW Subsurface Sediment 2006	1.9	2006	—	PCBs (total calc'd)	0	0.5	490	µg/kg dw	Yes	2.3	No	0.43	0.5	1	790	µg/kg dw	Yes	3.1	No	0.57	-38	Equilibrium	Lack of Data Density
						1	1.5	4700	µg/kg dw	Yes	16	Yes	2.9	1.5	2	2500	µg/kg dw	Yes	8.3	Yes	1.5	—		
						2	2.5	210	µg/kg dw	Yes	1.3	No	0.25	—	—	—	—	—	—	—	—	—		
LDW-SC34	LDW Subsurface Sediment 2006	1.9	2006	—	Benzyl alcohol	0	1	34	µg/kg dw	No	0.6	No	0.47	1	2	210	µg/kg dw	Yes	3.7	Yes	2.9	-84	Below SQS	Mixed
					Bis(2-ethylhexyl)phthalate	0	1	920	µg/kg dw	No	0.68	No	0.41	1	2	3900	µg/kg dw	Yes	2.8	Yes	1.7	-76		
					Butyl benzyl phthalate	0	1	440	µg/kg dw	Yes	3.1	No	0.23	1	2	400	µg/kg dw	Yes	2.7	No	0.2	10		
LDW-SC203	LDW Subsurface Sediment 2006	1.9	2006	—	Benzyl alcohol	0	1	66	µg/kg dw	Yes	1.2	No	0.9	1	2	41	µg/kg dw	No	0.72	No	0.56	61	Below SQS	Mixed
					Bis(2-ethylhexyl) phthalate	0	1	1800	µg/kg dw	Yes	1.2	No	0.71	1	2	2600	µg/kg dw	Yes	1.9	Yes	1.1	-31		
					Butyl benzyl phthalate	0	1	380	µg/kg dw	Yes	2.4	No	0.19	1	2	400	µg/kg dw	Yes	2.9	No	0.22	-5		
LDW-SC36	LDW Subsurface Sediment 2006	2.1	2006	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
LDW-SC37	LDW Subsurface Sediment 2006	2.1	2006	—	Arsenic	0	1	150	mg/kg dw	Yes	2.6	Yes	1.6	1	2	121	mg/kg dw	Yes	2.1	Yes	1.3	24	Decrease	Mixed
					Benzo(a) anthracene	0	1	1100	µg/kg dw	No	0.45	No	0.18	1	2	3100	µg/kg dw	Yes	1.1	No	0.44	-65		
					Benzo(a)pyrene	0	1	2000	µg/kg dw	No	0.9	No	0.42	1	2	5300	µg/kg dw	Yes	2	No	0.95	-62		
					Benzo(g,h,i) perylene	0	1	530	µg/kg dw	No	0.77	No	0.31	1	2	1000	µg/kg dw	Yes	1.2	No	0.47	-47		
					Benzofluoranthenes (total-calc'd)	0	1	5100	µg/kg dw	No	1	No	0.51	1	2	10200	µg/kg dw	Yes	1.7	No	0.84	-50		
					Chrysene	0	1	1600	µg/kg dw	No	0.65	No	0.15	1	2	4800	µg/kg dw	Yes	1.6	No	0.39	-67		
					Dibenzo(a,h) anthracene	0	1	170	µg/kg dw	No	0.63	No	0.23	1	2	360	µg/kg dw	Yes	1.1	No	0.39	-53		
					Fluoranthene	0	1	1600	µg/kg dw	No	0.44	No	0.059	1	2	4500	µg/kg dw	Yes	1.1	No	0.14	-64		
					Indeno(1,2,3-cd) pyrene	0	1	750	µg/kg dw	No	0.97	No	0.38	1	2	1500	µg/kg dw	Yes	1.6	No	0.64	-50		
					Mercury	0	1	0.26	mg/kg dw	No	0.63	No	0.44	1	2	0.45	mg/kg dw	Yes	1.1	No	0.76	-42		
					PCBs (total calc'd)	0	1	450	µg/kg dw	Yes	1.7	No	0.31	1	2	950	µg/kg dw	Yes	3	No	0.55	-53		
					Total HPAH (calc'd)	0	1	15800	µg/kg dw	No	0.73	No	0.13	1	2	40000	µg/kg dw	Yes	1.6	No	0.28	-61		
					Zinc	0	1	386	mg/kg dw	No	0.94	No	0.4	1	2	490	mg/kg dw	Yes	1.2	No	0.51	-21		
LDW-SC38a	LDW Subsurface Sediment 2006	2.1	2006	—	PCBs (total calc'd)	0	1	450	µg/kg dw	Yes	1.9	No	0.35	1	2	710	µg/kg dw	Yes	4.3	No	0.8	-37	Equilibrium	Below SQS
LDW-SC202	LDW Subsurface Sediment 2006	2.1	2006	—	Benzyl alcohol	0	1	15	µg/kg dw	No	0.53	No	0.41	1	2	29	µg/kg dw	Yes	1	No	0.79	-48	Below SQS	Mixed
					Hexachlorobenzene	0	1	3	µg/kg dw	Yes	1.2	No	0.2	1	2	6	µg/kg dw	Yes	1.8	No	0.3	-50		
DR106	EPA SI	2.1	1998	2005	Total PAH (calc'd)	Surface	—	820	µg/kg dw	—	—	—	—	0	2	1220	µg/kg dw	—	—	—	—	-33	Lack of Data Density	Below SQS
DR112	EPA SI	2.1	1998	1998	Fluoranthene	Surface	—	5300	µg/kg dw	Yes	1.3	No	0.17	0	2	550	µg/kg dw	No	0.14	No	0.018	864	Lack of Data Density	Increase
					Total PAH (calc'd)	Surface	—	15800	µg/kg dw	—	—	—	—	0	2	3150	µg/kg dw	—	—	—	—	402		
LDW-SC39	LDW Subsurface Sediment 2006	2.2	2006	1997	PCBs (total calc'd)	Surface	—	110	µg/kg dw	No	0.45	No	0.083	0	1	208	µg/kg dw	Yes	1.7	No	0.31	-47	Equilibrium	Below SQS
						1	2	440	µg/kg dw	Yes	5.8	Yes	1.1	—	—	—	—	—	—	—	—	—		
DR137	EPA SI	2.2	1998	1998	PCBs (total calc'd)	Surface	—	181	µg/kg dw	No	0.68	No	0.13	0	2	470	µg/kg dw	Yes	1.6	No	0.29	-61	Decrease	Below SQS
					Total PAH (calc'd)	Surface	—	2760	µg/kg dw	—	—	—	—	0	2	570	µg/kg dw	—	—	—	—	384		
LDW-SC40	LDW Subsurface Sediment 2006	2.3	2006	—	PCBs (total calc'd)	0	1.3	160	µg/kg dw	Yes	1.8	No	0.32	1.3	2	2	µg/kg dw	No	0.031	No	0.004	3900	Increase	Below SQS
LDW-SC41	LDW Subsurface Sediment 2006	2.4	2006	—	PCBs (total calc'd)	0	1	370	µg/kg dw	Yes	1.3	No	0.23	1	2	256	µg/kg dw	No	0.92	No	0.17	45	Equilibrium	Below SQS
LDW-SC42	LDW Subsurface Sediment 2006	2.5	2006	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
WRC-SS-B1	Boyer Towing	2.5	2004	2004	Total PAH (calc'd)	Surface	—	1370	µg/kg dw	—	—	—	—	1	2	9.5	µg/kg dw	—	—	—	—	7111	Lack of Data Density	Below SQS

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
WRC-SS-B2	Boyer Towing	2.5	2004	2004	Total PAH (calc'd)	Surface	—	4400	µg/kg dw	—	—	—	—	1	2	16	µg/kg dw	—	—	—	—	27400	Lack of Data Density	Below SQS
						1	2	9.5	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
WRC-SS-B3	Boyer Towing	2.5	2004	2004	Total PAH (calc'd)	Surface	—	490	µg/kg dw	—	—	—	—	1	2	10	µg/kg dw	—	—	—	—	2350	Lack of Data Density	Increase
					Zinc	Surface	—	479	mg/kg dw	Yes	1.2	No	0.5	1	2	23.8	mg/kg dw	No	0.058	No	0.025	1913		
DR171	EPA SI	2.5	1998	1998	Total PAH (calc'd)	Surface	—	4100	µg/kg dw	—	—	—	—	0	2	2270	µg/kg dw	—	—	—	—	81	Lack of Data Density	Below SQS
LDW-SC44	LDW Subsurface Sediment 2006	2.7	2006	—	PCBs (total calc'd)	0	0.5	260	µg/kg dw	Yes	1.3	No	0.23	0.5	1	880	µg/kg dw	Yes	4.3	No	0.8	-70	Decrease	Lack of Data Density
						1	1.5	200	µg/kg dw	No	1	No	0.18	1.5	2	140	µg/kg dw	No	0.61	No	0.11	—		
						2	2.5	270	µg/kg dw	Yes	1.2	No	0.22	—	—	—	—	—	—	—	—	—		
LDW-SC46	LDW Subsurface Sediment 2006	2.7	2006	2005	Acenaphthene	Surface	—	4600	µg/kg dw	Yes	11	Yes	3	0	1	96	µg/kg dw	No	0.33	No	0.093	4692	Equilibrium	Mixed
						1	2	63	µg/kg dw	No	0.28	No	0.077	—	—	—	—	—	—	—	—	—		
					Anthracene	Surface	—	10000	µg/kg dw	Yes	1.7	No	0.32	0	1	360	µg/kg dw	No	0.091	No	0.017	2678		
						1	2	350	µg/kg dw	No	0.11	No	0.021	—	—	—	—	—	—	—	—	—		
					Benzo(a) anthracene	Surface	—	4000	µg/kg dw	Yes	1.4	No	0.56	0	1	940	µg/kg dw	No	0.47	No	0.19	326		
						1	2	1200	µg/kg dw	No	0.77	No	0.31	—	—	—	—	—	—	—	—	—		
					Benzyl alcohol	0	1	18	µg/kg dw	No	0.32	No	0.25	1	2	64	µg/kg dw	Yes	1.1	No	0.88	-72		
					Chrysene	Surface	—	5700	µg/kg dw	Yes	2	No	0.48	0	1	1100	µg/kg dw	No	0.55	No	0.13	418		
						1	2	1500	µg/kg dw	No	1	No	0.24	—	—	—	—	—	—	—	—	—		
					Dibenzofuran	Surface	—	4000	µg/kg dw	Yes	10	Yes	2.6	0	1	92	µg/kg dw	No	0.34	No	0.088	4248		
						1	2	49.5	µg/kg dw	No	0.47	No	0.12	—	—	—	—	—	—	—	—	—		
					Fluoranthene	Surface	—	17000	µg/kg dw	Yes	4	No	0.53	0	1	3900	µg/kg dw	Yes	1.4	No	0.18	336		
						1	2	2900	µg/kg dw	Yes	1.3	No	0.17	—	—	—	—	—	—	—	—	—		
					Fluorene	Surface	—	6800	µg/kg dw	Yes	11	Yes	3.3	0	1	150	µg/kg dw	No	0.36	No	0.11	4433		
						1	2	67	µg/kg dw	No	0.2	No	0.059	—	—	—	—	—	—	—	—	—		
					Hexachloro-benzene	0	1	3	µg/kg dw	No	0.87	No	0.14	1	2	10	µg/kg dw	Yes	1.8	No	0.3	-40		
					Indeno(1,2,3-cd) pyrene	Surface	—	970	µg/kg dw	Yes	1.1	No	0.42	0	1	140	µg/kg dw	No	0.23	No	0.088	593		
						1	2	190	µg/kg dw	No	0.38	No	0.15	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	198	µg/kg dw	No	0.63	No	0.12	0	1	214	µg/kg dw	No	1	No	0.18	-7		
						1	2	185	µg/kg dw	Yes	1.1	No	0.2	—	—	—	—	—	—	—	—	—		
					Phenanthrene	Surface	—	22000	µg/kg dw	Yes	8.3	Yes	1.7	0	1	1400	µg/kg dw	No	0.77	No	0.16	1471		
						1	2	380	µg/kg dw	No	0.27	No	0.056	—	—	—	—	—	—	—	—	—		
					Total HPAH (calc'd)	Surface	—	48000	µg/kg dw	Yes	1.9	No	0.34	0	1	10500	µg/kg dw	No	0.6	No	0.11	357		
						1	2	13700	µg/kg dw	No	1	No	0.18	—	—	—	—	—	—	—	—	—		
					Total LPAH (calc'd)	Surface	—	44000	µg/kg dw	Yes	4.6	Yes	2.2	0	1	2100	µg/kg dw	No	0.32	No	0.15	1995		
						1	2	1290	µg/kg dw	No	0.25	No	0.12	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	92000	µg/kg dw	—	—	—	—	0	1	12600	µg/kg dw	—	—	—	—	630		
						1	2	15000	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
LDW-SC45	LDW Subsurface Sediment 2006	2.8	2006	—	PCBs (total calc'd)	0	1	230	µg/kg dw	Yes	1.3	No	0.25	1	2	270	µg/kg dw	Yes	1.6	No	0.29	-15	Equilibrium	Below SQS
SC01	Slip4-EarlyAction	2.8	2004	2004	PCBs (total calc'd)	Surface	—	1620	µg/kg dw	Yes	12	Yes	1.6	0	0	35000	µg/kg dw	Yes	130	Yes	23	-95	Decrease	Lack of Data Density
SC03	Slip4-EarlyAction	2.8	2004	2004	PCBs (total calc'd)	Surface	—	470	µg/kg dw	Yes	1.3	No	0.23	0	2	560	µg/kg dw	Yes	1.5	No	0.28	-16	Equilibrium	Lack of Data Density
SC04	Slip4-EarlyAction	2.8	2004	2004	PCBs (total calc'd)	Surface	—	710	µg/kg dw	Yes	1.9	No	0.35	0	2	14000	µg/kg dw	Yes	39	Yes	7.2	-95	Decrease	Lack of Data Density
SC05	Slip4-EarlyAction	2.8	2004	2004	PCBs (total calc'd)	Surface	—	310	µg/kg dw	No	0.78	No	0.14	0	2	1300	µg/kg dw	Yes	4.1	No	0.75	-76	Decrease	Lack of Data Density
SC06	Slip4-EarlyAction	2.8	2004	2004	PCBs (total calc'd)	Surface	—	200	µg/kg dw	No	0.6	No	0.11	0	2	350	µg/kg dw	Yes	1.3	No	0.23	-43	Equilibrium	Lack of Data Density
SLP4-08-01	Slip 4-Landau 2008	2.8	2008	—	PCBs (total calc'd)	0	0.5	1300	µg/kg dw	Yes	10	Yes	1.3	0.5	1	3300	µg/kg dw	Yes	25	Yes	3.3	-61	Decrease	No SMS Contaminants other than PCBs Analyzed
						1	1.5	28000	µg/kg dw	Yes	220	Yes	28	1.5	2	37000	µg/kg dw	Yes	280	Yes	37	-24		
SLP4-08-02	Slip 4-Landau 2008	2.8	2008	—	PCBs (total calc'd)	0	0.5	4000	µg/kg dw	Yes	31	Yes	4	0.5	1	13400	µg/kg dw	Yes	100	Yes	13	-70	Decrease	No SMS Contaminants other than PCBs Analyzed
						1	1.5	1700	µg/kg dw	Yes	13	Yes	1.7	1.5	2	110	µg/kg dw	No	0.85	No	0.11	1445		
SLP4-08-03	Slip 4-Landau 2008	2.8	2008	—	PCBs (total calc'd)	0	0.5	1600	µg/kg dw	Yes	12	Yes	1.6	0.5	1	2600	µg/kg dw	Yes	20	Yes	2.6	-38	Equilibrium	No SMS Contaminants other than PCBs Analyzed
						1	1.5	6200	µg/kg dw	Yes	48	Yes	6.2	1.5	2	210	µg/kg dw	Yes	1.6	No	0.21	2852		
SC07	Slip4-EarlyAction	2.9	2004	2004	PCBs (total calc'd)	Surface	—	300	µg/kg dw	No	0.92	No	0.17	0	2	6900	µg/kg dw	Yes	24	Yes	4.5	-96	Decrease	Lack of Data Density
LDW-SC47	LDW Subsurface Sediment 2006	3	2006	—	PCBs (total calc'd)	0	1	72	µg/kg dw	No	0.56	No	0.1	1	2	2000	µg/kg dw	Yes	9.2	Yes	1.7	-96	Decrease	Below SQS
DR224	EPA SI	3	1998	1998	Total PAH (calc'd)	Surface	—	820	µg/kg dw	—	—	—	—	0	2	100	µg/kg dw	—	—	—	—	720	Lack of Data Density	Below SQS
LDW-SC48	—	3.3	2006	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-DUW07	Plant 2 RFI-2b	3.3	1996	1995	PCBs (total calc'd)	Surface	—	1100	µg/kg dw	Yes	4.2	No	0.77	0	1.9	4400	µg/kg dw	Yes	26	Yes	4.8	-75	Decrease	No SMS Contaminants other than PCBs Analyzed
SD-DUW34	Plant 2 RFI-2b	3.3	1996	1995	PCBs (total calc'd)	Surface	—	3500	µg/kg dw	Yes	27	Yes	4.9	0	1.9	11300	µg/kg dw	Yes	63	Yes	12	-69	Decrease	No SMS Contaminants other than PCBs Analyzed
					Total PAH (calc'd)	Surface	—	330	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-04107	Plant 2 RFI-1	3.3	1995	1995	Cadmium	Surface	—	0.6	mg/kg dw	No	0.12	No	0.09	0.3	1.5	18	mg/kg dw	Yes	3.5	Yes	2.7	-97	Decrease	Decrease
					PCBs (total calc'd)	Surface	—	9600	µg/kg dw	Yes	28	Yes	5.2	0.3	1.5	22000	µg/kg dw	Yes	92	Yes	17	-56		
					Total PAH (calc'd)	Surface	—	5750	µg/kg dw	—	—	—	—	0.3	1.5	12300	µg/kg dw	—	—	—	—	-53		
SB-04117	Plant 2 RFI-1	3.3	1994	1995	Benzo(g,h,i) perylene	Surface	—	700	µg/kg dw	Yes	1	No	0.41	0.5	1	90	µg/kg dw	No	0.27	No	0.25	289	No PCBs Analyzed	Increase
					Chrysene	Surface	—	2800	µg/kg dw	Yes	1.2	No	0.28	0.5	1	390	µg/kg dw	No	0.28	No	0.14	618		
						2	2.5	460	µg/kg dw	No	0.33	No	0.16	—	—	—	—	—	—	—	—	—		
					Dibenzo(a,h) anthracene	Surface	—	330	µg/kg dw	Yes	1.3	No	0.45	0.5	1	90	µg/kg dw	No	0.78	No	0.33	83		
						2	2.5	200	µg/kg dw	Yes	1.7	No	0.74	—	—	—	—	—	—	—	—	—		
					Indeno(1,2,3-cd) pyrene	Surface	—	830	µg/kg dw	Yes	1.1	No	0.43	0.5	1	90	µg/kg dw	No	0.3	No	0.26	361		
						2	2.5	200	µg/kg dw	No	0.67	No	0.58	—	—	—	—	—	—	—	—	—		
					Total HPAH (calc'd)	Surface	—	21600	µg/kg dw	Yes	1	No	0.18	0.5	1	2750	µg/kg dw	No	0.23	No	0.16	685		
						2	2.5	4400	µg/kg dw	No	0.37	No	0.26	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	22200	µg/kg dw	—	—	—	—	0.5	1	2750	µg/kg dw	—	—	—	—	707		
						2	2.5	4400	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
SD-UB-009	Boeing P2 Under Bldg	3.4	2008	—	PCBs (total calc'd)	0	1	171	µg/kg dw	Yes	1	No	0.19	1	2	27	µg/kg dw	No	0.092	No	0.017	533	Increase	No SMS Contaminants other than PCBs Analyzed
LDW-SC49	LDW Subsurface Sediment 2006	3.5	2006	—	Benzoic acid	0	1	750	µg/kg dw	Yes	1.2	Yes	1.2	1	2	100	µg/kg dw	No	0.15	No	0.15	650	Below SQS	Increase
					Benzyl alcohol	0	1	200	µg/kg dw	Yes	3.5	Yes	2.7	1	2	30	µg/kg dw	Yes	1.1	No	0.82	233		
T117-SE-70-SC	T-117 Boundary Definition	3.5	2004	2004	PCBs (total calc'd)	Surface	—	34000	µg/kg dw	Yes	120	Yes	22	0.5	1	11000	µg/kg dw	Yes	46	Yes	8.5	209	Increase	Below SQS
						1	2	1380	µg/kg dw	Yes	6.1	Yes	1.1	—	—	—	—	—	—	—	—	—		
T117-SE-71-SC	T-117 Boundary Definition	3.5	2004	2003	PCBs (total calc'd)	Surface	—	1200	µg/kg dw	Yes	5	No	0.92	0	1	730	µg/kg dw	Yes	4.7	No	0.86	64	Increase	Below SQS
						1	2	9.5	µg/kg dw	No	0.15	No	0.019	—	—	—	—	—	—	—	—	—		
T117-SE-72-SC	T-117 Boundary Definition	3.5	2004	—	PCBs (total calc'd)	0	1	540	µg/kg dw	Yes	2	No	0.38	1	2	1410	µg/kg dw	Yes	6.2	Yes	1.1	-62	Decrease	Below SQS
						2	2.4	2200	µg/kg dw	Yes	9.2	Yes	1.7	—	—	—	—	—	—	—	—	—		
DUW102	DSOAvertchar	3.5	2001	1995	PCBs (total calc'd)	Surface	—	1100	µg/kg dw	Yes	7.7	Yes	1.4	0	0.6	1080	µg/kg dw	Yes	5.3	No	0.98	2	Equilibrium	No SMS Contaminants other than PCBs Analyzed
						1	2	590	µg/kg dw	Yes	4.5	No	0.59	—	—	—	—	—	—	—	—	—		
DUW103	DSOAvertchar	3.5	2001	—	PCBs (total calc'd)	0	0.7	1600	µg/kg dw	Yes	6.7	Yes	1.2	1	1.7	610	µg/kg dw	Yes	10	Yes	1.8	162	Increase	No SMS Contaminants other than PCBs Analyzed
DR206	EPA SI	3.5	1998	1998	Bis(2-ethylhexyl) phthalate	Surface	—	280	µg/kg dw	No	0.2	No	0.12	0	2	520	µg/kg dw	Yes	1.4	No	0.85	-46	Decrease	Equilibrium
					Butyl benzyl phthalate	Surface	—	40	µg/kg dw	No	0.27	No	0.02	0	2	40	µg/kg dw	Yes	1	No	0.08	0		
					PCBs (total calc'd)	Surface	—	210	µg/kg dw	No	0.59	No	0.11	0	2	1250	µg/kg dw	Yes	13	Yes	2.5	-83		
					Total PAH (calc'd)	Surface	—	1260	µg/kg dw	—	—	—	—	0	2	2880	µg/kg dw	—	—	—	—	-56		
SD-DUW28	Plant 2 RFI-2b	3.5	1996	1995	Mercury	Surface	—	0.51	mg/kg dw	Yes	1.2	No	0.86	0	1.9	0.25	mg/kg dw	No	0.61	No	0.42	104	Equilibrium	Lack of Data Density
					PCBs (total calc'd)	Surface	—	11000	µg/kg dw	Yes	38	Yes	7.1	0	1.9	13000	µg/kg dw	Yes	49	Yes	9.1	-15		
					Total PAH (calc'd)	Surface	—	830	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-04402	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	190	µg/kg dw	No	0.58	No	0.11	0.3	1	600	µg/kg dw	Yes	4.6	No	0.6	-68	Decrease	No SMS Contaminants other than PCBs Analyzed
SD-04405	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	170	µg/kg dw	Yes	1.3	No	0.17	0.3	1.5	120	µg/kg dw	Yes	1.5	No	0.28	42	Equilibrium	No SMS Contaminants other than PCBs Analyzed
SD-04901	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	3800	µg/kg dw	Yes	39	Yes	7.2	0.3	1.5	350	µg/kg dw	Yes	3.6	No	0.66	986	Increase	No SMS Contaminants other than PCBs Analyzed
SD-04902	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	2100	µg/kg dw	Yes	39	Yes	7.2	0.3	1.5	370	µg/kg dw	Yes	3.5	No	0.65	468	Increase	No SMS Contaminants other than PCBs Analyzed
SD-04903	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	280	µg/kg dw	Yes	39	Yes	7.2	0.3	1.5	3000	µg/kg dw	Yes	23	Yes	3	-91	Decrease	No SMS Contaminants other than PCBs Analyzed
SD-04904	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	10200	µg/kg dw	Yes	38	Yes	7.1	0.3	1.5	8300	µg/kg dw	Yes	32	Yes	5.8	23	Equilibrium	No SMS Contaminants other than PCBs Analyzed
SD-04905	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	26000	µg/kg dw	Yes	70	Yes	13	0.3	1.5	890000	µg/kg dw	Yes	2400	Yes	450	-97	Decrease	No SMS Contaminants other than PCBs Analyzed
SD-04920	Plant 2 RFI-1	3.5	1995	1995	PCBs (total calc'd)	Surface	—	2300	µg/kg dw	Yes	7.1	Yes	1.3	0.3	2	950	µg/kg dw	Yes	3.6	No	0.66	142	Increase	No SMS Contaminants other than PCBs Analyzed
SD-201	Jorgensen April 2004	3.6	2004	—	PCBs (total calc'd)	0	1	340	µg/kg dw	Yes	1.3	No	0.25	1	2	2500	µg/kg dw	Yes	8.3	Yes	1.5	-86	Decrease	Below SQS
SD-202	Jorgensen April 2004	3.6	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-203	Jorgensen April 2004	3.6	2004	—	PCBs (total calc'd)	0	1	7100	µg/kg dw	Yes	43	Yes	7.8	1	2	6500	µg/kg dw	Yes	52	Yes	9.5	9	Equilibrium	Decrease
					Zinc	0	1	183	mg/kg dw	No	0.45	No	0.19	1	2	567	mg/kg dw	Yes	1.4	No	0.59	-68		
SD-204	Jorgensen April 2004	3.6	2004	—	PCBs (total calc'd)	0	1	125	µg/kg dw	No	0.46	No	0.085	1	2	240	µg/kg dw	Yes	1.1	No	0.2	-48	Equilibrium	Below SQS
SD-205	Jorgensen April 2004	3.6	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-205D	Jorgensen April 2004	3.6	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-206	Jorgensen April 2004	3.6	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-207	Jorgensen April 2004	3.6	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-208	Jorgensen April 2004	3.6	2004	2004	PCBs (total calc'd)	Surface	—	340	µg/kg dw	Yes	1.9	No	0.35	0	1	94	µg/kg dw	No	0.4	No	0.074	262	Increase	Below SQS
						1	2	137	µg/kg dw	No	0.58	No	0.11	—	—	—	—	—	—	—	—	—		
SD-213	Jorgensen April 2004	3.6	2004	2004	PCBs (total calc'd)	Surface	—	610	µg/kg dw	Yes	2.3	No	0.43	0	1	35	µg/kg dw	No	0.13	No	0.025	1643	Increase	Below SQS
						1	2	186	µg/kg dw	No	0.74	No	0.14	—	—	—	—	—	—	—	—	—		
SD-215	Jorgensen April 2004	3.6	2004	2004	PCBs (total calc'd)	Surface	—	880	µg/kg dw	Yes	4.5	No	0.83	0	1	121	µg/kg dw	No	0.51	No	0.094	627	Increase	Below SQS
						1	2	420	µg/kg dw	Yes	1.6	No	0.29	—	—	—	—	—	—	—	—	—		
SD-301	Jorgensen April 2004	3.6	2004	—	Mercury	0	1	0.22	mg/kg dw	No	0.54	No	0.37	1	2	0.43	mg/kg dw	Yes	1	No	0.73	-49	Decrease	Equilibrium
					PCBs (total calc'd)	0	1	550	µg/kg dw	Yes	2.6	No	0.48	1	2	1340	µg/kg dw	Yes	7	Yes	1.3	-59		
					Zinc	0	1	243	mg/kg dw	No	0.59	No	0.25	1	2	1050	mg/kg dw	Yes	2.6	Yes	1.1	-77		

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concentration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concentration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
SD-302	Jorgensen April 2004	3.6	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-303	Jorgensen April 2004	3.6	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-317-C	Jorgensen August 2004	3.6	2004	1998	PCBs (total calc'd)	Surface	—	75	µg/kg dw	No	0.32	No	0.058	1	2	1529	µg/kg dw	Yes	6.4	Yes	1.2	-95	Decrease	Lack of Data Density
					Total PAH (calc'd)	Surface	—	6100	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-318-C	Jorgensen August 2004	3.6	2004	2004	PCBs (total calc'd)	Surface	—	930	µg/kg dw	Yes	3.8	No	0.69	0	1.5	6.5	µg/kg dw	No	0.13	No	0.025	7054	Increase	Lack of Data Density
					Phenol	Surface	—	800	µg/kg dw	Yes	1.9	No	0.7	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	6900	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-319-C	Jorgensen August 2004	3.6	2004	2004	PCBs (total calc'd)	Surface	—	3100	µg/kg dw	Yes	15	Yes	2.8	1	2	120	µg/kg dw	No	0.56	No	0.1	2483	Increase	Lack of Data Density
					Total PAH (calc'd)	Surface	—	860	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-321-C	Jorgensen August 2004	3.6	2004	2004	PCBs (total calc'd)	Surface	—	570	µg/kg dw	Yes	2.1	No	0.38	1	2	750	µg/kg dw	Yes	3.7	No	0.68	-24	Equilibrium	Lack of Data Density
					Total PAH (calc'd)	Surface	—	1310	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-DUW158	Plant 2-Transformer Phase 1	3.6	2003	1997	PCBs (total calc'd)	Surface	—	1700	µg/kg dw	Yes	7	Yes	1.3	0	1	5000	µg/kg dw	Yes	23	Yes	4.3	-66	Decrease	Lack of Data Density
SD-DUW165	Plant 2-Transformer Phase 1	3.6	2003	1996	PCBs (total calc'd)	Surface	—	2700	µg/kg dw	Yes	10	Yes	1.8	0	0.7	4800	µg/kg dw	Yes	17	Yes	3.1	-44	Equilibrium	Lack of Data Density
					Zinc	Surface	—	3500	mg/kg dw	Yes	8.5	Yes	3.6	—	—	—	—	—	—	—	—	—		
T117-SE-15-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	132	µg/kg dw	No	0.48	No	0.088	0	1	310	µg/kg dw	Yes	1.3	No	0.25	-57	Decrease	No SMS Contaminants other than PCBs Analyzed
						1	2	320	µg/kg dw	Yes	1.4	No	0.26	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	767	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
T117-SE-16-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	2800	µg/kg dw	Yes	13	Yes	2.5	0	0.9	3400	µg/kg dw	Yes	17	Yes	3.1	-18	Equilibrium	No SMS Contaminants other than PCBs Analyzed
						0.9	1.3	2900	µg/kg dw	Yes	12	Yes	2.2	1.3	2	590	µg/kg dw	Yes	3.5	No	0.65	—		
T117-SE-17-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	12000	µg/kg dw	Yes	46	Yes	8.5	0	1	3700	µg/kg dw	Yes	16	Yes	2.9	224	Increase	No SMS Contaminants other than PCBs Analyzed
						1	2	3200	µg/kg dw	Yes	13	Yes	2.3	—	—	—	—	—	—	—	—	—		
T117-SE-20-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	1300	µg/kg dw	Yes	8.3	Yes	1.5	0	1	2800	µg/kg dw	Yes	21	Yes	3.8	-54	Decrease	No SMS Contaminants other than PCBs Analyzed
						1	2	420	µg/kg dw	Yes	2.5	No	0.46	—	—	—	—	—	—	—	—	—		
T117-SE-21-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	38000	µg/kg dw	Yes	180	Yes	34	0	1	16000	µg/kg dw	Yes	63	Yes	12	138	Increase	No SMS Contaminants other than PCBs Analyzed
						1	2	280	µg/kg dw	Yes	1.3	No	0.25	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	3700	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
T117-SE-23-SC	T-117 Boundary Definition	3.6	2003	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	No SMS Contaminants other than PCBs Analyzed
T117-SE-24-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	3500	µg/kg dw	Yes	19	Yes	3.5	0	1	1310	µg/kg dw	Yes	9.2	Yes	1.7	167	Increase	No SMS Contaminants other than PCBs Analyzed
						1	2	122	µg/kg dw	No	0.83	No	0.15	—	—	—	—	—	—	—	—	—		
T117-SE-25-SC	T-117 Boundary Definition	3.6	2003	2003	Acenaphthene	Surface	—	250	µg/kg dw	Yes	1.1	No	0.32	—	—	—	—	—	—	—	—	—	Increase	No SMS Contaminants other than PCBs Analyzed
					Indeno(1,2,3-cd) pyrene	Surface	—	520	µg/kg dw	Yes	1.1	No	0.42	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	4000	µg/kg dw	Yes	24	Yes	4.5	0	1	2000	µg/kg dw	Yes	22	Yes	4	100		
						1	2	380	µg/kg dw	Yes	1.6	No	0.29	—	—	—	—	—	—	—	—	—		
					Phenanthrene	Surface	—	1900	µg/kg dw	Yes	1.4	No	0.29	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	11900	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
T117-SE-30-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	320	µg/kg dw	Yes	1.6	No	0.29	0	1	990	µg/kg dw	Yes	6.9	Yes	1.3	-68	Decrease	No SMS Contaminants other than PCBs Analyzed
						1	2	158	µg/kg dw	No	1	No	0.18	—	—	—	—	—	—	—	—	—		
T117-SE-31-SC	T-117 Boundary Definition	3.6	2003	—	PCBs (total calc'd)	0	1	51000	µg/kg dw	Yes	220	Yes	40	1	2	26	µg/kg dw	No	0.14	No	0.026	196054	Increase	Below SQS
T117-SE-35-SC	T-117 Boundary Definition	3.6	2003	2003	PCBs (total calc'd)	Surface	—	47	µg/kg dw	No	0.17	No	0.031	0	1	135	µg/kg dw	No	0.53	No	0.098	-65	Decrease	No SMS Contaminants other than PCBs Analyzed
						1	2	480	µg/kg dw	Yes	2.1	No	0.38	—	—	—	—	—	—	—	—	—		
T117-SE-36-SC	T-117 Boundary Definition	3.6	2003	2003	Total PAH (calc'd)	Surface	—	1314	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	No SMS Contaminants other than PCBs Analyzed
T117-SE-37-SC	T-117 Boundary Definition	3.6	2003	2003	2-Methyl-naphthalene	Surface	—	1400	µg/kg dw	Yes	1.9	Yes	1.2	1	2	10	µg/kg dw	No	0.03	No	0.014	6900	Equilibrium	Increase
					Acenaphthene	Surface	—	3900	µg/kg dw	Yes	13	Yes	3.7	1	2	10	µg/kg dw	No	0.04	No	0.027	19400		
					Anthracene	Surface	—	4300	µg/kg dw	Yes	1	No	0.19	1	2	10	µg/kg dw	No	0.021	No	0.0045	21400		
					Benzo(a) anthracene	Surface	—	8400	µg/kg dw	Yes	4	Yes	1.6	1	2	10	µg/kg dw	No	0.015	No	0.013	41900		
					Benzo(a)pyrene	Surface	—	7900	µg/kg dw	Yes	4.2	Yes	2	1	2	10	µg/kg dw	No	0.013	No	0.0067	39400		
					Benzo(g,h,i) perylene	Surface	—	1200	µg/kg dw	Yes	2	No	0.81	—	—	—	—	—	—	—	—	—		
					Benzofluoranthenes (total-calc'd)	Surface	—	17000	µg/kg dw	Yes	3.9	Yes	2	1	2	10	µg/kg dw	No	0.0063	No	0.0056	84900		
					Chrysene	Surface	—	7700	µg/kg dw	Yes	3.7	No	0.89	1	2	10	µg/kg dw	No	0.014	No	0.0071	38400		
					Dibenzo(a,h) anthracene	Surface	—	640	µg/kg dw	Yes	2.8	Yes	1	1	2	10	µg/kg dw	No	0.087	No	0.037	3100		
					Dibenzofuran	Surface	—	4200	µg/kg dw	Yes	15	Yes	3.8	1	2	10	µg/kg dw	No	0.037	No	0.029	20900		
					Fluoranthene	Surface	—	24000	µg/kg dw	Yes	8.1	Yes	1.1	1	2	10	µg/kg dw	No	0.012	No	0.008	119900		
					Fluorene	Surface	—	5500	µg/kg dw	Yes	13	Yes	3.7	1	2	10	µg/kg dw	No	0.037	No	0.02	27400		
					Indeno(1,2,3-cd) pyrene	Surface	—	1900	µg/kg dw	Yes	2.9	Yes	1.1	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	4300	µg/kg dw	Yes	19	Yes	3.5	0	1	3100	µg/kg dw	Yes	24	Yes	3.1	39		
						1	2	9.5	µg/kg dw	No	0.15	No	0.019	—	—	—	—	—	—	—	—	—		
					Phenanthrene	Surface	—	28000	µg/kg dw	Yes	15	Yes	3.1	1	2	10	µg/kg dw	No	0.013	No	0.0037	139900		
					Total HPAH (calc'd)	Surface	—	85000	µg/kg dw	Yes	4.7	No	0.85	1	2	10	µg/kg dw	No	0.0017	No	0.0012	424900		
					Total LPAH (calc'd)	Surface	—	43000	µg/kg dw	Yes	6.2	Yes	2.9	1	2	10	µg/kg dw	No	0.0038	No	0.0015	214900		
					Total PAH (calc'd)	Surface	—	128000	µg/kg dw	—	—	—	—	1	2	10	µg/kg dw	—	—	—	—	639900		
SD-209	Jorgensen April 2004	3.7	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-210	Jorgensen April 2004	3.7	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
SD-210D	Jorgensen April 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	130	µg/kg dw	No	0.41	No	0.075	0	1	10	µg/kg dw	No	0.1	No	0.018	550	Increase	Below SQS
						1	2	300	µg/kg dw	Yes	1.3	No	0.25	—	—	—	—	—	—	—	—	—		
SD-211	Jorgensen April 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	610	µg/kg dw	Yes	2.3	No	0.43	0	1	1170	µg/kg dw	Yes	4.9	No	0.91	-48	Equilibrium	Below SQS
						1	2	670	µg/kg dw	Yes	2.9	No	0.54	—	—	—	—	—	—	—	—	—		
SD-212	Jorgensen April 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	48.9	µg/kg dw	No	0.18	No	0.032	0	1	26	µg/kg dw	No	0.11	No	0.02	88	Increase	Below SQS
						1	2	230	µg/kg dw	Yes	1.2	No	0.22	—	—	—	—	—	—	—	—	—		
SD-214	Jorgensen April 2004	3.7	2004	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	Below SQS
SD-216	Jorgensen April 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	360	µg/kg dw	Yes	1.5	No	0.28	0	1	62	µg/kg dw	No	0.33	No	0.06	481	Increase	Below SQS
						1	2	230	µg/kg dw	Yes	1.3	No	0.23	—	—	—	—	—	—	—	—	—		
SD-217	Jorgensen April 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	293	µg/kg dw	Yes	1.3	No	0.24	0	0.9	400	µg/kg dw	Yes	1.9	No	0.35	-27	Equilibrium	Below SQS
						1	1.9	690	µg/kg dw	Yes	3.8	No	0.71	—	—	—	—	—	—	—	—	—		
SD-312-C	Jorgensen August 2004	3.7	2004	2004	Dibenzofuran	Surface	—	460	µg/kg dw	Yes	1.2	No	0.31	—	—	—	—	—	—	—	—	—	Equilibrium	Decrease
					Fluorene	Surface	—	940	µg/kg dw	Yes	1.6	No	0.46	—	—	—	—	—	—	—	—	—		
					Lead	Surface	—	196	mg/kg dw	No	0.44	No	0.37	1	2	514	mg/kg dw	Yes	1.1	No	0.97	-62		
					PCBs (total calc'd)	Surface	—	1200	µg/kg dw	Yes	3.9	No	0.72	1	2	1870	µg/kg dw	Yes	14	Yes	2.6	-36		
					Phenanthrene	Surface	—	3800	µg/kg dw	Yes	1.5	No	0.31	—	—	—	—	—	—	—	—	—		
					Phenol	Surface	—	610	µg/kg dw	Yes	1.5	No	0.51	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	17400	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
					Zinc	Surface	—	174	mg/kg dw	No	0.42	No	0.18	1	2	457	mg/kg dw	Yes	1.1	No	0.48	-62		
SD-314-C	Jorgensen August 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	760	µg/kg dw	Yes	3.8	No	0.69	1	2	10	µg/kg dw	No	0.067	No	0.012	3700	Increase	Lack of Data Density
					Total PAH (calc'd)	Surface	—	5600	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-315-C	Jorgensen August 2004	3.7	2004	2004	Butyl benzyl phthalate	Surface	—	140	µg/kg dw	Yes	1.8	No	0.14	—	—	—	—	—	—	—	—	—	Increase	Lack of Data Density
					PCBs (total calc'd)	Surface	—	260	µg/kg dw	Yes	1.4	No	0.26	1	2	11.3	µg/kg dw	No	0.17	No	0.023	1050		
					Total PAH (calc'd)	Surface	—	10300	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-320-C	Jorgensen August 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	8900	µg/kg dw	Yes	46	Yes	8.5	1	2	1480	µg/kg dw	Yes	5.5	Yes	1	501	Increase	Lack of Data Density
					Total PAH (calc'd)	Surface	—	1850	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-322-C	Jorgensen August 2004	3.7	2004	2004	PCBs (total calc'd)	Surface	—	110	µg/kg dw	No	0.45	No	0.083	1	2	960	µg/kg dw	Yes	4.3	No	0.78	-89	Decrease	Lack of Data Density
					Total PAH (calc'd)	Surface	—	1400	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SD-323-C	Jorgensen August 2004	3.7	2004	2005	Lead	Surface	—	870	mg/kg dw	Yes	1.9	Yes	1.6	1	2	171	mg/kg dw	No	0.38	No	0.32	409	Increase	Increase
					PCBs (total calc'd)	Surface	—	13000	µg/kg dw	Yes	48	Yes	8.9	1	2	792	µg/kg dw	Yes	4.2	No	0.77	1541		
						1	2	285	µg/kg dw	Yes	1.4	No	0.27	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	2240	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
T117-SE-42-SC	T-117 Boundary Definition	3.7	2003	2003	PCBs (total calc'd)	Surface	—	136	µg/kg dw	No	0.49	No	0.091	0	1	470	µg/kg dw	Yes	3	No	0.55	-71	Decrease	No SMS Contaminants other than PCBs Analyzed
						1	2	47	µg/kg dw	No	0.24	No	0.045	—	—	—	—	—	—	—	—	—		
T117-SE-43-SC	T-117 Boundary Definition	3.7	2003	—	No SQS Exceedances	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Below SQS	No SMS Contaminants other than PCBs Analyzed
LDW-SC50a	LDW Subsurface Sediment 2006	3.8	2006	2005	Arsenic	Surface	—	1100	mg/kg dw	Yes	19	Yes	12	0	1	707	mg/kg dw	Yes	12	Yes	7.6	56	Increase	Increase
						1	2	281	mg/kg dw	Yes	4.9	Yes	3	—	—	—	—	—	—	—	—	—		
					Bis(2-ethylhexyl) phthalate	Surface	—	1200	µg/kg dw	Yes	1.7	No	1	0	1	680	µg/kg dw	Yes	2.3	Yes	1.4	76		
						1	2	64	µg/kg dw	No	0.17	No	0.1	—	—	—	—	—	—	—	—	—		
					Chrysene	Surface	—	1900	µg/kg dw	Yes	1.1	No	0.26	0	1	330	µg/kg dw	No	0.47	No	0.11	476		
						1	2	160	µg/kg dw	No	0.18	No	0.043	—	—	—	—	—	—	—	—	—		
					Fluoranthene	Surface	—	3100	µg/kg dw	Yes	1.3	No	0.17	0	1	770	µg/kg dw	No	0.75	No	0.1	303		
						1	2	200	µg/kg dw	No	0.16	No	0.021	—	—	—	—	—	—	—	—	—		
					Indeno(1,2,3-cd) pyrene	Surface	—	560	µg/kg dw	Yes	1.1	No	0.42	0	1	100	µg/kg dw	No	0.47	No	0.18	460		
						1	2	35	µg/kg dw	No	0.13	No	0.049	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	Surface	—	820	µg/kg dw	Yes	4.5	No	0.83	0	1	510	µg/kg dw	Yes	6.8	Yes	1.2	61		
						1	2	780	µg/kg dw	Yes	8	Yes	1.5	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	15600	µg/kg dw	—	—	—	—	0	1	3410	µg/kg dw	—	—	—	—	357		
						1	2	1110	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
LDW-SC51	LDW Subsurface Sediment 2006	3.8	2006	2005	Acenaphthene	0	0.5	350	µg/kg dw	Yes	1.4	No	0.39	0.5	1	180	µg/kg dw	No	0.69	No	0.19	94	Decrease	Mixed
						1	1.5	250	µg/kg dw	No	0.5	No	0.34	1.5	2	84	µg/kg dw	No	0.81	No	0.23	—		
					Benzo(g,h,i) perylene	0	0.5	590	µg/kg dw	Yes	1.2	No	0.47	0.5	1	130	µg/kg dw	No	0.25	No	0.1	354		
						1	1.5	31	µg/kg dw	No	0.093	No	0.086	1.5	2	31	µg/kg dw	No	0.31	No	0.12	—		
					Benzyl alcohol	0	0.5	180	µg/kg dw	Yes	3.2	Yes	2.5	0.5	1	15	µg/kg dw	No	0.53	No	0.41	500		
						1	1.5	15.5	µg/kg dw	No	0.54	No	0.42	1.5	2	15.5	µg/kg dw	No	0.54	No	0.42	—		
					Bis(2-ethylhexyl) phthalate	0	0.5	970	µg/kg dw	Yes	1.3	No	0.77	0.5	1	1800	µg/kg dw	Yes	2.3	Yes	1.4	-46		
						1	1.5	31	µg/kg dw	No	0.048	No	0.033	1.5	2	75	µg/kg dw	No	0.26	No	0.15	—		
					Chrysene	0	0.5	1900	µg/kg dw	Yes	1.1	No	0.26	0.5	1	490	µg/kg dw	No	0.27	No	0.065	288		
						1	1.5	120	µg/kg dw	No	0.086	No	0.043	1.5	2	67	µg/kg dw	No	0.091	No	0.022	—		
					Dibenzo(a,h) anthracene	0	0.5	160	µg/kg dw	No	0.83	No	0.3	0.5	1	38	µg/kg dw	No	0.19	No	0.07	321		
						1	1.5	4.3	µg/kg dw	No	0.019	No	0.008	1.5	2	3.7	µg/kg dw	No	0.048	No	0.018	—		
					Dibenzofuran	0	0.5	230	µg/kg dw	No	0.93	No	0.24	0.5	1	89	µg/kg dw	No	0.36	No	0.093	158		
						1	1.5	130	µg/kg dw	No	0.24	No	0.19	1.5	2	92	µg/kg dw	No	0.93	No	0.24	—		
					Fluoranthene	0	0.5	4000	µg/kg dw	Yes	1.6	No	0.21	0.5	1	1200	µg/kg dw	No	0.46	No	0.061	233		
						1	1.5	720	µg/kg dw	No	0.42	No	0.29	1.5	2	730	µg/kg dw	No	0.69	No	0.092	—		
					Indeno(1,2,3-cd) pyrene	0	0.5	690	µg/kg dw	Yes	1.3	No	0.49	0.5	1	160	µg/kg dw	No	0.29	No	0.11	331		
						1	1.5	31	µg/kg dw	No	0.1	No	0.09	1.5	2	31	µg/kg dw	No	0.28	No	0.11	—		
					PCBs (total calc'd)	Surface	—	220	µg/kg dw	No	0.92	No	0.17	0	2	1290	µg/kg dw	Yes	7.3	Yes	1.4	-83		
					Phenanthrene	0	0.5	2300	µg/kg dw	Yes	1.4	No	0.29	0.5	1	840	µg/kg dw	No	0.51	No	0.11	174		
						1	1.5	120	µg/kg dw	No	0.08	No	0.022	1.5	2	97	µg/kg dw	No	0.15	No	0.031	—		
					Total HPAH (calc'd)	0	0.5	16100	µg/kg dw	Yes	1	No	0.19	0.5	1	4500	µg/kg dw	No	0.28	No	0.051	258		
						1	1.5	1570	µg/kg dw	No	0.13	No	0.092	1.5	2	1380	µg/kg dw	No	0.22	No	0.04	—		
					Total PAH (calc'd)	0	0.5	19900	µg/kg dw	—	—	—	—	0.5	1	5800	µg/kg dw	—	—	—	—	243		
						1	1.5	1990	µg/kg dw	—	—	—	—	1.5	2	1600	µg/kg dw	—	—	—	—	—		

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
DR220	EPA SI	3.8	1998	1998	PCBs (total calc'd)	Surface	—	77	µg/kg dw	No	0.23	No	0.043	0	2	830	µg/kg dw	Yes	2.8	No	0.52	-91	Decrease	Below SQS
					Total PAH (calc'd)	Surface	—	1710	µg/kg dw	—	—	—	—	0	2	860	µg/kg dw	—	—	—	—	99		
AN-042	8801 EMW Core 2008	3.9	2008	—	Butyl benzyl phthalate	0	1	130	µg/kg dw	Yes	1.7	No	0.13	—	—	—	—	—	—	—	—		Equilibrium	No SMS Contaminants other than PCBs Analyzed
					PCBs (total calc'd)	0	1	1500	µg/kg dw	Yes	8.1	Yes	1.5	1	2	1400	µg/kg dw	Yes	5.6	Yes	1	7.14		
AN-043	8801 EMW Core 2008	3.9	2008	—	Butyl benzyl phthalate	0	1	57	µg/kg dw	Yes	1.1	No	0.084	—	—	—	—	—	—	—	—		Decrease	Decrease
					PCBs (total calc'd)	0	1	270	µg/kg dw	Yes	2.1	No	0.38	1	2	1800	µg/kg dw	Yes	5.3	No	0.97	-85.00		
					2,4-Dimethylphenol	—	—	—	—	—	—	—	—	1	2	54	µg/kg dw	Yes	1.9	Yes	1.9			
					Cadmium	0	1	0.6	mg/kg dw	No	0.12	No	0.09	1	2	16.9	mg/kg dw	Yes	3.3	Yes	2.5	-96.45		
					Chromium	0	1	30	mg/kg dw	No	0.12	No	0.11	1	2	514	mg/kg dw	Yes	2	Yes	1.9	-94.16		
					Lead	0	1	1	mg/kg dw	No	0.0022	No	0.0019	1	2	2530	mg/kg dw	Yes	5.6	Yes	4.8	-99.96		
					Mercury	0	1	0.09	mg/kg dw	No	0.22	No	0.15	1	2	1.51	mg/kg dw	Yes	3.7	Yes	2.6	-94.04		
					Zinc	0	1	112	mg/kg dw	No	0.27	No	0.12	1	2	1250	mg/kg dw	Yes	3	Yes	1.3	-91.04		
AN-044	8801 EMW Core 2008	3.9	2008	—	Butyl benzyl phthalate	0	1	240	µg/kg dw	Yes	2	No	0.16	1	2	8	µg/kg dw	No	0.15	No	0.012	2900.00	Increase	Increase
					PCBs (total calc'd)	0	1	3000	µg/kg dw	Yes	11	Yes	2	1	2	420	µg/kg dw	Yes	1.4	No	0.26	614		
LDW-SC52	LDW Subsurface Sediment 2006	3.9	2006	—	2-Methylphenol	0	1	160	µg/kg dw	Yes	2.5	Yes	2.5	1	2	6	µg/kg dw	No	0.19	No	0.19	1233	Increase	Increase
					Butyl benzyl phthalate	0	1	610	µg/kg dw	Yes	5.3	No	0.41	1	2	6	µg/kg dw	No	0.09	No	0.0069	4983		
					Mercury	0	1	0.67	mg/kg dw	Yes	1.6	Yes	1.1	1	2	0.25	mg/kg dw	No	0.61	No	0.42	168		
					PCBs (total calc'd)	0	1	3000	µg/kg dw	Yes	11	Yes	2	1	2	65	µg/kg dw	No	0.2	No	0.037	4515		
AN-041	8801 EMW Core 2008	4	2008	—	PCBs (total calc'd)	0	1	1060	µg/kg dw	Yes	5.6	Yes	1	1	2	210	µg/kg dw	No	1	No	0.18	405	Increase	No SMS Contaminants other than PCBs Analyzed
SB-12	Rhône Poulenc 2004	4.1	2004	2004	Benzoic acid	Surface	—	1300	µg/kg dw	Yes	2	Yes	2	0.33	0.69	1300	µg/kg dw	Yes	2	Yes	2	0	Below SQS	Mixed
					Bis(2-ethylhexyl) phthalate	0.33	0.69	550	µg/kg dw	Yes	1.3	No	0.78	—	—	—	—	—	—	—	—	—		
					Dibenzo(a,h) anthracene	Surface	—	420	µg/kg dw	Yes	2.2	No	0.79	0.33	0.69	380	µg/kg dw	Yes	1.8	No	0.64	11		
					Di-n-octyl phthalate	0.33	0.69	550	µg/kg dw	Yes	1.1	No	0.014	—	—	—	—	—	—	—	—	—		
					Fluoranthene	Surface	—	5300	µg/kg dw	Yes	2.1	No	0.28	0.33	0.69	2700	µg/kg dw	No	0.94	No	0.13	96		
					Pentachloro-phenol	0.33	0.69	1150	µg/kg dw	Yes	6.4	Yes	3.3	—	—	—	—	—	—	—	—	—		
					Total HPAH (calc'd)	Surface	—	16100	µg/kg dw	Yes	1	No	0.19	0.33	0.69	11100	µg/kg dw	No	0.65	No	0.12	45		
					Total PAH (calc'd)	Surface	—	17200	µg/kg dw	—	—	—	—	0.33	0.69	11500	µg/kg dw	—	—	—	—	50		
SH-03	Rhône Poulenc 2004	4.1	2004	2004	Benzoic acid	Surface	—	940	µg/kg dw	Yes	1.4	Yes	1.4	0.33	0.82	800	µg/kg dw	Yes	2.5	Yes	2.5	-41	Below SQS	Mixed
						0.33	0.82	800	µg/kg dw	Yes	2.5	Yes	2.5	—	—	—	—	—	—	—	—	—		
					Dibenzo(a,h) anthracene	Surface	—	220	µg/kg dw	No	0.96	No	0.41	0.33	0.82	405	µg/kg dw	Yes	3.5	Yes	1.5	-73		
					Dibenzo(a,h) anthracene	0.33	0.82	410	µg/kg dw	Yes	3.6	Yes	1.5	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	1080	µg/kg dw	—	—	—	—	0.33	0.82	405	µg/kg dw	—	—	—	—	33		
						0.33	0.82	410	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
SH-06	Rhône Poulenc 2004	4.1	2004	2004	Benzoic acid	Surface	—	840	µg/kg dw	Yes	1.3	Yes	1.3	0.33	0.82	750	µg/kg dw	Yes	2.3	Yes	2.3	-44	Increase	Equilibrium
					PCBs (total calc'd)	Surface	—	94	µg/kg dw	Yes	1.6	No	0.29	0.33	0.82	44	µg/kg dw	No	0.34	No	0.044	114		
					Total PAH (calc'd)	Surface	—	370	µg/kg dw	—	—	—	—	0.33	0.82	370	µg/kg dw	—	—	—	—	-50		
DR284	EPA SI	4.1	1998	—	Total HPAH (calc'd)	Surface	—	1530	µg/kg dw	No	0.071	No	0.013	0	2	1630	µg/kg dw	No	0.076	No	0.014	7	Below SQS	Below SQS
					Total LPAH (calc'd)	Surface	—	210	µg/kg dw	No	0.025	No	0.012	0	2	130	µg/kg dw	No	0.016	No	0.0074	-56		
SB-1	Rhône Poulenc 2004	4.2	2004	2004	Benzo(g,h,i) perylene	Surface	—	1100	µg/kg dw	Yes	1.3	No	0.51	0.33	0.69	860	µg/kg dw	Yes	1.1	No	0.44	28	Lack of Data Density	Equilibrium
					Benzoic acid	0.33	0.69	1350	µg/kg dw	Yes	4.2	Yes	4.2	—	—	—	—	—	—	—	—	—		
					Bis(2-ethylhexyl) phthalate	Surface	—	1600	µg/kg dw	Yes	1.3	No	0.76	0.33	0.69	1600	µg/kg dw	Yes	1.4	No	0.82	0		
					Dibenzo(a,h) anthracene	Surface	—	700	µg/kg dw	Yes	2.2	No	0.79	0.33	0.69	630	µg/kg dw	Yes	2.1	No	0.76	11		
					Fluoranthene	Surface	—	4800	µg/kg dw	Yes	1.1	No	0.15	0.33	0.69	3500	µg/kg dw	No	0.88	No	0.12	37		
					Indeno(1,2,3-cd) pyrene	Surface	—	1200	µg/kg dw	Yes	1.3	No	0.5	0.33	0.69	970	µg/kg dw	Yes	1.1	No	0.44	24		
					Total PAH (calc'd)	Surface	—	22300	µg/kg dw	—	—	—	—	0.33	0.69	17100	µg/kg dw	—	—	—	—	30		
SB-3	Rhône Poulenc 2004	4.2	2004	2004	Benzoic acid	0.33	0.69	2000	µg/kg dw	Yes	3.1	Yes	3.1	—	—	—	—	—	—	—	—	—	Lack of Data Density	Mixed
					Bis(2-ethylhexyl) phthalate	Surface	—	2100	µg/kg dw	Yes	1.6	No	0.99	0.33	0.69	2100	µg/kg dw	Yes	1.5	No	0.91	0		
					Dibenzo(a,h) anthracene	Surface	—	630	µg/kg dw	Yes	1.9	No	0.7	0.33	0.69	540	µg/kg dw	Yes	1.5	No	0.55	17		
					Indeno(1,2,3-cd) pyrene	Surface	—	950	µg/kg dw	Yes	1	No	0.4	0.33	0.69	800	µg/kg dw	No	0.79	No	0.31	19		
					Phenol	Surface	—	1400	µg/kg dw	Yes	3.3	Yes	1.2	0.33	0.69	3100	µg/kg dw	Yes	7.4	Yes	2.6	-55		
					Total PAH (calc'd)	Surface	—	15900	µg/kg dw	—	—	—	—	0.33	0.69	12400	µg/kg dw	—	—	—	—	28		
SB-4	Rhône Poulenc 2004	4.2	2004	2004	Benzoic acid	Surface	—	1900	µg/kg dw	Yes	2.9	Yes	2.9	0.33	0.69	1700	µg/kg dw	Yes	2.6	Yes	2.6	12	Lack of Data Density	Mixed
					Bis(2-ethylhexyl) phthalate	Surface	—	1900	µg/kg dw	Yes	1.3	No	0.77	0.33	0.69	1700	µg/kg dw	Yes	1	No	0.63	12		
					Dibenzo(a,h) anthracene	Surface	—	460	µg/kg dw	Yes	1.3	No	0.45	0.33	0.69	490	µg/kg dw	Yes	1.2	No	0.42	-6		
					Phenol	Surface	—	1400	µg/kg dw	Yes	3.3	Yes	1.2	0.33	0.69	140	µg/kg dw	No	0.67	No	0.23	400		
					Total PAH (calc'd)	Surface	—	7500	µg/kg dw	—	—	—	—	0.33	0.69	8000	µg/kg dw	—	—	—	—	-6		
SB-5	Rhône Poulenc 2004	4.2	2004	—	Benzoic acid	0.33	0.69	1800	µg/kg dw	Yes	2.8	Yes	2.8	—	—	—	—	—	—	—	—	—	Equilibrium	Lack of Data Density
					PCBs (total calc'd)	Surface	—	150	µg/kg dw	Yes	1.2	No	0.15	0.33	0.69	190	µg/kg dw	No	0.55	No	0	-21		
					Pentachlorophenol	0.33	0.69	1350	µg/kg dw	Yes	8.5	Yes	4.9	—	—	—	—	—	—	—	—	—		
SB-8	Rhône Poulenc 2004	4.2	2004	2004	Benzoic acid	Surface	—	1700	µg/kg dw	Yes	2.6	Yes	2.6	0.33	0.69	1500	µg/kg dw	Yes	2.3	Yes	2.3	13	Lack of Data Density	Equilibrium
					Dibenzo(a,h) anthracene	Surface	—	440	µg/kg dw	Yes	1.3	No	0.45	0.33	0.69	410	µg/kg dw	Yes	1.4	No	0.52	7		
					Total PAH (calc'd)	Surface	—	4610	µg/kg dw	—	—	—	—	0.33	0.69	4560	µg/kg dw	—	—	—	—	1		
SH-09	Rhône Poulenc 2004	4.2	2004	2004	Total PAH (calc'd)	Surface	—	410	µg/kg dw	—	—	—	—	0.33	0.82	490	µg/kg dw	—	—	—	—	-16	Below SQS	Below SQS
DR246	EPA SI	4.2	1998	1998	Total PAH (calc'd)	Surface	—	1930	µg/kg dw	—	—	—	—	0	2	1860	µg/kg dw	—	—	—	—	4	Lack of Data Density	Below SQS
DR269	EPA SI	4.6	1998	1998	Total PAH (calc'd)	Surface	—	880	µg/kg dw	—	—	—	—	0	2	1090	µg/kg dw	—	—	—	—	-19	Lack of Data Density	Below SQS
LDW-SC55	LDW Subsurface Sediment 2006	4.9	2006	2005	PCBs (total calc'd)	Surface	—	2700	µg/kg dw	Yes	33	Yes	6	0	1	13.5	µg/kg dw	No	0.075	No	0.014	19900	Increase	Below SQS
						1	2	1.95	µg/kg dw	No	0.047	No	0.0086	—	—	—	—	—	—	—	—	—		
					Total PAH (calc'd)	Surface	—	550	µg/kg dw	—	—	—	—	0	1	24	µg/kg dw	—	—	—	—	2192		
						1	2	10	µg/kg dw	—	—	—	—	—	—	—	—	—	—	—	—	—		
NFK008	Norfolk-cleanup2	4.9	1995	—	Mercury	0	0.98	0.16	mg/kg dw	No	0.39	No	0.27	0.98	1.97	37	mg/kg dw	Yes	90	Yes	63	-100	Decrease	Decrease
					PCBs (total calc'd)	0	0.98	710	µg/kg dw	Yes	3.1	No	0.57	0.98	1.97	81700	µg/kg dw	Yes	330	Yes	60	-99		

Table F-8 SMS Contaminant Trends by Depth in the Top Two Intervals of Cores

						Shallow Sediment / Top Layer								Deeper Sediment									Core Trend for:	
Core Location Name	Event Name	River Mile	Year Core Collected	Year Surface Grab Collected, if Used[a]	SMS Contaminant with Detected SQS Exceedance (and Total PAHs)	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Upper Depth (ft)	Lower Depth (ft)	Concen-tration or Half if Undetected	Units	Exceeds SQS?	SQS Exceedance Factor	Exceeds CSL?	CSL Exceedance Factor	Percent Change for SMS Contaminant	Total PCBs	Other SMS Contaminants
NFK207	Norfolk-cleanup2	4.9	1995	—	1,4-Dichlorobenzene	0	0.98	750	µg/kg dw	Yes	6.8	Yes	6.3	0.98	1.97	17	µg/kg dw	No	0.15	No	0.14	4312	Below SQS	Mixed
					Bis(2-ethylhexyl) phthalate	0	0.98	1400	µg/kg dw	Yes	1.1	No	0.74	0.98	1.97	130	µg/kg dw	No	0.1	No	0.068	977		
					Butyl benzyl phthalate	0	0.98	130	µg/kg dw	Yes	2.1	No	0.14	0.98	1.97	9	µg/kg dw	No	0.29	No	0.02	622		
					Indeno(1,2,3-cd) pyrene	0	0.98	630	µg/kg dw	Yes	1.1	No	0.91	0.98	1.97	150	µg/kg dw	No	0.25	No	0.22	320		
					N-Nitrosodi-phenylamine	0	0.98	33	µg/kg dw	Yes	1.2	No	0.83	0.98	1.97	15	µg/kg dw	Yes	1.1	No	0.75	10		
NFK009	Norfolk-cleanup1	4.9	1994	—	1,4-Dichlorobenzene	0.49	0.98	1400	µg/kg dw	Yes	23	Yes	7.8	0.98	1.48	2800	µg/kg dw	Yes	160	Yes	56	-50	Increase	Mixed
						1.48	1.97	550	µg/kg dw	Yes	32	Yes	11	—	—	—	—	—	—	—	—	—		
						0	0.98	80	µg/kg dw	Yes	3.9	Yes	1.3	0.98	1.97	91	µg/kg dw	No	0.83	No	0.76	—		
					Bis(2-ethylhexyl) phthalate	0.49	0.98	390	µg/kg dw	No	0.43	No	0.26	0.98	1.48	840	µg/kg dw	Yes	3.2	Yes	1.9	-54		
						0	0.98	570	µg/kg dw	Yes	1.8	Yes	1.1	0.98	1.97	29	µg/kg dw	No	0.022	No	0.015	—		
					Butyl benzyl phthalate	1.48	1.97	93	µg/kg dw	Yes	3.5	No	0.27	—	—	—	—	—	—	—	—	—		
					Mercury	0.49	0.98	0.85	mg/kg dw	Yes	2.1	Yes	1.4	0.98	1.48	0.11	mg/kg dw	No	0.27	No	0.19	673		
						1.48	1.97	0.03	mg/kg dw	No	0.073	No	0.051	—	—	—	—	—	—	—	—	—		
						0	0.98	0.55	mg/kg dw	Yes	1.3	No	0.93	0.98	1.97	0.03	mg/kg dw	No	0.073	No	0.051	—		
					N-Nitrosodi-phenylamine	0.49	0.98	120	µg/kg dw	No	0.55	No	0.55	0.98	1.48	16	µg/kg dw	No	0.52	No	0.52	275		
						1.48	1.97	16.5	µg/kg dw	No	0.55	No	0.55	—	—	—	—	—	—	—	—	—		
					PCBs (total calc'd)	0.49	0.98	296	µg/kg dw	Yes	1.3	No	0.23	0.98	1.48	7.5	µg/kg dw	No	0.23	No	0.042	3847		
						0	0.98	247	µg/kg dw	Yes	3	No	0.55	0.98	1.97	7	µg/kg dw	No	0.11	No	0.014	—		

Greater than or equal to 50% concentration increase.
Minimal change (<50% change in concentration).
Greater than or equal to 50% concentration decrease.

Notes:

1. This table contains all cores with the appropriate sampling intervals for assessing empirical trends (165 cores). For each core, the SMS contaminants with detected SQS exceedances are included. Total PAHs are also included to provide additional information about core trends. However, total PAH trends were not used for other SMS contaminant trend assignments (last column).
2. Core locations were included if the following criteria were met: a) proper vertical resolution, and b) one or more contaminants were analyzed or suites of contaminants were analyzed, and c) the sample was not a composite sample. The following core locations were not added: DUD206, S12, SB-2, SB-6, SB-7, SB-11, SB-13, SB-17, SC08, SC09, SC10, SH-01, SH-02, SH-04, SH-05, SH-07, SH-08, T117-SE-91-SC, T117-SE-93-SC, and T117-SE-COMP4-SC.

a. A surface sediment sample was used to represent the shallow interval if it was within 10 ft of the core.

CSL = cleanup screening level; HPAH = high molecular weight polycyclic aromatic hydrocarbon; LDW = Lower Duwamish Waterway; LPAH = low molecular weight polycyclic aromatic hydrocarbon; µg/kg dw = microgram per kilogram dry weight; mg/kg dw = milligram per kilogram dry weight; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; SMS = Sediment Management Standards; SQS = sediment quality standards

Table F-9 Summary of SMS Contaminant Trends in the Top Two Intervals of Cores

SMS Contaminant	Total Number of Cores Analyzed for SMS Contaminant	Number of Cores Evaluated for SMS Contaminant (Detected SQS Exceedances)	Number of Cores with Increasing Trends	Number of Cores in Equilibrium	Number of Cores with Decreasing Trends
1,2,4-Trichlorobenzene	259	2	0	1	1
1,2-Dichlorobenzene	253	2	1	0	1
1,4-Dichlorobenzene	252	3	1	1	1
2-Methylnaphthalene	261	2	2	0	0
2-Methylphenol	258	1	1	0	0
Acenaphthene	280	6	4	1	1
Anthracene	281	2	2	0	0
Arsenic	290	8	2	3	3
Benzo(a)anthracene	281	3	2	0	1
Benzo(a)pyrene	278	4	3	0	1
Butyl benzyl phthalate	262	15	4	8	3
Bis(2-ethylhexyl)phthalate	282	17	5	9	3
Benzo(g,h,i)perylene	281	4	3	1	0
Benzofluoranthenes (total-calc'd)	281	4	3	1	0
Benzoic acid	280	9	1	8	0
Benzyl alcohol	258	9	5	1	3
Cadmium	334	4	0	2	2
Chromium	274	1	0	0	1
Chrysene	281	11	9	1	1
Copper	341	2	0	0	2
Dibenzo(a,h)anthracene	278	11	3	6	2
Dibenzofuran	267	6	4	1	1
Fluoranthene	281	16	10	3	3
Fluorene	281	5	3	1	1
Hexachlorobenzene	244	2	0	2	0
Indeno(1,2,3-cd) pyrene	281	12	7	5	0
Lead	340	7	2	1	4
Mercury	336	23	6	12	5
Naphthalene	262	1	1	0	0
N-Nitrosodiphenylamine	474	3	1	1	1
PCBs (total calc'd)	518	119	38	38	43
Phenanthrene	281	9	6	3	0
Phenol	281	5	2	2	1
Pyrene	281	2	1	1	0
Total LPAH (calc'd)	281	5	3	1	1
Total HPAH (calc'd)	281	12	8	3	1
Zinc	341	14	2	7	5

Notes:

1. See Table F-8 for data.

Increasing = Greater than or equal to 50% concentration increase.
Equilibrium = Minimal change (<50% change in concentration).
Deceasing = Greater than or equal to 50% concentration decrease.

2. SMS contaminant data summarized here are only for detected SQS exceedances in the top two intervals of cores, if those intervals are within the top 2 feet of the core. Data could also be from a co-located surface sediment location and a 0- to1-ft or a 0- to 2-ft interval in a core. Trends for concentration changes from the deeper to the shallower sample. Data are in Table F-8.

ft = foot; HPAH = high molecular weight polycyclic aromatic hydrocarbon; LPAH = low molecular weight polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; SMS = Sediment Management Standards; SQS = sediment quality standards

Table F-10 Average Total PCB Concentrations in English Sole Fillet Samples Collected in the LDW

Event and/or Source	Year	Season	Location	Size or Age	Sample Size	Number of Fish per Composite	Avg Total PCBs (µg/kg ww)	Avg Lipid (%)	Avg Total PCBs (mg/kg lipid)[a]
Butler and Schutzmann (1978)	1972	Fall	Duwamish River	yearling	1	25	1,760[b]	nr	n/a
	1973	Spring/Fall	Duwamish River	yearling	2	25	998[b]	nr	n/a
	1974	Spring/Fall	Duwamish River	yearling	2	25	963[b]	nr	n/a
	1975	Spring	Duwamish River	yearling	1	25	1,337[b]	nr	n/a
	1976	Spring	Duwamish River	yearling	1	25	1,120[b]	nr	n/a
Malins et al. (1982)	1979 or 1980	Unknown	Duwamish River/ Elliott Bay	nr	5	appears to be 1	1,000[c]	nr	n/a
EBAP (PTI Environmental & Tetra Tech 1988)	1985	September	RM 0 – 2	7 – 11 yrs	2	1	395[d]	1.9	21
PSAMP (West et al. 2001)	1992	May	RM 0.4 – 1.3	>200 mm	3	20	111[d]	0.48	23
PSAMP (West et al. 2001)	1995	May	RM 0.4 – 1.3	>200 mm	3	20	227[d]	0.35	69
EVS-95 (Battelle 1996)	1995[d]	December	RM 1.1 – 1.4	nr	3	6	207[d]	11	1.9
KCWQA (King County 1999)	1997	July	RM 0.5 – 0.9	>200 mm	3	20	220[d]	0.30	74
WSOU (ESG 1999)	1998	October	RM 2.1 – 4.4	>200 mm	3	5	370[d]	nr	n/a
LDW RI (Windward 2010)	2004	August	RM 0.2 – 4.4	>200 mm	7	5	1,400[c]	2.9	49
LDW RI (Windward 2010)	2005	Aug/Sept	RM 0.2 – 4.4	>200 mm	10	5	920[c]	3.53	26
KC fish tissue (Anchor and King County 2007)	2006	September	RM 0.2 – 1.0	>200 mm	6	5	490[b]	3.67	14
LDW RI (Windward 2010)	2007	September	RM 0.2 – 4.4	>200 mm	9	5	350[c]	2.99	12

Notes:

a. Lipid-normalized total PCB concentrations were calculated on a sample-by-sample basis. Average values and standard deviations were then calculated for each dataset.

b. Whole-body concentration reported in original source was converted to an equivalent fillet concentration assuming the LDW RI-derived fillet-to-whole body ratio of 0.526.

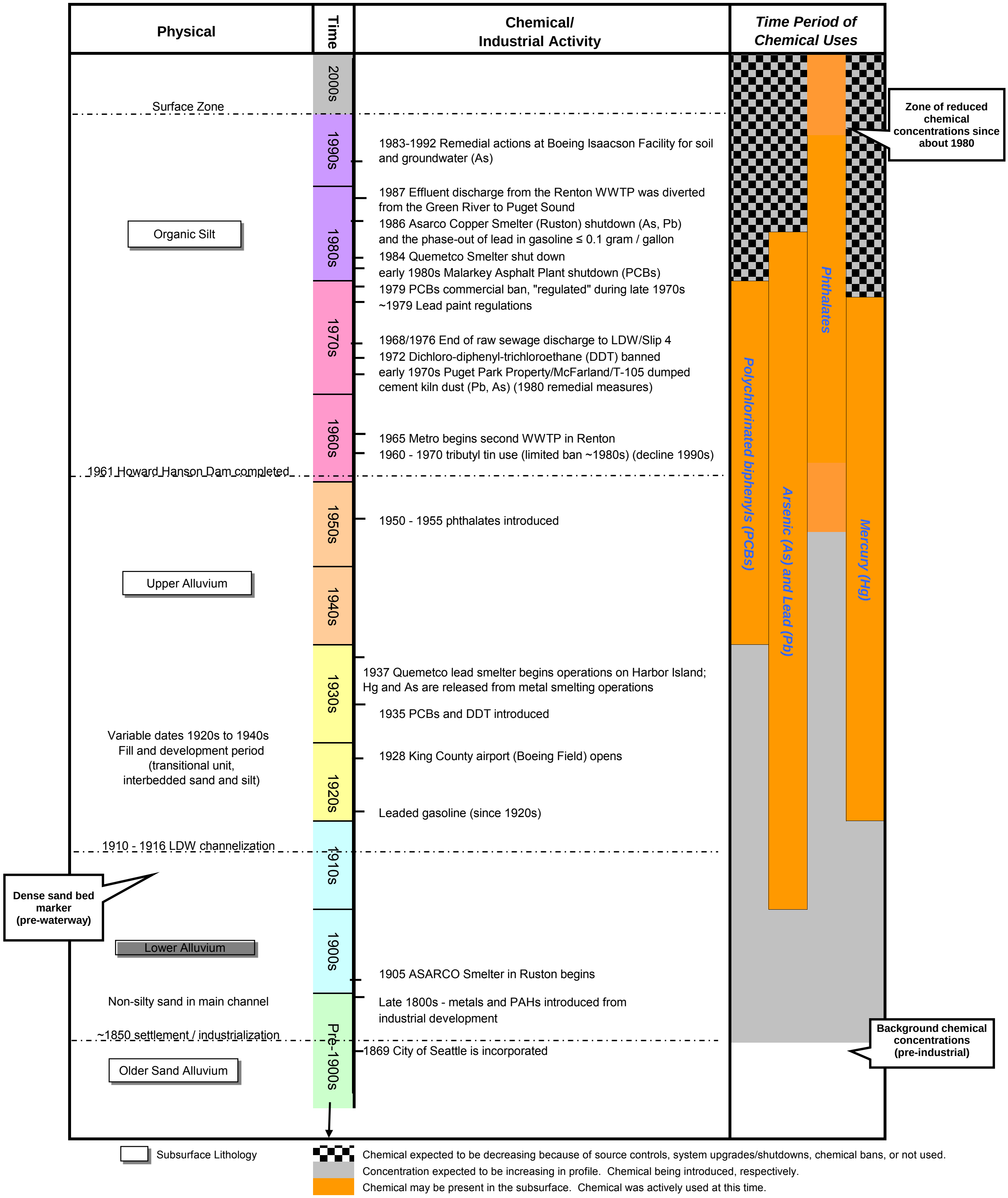
c. Skin-on fillet.

d. Skin-off fillet.

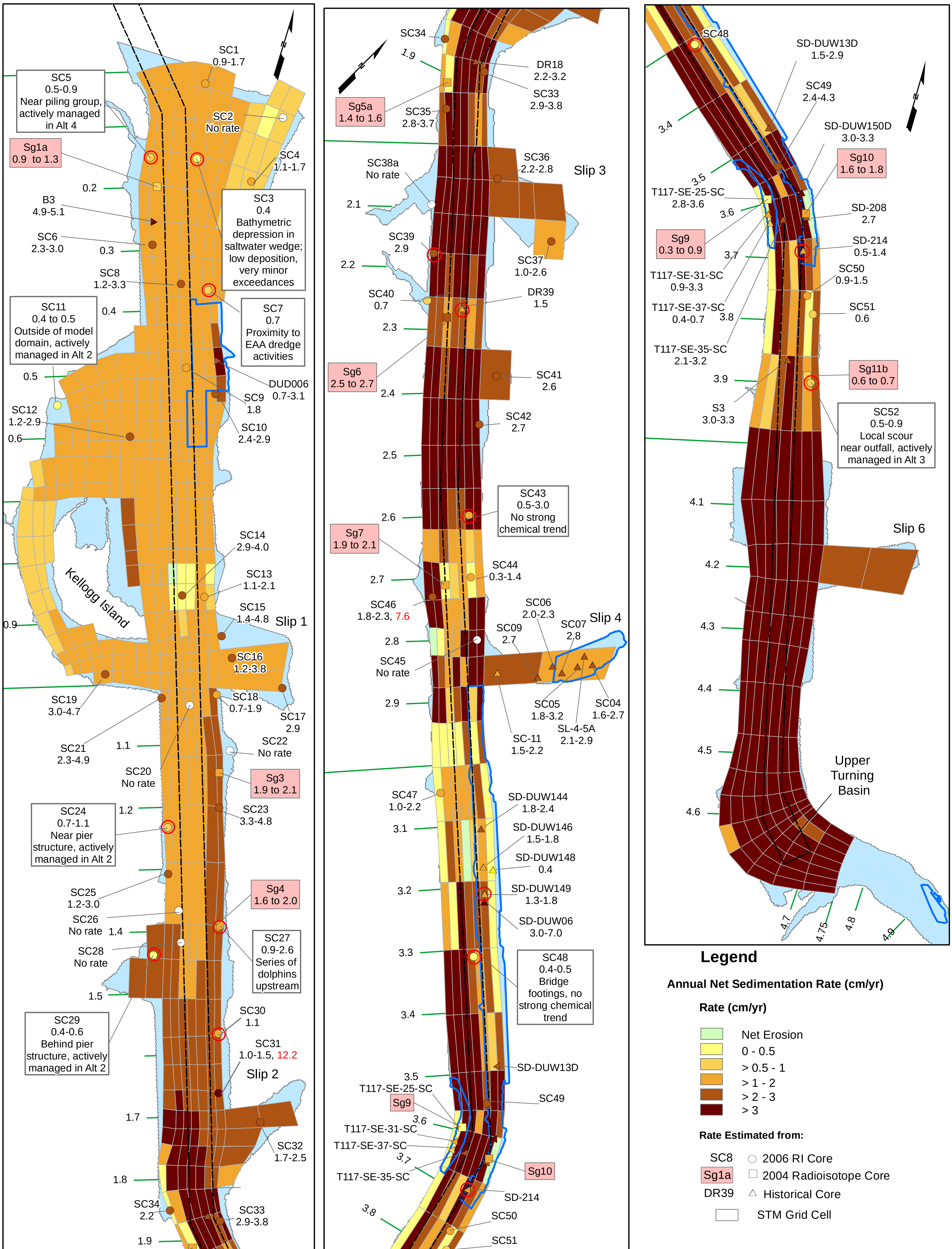
e. The average concentration from December 1995 was graphed as 1996 in Figures F-14 and F-15.

EBAP = Elliott Bay Action Program; ESG = Environmental Solutions Group; KCWQA = King County Water Quality Assessment; LDW = Lower Duwamish Waterway; mm = millimeters; n/a = not available; nr = not reported; PCB = polychlorinated biphenyl; PSAMP = Puget Sound Ambient Monitoring Program; RI = remedial investigation; RM = river mile; WSOU = Waterway Sediment Operable Unit

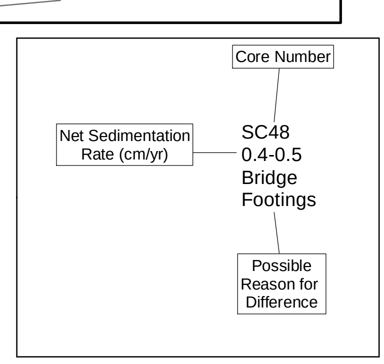
Figure F-1 Example Schematic of Historical Events, Chemical Uses, and Source Control Evidenced through Stratigraphic Units and Chemical Profiles in Cores



WWTP= wastewater treatment plant



Notes:
1. Net sedimentation rates estimated from radioisotope core data, 2006 core chemistry data and historical core data in FS project database.
2. Numerous time markers used to estimate net sedimentation rates are from radioisotope, physical, and chemical geochronology profiles.
3. Ranges shown are calculated from recovered depths.
4. Red font represents rate from dredging event marker outside range of other rates.
5. STM GIS shapefile from 30-year run (QEA Feb. 2009).
6. Seven RI cores for which rates could not be calculated are displayed as white circles. Historical cores for which rates could not be calculated are not shown.
7. Cores SC11, SC40 and SC42 are outside of the model domain and therefore are not circled. Core SC46 has interference from a dredge event and was not circled. Historical core SC11 (in Slip 4) range matched model predictions. Core SC51 straddled two grid cells and therefore was not circled.



AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

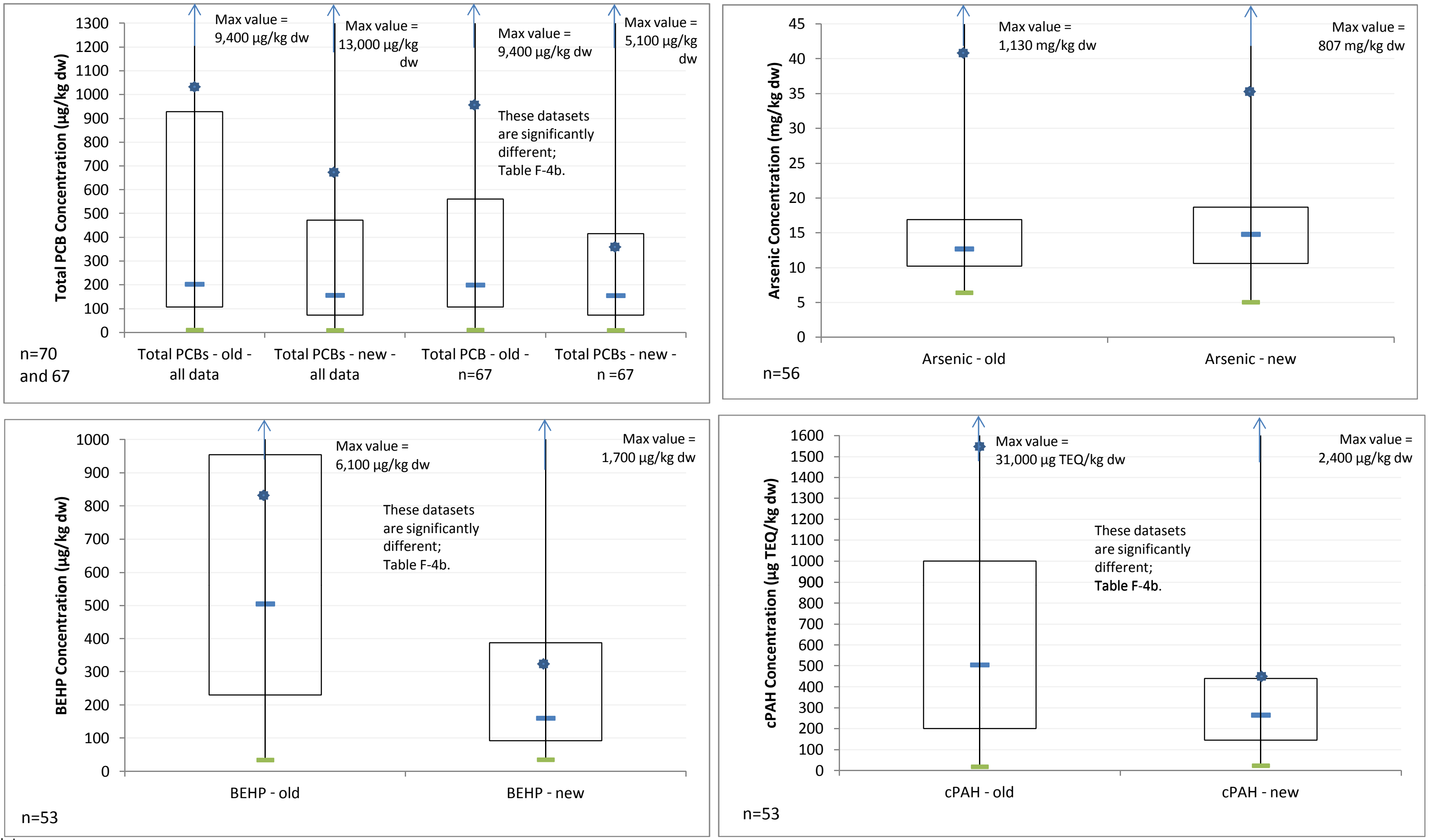
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Comparison of Net Sedimentation Rates Estimated from the STM and from Sediment Cores

DATE: 10/31/12 | DWN. BY: MVI/sea | **FIGURE F-2**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\Figure5_2NetSedvsCores.mxd

Figure F-3a Population Statistics for Resampled Surface Sediment Locations



Notes:

1. Newer data are co-located with older data (i.e., within 10 ft). Older data are not included in the FS baseline dataset.
2. Statistics calculated using ProUCL v.4.00.04 (Table F-3).
3. Undetected data were set to the reporting limit.
4. The n=67 total PCB dataset omitted these samples: LDW-SS110/SD-323-S; LDW-SS111/DR186; and SD-320-S/SD-DUW92.
5. BEHP = bis(2-ethyhexyl)phthalate; cPAH =carcinogenic polycyclic aromatic hydrocarbon;

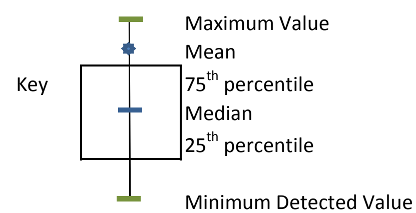
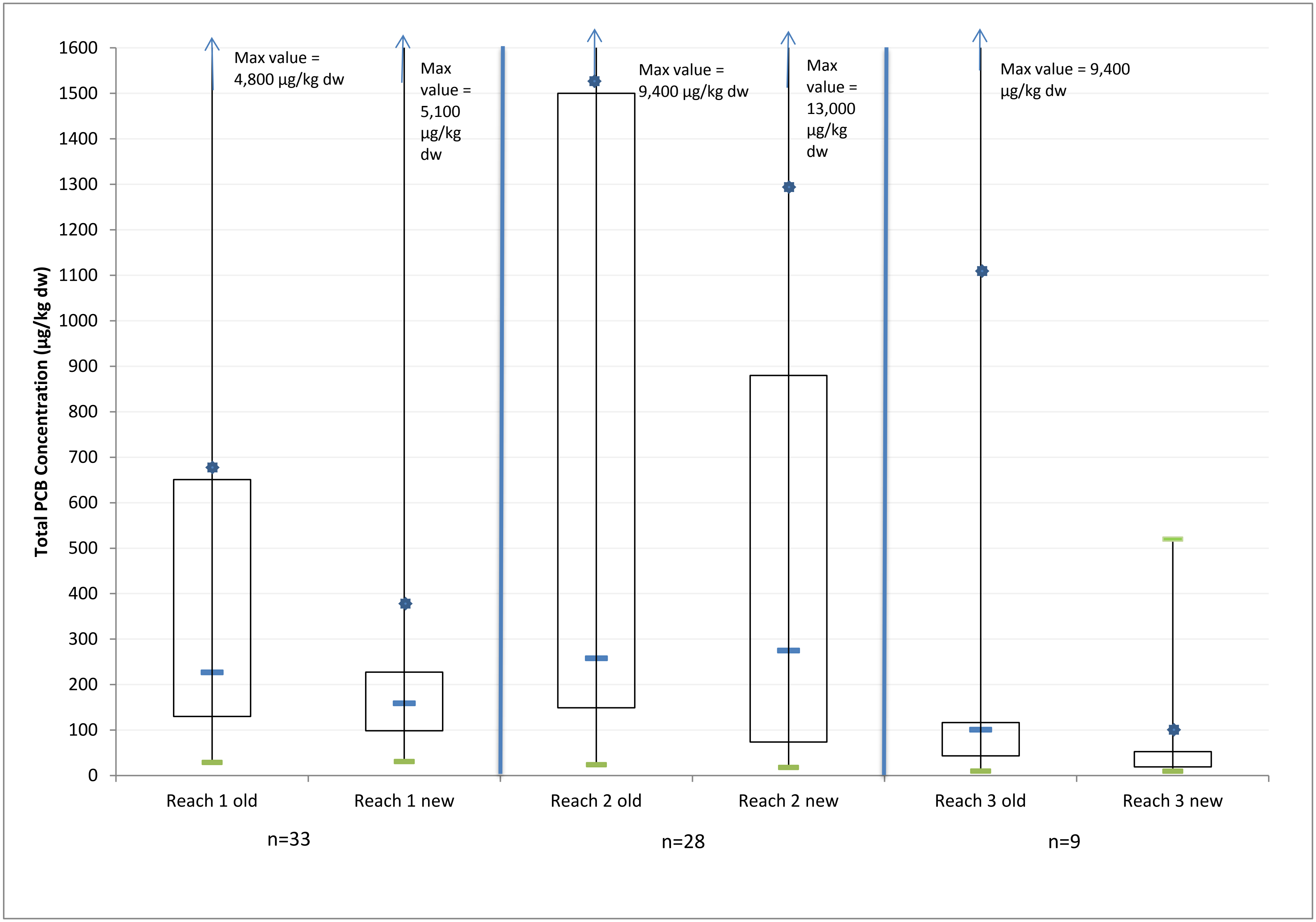
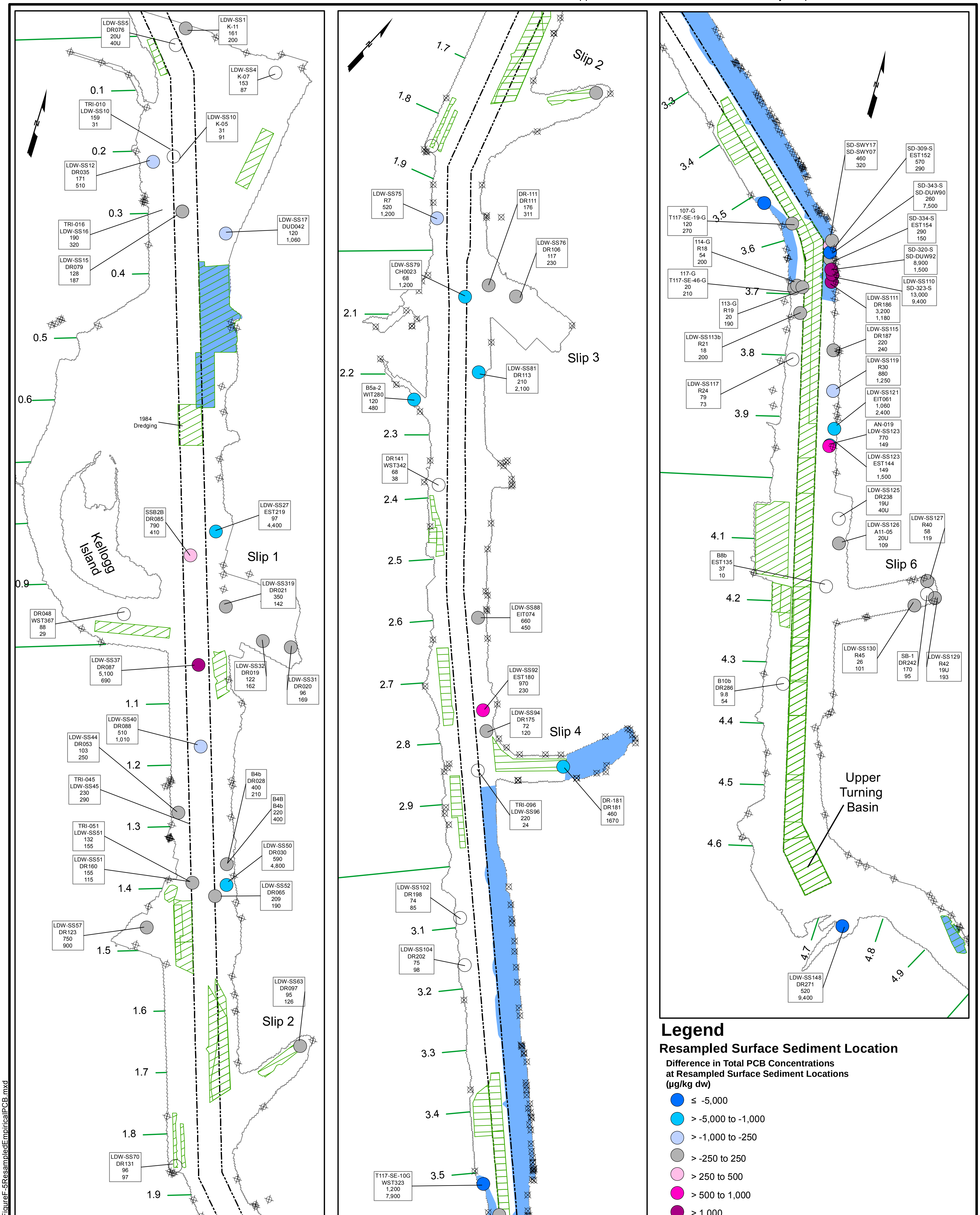


Figure F-3b Total PCB Population Statistics by Reach at Resampled Surface Sediment Locations





Notes:
1. Resampled locations are those trumped for both the RI and FS baseline datasets.
2. Locations were considered to have been resampled if the new location was within 10 ft of the old location.
3. Average time between sample collection dates for the newer and older datasets is 7 years.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

New Location ID
Old Location ID
LDW-SS104
DR202
75
98
New Total PCB Value
Old Total PCB Value

Legend

Resampled Surface Sediment Location

Difference in Total PCB Concentrations at Resampled Surface Sediment Locations (µg/kg dw)

- ≤ -5,000
- > -5,000 to -1,000
- > -1,000 to -250
- > -250 to 250
- > 250 to 500
- > 500 to 1,000
- > 1,000
- Older Data < 100 and Concentration Change < 250
- Outfall Location
- Early Action Area
- Dredging Event within Last 30 Years
- Navigation Channel
- River Mile Marker

Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

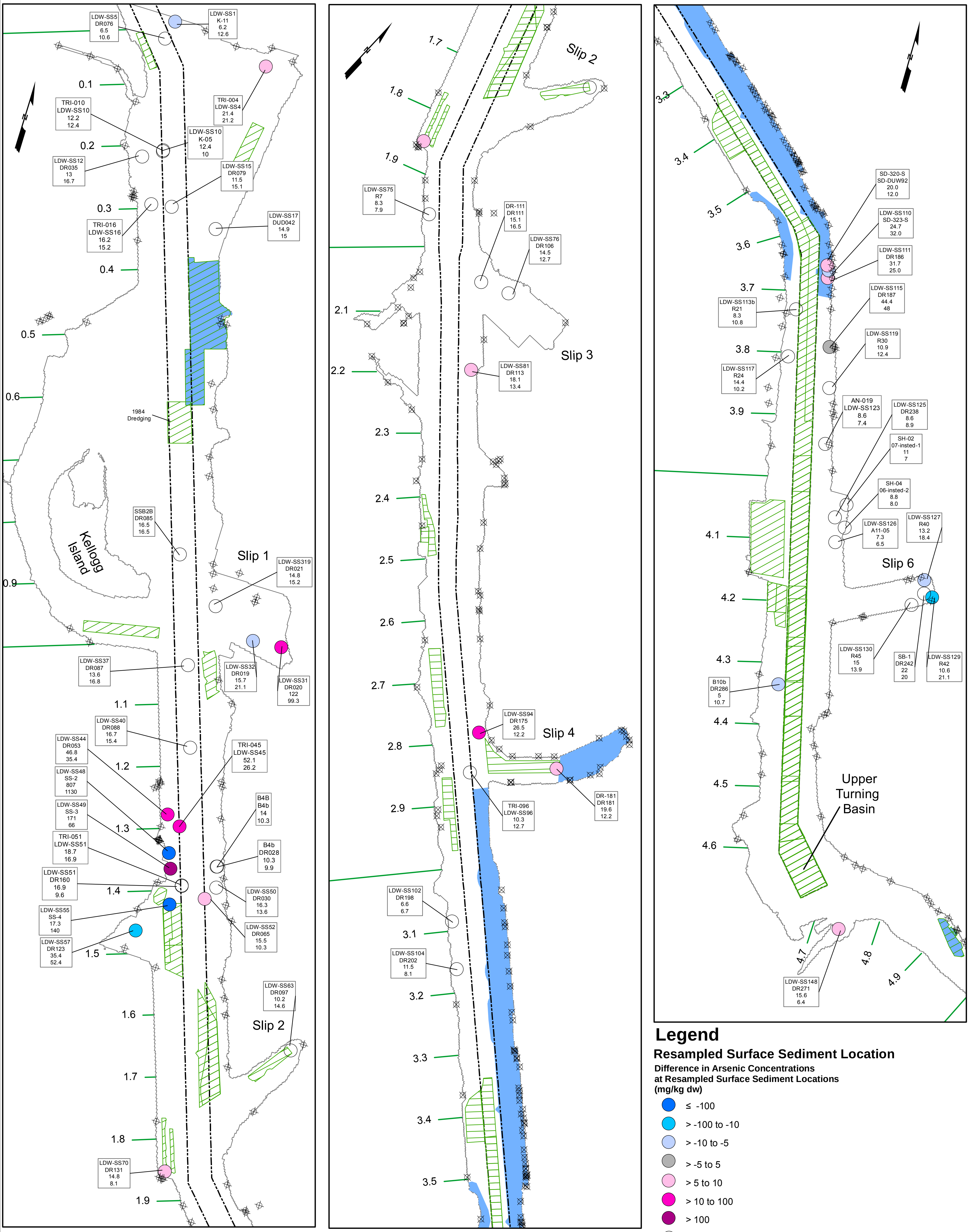
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Empirical Total PCB Trends at Resampled Surface Sediment Locations

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE F-4

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-5ResampledEmpiricalPCB.mxd



Legend

Resampled Surface Sediment Location

Difference in Arsenic Concentrations at Resampled Surface Sediment Locations (mg/kg dw)

- ≤ -100
- > -100 to -10
- > -10 to -5
- > -5 to 5
- > 5 to 10
- > 10 to 100
- > 100
- Older Data < 25 and Concentration Change < 5

Outfall Location

Early Action Area

Dredging Event within Last 30 Years

Navigation Channel

River Mile Marker

Notes:
1. Resampled locations are those trumped in both the RI and FS baseline datasets.
2. Locations were considered to have been resampled if the new location was within 10 ft of the old location.
3. Average time between sample collection dates for the newer and older datasets is 7 years.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

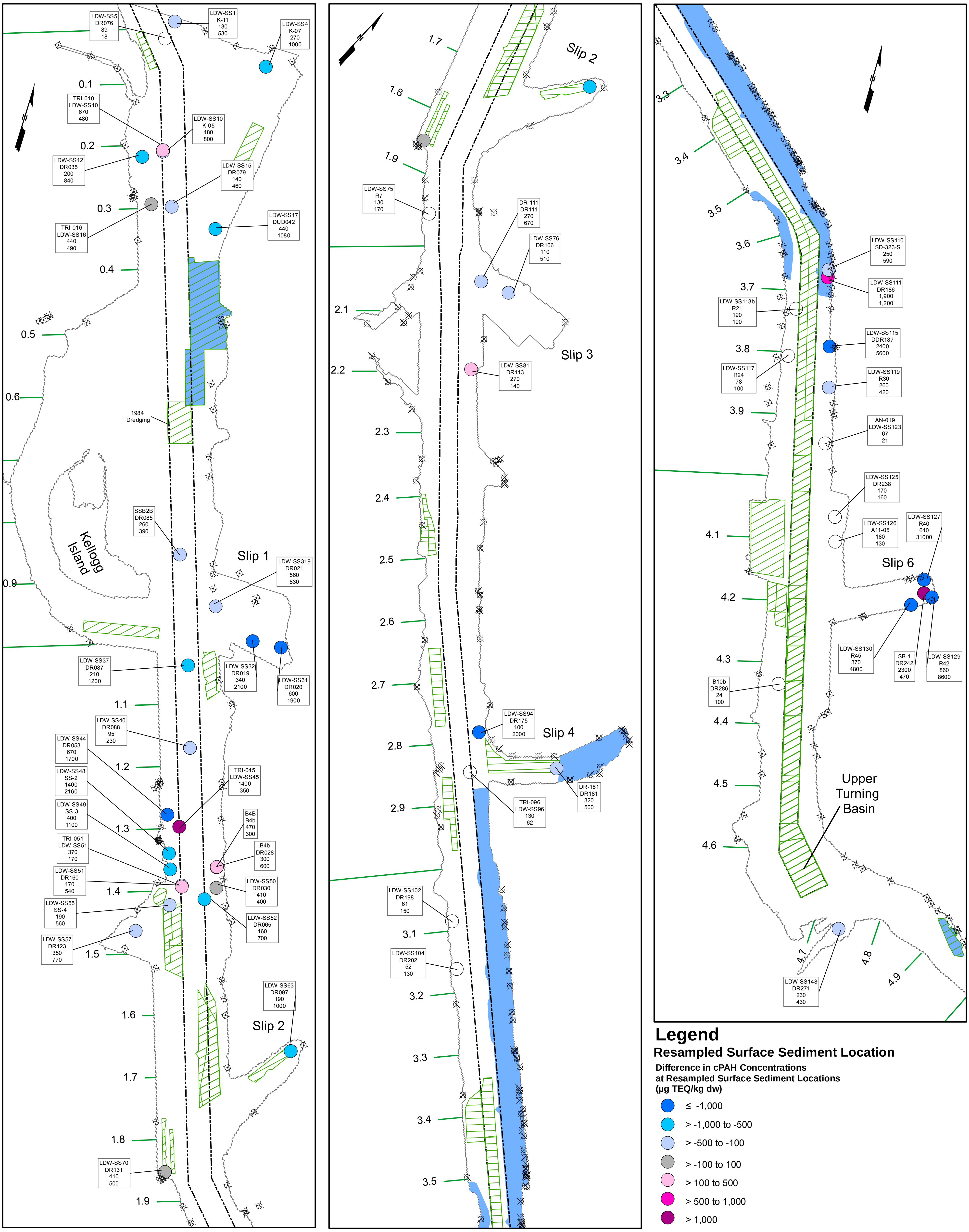
New Location ID
Old Location ID
LDW-SS104
DR202
11.5
8.1
New Arsenic Value
Old Arsenic Value

Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49	Empirical Arsenic Trends at Resampled Surface Sediment Locations
DATE: 10/31/12 · DWRN:MVI/sea · Revision: 0	FIGURE F-5



Legend

Resampled Surface Sediment Location

Difference in cPAH Concentrations at Resampled Surface Sediment Locations (µg TEQ/kg dw)

- ≤ -1,000
- > -1,000 to -500
- > -500 to -100
- > -100 to 100
- > 100 to 500
- > 500 to 1,000
- > 1,000
- Older Data < 250 and Concentration Change < 100
- Outfall Location
- Early Action Area
- Dredging Event within Last 30 Years
- Navigation Channel
- River Mile Marker

New Location ID
Old Location ID
LDW-SS104
DR202
52
130
New cPAH Value
Old cPAH Value

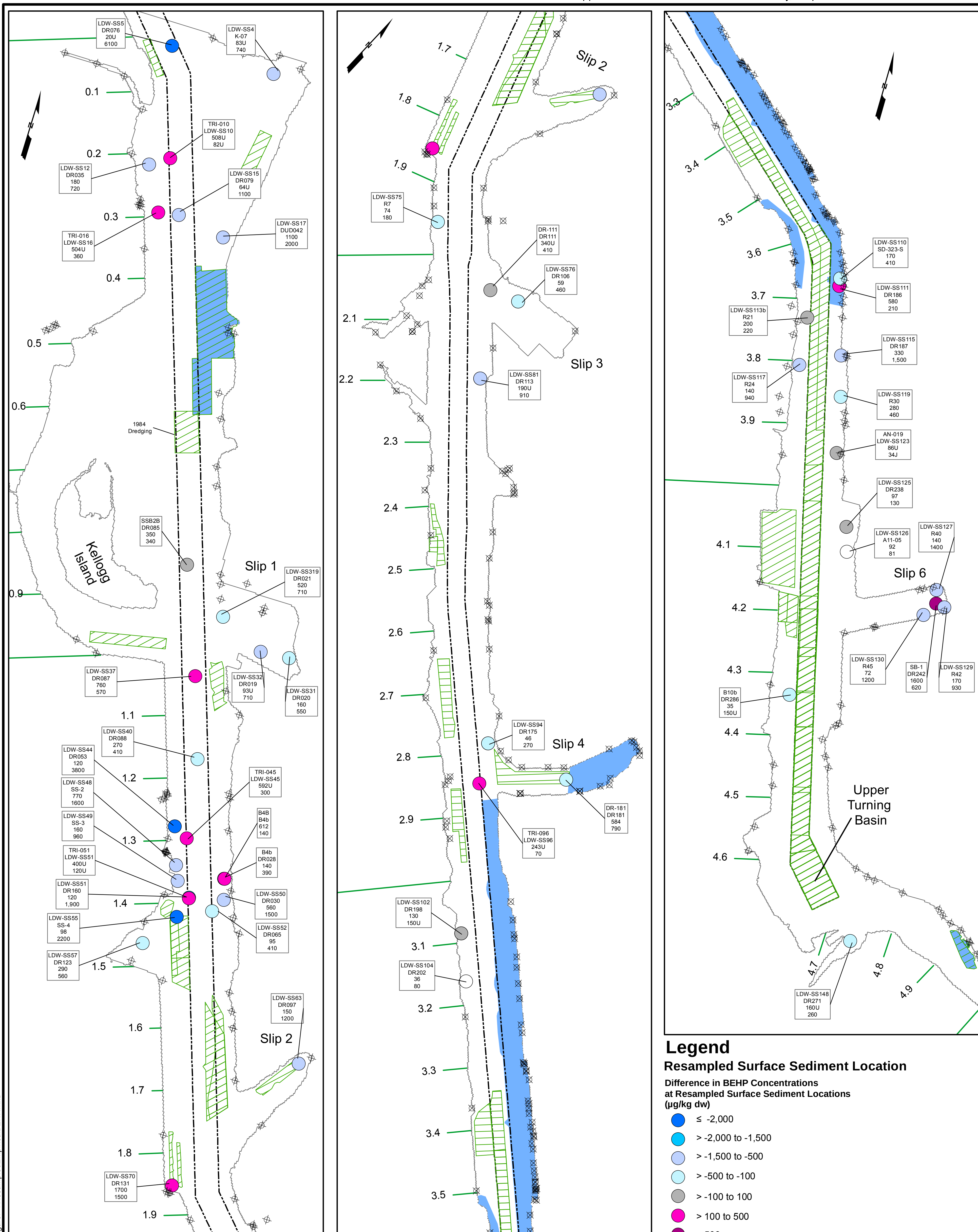
0 200 400 800 Feet

Notes:
1. Resampled locations are those trumped in both the RI and FS baseline datasets.
2. Locations were considered to have been resampled if the new location was within 10 ft of the old location.
3. Average time between sample collection dates for the newer and older database is 7 years.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-6ResampledEmpiricalcPAH.mxd

AECOM
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Empirical cPAH Trends at Resampled Surface Sediment Locations
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE F-6

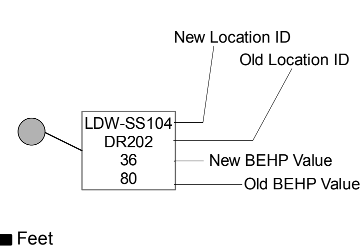


Legend

Resampled Surface Sediment Location

Difference in BEHP Concentrations at Resampled Surface Sediment Locations (µg/kg dw)

- ≤ -2,000
- > -2,000 to -1,500
- > -1,500 to -500
- > -500 to -100
- > -100 to 100
- > 100 to 500
- > 500
- Older data < 100 and Concentration Change < 100
- Outfall Location
- Early Action Area
- Dredging Event within Last 30 Years
- Navigation Channel
- River Mile Marker



Notes:
1. Resampled locations are those trumped in the RI and FS baseline datasets.
2. Locations were considered to have been resampled if the new location was within 10 ft of the old location.
3. Average time between sample collection for the newer and older datasets is 7 years.
4. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-7ResampledEmpiricalBEHP.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Empirical BEHP Trends at Resampled Surface Sediment Locations

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE F-7**

Legend

Recovery Category

- Category 1: Recovery Presumed to be Limited (77 acres)
- Category 2: Recovery Less Certain (44 acres)
- Category 3: Predicted to Recover (281 acres)
- Early Action Area (29 acres)

Resampled Surface Sediment Location

Total PCBs — Other SMS Contaminants

- Below SQS
- Data that do not Support Recovery (≥50% Concentration Increase)
- Data that Support Recovery (≥50% Concentration Decrease)
- Station in Equilibrium or Mixed Result

- Outfall Location
- River Mile Marker
- Navigation Channel

Notes:
1. Resampled locations are those trumped in both the RI and FS datasets.
2. Locations were considered to have been resampled if the new location was within 10 ft of the old location.
3. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.
4. Locations in EAAs are not shown.

Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-8RecoveryCatsEmp.mxd

AECOM

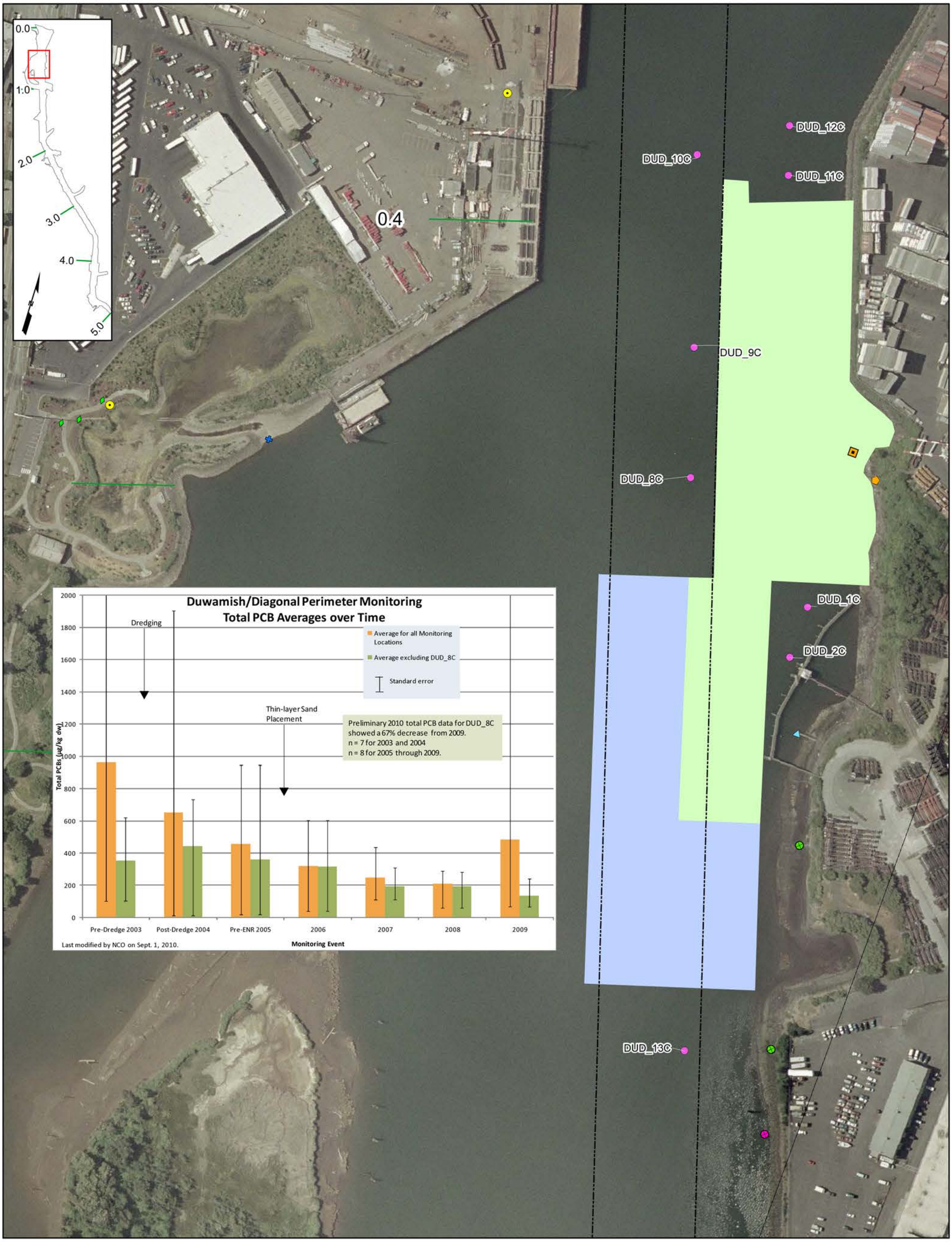
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

DATE: 10/31/12	DWRN:de/SEA	Revision: 0

Recovery Categories and Resampled Surface Sediment Locations

FIGURE F-8



Notes:
1. USGS 2002 photograph provided by Windward Environmental.
2. CSO= combined sewer overflow; EOF= emergency overflow.
3. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

Outfall Location

- Private storm drain
- Permitted private storm drain
- Public storm drain
- CSO/storm drain
- EOF
- Stream, channel, or swale
- Abandoned
- Pipe of unresolved origin and/or use

Legend

- Dredge and Cap (2003-2004)
- Thin-layer Sand Placement (2005)
- Perimeter Monitoring Location
- River Mile Marker
- Navigation Channel

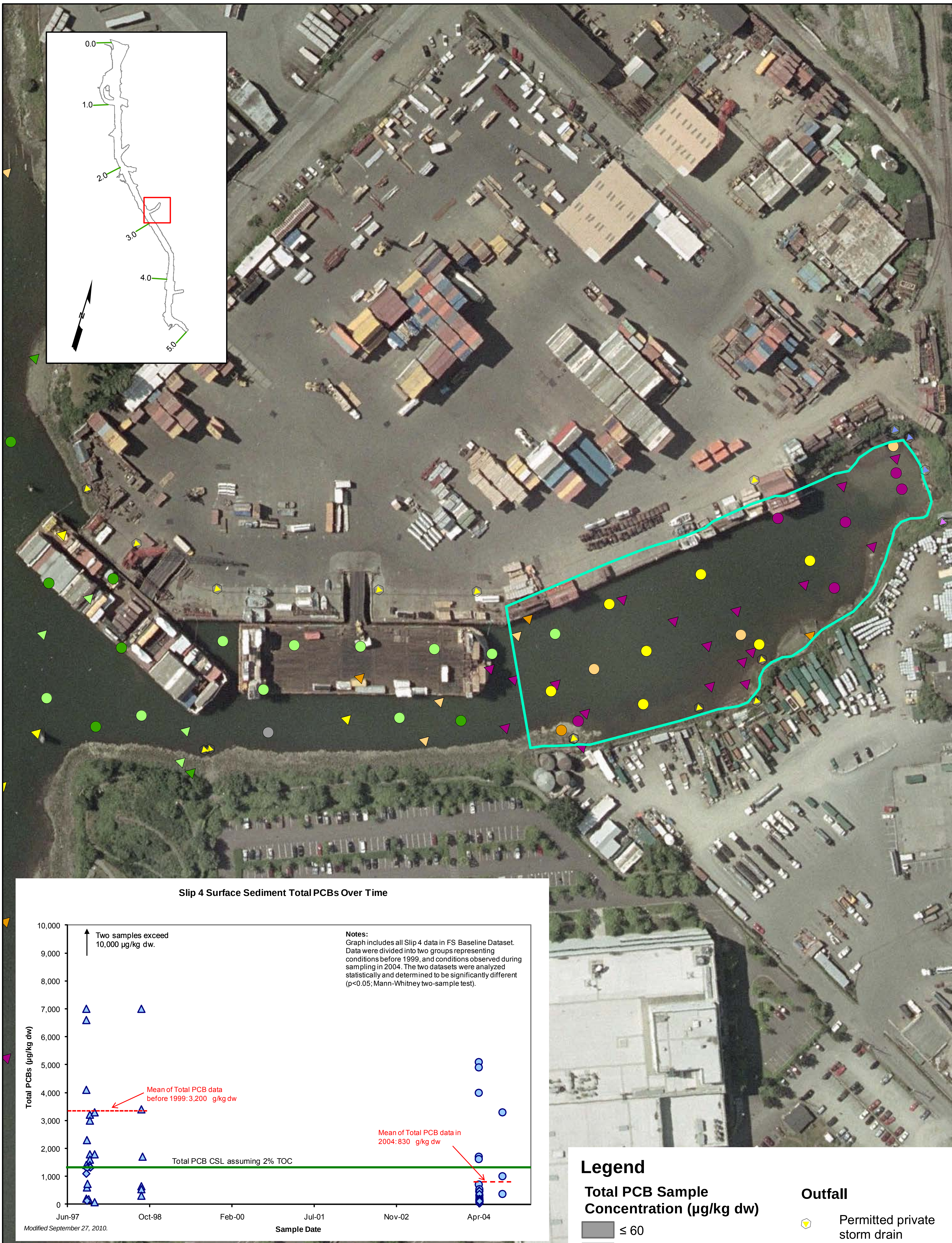
0 125 250 500 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Surface Sediment Total PCB Trends at Duwamish/Diagonal Perimeter Locations
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE F-9

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-9SurfsedDD.mxd



Legend

Total PCB Sample Concentration (µg/kg dw)

- ≤ 60
- > 60 - 120
- >120 - 240
- >240 - 480 (> SQS)
- > 480 - 720
- >720 - 1,300
- > 1,300 (> CSL)

- In 2004
- Before 1999

Outfall

- Permitted private storm drain
- Public storm drain

2011 Cleanup Action Boundary

Notes:
1. USGS 2002 photograph provided by Windward Environmental.
2. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.
3. SQS value of 240 µg/kg dw based on conversion of 12 mg/kg oc to a dry weight value using 2% TOC.

N

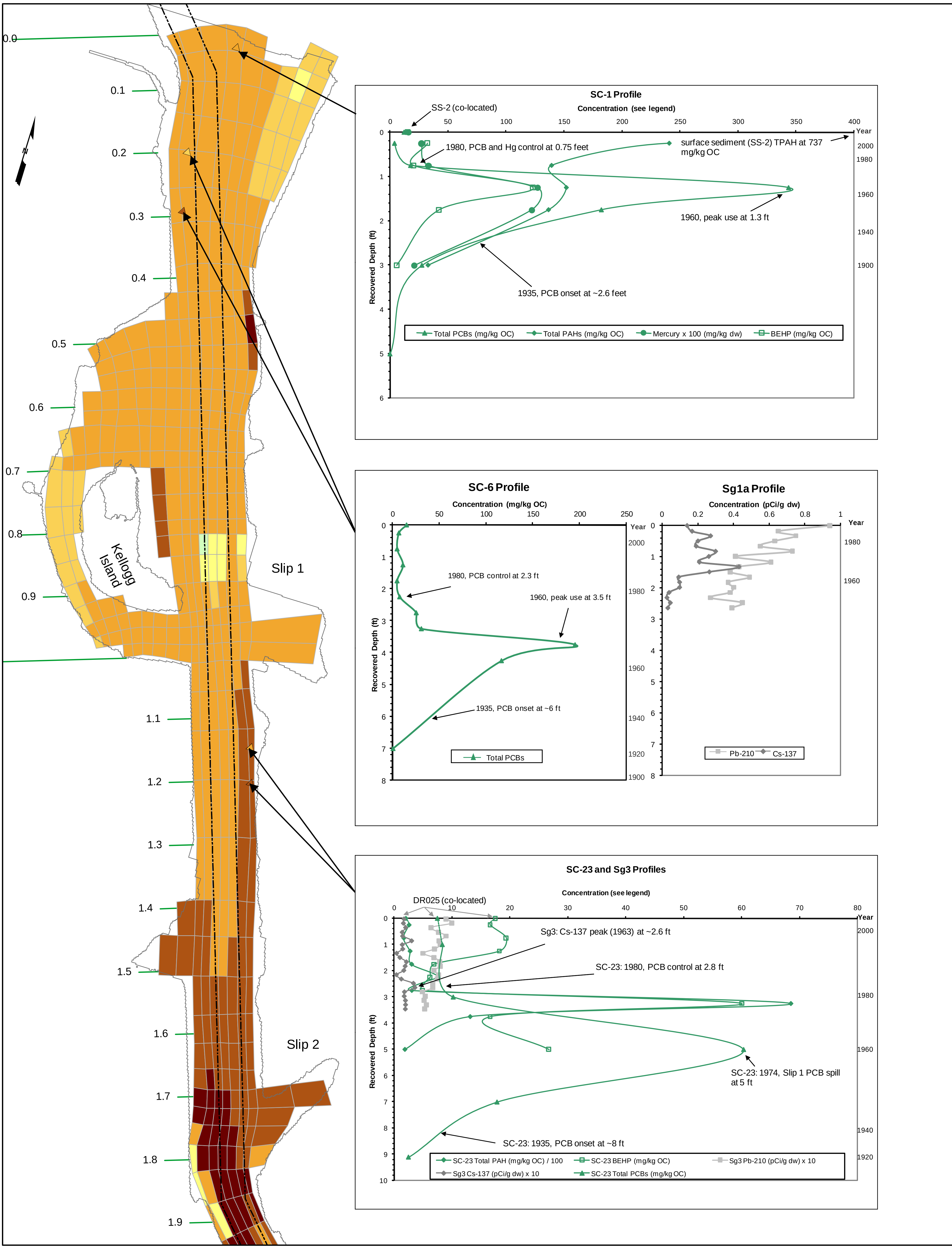
Feet
0 50 100 200

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-xSlip4EAA.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Surface Sediment Total PCB Trends in Slip 4
DATE: 10/31/12	DWRN:MVI/sea	Revision: 1	FIGURE F-10



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Empirical net sedimentation rates estimated using multiple time markers in cores.
The example profiles shown on this map were used to identify the chemical markers.
Physical markers (changes in lithology) were also used to estimate net sedimentation rates.

Legend

- Navigation Channel
- River Mile Marker

Estimated Annual Net Sedimentation Rate (cm/yr)

- Net Erosion
- 0 - 0.5
- > 0.5 - 1.0
- > 1.0 - 2.0
- > 2.0 - 3.0
- > 3.0

Rate Estimated from:

- 2006 RI or Radioisotope Core
- STM Grid Cell

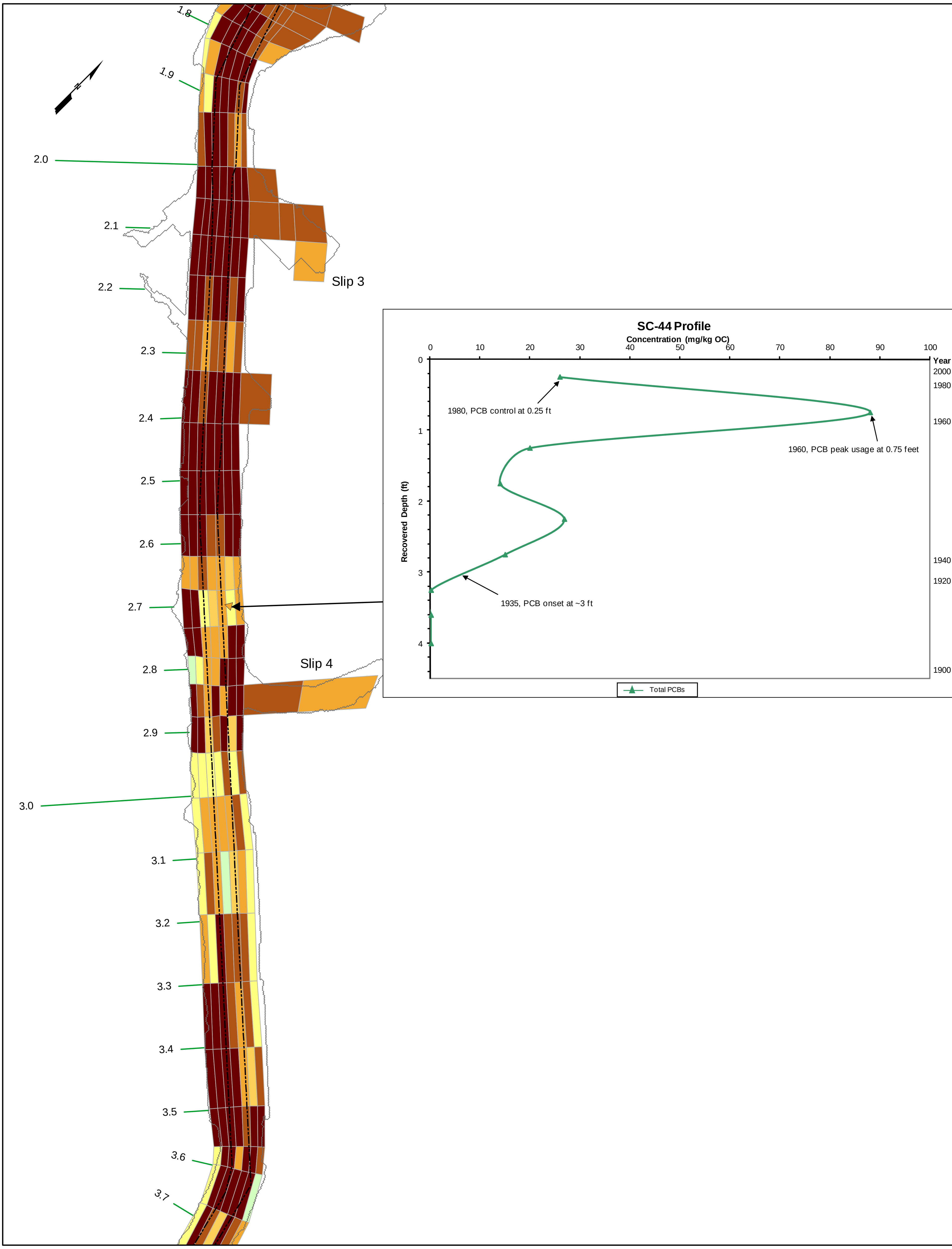
Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Example Core Profiles Used as Empirical Data (RM 0.0 to 1.9)
DATE: 10/31/12	DWRN: MVI/sea	Revision: 1	FIGURE F-11a

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-11aSedratePCB_RadioReach1.mxd



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Empirical net sedimentation rates estimated using multiple time markers in cores.
   The example profiles shown on this map were used to identify the chemical markers.
   Physical markers (changes in lithology) were also used to estimate net sedimentation rates.

Legend

Navigation Channel

River Mile Marker

Estimated Annual Net Sedimentation Rate (cm/yr)

- Net Erosion
- 0 - 0.5
- > 0.5 - 1.0
- > 1.0 - 2.0
- > 2.0 - 3.0
- > 3.0

Rate Estimated from:

- 2006 RI Core
- STM Grid Cell

Feet
0 200 400 800

AECOM

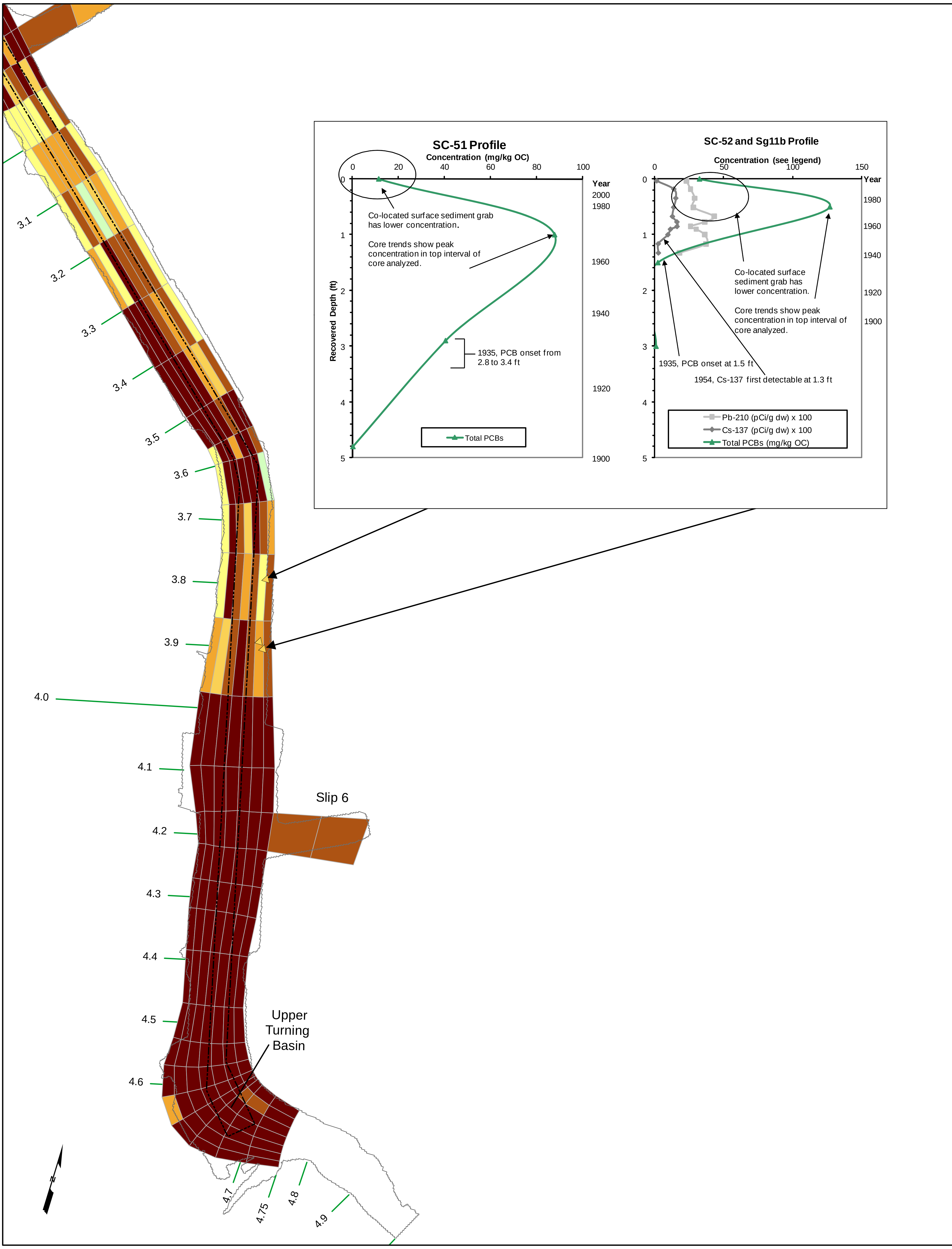
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Example Core Profiles Used as Empirical Data (RM 1.9 to 3.6)

DATE: 10/31/12	DWRN: MVI/sea	Revision: 1		**FIGURE F-11b**

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-11bSedratePCB_RadioReach2.mxd



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Empirical net sedimentation rates estimated using multiple time markers in cores.
The example profiles shown on this map were used to identify the chemical markers.
Physical markers (changes in lithology) were also used to estimate net sedimentation rates.

Legend

- Navigation Channel
- River Mile Marker

Estimated Annual Net Sedimentation Rate (cm/yr)

- Net Erosion
- 0 - 0.5
- > 0.5 - 1.0
- > 1.0 - 2.0
- > 2.0 - 3.0
- > 3.0

Rate Estimated from:

- 2006 RI or Radioisotope Core
- STM Grid Cell

Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-11cSedratePCB_RadioReach3.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

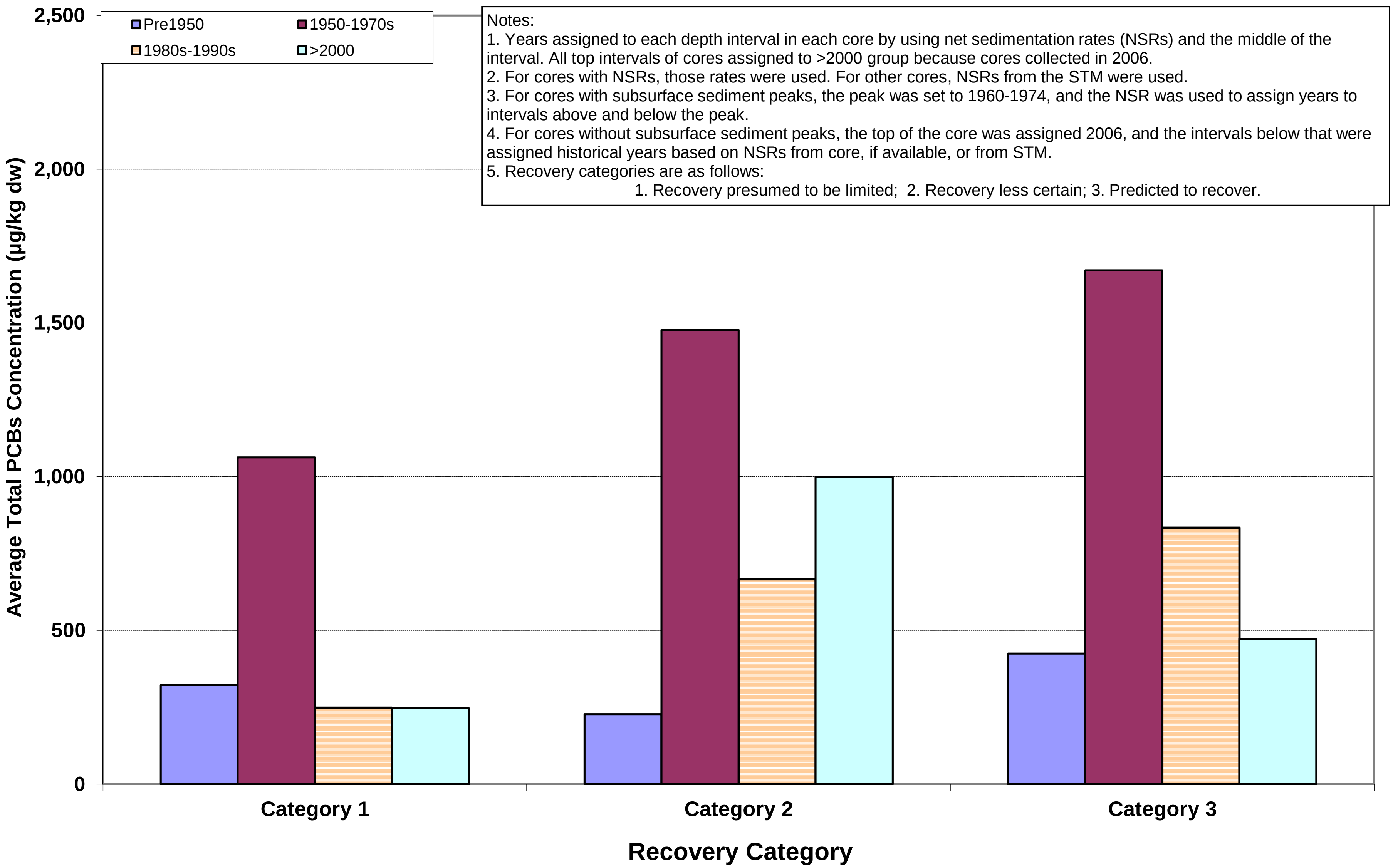
Lower Duwamish Waterway
Final Feasibiltiy Study
60150279-14.49

Example Core Profiles Used as Empirical Data (RM 3.6 to 5.0)

DATE: 10/31/12 | DWRN: MVI/sea | Revision: 1

FIGURE F-11c

Figure F-12 Average Total PCB Concentrations by Decade (using core depths) and by Recovery Category



Legend

Recovery Category

- Category 1: Recovery Presumed to be Limited (77 acres)
- Category 2: Recovery Less Certain (44 acres)
- Category 3: Predicted to Recover (281 acres)
- Early Action Area (29 acres)

Trends in Top Two Invervals of Cores

Total PCBs — Other SMS Contaminants

- Below SQS
- Data that do not Support Recovery (≥50% Concentration Increase)
- Data that Support Recovery (≥50% Concentration Decrease)
- Station in Equilibrium or Mixed Result

Outfall Location
River Mile Marker
Navigation Channel

0 200 400 800 Feet

Notes:
1. If a core symbol does not appear, the core did not have samples at the appropriate intervals to evaluate trends for either total PCBs or other SMS contaminants. For example, there is no total PCB symbol for SC23 because PCBs were only analyzed in the 2-ft samples. Other SMS contaminants were analyzed at finer depth intervals.
2. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.
3. Core locations were included if the following criteria were met: a) proper vertical resolution, and b) one or more contaminants were analyzed or suites of contaminants were analyzed, and c) the sample was not a composite sample. Surrounding data were also considered. The following core locations were not added to the map: DUD206, S12, SB-2, SB-6, SB-7, SB-11, SB-13, SB-17, SC08, SC09, SC10, SH-01, SH-02, SH-04, SH-05, SH-07, SH-08, T117-SE-91-SC, T117-SE-93-SC, and T117-SE-COMP4-SC.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

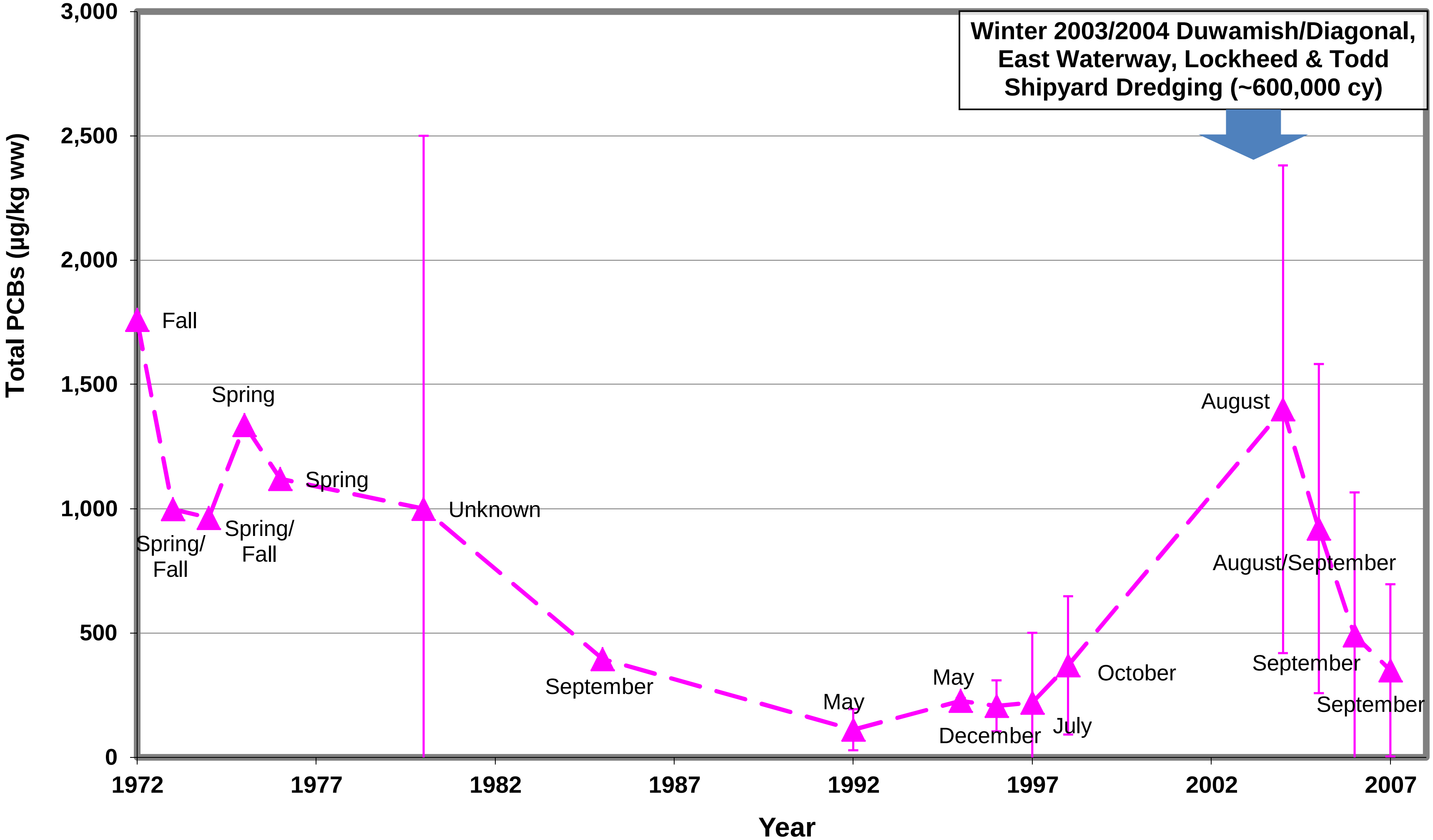
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Recovery Categories and Trends in Top Two Invervals of Cores

DATE: 10/31/12 | DWRN:mvi/SEA | Revision: 3 | FIGURE F-13

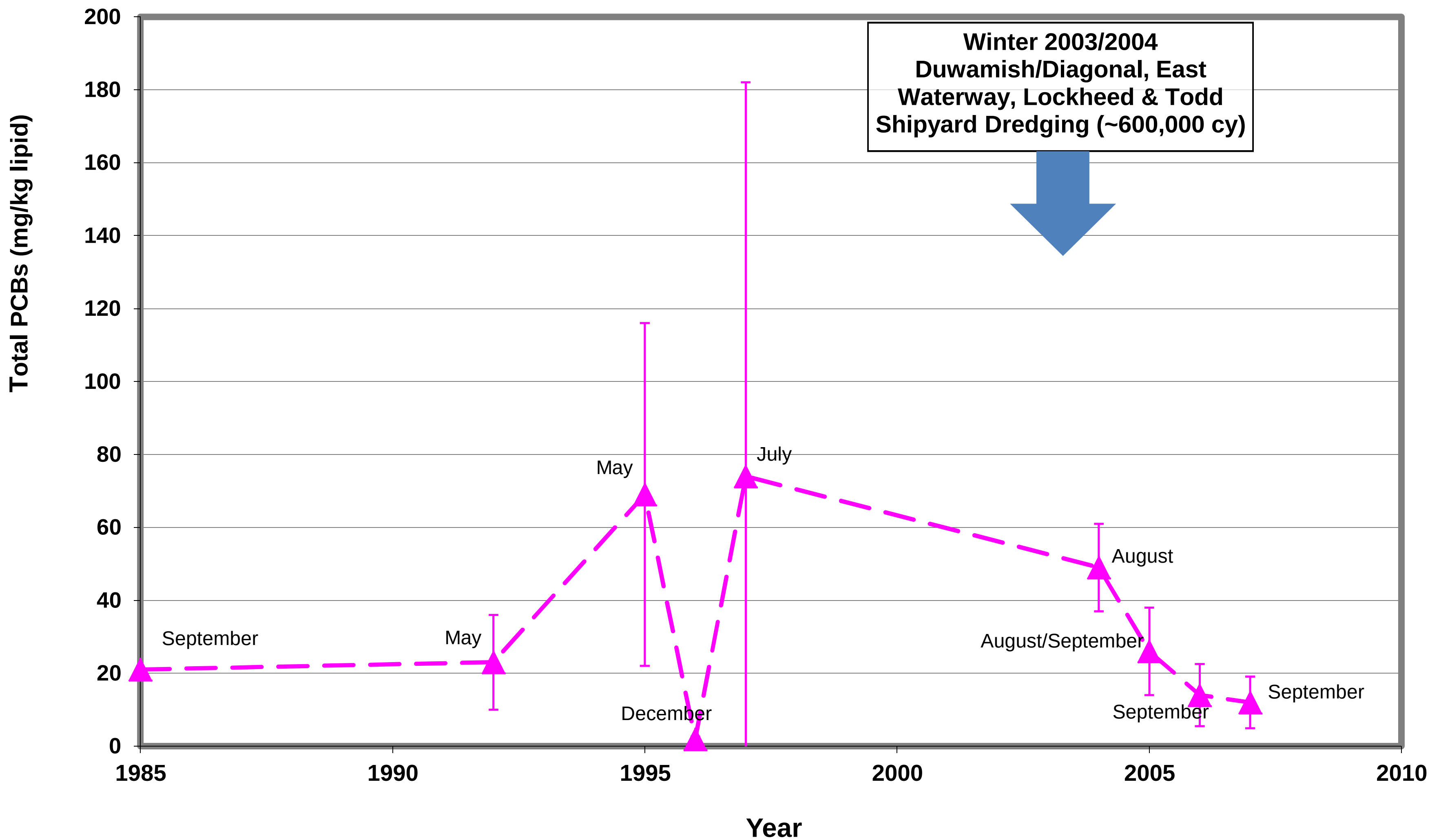
L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-13RecoveryCatsEmpCores.mxd

Figure F-14 Trends in Total PCB Concentrations in English Sole Fillets in the LDW

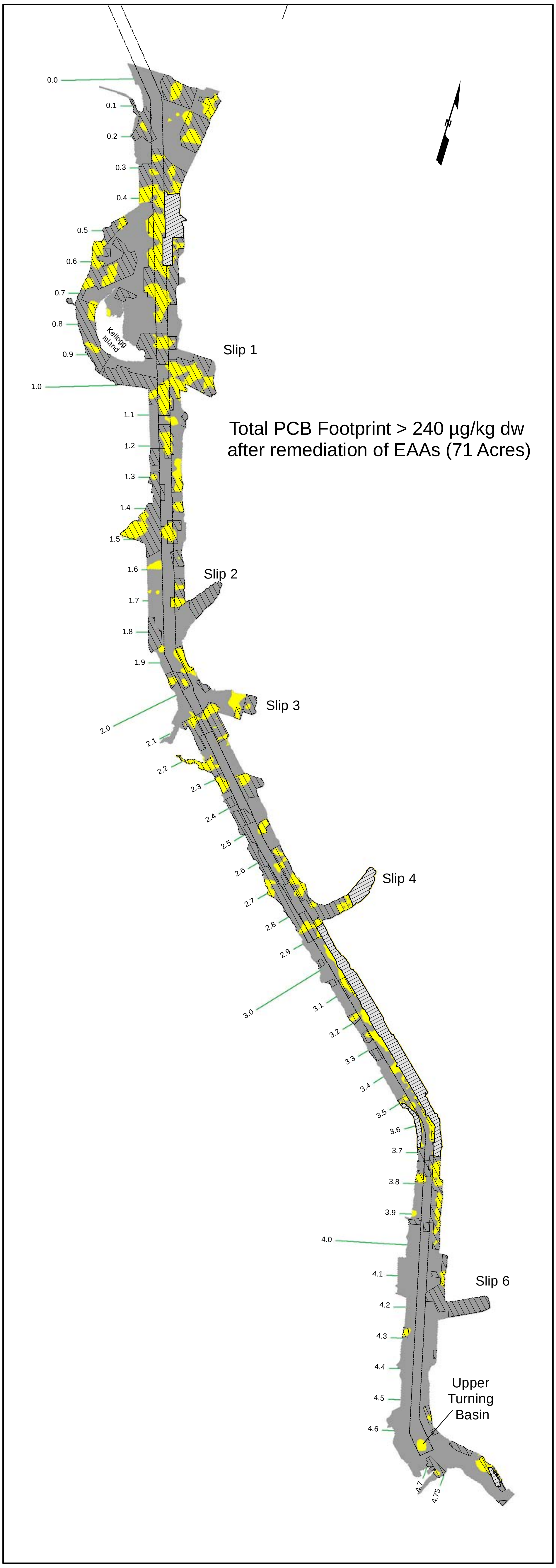


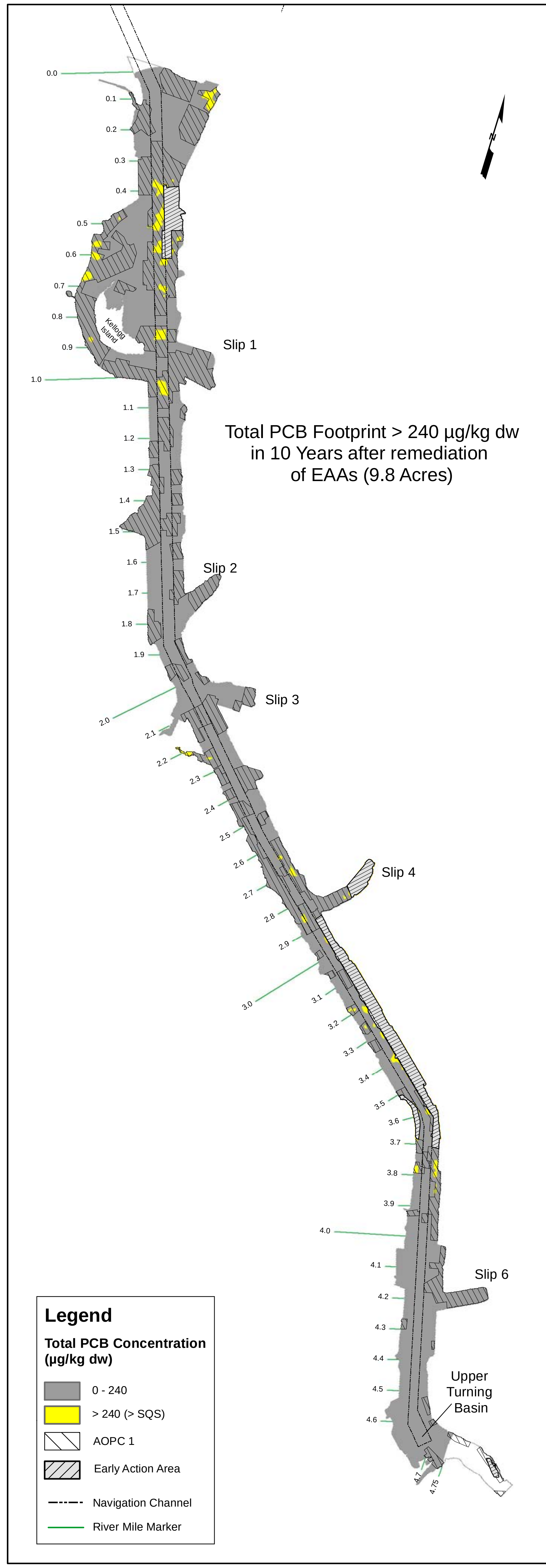
Notes: 1. Months/seasons listed represent sample collection. Samples collected in December 1995 are graphed as 1996.
2. Triangles represent average values. Error bars represent two standard deviations from the mean. Standard deviation could not be calculated for the 1970s and 1985 data.
3. The 1980 average concentration represents combined Duwamish River and Elliott Bay data.

Figure F-15 Trends in Lipid-Normalized Total PCB Concentrations in English Sole Fillets in the LDW



Notes: 1. Months/seasons listed represent sample collection. Samples collected in December 1995 are graphed as 1996.
2. Triangles represent average values. Error bars represent two standard deviations from the mean. No standard deviation could be calculated for 1985 data.





Notes:
1. Ten-year run from STM base-case run (QEA Feb. 2009) using recommended upstream and lateral input parameters.
2. SQS value of 240 µg/kg dw based on conversion of 12 mg/kg oc to a dry weight value using 2% TOC.
3. A concentration of 240 µg/kg dw is displayed because it is the threshold for delineating Area of Potential Concern 1 (AOPC 1), and is one of the remedial action levels considered in this FS.
4. Surface sediment concentrations at year 10 were predicted using the BCM with best estimate inputs and starting sediment concentrations at year 0 (post-EAAs), then allowing natural recovery to occur for 10 years with no further active remediation.

Feet
0 625 1,250 2,500

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF_16T0vsT10PCBs.mxd

AECOM

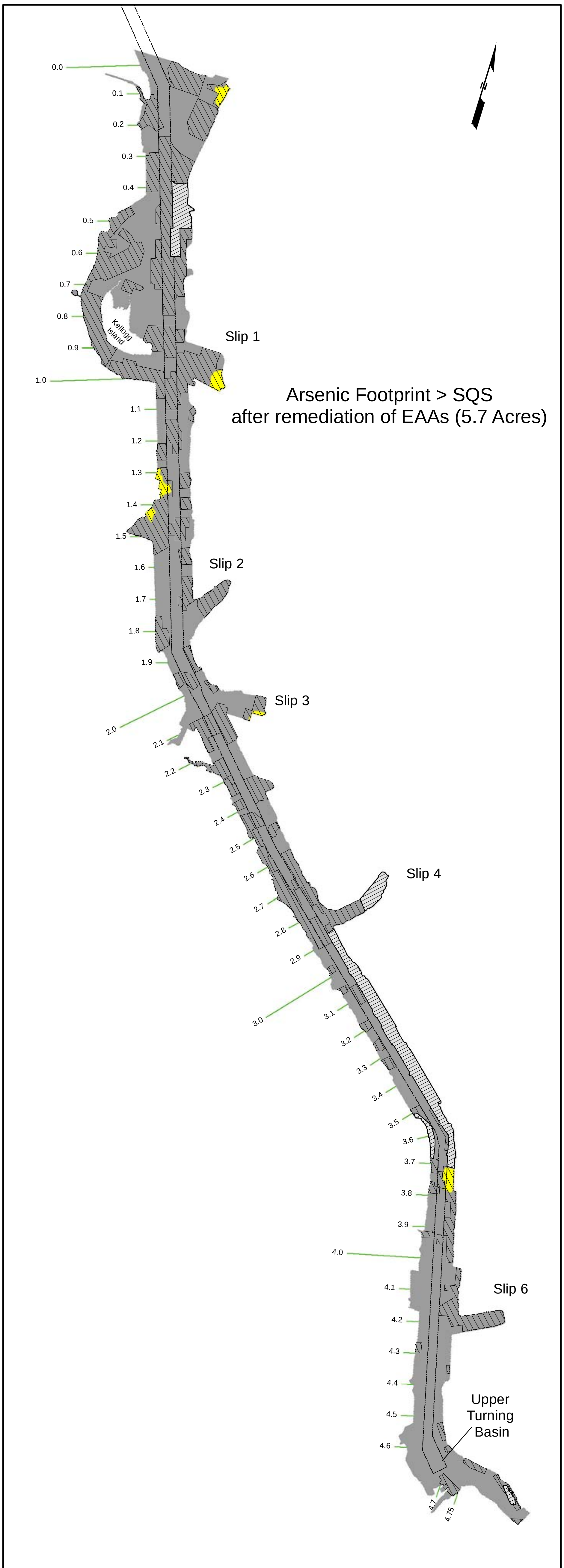
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

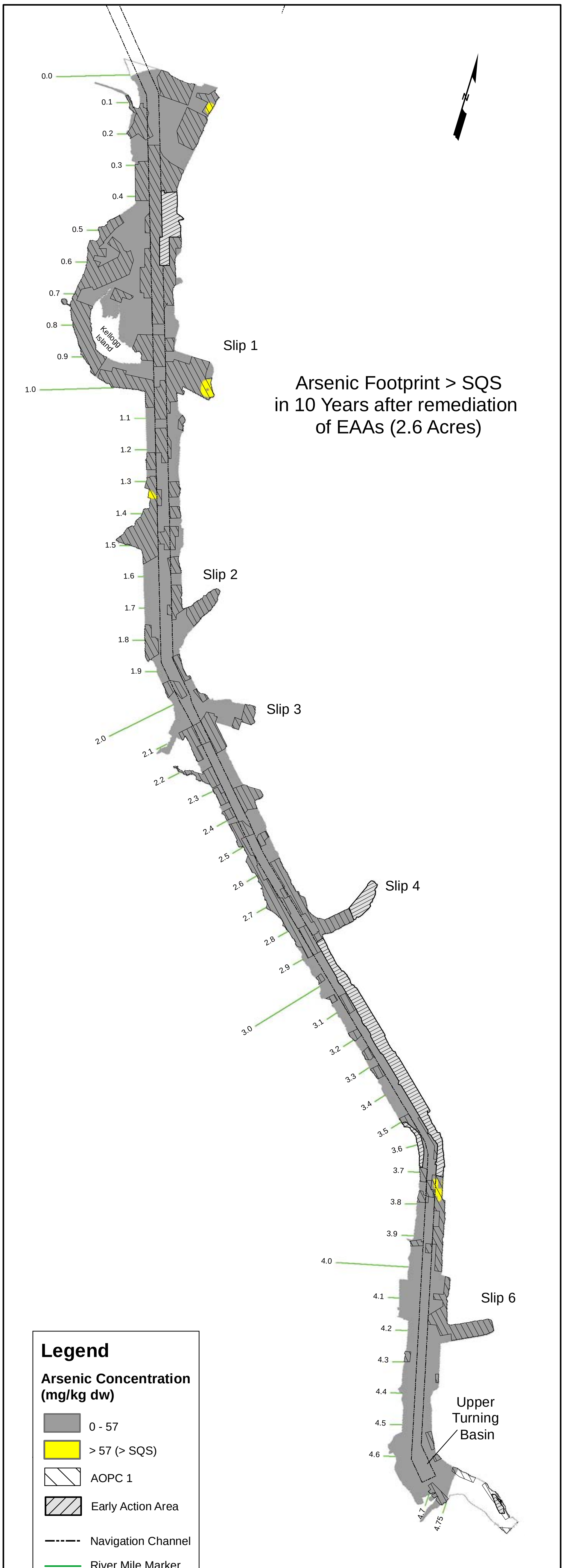
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

DATE: 10/31/12 | DWRN: MVI/sea | Revision: 0

Predicted Reduction in Footprint of Total PCBs > 240 µg/kg dw in 10 Years

FIGURE F-16





Notes:
1. Ten-year run from STM base-case run (QEA Feb. 2009) using recommended upstream and lateral input parameters.
2. A concentration of 57 mg/kg dw is displayed because it is the threshold for delineating Area of Potential Concern 1 (AOPC 1), and is one of the remedial action levels considered in this FS.
3. Surface sediment concentrations at year 10 were predicted using the BCM with best estimate inputs and starting sediment concentrations at year 0 (post-EAAs), then allowing natural recovery to occur for 10 years with no further active remediation.

0 900 1,800 3,600 Feet

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF_17T0vsT10As.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Predicted Reduction in Footprint of Arsenic > SQS in 10 Years
DATE: 10/31/12	DWRN: MVI/sea	Revision: 0	FIGURE F-17

Notes:
1. Ten-year run from STM base-case run (QEA Feb. 2009) using recommended upstream and lateral input parameters.
2. A concentration of 1,000 µg TEQ/kg dw is displayed because it is the threshold for delineating Area of Potential Concern 1 (AOPC 1), and is one of the remedial action levels considered in this FS.
3. Surface sediment concentrations at year 10 were predicted using the BCM with best estimate inputs and starting sediment concentrations at year 0 (post-EAAs), then allowing natural recovery to occur for 10 years with no further active remediation.

Feet
0 650 1,300 2,600

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF_18T0vsT10cPAH.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

DATE: 10/31/12 | DWRN: MVI/sea | Revision: 0

Predicted Reduction in Footprint of cPAHs > 1,000 µg TEQ/kg dw in 10 Years

FIGURE F-18

Notes:
1. Ten-year run from STM base-case run (QEA Feb. 2009) using recommended upstream and lateral input parameters.
2. A concentration of 25 ng TEQ/kg dw is displayed because it is the threshold for delineating Area of Potential Concern 1 (AOPC 1), and is one of the remedial action levels considered in this FS.
3. Surface sediment concentrations at year 10 were predicted using the BCM with best estimate inputs and starting sediment concentrations at year 0 (post-EAAs), then allowing natural recovery to occur for 10 years with no further active remediation.

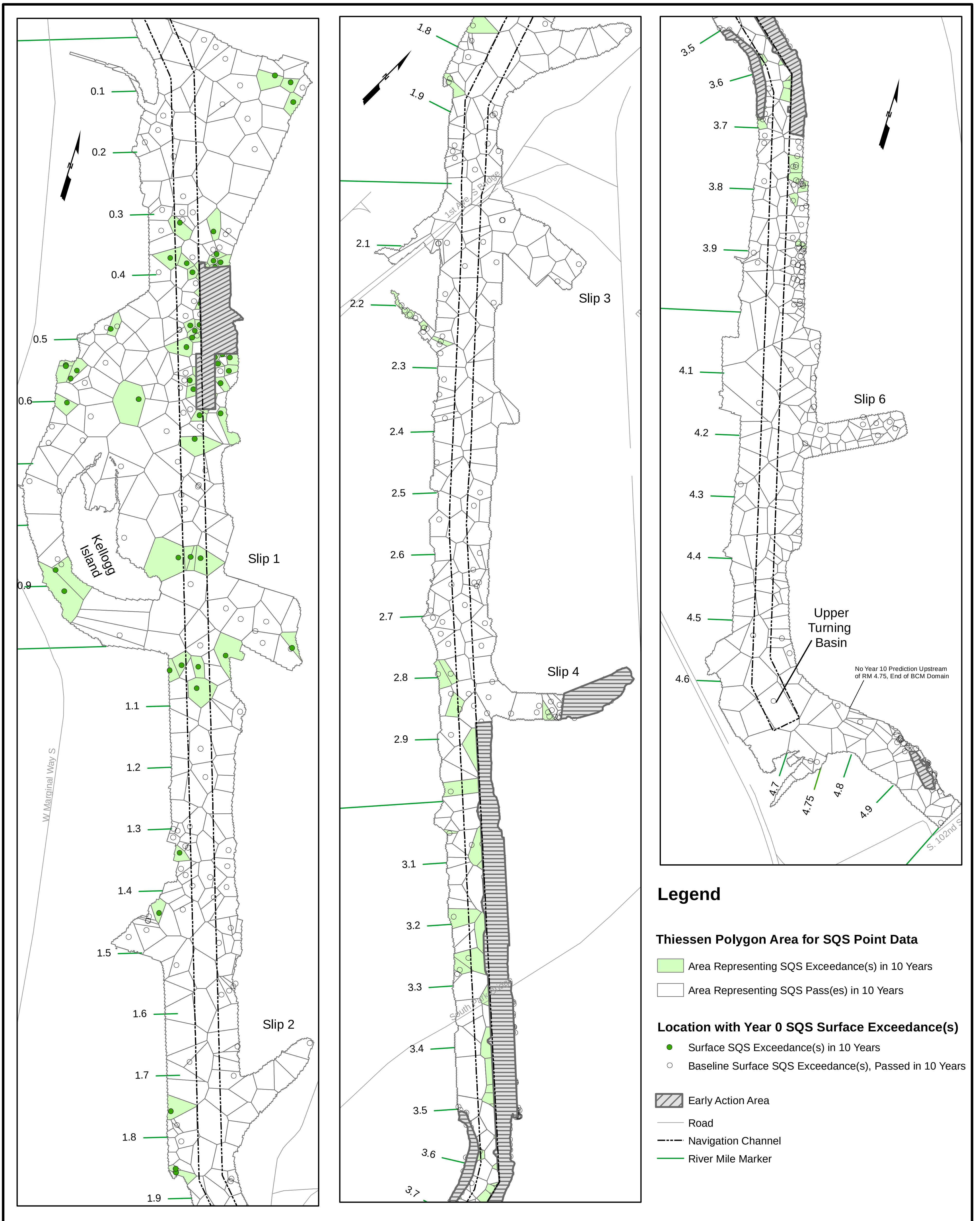
Feet
0 700 1,400 2,800

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF_19T0vsT10PCBs.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Predicted Reduction in Footprint of Dioxin/Furan > 25 ng TEQ/kg dw in 10 Years
DATE: 10/31/12	DWRN: MVI/sea	Revision: 0	FIGURE F-19



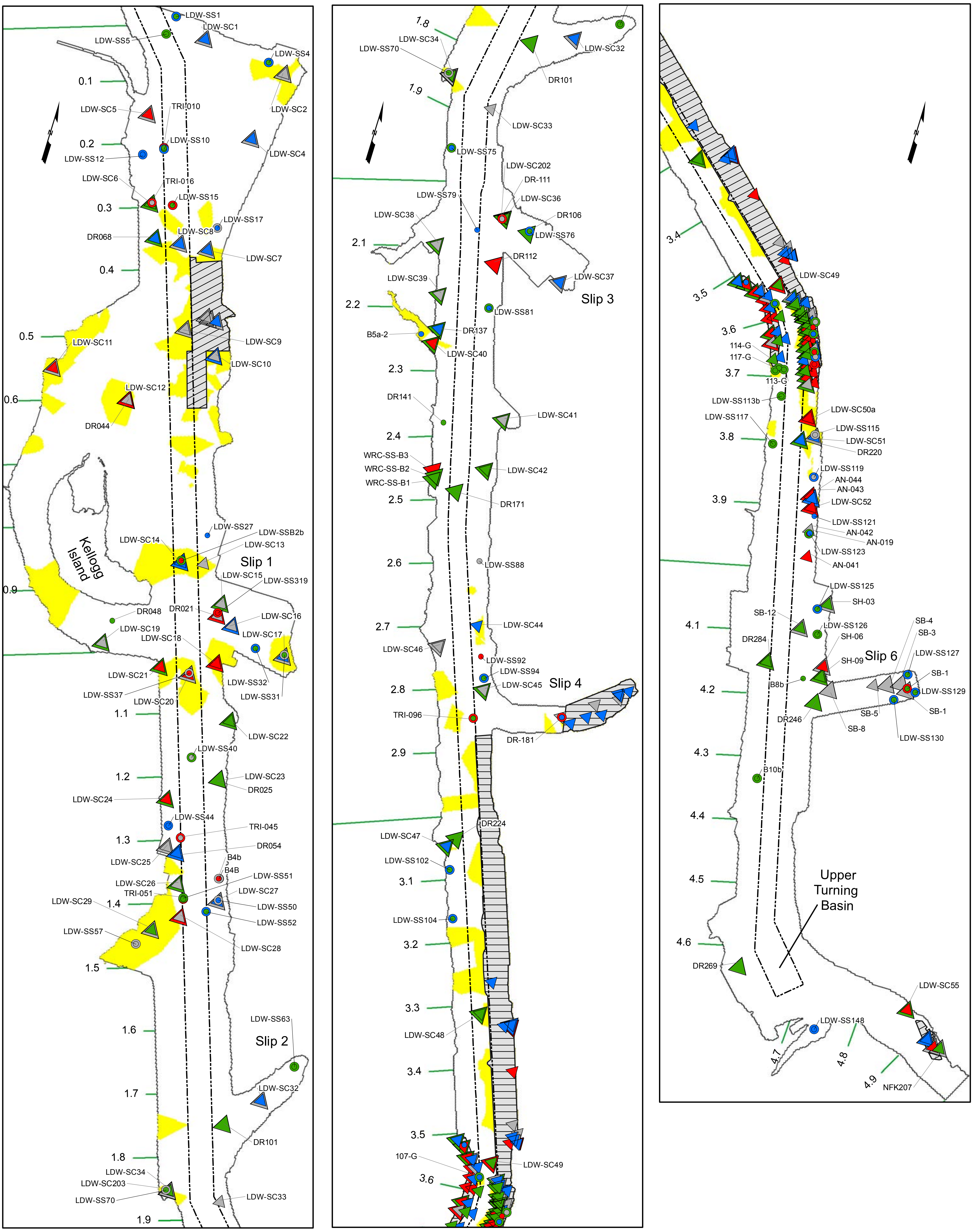
Notes:
1. Baseline exceedances are for any detected SMS contaminant.
2. Exceedances in 10 years were calculated by using representative chemicals described in Section 5.
3. Baseline locations with sediment toxicity test passes are not considered SQS exceedances.
4. Ten-year run from STM base-case run (QEA Feb. 2009).
5. Surface sediment concentrations at year 10 were predicted using the BCM with best estimate inputs and starting sediment concentrations at year 0 (post-EAAs), then allowing natural recovery to occur for 10 years with no further active remediation.

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\FigureF-20T10SQSExceed.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Predicted SQS Exceedances After 10 Years
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE F-20



Notes:
1. Exceedance defined as total PCBs, arsenic, or any SMS contaminants above SQS, or cPAHs or dioxins/furans above 1,000 µg TEQ/kg dw or 25 ng TEQ/kg dw, respectively.
2. BCM predictions for the 10-year run use recommended inputs, base case BCM run (QEA Feb. 2009).
3. SQS value of 240 µg/kg dw for total PCBs based on conversion of 12 mg/kg oc to a dry weight value using 2% TOC.
4. If a core symbol does not appear, the core did not have samples at the appropriate intervals to evaluate trends for either total PCBs or other SMS contaminants. For example, there is no total PCB symbol for LDW-SC23 because PCBs were only analyzed in the 2-ft samples. Other SMS contaminants were analyzed at finer depth intervals.

Legend

Natural Recovery Empirical Data

Resampled Surface Sediment Location Total PCBs — Resampled Surface Sediment Location Other SMS Contaminants

Top Two Intervals in Cores Total PCBs — Top Two Intervals in Cores Other SMS Contaminants

- Below SQS
- Data that do not Support Recovery (≥ 50% Concentration Increase)
- Data that do Support Recovery (≥ 50% Concentration Decrease)
- Station in Equilibrium or Mixed Result

Exceedance Predicted by BCM in 10 Years

- Total PCBs, Arsenic, or cPAHs by Interpolation (IDW) or Dioxins/Furans or SMS Contaminants by Thiessen Polygon
- Early Action Area
- Navigation Channel
- River Mile Marker

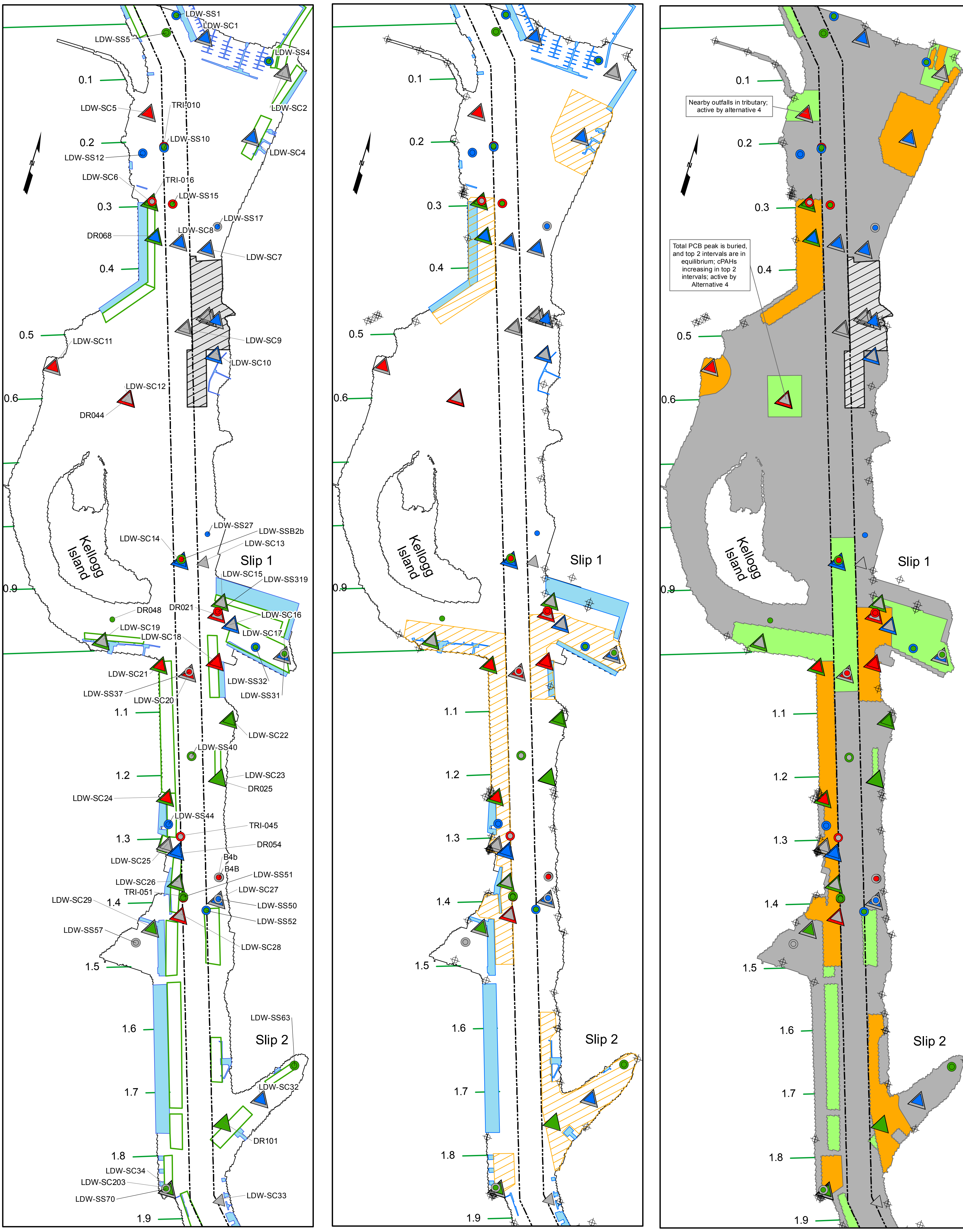
Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\F-21T10RecoveryEmp.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49			Comparison of BCM Predictions of Year 10 Exceedances and Empirical Trends
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE F-21



Notes:

1. If a core symbol does not appear, the core did not have samples at the appropriate intervals to evaluate trends for either total PCBs or other SMS contaminants. For example, there is no total PCB symbol for SC23 because PCBs were only analyzed in the 2-ft samples. Other SMS contaminants were analyzed at finer depth intervals.
2. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

Legend

Natural Recovery Empirical Data

- Resampled Surface Sediment Location Total PCBs / Resampled Surface Sediment Location Other SMS Contaminants
- Top Two Intervals in Cores Total PCBs / Top Two Intervals in Cores Other SMS Contaminants
- Below SQS
- Data that do not Support Recovery (≥ 50% Concentration Increase)
- Data that do Support Recovery (≥ 50% Concentration Decrease)
- Station in Equilibrium or Mixed Result

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour ≥ 10 cm
- Evidence of Propeller Wash Scour
- Berthing Area
- Overwater Structure

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker
- Outfall Location

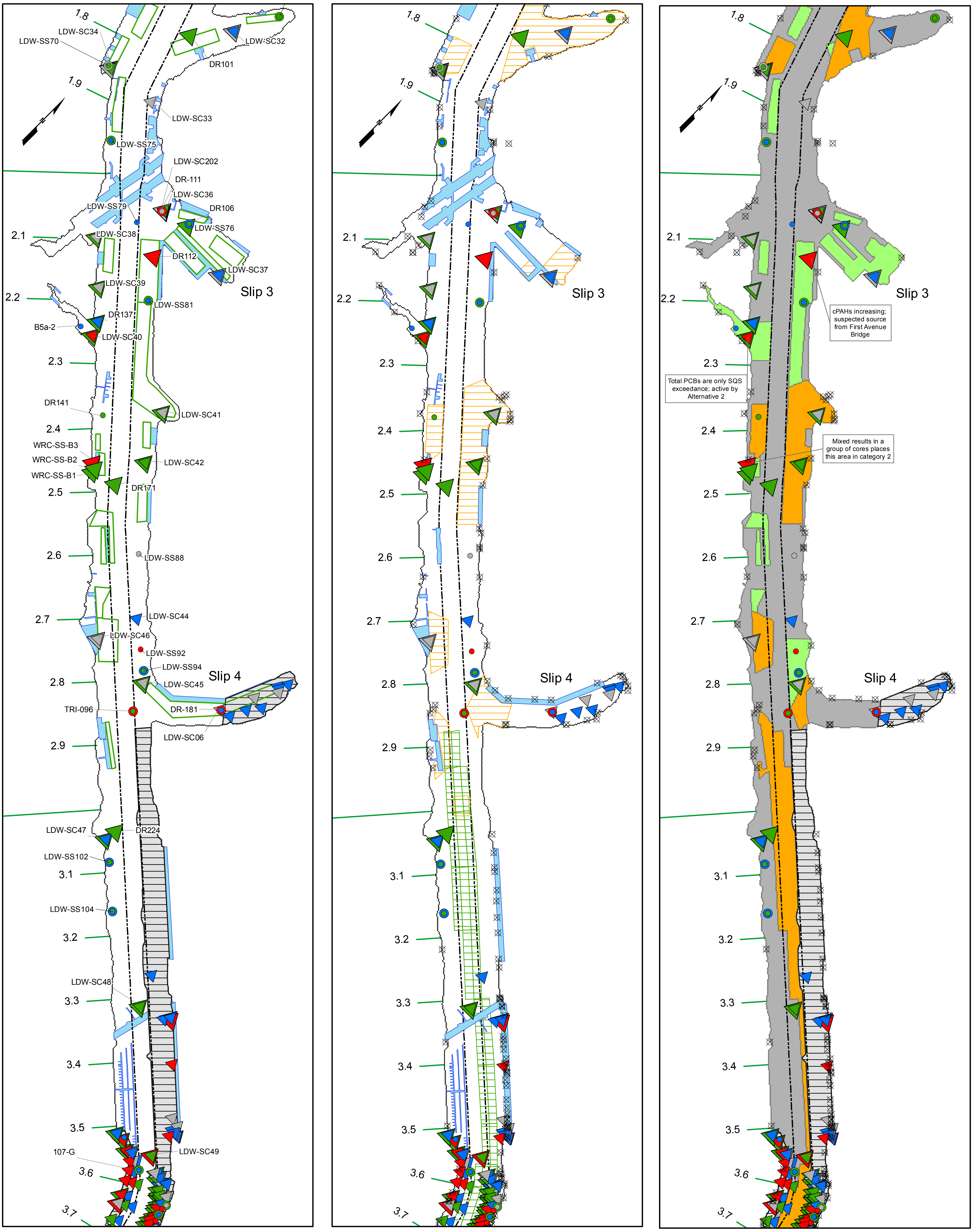
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49	Empirical Trends, Scour Areas, and Recovery Categories (RM 0.0 to 1.9)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE F-22a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\F-22aT10PCBRecoveryNorth.mxd



Notes:

1. If a core symbol does not appear, the core did not have samples at the appropriate intervals to evaluate trends for either total PCBs or other SMS contaminants. For example, there is no total PCB symbol for SC23 because PCBs were only analyzed in the 2-ft samples. Other SMS contaminants were analyzed at finer depth intervals.
2. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

Legend

Natural Recovery Empirical Data

Resampled Surface Sediment Location Total PCBs | Resampled Surface Sediment Location Other SMS Contaminants

Top Two Intervals in Cores Total PCBs | Top Two Intervals in Cores Other SMS Contaminants

- Below SQS
- Data that do not Support Recovery (≤ 50% Concentration Increase)
- Data that do Support Recovery (≥ 50% Concentration Increase)
- Station in Equilibrium or Mixed Result

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour ≥ 10 cm
- Evidence of Propeller Scour
- Berthing Area
- Overwater Structure

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker
- Outfall Location

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

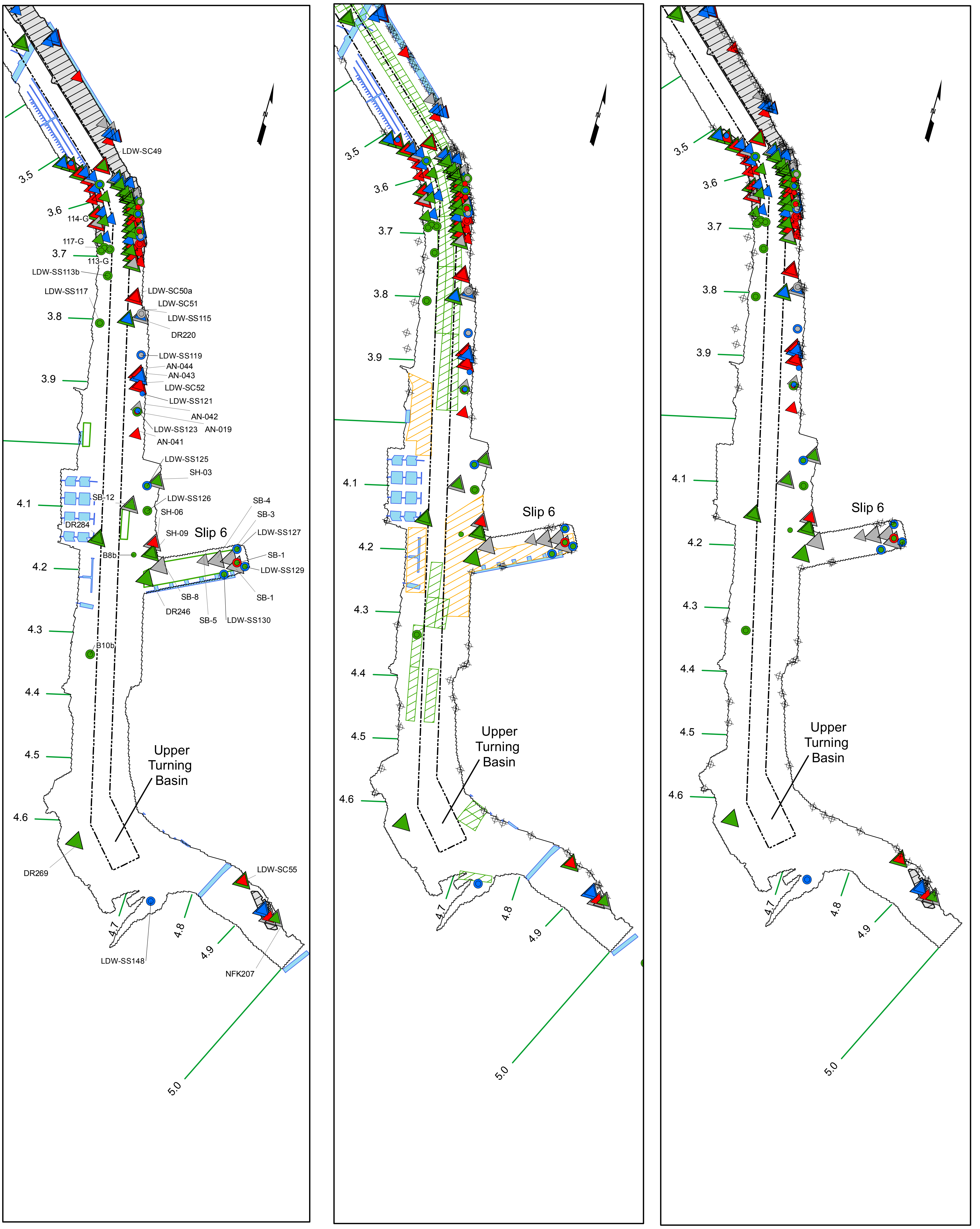
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Empirical Trends, Scour Areas, and Recovery Categories (RM 1.9 to 3.6)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE F-22b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\F-22bT10PCBRecoveryMid.mxd



Notes:
1. If a core symbol does not appear, the core did not have samples at the appropriate intervals to evaluate trends for either total PCBs or other SMS contaminants. For example, there is no total PCB symbol for SC23 because PCBs were only analyzed in the 2-ft samples. Other SMS contaminants were analyzed at finer depth intervals.
2. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

Legend

Natural Recovery Empirical Data

Resampled Surface Sediment Location Total PCBs — Resampled Surface Sediment Location Other SMS Contaminants

Top Two Intervals in Cores Total PCBs — Top Two Intervals in Cores Other SMS Contaminants

- Below SQS
- Data that do not Support Recovery (≤ 50% Concentration Increase)
- Data that do Support Recovery (≥ 50% Concentration Increase)
- Station in Equilibrium or Mixed Result

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour ≥ 10 cm
- Evidence of Propeller Wash Scour
- Berthing Area
- Overwater Structure

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 1: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker
- Outfall Location

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

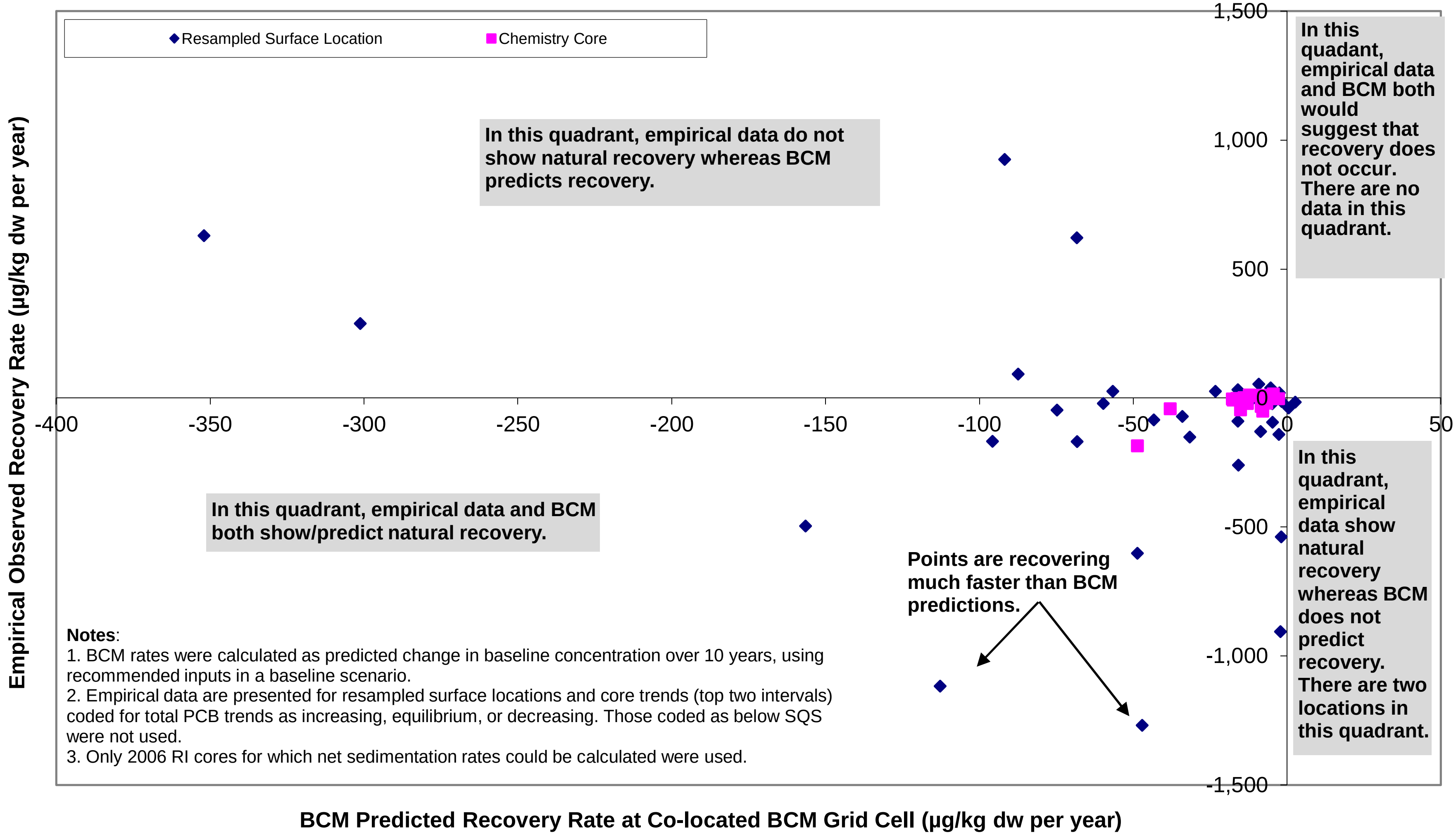
Empirical Trends, Scour Areas, and Recovery Categories (RM 3.6 to 5.0)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE F-22c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix F\F-22c T10PCBRecoverySouth.mxd

Figure F-23 Comparison of BCM and Empirical Data Recovery Rates for Total PCBs



Lower Duwamish Waterway Group

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

Appendix G
Remaining Subsurface Sediment Contamination for the LDW Remedial Alternatives

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

List of Tables

List of Figures

List of Figures

List of Figures

List of Figures

List of Figures

G.1 Introduction

This appendix presents a series of figures depicting Lower Duwamish Waterway (LDW) surface and subsurface sediment exceedances of the sediment quality standards (SQS) or the cleanup screening levels (CSL) of the Washington State Sediment Management Standards (SMS) or the remedial action levels (RALs) developed for the remedial alternatives, selected physical conditions, and the remedial alternative technology assignments. The figures in this appendix provide a reference for each remedial alternative, illustrating the remedial technology selection, dredge depths, and the locations of subsurface contamination left-in-place after construction.

This appendix presents three types of figures for each remedial alternative. The first figure type a plan-view map for each alternative that shows the technology assignments, recovery categories, surface sediment point exceedances above the RALs specific to that remedial alternative, and sediment core locations, and the SMS exceedance status. [1] The core is designated as exceeding the SQS or CSL if any contaminant at any depth exceeds the SMS or CSL. The plan-view maps are described in more detail in Section G.2 and provide the same information shown on the remedial alternative maps presented in Section 8 and add information that can be used for reference.

The second figure type is a 3-panel map showing the subsurface contamination remaining in the upper 4 feet (ft) of sediment at each core location for each remedial alternative. These maps are described in more detail in Section G.3. The panels provide technology assignments, scour areas, recovery categories, and the predicted SMS exceedance status in the 0- to 2-ft and 2- to 4-ft intervals following remediation.

The third figure type is a diagram showing all the sediment cores outside of the early action areas (EAAs) in the LDW, the SMS exceedance status for each sample interval, the technology assignment for the area where that core is located for each remedial alternative, and the anticipated dredge depths. These vertical diagrams are similar to those presented in Section 2 and are described in more detail in Section G.4. Tables G-1 through G-3 (on the attached CD), accompany these core diagrams and provide the contaminant concentrations for the SMS exceedances shown in the diagrams.

The figure types are grouped by alternative, such that figure type one, two, and three are presented in order for each alternative. The following sections describe the development of each figure type. The information presented here provides adequate detail and precision for a feasibility study (FS). During remedial design, the current

1 SMS exceedance status is the maximum sediment concentration relative to the SQS and CSL for any detected SMS contaminants. The SMS contaminants include two of the four human health risk drivers, total polychlorinated biphenyls (PCBs) and arsenic; however, the other two human health risk drivers, carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and dioxins/furans are not SMS contaminants. Therefore the exceedances shown on the figures for Appendix G, do not reflect cPAHs or dioxins/furans.

understanding of the chemical and physical conditions of the LDW and technologies employed for the selected remedial alternative will be refined.

G.2 Development of Remedial Alternative Maps

The remedial alternative maps developed in Section 8 are shown in this appendix with additional information, including surface and subsurface sediment sample locations and the relationship of FS baseline surface sediment risk-driver concentrations to the RALs. These maps also display the recovery categories (developed in Section 6). In this appendix, the surface sediment concentrations are color-coded to alternative-specific RALs, as developed in Sections 6 and 8. Subsurface sediment concentrations are color-coded according to whether the maximum concentrations of any detected SMS contaminant at any sample interval (i.e., any depth below mudline) are above the CSL, between the CSL and the SQS, or below the SQS, as also shown in Section 2. Section 6 describes the development of the recovery categories, and Section 8 shows how the technology assignments were used to develop the remedial alternatives.

G.3 Maps Showing Potential for Exposure of Subsurface Contamination

The second set of figures are 3-panel maps showing the remedial alternatives developed in Section 8, the scour areas delineated in Section 2, and the recovery categories developed in Section 6. As discussed in Section 5, the potential maximum depths of scour in the LDW are 22 centimeters (cm; approx. 9 inches) from high-flow events and 36 cm (approx. 14 inches, upper bound) from propeller wash from vessels operating in the LDW. The extent of potential for exposure of subsurface contamination is therefore 36 cm, but has been conservatively set to include the upper 2- to 4-ft of the sediment bed depending on location. This extent covers the maximum modeled scour depths and provides a buffer to accommodate anchoring and other physical activities that also may expose subsurface contamination.

The subsurface contamination symbols are developed in this appendix according to the following criteria and simplifying assumptions. Each core is represented by stacked triangles, which reflect the expected subsurface sediment contamination following remediation within the upper 4 feet. In contrast, the first set of remedial alternative maps shows the maximum exceedance status at any depth below mudline, as discussed in Section G.2, above). The inner triangle provides the maximum SQS exceedance status (for any detected SMS contaminant) in the 0- to 2-ft core interval. The outer triangle provides the same information, but for the 2- to 4-ft core interval. When available, estimated *in situ* depths are used to place core data in these depth intervals. If a core sample overlaps both the 0- to 2-ft and the 2- to 4-ft core intervals (e.g., a 0- to 4-ft composite sample), then the sample interval is considered to represent both intervals.

The core symbols have been adjusted to represent subsurface conditions following remediation.[2] For cores where no contamination remains following dredging, a green dot is substituted for the triangles. For capping, the new top interval is assumed to be composed of cap material and is coded as below the SQS. The former 0- to 2-ft interval is now below the cap and its SQS exceedance status is used to color the outer triangle (2- to 4-ft interval). For partial dredging and capping, the 0- to 2-ft interval is assumed to be removed and then backfilled, therefore the interval is shown as below the SQS. The original SQS exceedance status for the 2- to 4-ft interval remains as-is. For enhanced natural recovery (ENR)/*in situ*, the core symbols are assumed to be unchanged, although the application of a thin layer of sand would probably reduce concentrations in the 0- to 2- ft interval. The core symbols provide a useful picture of subsurface contamination remaining in the near surface. To produce these figures, several simplifications have been made. First, the assumed cap thickness in the FS is 3 ft. However, the data are displayed assuming the sand cap extends 2 ft below surface sediment. This is a simplifying step to better match the majority of data in the FS dataset. Second, partial dredging depths may be more or less than 3 ft to account for location-specific clearance requirements (e.g., maintenance dredging depths in the navigation channel) or overdredging. For these figures, a 2-ft partial dredging depth has been assumed in all locations. Finally, as noted above, the thin layer of ENR sand is not accounted for in these core symbols, although approximately 6 inches of clean sand would be present in the 0- to 2-ft interval in ENR locations. While these figures provide a useful picture of subsurface sediment remaining in the nearsurface, the core diagrams (discussed in Section G.4) provide a more detailed and accurate view of all subsurface sediment remaining, particularly in capping and partial dredging/capping locations.

G.4 Development of Core Diagrams

The core diagrams provide a snap-shot of locations where subsurface sediment contamination will be removed and locations where subsurface contamination will remain in place for each remedial alternative. These are generated based on the core diagrams in Section 2, with some modifications and additions.

The cores have been expanded to represent the *in situ* contamination depth as opposed to the recovered contamination depth. For those cores with adequate recovery information, the *in situ* contamination depth is determined by dividing the recovered depth of each unit by the percent recovery (as a fraction) for the core. Therefore, the cores are expanded uniformly; all units within a given core are assumed to have undergone the same degree of compaction during sampling. If the percent recovery is

[2] Except for Alternative 1, in which the core symbols represent baseline conditions in the subsurface prior to remediation.

not available, the *in situ* sample intervals are assumed to be identical to the recovered sample intervals.

The core diagrams present all subsurface sediment data in the FS baseline dataset for cores located outside of EAAs. In some cases, the cores were collected in areas proposed for navigation dredging to assess the suitability of the sediment for open water disposal following dredging. In many of those cases, the area being evaluated was subsequently dredged. Nevertheless, those cores are still included in the core diagrams even though the sediment represented by those samples has been removed from the LDW. All cores in areas subsequently dredged are footnoted as such on the diagrams. The exact depths to which dredging extended are not always known, so it was not possible to categorically delete these cores from the diagrams. Caution is advised, therefore, in interpreting such cores as being indicative of conditions left behind after any given remedial action.

The core diagrams show the remedial technology assigned at the location of each core. The dredge depths shown on the cores represent dredging to the maximum depth of contamination, based on the isopach layer (i.e., the "neat-line volume" dredge depth of detected SQS exceedances) developed in Appendix E. The dredge depths do not include the additional factors used in estimating dredge volumes (a 50% constructability factor is assumed for Alternatives 2 through 6 and a 34% additional dredge depth is assumed to achieve the Alternative 6 RALs below the SQS; see Appendix E).

In partial dredge and cap locations, the dredge depth is 3 ft in habitat areas. In the navigation channel and berthing areas, the dredge depths for partial dredge and cap were calculated based on the capping clearance requirements developed in Section 8, and location-specific maintenance dredge and bathymetric elevations. In the navigation channel, the dredge depth is the depth from the authorized channel depth) to a depth of 6 ft below the authorized channel depth. This allows for placement of an assumed 3-ft cap while still leaving a 3-ft clearance below the authorized channel depth. As noted in Section 8.1.2.3, because this is less than the 4-ft clearance requested in the U.S. Army Corps of Engineers (USACE, 2010) letter, final clearances in the navigation channel (as well as for berthing areas) will be determined in consultation with the U.S. Environmental Protection Agency (EPA) and other relevant parties during remedial design. In berthing areas, the dredge depth is the depth from the existing bed elevation (regardless of whether it is currently above or below the permitted berthing depth) to a depth of 5 ft below the permitted berthing depth. This allows for placement of an assumed 3-ft cap while still leaving a 2-ft clearance below the permitted berthing depth requested by the USACE. These depths provide room for capping, maintenance dredging, and a safety factor.

The extent of subsurface contamination and technology assignments will be refined during remedial design.

If a surface grab sample is located within 10 ft of a core, the location name and exceedance status is included directly above the core. If the sample was analyzed for toxicity, then the exceedance status is shown based on toxicity results as opposed to sediment chemistry, as noted on the figures.

Tables G-1 through G-6 (on the attached CD) accompany these core diagrams to provide the contaminant concentrations for the SMS exceedances shown in the diagram. The tables include contaminant concentrations for all detected SMS contaminants that exceed the SQS in the subsurface sediment dataset (excluding cores in EAAs). The tables also provide the recovery category for the sediment around the core and the remedial alternative under which the location is first dredged or partially dredged/capped.[3] For any sample interval with detected concentrations exceeding the SQS, data are provided for the detected SMS contaminant exceeding the SQS.

G.5 Summary

The figures and tables presented in this appendix provide a reference for analyzing the remedial technology assignments, the extent of subsurface contamination removed, the SMS contaminants responsible for subsurface sediment contamination (detected SMS contaminants exceeding the SQS), and the locations of subsurface contamination remaining following active remediation. This valuable information can be used to evaluate the remedial alternatives, review the dredging volume estimates, and plan location-specific remedial design investigations to refine the extent of subsurface contamination and the technology assignments during remedial design.

[3] Note that the corresponding removal-emphasis and the combined-technology remedial alternatives (e.g., Alternatives 3R and 3C) share the same active remedial footprint. Therefore, if a core is dredged for a removal-emphasis alternative, then it is actively remediated (i.e., dredged, partially dredged and capped, capped, or ENR/*in situ*) for the corresponding combined-technology alternative.

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concentration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-0-0.5	0	0.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-0-2	0	2	>CSL	2.1	No	Mercury	0.61		mg/kg dw	Yes		Yes	Yes	1	1.5
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-0-2	0	2	>CSL	2.1	No	Total PCBs	3400		µg/kg dw	Yes	160	Yes	Yes	2.5	13
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-0-2	0	2	>CSL	2.1	No	BEHP	1800		µg/kg dw	Yes	86	Yes	Yes	1.1	1.8
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-0.5-1	0.5	1	>SQS, ≤CSL	1.97	No	Total PCBs	350		µg/kg dw	Yes	18	No	Yes	0.28	1.5
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-1-1.5	1	1.5	>CSL	1.95	No	Mercury	1.27		mg/kg dw	Yes		Yes	Yes	2.2	3.1
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-1-1.5	1	1.5	>CSL	1.95	No	1,2,4-Trichlorobenzene	20		µg/kg dw	Yes	1	No	Yes	0.56	1.2
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-1-1.5	1	1.5	>CSL	1.95	No	Total PCBs	6700		µg/kg dw	Yes	340	Yes	Yes	5.2	28
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-1-1.5	1	1.5	>CSL	1.95	No	BEHP	2400		µg/kg dw	Yes	120	Yes	Yes	1.5	2.6
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-1-1.5	1	1.5	>CSL	1.95	No	Butyl benzyl phthalate	98	J	µg/kg dw	Yes	5	No	Yes	0.078	1
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-1.5-2	1.5	2	>CSL	2.36	No	Mercury	1.22		mg/kg dw	Yes		Yes	Yes	2.1	3
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-1.5-2	1.5	2	>CSL	2.36	No	Total PCBs	4300		µg/kg dw	Yes	180	Yes	Yes	2.8	15
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-2-4	2	4	>SQS, ≤CSL	1.6	No	Total PCBs	440		µg/kg dw	Yes	28	No	Yes	0.43	2.3
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	No	-	LDW-SC1-4-6	4	6	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-0-2	0	2	>CSL	0.897	No	Arsenic	190		mg/kg dw	Yes		Yes	Yes	2	3.3
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-0-2	0	2	>CSL	0.897	No	Lead	569		mg/kg dw	Yes		Yes	Yes	1.1	1.3
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-0-2	0	2	>CSL	0.897	No	Zinc	748		mg/kg dw	Yes		No	Yes	0.78	1.8
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-0-2	0	2	>CSL	0.897	No	Total PCBs	1380		µg/kg dw	Yes	150	Yes	Yes	2.3	13
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-0-2	0	2	>CSL	0.897	No	BEHP	900		µg/kg dw	Yes	100	Yes	Yes	1.3	2.1
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-2-4	2	4	>CSL	6.29	No	Arsenic	210		mg/kg dw	Yes		Yes	Yes	2.3	3.7
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-2-4	2	4	>CSL	6.29	No	Lead	1050		mg/kg dw	Yes		Yes	Yes	2	2.3
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-2-4	2	4	>CSL	6.29	No	Zinc	604		mg/kg dw	Yes		No	Yes	0.63	1.5
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-2-4	2	4	>CSL	6.29	Yes	Total PCBs	2900		µg/kg dw	Yes		Yes	Yes	2.9	22
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-2-4	2	4	>CSL	6.29	Yes	BEHP	1800		µg/kg dw	Yes		No	Yes	0.95	1.4
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-4-6	4	6	>CSL	0.31	No	Arsenic	270		mg/kg dw	Yes		Yes	Yes	2.9	4.7
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-4-6	4	6	>CSL	0.31	No	Lead	1210		mg/kg dw	Yes		Yes	Yes	2.3	2.7
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-4-6	4	6	>CSL	0.31	No	Zinc	1430		mg/kg dw	Yes		Yes	Yes	1.5	3.5
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-4-6	4	6	>CSL	0.31	Yes	Total PCBs	209		µg/kg dw	Yes		No	Yes	0.21	1.6
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-8-10	8	10	>CSL	0.45	No	Arsenic	380	J	mg/kg dw	Yes		Yes	Yes	4.1	6.7
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-8-10	8	10	>CSL	0.45	No	Lead	1400	J	mg/kg dw	Yes		Yes	Yes	2.6	3.1
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-8-10	8	10	>CSL	0.45	No	Zinc	2380	J	mg/kg dw	Yes		Yes	Yes	2.5	5.8
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-8-10	8	10	>CSL	0.45	Yes	Total PCBs	237	J	µg/kg dw	Yes		No	Yes	0.24	1.8
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	No	-	LDW-SC2-10.7-12	10.7	12	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC3	1266432	210649	0.2	outside of AOPCs	outside of AOPCs	3	No	No	-	LDW-SC3-0-2	0	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC3	1266432	210649	0.2	outside of AOPCs	outside of AOPCs	3	No	No	-	LDW-SC3-2-4	2	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	No	-	LDW-SC4-0-1	0	1	>SQS, ≤CSL	1.54	No	Mercury	0.53	J	mg/kg dw	Yes		No	Yes	0.9	1.3
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	No	-	LDW-SC4-1-2	1	2	>SQS, ≤CSL	1.97	No	Arsenic	63		mg/kg dw	Yes		No	Yes	0.68	1.1
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	No	-	LDW-SC4-1-2	1	2	>SQS, ≤CSL	1.97	No	Mercury	0.43	J	mg/kg dw	Yes		No	Yes	0.73	1
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	No	-	LDW-SC4-1-2	1	2	>SQS, ≤CSL	1.97	No	Total PCBs	490		µg/kg dw	Yes	25	No	Yes	0.38	2.1
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	No	-	LDW-SC4-2-4	2	4	>CSL	1.73	No	2,4-Dimethylphenol	46		µg/kg dw	Yes		Yes	Yes	1.6	1.6
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	No	-	LDW-SC4-2-4	2	4	>CSL	1.73	No	Total PCBs	600		µg/kg dw	Yes	35	No	Yes	0.54	2.9
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	No	-	LDW-SC4-4-6	4	6	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC5	1266048	210543	0.2	4	not dredged	2	No	No	-	LDW-SC5-0-1	0	1	>SQS, ≤CSL	1.68	No	Total PCBs	510		µg/kg dw	Yes	30	No	Yes	0.46	2.5
LDW Subsurface Sediment 2006	LDW-SC5	1266048	210543	0.2	4	not dredged	2	No	No	-	LDW-SC5-1-2.2	1	2.2	>SQS, ≤CSL	3.93	No	Mercury	0.51		mg/kg dw	Yes		No	Yes	0.86	1.2
LDW Subsurface Sediment 2006	LDW-SC5	1266048	210543	0.2	4	not dredged	2	No	No	-	LDW-SC5-2.2-4	2.2	4	>SQS, ≤CSL, ND												

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
EPA SI	DR068	1266404	209574	0.3	2	3	1	No	No	-	SD-DR068-0000A	0	2	>CSL	1.67	No	Total PCBs	2600		µg/kg dw	Yes	160	Yes	Yes	2.5	13
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-0-0.5	0	0.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-0.5-1	0.5	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-1-1.5	1	1.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-1.5-2	1.5	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-2-2.5	2	2.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-2-4.5	2	4.5	>CSL	1.65	No	Mercury	0.44		mg/kg dw	Yes		No	Yes	0.75	1.1
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-2-4.5	2	4.5	>CSL	1.65	No	Total PCBs	1640		µg/kg dw	Yes	99	Yes	Yes	1.5	8.3
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-2-4.5	2	4.5	>CSL	1.65	No	BEHP	1100		µg/kg dw	Yes	67	No	Yes	0.86	1.4
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-2.5-3	2.5	3	>SQS, ≤CSL	1.37	No	Total PCBs	350		µg/kg dw	Yes	26	No	Yes	0.4	2.2
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-3-3.5	3	3.5	>SQS, ≤CSL	1.58	No	Total PCBs	490		µg/kg dw	Yes	31	No	Yes	0.48	2.6
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-3.5-4	3.5	4	>CSL	0.814	No	Total PCBs	1590		µg/kg dw	Yes	200	Yes	Yes	3.1	17
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-4-4.5	4	4.5	>CSL	2.23	No	Total PCBs	2600		µg/kg dw	Yes	120	Yes	Yes	1.8	10
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	No	-	LDW-SC6-6-8	6	8	>SQS, ≤CSL, ND												
Duw/Diag-2	DUD250	1266871	209564	0.4	5	not dredged	3	No	No	-	L8542-12	0	3	>CSL	0.74	No	Total PCBs	500	J	µg/kg dw	Yes	68	Yes	Yes	1	5.7
Duw/Diag-2	DUD250	1266871	209564	0.4	5	not dredged	3	No	No	-	L8542-12	0	3	>CSL	0.74	No	BEHP	780		µg/kg dw	Yes	110	Yes	Yes	1.4	2.3
Duw/Diag-2	DUD250	1266871	209564	0.4	5	not dredged	3	No	No	-	L8542-12	0	3	>CSL	0.74	No	Butyl benzyl phthalate	68		µg/kg dw	Yes	9.2	No	Yes	0.14	1.9
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	No	-	LDW-SC7-0-1	0	1	>SQS, ≤CSL	2.04	No	Mercury	0.47		mg/kg dw	Yes		No	Yes	0.8	1.1
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	No	-	LDW-SC7-0-1	0	1	>SQS, ≤CSL	2.04	No	Total PCBs	1300		µg/kg dw	Yes	64	No	Yes	0.98	5.3
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	No	-	LDW-SC7-0-1	0	1	>SQS, ≤CSL	2.04	No	BEHP	1200		µg/kg dw	Yes	59	No	Yes	0.76	1.3
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	No	-	LDW-SC7-1-1.7	1	1.7	>CSL	0.835	No	Total PCBs	1270	J	µg/kg dw	Yes	150	Yes	Yes	2.3	13
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	No	-	LDW-SC7-1.7-4	1.7	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-0-1	0	1	>SQS, ≤CSL	1.99	No	Total PCBs	290		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-1-2	1	2	>CSL	1.15	No	Mercury	0.48		mg/kg dw	Yes		No	Yes	0.81	1.2
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-1-2	1	2	>CSL	1.15	No	Total PCBs	1030		µg/kg dw	Yes	90	Yes	Yes	1.4	7.5
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-2-4	2	4	>CSL	1.41	No	Mercury	0.45		mg/kg dw	Yes		No	Yes	0.76	1.1
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-2-4	2	4	>CSL	1.41	No	Total PCBs	2900		µg/kg dw	Yes	210	Yes	Yes	3.2	18
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-2-4	2	4	>CSL	1.41	No	BEHP	1600		µg/kg dw	Yes	110	Yes	Yes	1.4	2.3
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-4-6	4	6	>CSL	1.55	No	Arsenic	62		mg/kg dw	Yes		No	Yes	0.67	1.1
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-4-6	4	6	>CSL	1.55	No	Mercury	0.77		mg/kg dw	Yes		Yes	Yes	1.3	1.9
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-4-6	4	6	>CSL	1.55	No	Zinc	527		mg/kg dw	Yes		No	Yes	0.55	1.3
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-4-6	4	6	>CSL	1.55	No	Total PCBs	5500		µg/kg dw	Yes	350	Yes	Yes	5.4	29
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-4-6	4	6	>CSL	1.55	No	BEHP	2200		µg/kg dw	Yes	140	Yes	Yes	1.8	3
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-6-8	6	8	>CSL	1.97	No	Total PCBs	3800		µg/kg dw	Yes	190	Yes	Yes	2.9	16
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-6-8	6	8	>CSL	1.97	No	BEHP	1400		µg/kg dw	Yes	71	No	Yes	0.91	1.5
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-8-10	8	10	>CSL	1.9	No	Mercury	0.89		mg/kg dw	Yes		Yes	Yes	1.5	2.2
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	No	-	LDW-SC8-8-10	8	10	>CSL	1.9	No	Total PCBs	540		µg/kg dw	Yes	28	No	Yes	0.43	2.3
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	No	-	L8542-27	0	3	>CSL	3.5	No	Mercury	0.46		mg/kg dw	Yes		No	Yes	0.78	1.1
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	No	-	L8542-27	0	3	>CSL	3.5	No	Total PCBs	690	J	µg/kg dw	Yes	20	No	Yes	0.31	1.7
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	No	-	L8542-27	0	3	>CSL	3.5	No	BEHP	5100		µg/kg dw	Yes	150	Yes	Yes	1.9	3.2
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	No	-	L8542-27	0	3	>CSL	3.5	No	Butyl benzyl phthalate	310		µg/kg dw	Yes	8.9	No	Yes	0.14	1.8
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	No	-	L10112-8	3	6	>CSL	0.71	No	Total PCBs	580	J	µg/kg dw	Yes	82	Yes	Yes	1.3	6.8
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	No	-	L10112-9	6	9	≤SQS												

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-0-1	0	1	>SQS, ≤CSL	1.86	No	Total PCBs	260	J	µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-0-1	0	1	>SQS, ≤CSL	1.86	No	BEHP	1200		µg/kg dw	Yes	65	No	Yes	0.83	1.4
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-1-2	1	2	>CSL	2.23	No	Total PCBs	290		µg/kg dw	Yes	13	No	Yes	0.2	1.1
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-1-2	1	2	>CSL	2.23	No	BEHP	2800		µg/kg dw	Yes	130	Yes	Yes	1.7	2.8
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-1-2	1	2	>CSL	2.23	No	Butyl benzyl phthalate	160		µg/kg dw	Yes	7.2	No	Yes	0.11	1.5
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-2-4	2	4	>CSL	2.95	No	Mercury	0.74		mg/kg dw	Yes		Yes	Yes	1.3	1.8
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-2-4	2	4	>CSL	2.95	No	Total PCBs	1120		µg/kg dw	Yes	38	No	Yes	0.58	3.2
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-2-4	2	4	>CSL	2.95	No	BEHP	3900		µg/kg dw	Yes	130	Yes	Yes	1.7	2.8
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-2-4	2	4	>CSL	2.95	No	Butyl benzyl phthalate	180		µg/kg dw	Yes	6.1	No	Yes	0.095	1.2
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-4-5	4	5	>SQS, ≤CSL	1.04	No	Total PCBs	410		µg/kg dw	Yes	39	No	Yes	0.6	3.3
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	No	-	LDW-SC10-6-8	6	8	>SQS, ≤CSL	0.989	No	Total PCBs	350		µg/kg dw	Yes	35	No	Yes	0.54	2.9
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	No	Lead	639		mg/kg dw	Yes		Yes	Yes	1.2	1.4
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	No	Mercury	0.64		mg/kg dw	Yes		Yes	Yes	1.1	1.6
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	No	Zinc	482		mg/kg dw	Yes		No	Yes	0.5	1.2
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Benzo(a)anthracene	3600		µg/kg dw	Yes		Yes	Yes	2.3	2.8
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Benzo(a)pyrene	3100		µg/kg dw	Yes		Yes	Yes	1	1.9
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Chrysene	4300		µg/kg dw	Yes		Yes	Yes	1.5	3.1
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Fluoranthene	8100		µg/kg dw	Yes		Yes	Yes	3.2	4.8
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Indeno(1,2,3-cd)pyrene	670		µg/kg dw	Yes		No	Yes	0.97	1.1
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Pyrene	6700		µg/kg dw	Yes		Yes	Yes	2	2.6
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Total benzofluoranthenes	7600		µg/kg dw	Yes		Yes	Yes	2.1	2.4
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Total HPAHs	34700		µg/kg dw	Yes		Yes	Yes	2	2.9
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0-0.8	0	0.8	>CSL	4.23	Yes	Total PCBs	3000		µg/kg dw	Yes		Yes	Yes	3	23
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-0.8-2	0.8	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-2-3.4	2	3.4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	No	-	LDW-SC11-3.4-4.1	3.4	4.1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-0-1	0	1	>CSL	1.63	No	Mercury	0.42		mg/kg dw	Yes		No	Yes	0.71	1
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-0-1	0	1	>CSL	1.63	No	1,2,4-Trichlorobenzene	18	J	µg/kg dw	Yes	1.1	No	Yes	0.61	1.4
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-0-1	0	1	>CSL	1.63	No	Benzyl alcohol	140	J	µg/kg dw	Yes		Yes	Yes	1.9	2.5
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-0-1	0	1	>CSL	1.63	No	Total PCBs	3600		µg/kg dw	Yes	220	Yes	Yes	3.4	18
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-0-1	0	1	>CSL	1.63	No	BEHP	1700		µg/kg dw	Yes	100	Yes	Yes	1.3	2.1
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-1-2.6	1	2.6	>CSL	2.47	No	Cadmium	5.9		mg/kg dw	Yes		No	Yes	0.88	1.2
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-1-2.6	1	2.6	>CSL	2.47	No	Mercury	1.28		mg/kg dw	Yes		Yes	Yes	2.2	3.1
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-1-2.6	1	2.6	>CSL	2.47	No	Silver	7.5		mg/kg dw	Yes		Yes	Yes	1.2	1.2
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-1-2.6	1	2.6	>CSL	2.47	No	1,2,4-Trichlorobenzene	22	J	µg/kg dw	Yes	0.89	No	Yes	0.49	1.1
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-1-2.6	1	2.6	>CSL	2.47	No	Total PCBs	2700		µg/kg dw	Yes	110	Yes	Yes	1.7	9.2
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-1-2.6	1	2.6	>CSL	2.47	No	BEHP	1200	J	µg/kg dw	Yes	49	No	Yes	0.63	1
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	No	-	LDW-SC9-2.6-4	2.6	4	>SQS, ≤CSL, ND												
EPA SI	DR044	1266577	208216	0.6	4	5	2	No	No	-	SD-DR044-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR044	1266577	208216	0.6	4	5	2	No	No	-	SD-DR044-0020	2	4	>CSL	2.22	No	Mercury	0.5		mg/kg dw	Yes		No	Yes	0.85	1.2
EPA SI	DR044	1266577	208216	0.6	4	5	2	No	No	-	SD-DR044-0020	2	4	>CSL	2.22	No	Total PCBs	1900		µg/kg dw	Yes	86	Yes	Yes	1.3	7.2
Duw/Diag-2	DUD206	1267277	208630	0.6	outside of AOPCs	outside of AOPCs	3	No	No	-	L8542-28	0	3	>CSL, ND												
Duw/Diag-2	DUD260	1267150	208575	0.6	3	not dredged	0	No	No	-	L8542-29	0	3	>CSL	1.9	No	Total PCBs	1340	J	µg/kg dw	Yes	71	Yes	Yes	1.1	5.9
Duw/Diag-2	DUD260	1267150	208575	0.6	6	not dredged	0	No	No	-	L8542-29	0	3	>CSL	1.9	No	BEHP	1600		µg/kg dw	Yes	84	Yes	Yes	1.1	1.8
Duw/Diag-2	DUD260	1267150	208575	0.6	6	not dredged	0	No	No	-	L8542-29	0	3	>CSL	1.9	No	Butyl benzyl phthalate	120		µg/kg dw	Yes	6.3	No	Yes	0.098	1.3
Duw/Diag-2	DUD260	1267150	208575	0.6	6	not dredged	0	No	No	-	L8542-30	3	6	>CSL, ND												

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-0-0.5	0	0.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-0-2	0	2	>SQS, ≤CSL	1.92	No	Total PCBs	350		µg/kg dw	Yes	18	No	Yes	0.28	1.5
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-0.5-1	0.5	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-1-1.5	1	1.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-1.5-2	1.5	2	>SQS, ≤CSL	1.98	No	Total PCBs	320		µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-2-2.5	2	2.5	>CSL	2.24	No	Total PCBs	2000	J	µg/kg dw	Yes	89	Yes	Yes	1.4	7.4
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-2-4	2	4	>CSL	1.58	No	Mercury	0.45		mg/kg dw	Yes		No	Yes	0.76	1.1
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-2-4	2	4	>CSL	1.58	No	Total PCBs	2500		µg/kg dw	Yes	160	Yes	Yes	2.5	13
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-2.5-3	2.5	3	>SQS, ≤CSL	1.67	No	Total PCBs	630		µg/kg dw	Yes	38	No	Yes	0.58	3.2
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-3-3.5	3	3.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-3.5-4	3.5	4	>SQS, ≤CSL	1.61	No	Total PCBs	790		µg/kg dw	Yes	49	No	Yes	0.75	4.1
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-4-6.7	4	6.6	>CSL	1.92	No	Mercury	0.74		mg/kg dw	Yes		Yes	Yes	1.3	1.8
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-4-6.7	4	6.6	>CSL	1.92	No	Total PCBs	420		µg/kg dw	Yes	22	No	Yes	0.34	1.8
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	No	-	LDW-SC12-6.7-8.7	6.6	8.7	≤SQS												
EPA SI	DR021	1267822	206718	0.9	2	not dredged	1	No	No	-	SD-DR021-0000A	0	2	>SQS, ≤CSL	2.55	No	Total PCBs	520		µg/kg dw	Yes	20	No	Yes	0.31	1.7
EPA SI	DR021	1267822	206718	0.9	2	not dredged	1	No	No	-	SD-DR021-0020	2	4	>CSL	2.45	No	Mercury	0.64		mg/kg dw	Yes		Yes	Yes	1.1	1.6
EPA SI	DR021	1267822	206718	0.9	2	not dredged	1	No	No	-	SD-DR021-0020	2	4	>CSL	2.45	No	Zinc	630		mg/kg dw	Yes		No	Yes	0.66	1.5
EPA SI	DR021	1267822	206718	0.9	2	not dredged	1	No	No	-	SD-DR021-0020	2	4	>CSL	2.45	No	Total PCBs	4000		µg/kg dw	Yes	160	Yes	Yes	2.5	13
EPA SI	DR021	1267822	206718	0.9	2	not dredged	1	No	No	-	SD-DR021-0020	2	4	>CSL	2.45	No	BEHP	2000		µg/kg dw	Yes	82	Yes	Yes	1.1	1.7
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	No	-	LDW-SC13-0-0.5	0	0.5	>SQS, ≤CSL	1.51	No	Total PCBs	460		µg/kg dw	Yes	30	No	Yes	0.46	2.5
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	No	-	LDW-SC13-0-2	0	2	>SQS, ≤CSL	3.46	No	Total PCBs	480		µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	No	-	LDW-SC13-0.5-1	0.5	1	>SQS, ≤CSL	3.28	No	Total PCBs	470		µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	No	-	LDW-SC13-1-1.5	1	1.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	No	-	LDW-SC13-1.5-2	1.5	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	No	-	LDW-SC13-2-4	2	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-0-1.4	0	1.4	>CSL	1.72	No	Mercury	0.71		mg/kg dw	Yes		Yes	Yes	1.2	1.7
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-0-1.4	0	1.4	>CSL	1.72	No	Total PCBs	4500		µg/kg dw	Yes	260	Yes	Yes	4	22
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-0-1.4	0	1.4	>CSL	1.72	No	BEHP	1200		µg/kg dw	Yes	70	No	Yes	0.9	1.5
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-0-1.4	0	1.4	>CSL	1.72	No	Butyl benzyl phthalate	100		µg/kg dw	Yes	5.8	No	Yes	0.091	1.2
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-1.4-2	1.4	2	>CSL	1.63	No	Mercury	0.51		mg/kg dw	Yes		No	Yes	0.86	1.2
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-1.4-2	1.4	2	>CSL	1.63	No	Total PCBs	2060		µg/kg dw	Yes	130	Yes	Yes	2	11
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-2-4.1	2	4.1	>CSL	1.72	No	Mercury	0.7		mg/kg dw	Yes		Yes	Yes	1.2	1.7
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-2-4.1	2	4.1	>CSL	1.72	No	Total PCBs	1550		µg/kg dw	Yes	90	Yes	Yes	1.4	7.5
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-2-4.1	2	4.1	>CSL	1.72	No	Butyl benzyl phthalate	110		µg/kg dw	Yes	6.4	No	Yes	0.1	1.3
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-4.1-6	4.1	6	>CSL	1.82	No	Mercury	0.68		mg/kg dw	Yes		Yes	Yes	1.2	1.7
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-4.1-6	4.1	6	>CSL	1.82	No	Total PCBs	420		µg/kg dw	Yes	23	No	Yes	0.35	1.9
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-6-8.7	6	8.6	>SQS, ≤CSL	1.55	No	Mercury	0.42		mg/kg dw	Yes		No	Yes	0.71	1
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	No	-	LDW-SC14-10-11	10	11	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	No	-	LDW-SC15-0-1	0	1	>SQS, ≤CSL	2.37	No	Total PCBs	360		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	No	-	LDW-SC15-1-2	1	2	>SQS, ≤CSL	1.96	No	Total PCBs	340	J	µg/kg dw	Yes	17	No	Yes	0.26	1.4
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	No	-	LDW-SC15-2-4	2	4	>SQS, ≤CSL	1.62	No	Total PCBs	510		µg/kg dw	Yes	31	No	Yes	0.48	2.6
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	No	-	LDW-SC15-4-6	4	6	>CSL	2.19	No	Total PCBs	1950		µg/kg dw	Yes	89	Yes	Yes	1.4	7.4
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	No	-	LDW-SC15-8-10	8	10	≤SQS												
Lehigh NW	C2 (Lehigh NW)	1267920	206336	1.0	2	3	1	Yes	Yes	2004	C-2	0	4	>SQS, ≤CSL		Yes	Total PCBs	159		µg/kg dw	Yes		No	Yes	0.16	1.2
Lehigh NW	C3 (Lehigh NW)	1267936	206274	1.0	2	3	1	Yes	Yes	2004	C-3S	3.8	5	>SQS, ≤CSL, ND												

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-0-2	0	2	>SQS, ≤CSL	2.02	No	Fluoranthene	4700		µg/kg dw	Yes	230	No	Yes	0.19	1.4
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-0-2	0	2	>SQS, ≤CSL	2.02	No	Total PCBs	330	J	µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-2-4	2	4	>CSL	2.96	No	Mercury	0.85		mg/kg dw	Yes		Yes	Yes	1.4	2.1
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-2-4	2	4	>CSL	2.96	No	Zinc	428		mg/kg dw	Yes		No	Yes	0.45	1
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-2-4	2	4	>CSL	2.96	No	Total PCBs	5400		µg/kg dw	Yes	180	Yes	Yes	2.8	15
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-2-4	2	4	>CSL	2.96	No	BEHP	3100		µg/kg dw	Yes	100	Yes	Yes	1.3	2.1
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-4-6	4	6	>CSL	2.24	No	Mercury	0.98		mg/kg dw	Yes		Yes	Yes	1.7	2.4
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-4-6	4	6	>CSL	2.24	No	Fluoranthene	4900		µg/kg dw	Yes	220	No	Yes	0.18	1.4
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-4-6	4	6	>CSL	2.24	No	Total HPAHs	22000		µg/kg dw	Yes	980	No	Yes	0.18	1
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-4-6	4	6	>CSL	2.24	No	Total PCBs	3400		µg/kg dw	Yes	150	Yes	Yes	2.3	13
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-4-6	4	6	>CSL	2.24	No	BEHP	1600		µg/kg dw	Yes	71	No	Yes	0.91	1.5
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	No	-	LDW-SC16-8-10	8	10	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-0-1	0	1	>CSL	3.06	No	Arsenic	110		mg/kg dw	Yes		Yes	Yes	1.2	1.9
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-0-1	0	1	>CSL	3.06	No	Mercury	0.5		mg/kg dw	Yes		No	Yes	0.85	1.2
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-0-1	0	1	>CSL	3.06	No	Zinc	1260		mg/kg dw	Yes		Yes	Yes	1.3	3.1
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-0-1	0	1	>CSL	3.06	No	Benzyl alcohol	140		µg/kg dw	Yes		Yes	Yes	1.9	2.5
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-0-1	0	1	>CSL	3.06	No	Total PCBs	1220		µg/kg dw	Yes	40	No	Yes	0.62	3.3
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-1-2	1	2	>CSL	3.25	No	Arsenic	170		mg/kg dw	Yes		Yes	Yes	1.8	3
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-1-2	1	2	>CSL	3.25	No	Cadmium	7.6		mg/kg dw	Yes		Yes	Yes	1.1	1.5
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-1-2	1	2	>CSL	3.25	No	Mercury	0.6		mg/kg dw	Yes		Yes	Yes	1	1.5
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-1-2	1	2	>CSL	3.25	No	Zinc	2050		mg/kg dw	Yes		Yes	Yes	2.1	5
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-1-2	1	2	>CSL	3.25	No	Fluoranthene	5600		µg/kg dw	Yes	170	No	Yes	0.14	1.1
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-1-2	1	2	>CSL	3.25	No	Total PCBs	1040		µg/kg dw	Yes	32	No	Yes	0.49	2.7
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	No	Arsenic	60		mg/kg dw	Yes		No	Yes	0.65	1.1
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	No	Cadmium	15		mg/kg dw	Yes		Yes	Yes	2.2	2.9
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	No	Chromium	386		mg/kg dw	Yes		Yes	Yes	1.4	1.5
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	No	Lead	1740		mg/kg dw	Yes		Yes	Yes	3.3	3.9
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	No	Mercury	1.29		mg/kg dw	Yes		Yes	Yes	2.2	3.1
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	No	Zinc	3840		mg/kg dw	Yes		Yes	Yes	4	9.4
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	1,2,4-Trichlorobenzene	110	J	µg/kg dw	Yes		Yes	Yes	2.2	3.5
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	No	Benzoic acid	3000	J	µg/kg dw	Yes		Yes	Yes	4.6	4.6
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	2-Methylnaphthalene	4500		µg/kg dw	Yes		Yes	Yes	3.2	6.7
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Acenaphthene	4600		µg/kg dw	Yes		Yes	Yes	6.3	9.2
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Anthracene	1900		µg/kg dw	Yes		No	Yes	0.43	2
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Benzo(a)anthracene	1500		µg/kg dw	Yes		No	Yes	0.94	1.2
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Chrysene	1800		µg/kg dw	Yes		No	Yes	0.64	1.3
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Dibenzofuran	1700		µg/kg dw	Yes		Yes	Yes	2.4	3.1
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Fluoranthene	7400		µg/kg dw	Yes		Yes	Yes	3	4.4
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Fluorene	4300		µg/kg dw	Yes		Yes	Yes	4.3	8
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Naphthalene	3400		µg/kg dw	Yes		Yes	Yes	1.4	1.6
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Phenanthrene	13000		µg/kg dw	Yes		Yes	Yes	2.4	8.7
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Pyrene	5700		µg/kg dw	Yes		Yes	Yes	1.7	2.2
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Total HPAHs	20400	J	µg/kg dw	Yes		Yes	Yes	1.2	1.7
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Total LPAHs	27000	J	µg/kg dw	Yes		Yes	Yes	2.1	5.2
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	Total PCBs	9800		µg/kg dw	Yes		Yes	Yes	9.8	75
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-2-4	2	4	>CSL	6.35	Yes	BEHP	2300		µg/kg dw	Yes		Yes	Yes	1.2	1.8
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Arsenic	76		mg/kg dw	Yes		No	Yes	0.82	1.3

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Cadmium	20.4		mg/kg dw	Yes		Yes	Yes	3	4
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Lead	470		mg/kg dw	Yes		No	Yes	0.89	1
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Mercury	0.75		mg/kg dw	Yes		Yes	Yes	1.3	1.8
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Zinc	4550		mg/kg dw	Yes		Yes	Yes	4.7	11
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Acenaphthene	1200		µg/kg dw	Yes	37	No	Yes	0.65	2.3
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Dibenzofuran	710		µg/kg dw	Yes	22	No	Yes	0.38	1.5
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Fluoranthene	7100		µg/kg dw	Yes	220	No	Yes	0.18	1.4
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Fluorene	1400		µg/kg dw	Yes	43	No	Yes	0.54	1.9
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Phenanthrene	4200		µg/kg dw	Yes	130	No	Yes	0.27	1.3
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	No	-	LDW-SC17-6-8.2	6	8.6	>CSL	3.24	No	Total PCBs	1900		µg/kg dw	Yes	59	No	Yes	0.91	4.9
LDW Subsurface Sediment 2006	LDW-SC18	1267927	206334	1.0	2	3	1	No	No	-	LDW-SC18-0-1	0	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC18	1267927	206334	1.0	2	3	1	No	No	-	LDW-SC18-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC18	1267927	206334	1.0	2	3	1	No	No	-	LDW-SC18-2-4	2	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	No	-	LDW-SC19-0-1	0	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	No	-	LDW-SC19-1-2	1	2	>SQS, ≤CSL	1.7	No	Total PCBs	233		µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	No	-	LDW-SC19-2-4	2	4	>SQS, ≤CSL	1.56	No	Total PCBs	250		µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	No	-	LDW-SC19-4-6	4	6	>SQS, ≤CSL	1.26	No	Total PCBs	440		µg/kg dw	Yes	35	No	Yes	0.54	2.9
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	No	-	LDW-SC19-6-7	6	7	>CSL	1.54	No	Total PCBs	2400		µg/kg dw	Yes	160	Yes	Yes	2.5	13
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	No	-	LDW-SC19-9-11.9	9	11.9	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	No	-	LDW-SC20-0-2	0	2	>CSL	1.49	No	Mercury	0.65		mg/kg dw	Yes		Yes	Yes	1.1	1.6
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	No	-	LDW-SC20-0-2	0	2	>CSL	1.49	No	Total PCBs	3200		µg/kg dw	Yes	210	Yes	Yes	3.2	18
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	No	-	LDW-SC20-2-4	2	4	>SQS, ≤CSL	1.5	No	Total PCBs	600		µg/kg dw	Yes	40	No	Yes	0.62	3.3
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	No	-	LDW-SC20-4-6	4	6	>SQS, ≤CSL	2.22	No	Total PCBs	400		µg/kg dw	Yes	18	No	Yes	0.28	1.5
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	No	-	LDW-SC20-8-10	8	10	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	No	-	LDW-SC21-0-1	0	1	>SQS, ≤CSL	1.98	No	Total PCBs	250		µg/kg dw	Yes	13	No	Yes	0.2	1.1
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	No	-	LDW-SC21-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	No	-	LDW-SC21-2-4	2	4	>SQS, ≤CSL	1.64	No	Total PCBs	380	J	µg/kg dw	Yes	23	No	Yes	0.35	1.9
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	No	-	LDW-SC21-4-6.2	4	6.2	>CSL	1.94	No	Total PCBs	1680		µg/kg dw	Yes	87	Yes	Yes	1.3	7.3
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	No	-	LDW-SC21-6.2-8	6.2	8	<SQS												
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	No	-	LDW-SC21-10-11.3	10	11.3	≤SQS												
Lehigh NW	A1	1268045	206036	1.1	6	6	1	Yes	Yes	2004	C-1	0	4.4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC22	1268174	205908	1.1	3	not dredged	3	No	No	-	LDW-SC22-0-1.1	0	1.1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC22	1268174	205908	1.1	3	not dredged	3	No	No	-	LDW-SC22-1.1-2	1.1	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC22	1268174	205908	1.1	3	not dredged	3	No	No	-	LDW-SC22-2-4	2	4	>SQS, ≤CSL, ND												
EPA SI	DR025	1268230	205416	1.2	6	6	2	No	No	-	SD-DR025-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR025	1268230	205416	1.2	6	6	2	No	No	-	SD-DR025-0020	2	4	>CSL	2.54	No	Mercury	0.75		mg/kg dw	Yes		Yes	Yes	1.3	1.8
EPA SI	DR025	1268230	205416	1.2	6	6	2	No	No	-	SD-DR025-0020	2	4	>CSL	2.54	No	Total PCBs	1150		µg/kg dw	Yes	45	No	Yes	0.69	3.8
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-0-0.5	0	0.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-0.5-1	0.5	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-1-1.5	1	1.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-1.5-2	1.5	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-2.5	2	2.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-4	2	4	>SQS, ≤CSL	2.14	No	Benzo(a)anthracene	3200		µg/kg dw	Yes	150	No	Yes	0.56	1.4
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-4	2	4	>SQS, ≤CSL	2.14	No	Benzo(a)pyrene	2500		µg/kg dw	Yes	120	No	Yes	0.57	1.2
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-4	2	4	>SQS, ≤CSL	2.14	No	Chrysene	7200		µg/kg dw	Yes	340	No	Yes	0.74	3.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-4	2	4	>SQS, ≤CSL	2.14	No	Fluoranthene	7400	J	µg/kg dw	Yes	350	No	Yes	0.29	2.2
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-4	2	4	>SQS, ≤CSL	2.14	No	Total benzofluoranthenes	6000		µg/kg dw	Yes	280	No	Yes	0.62	1.2
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-4	2	4	>SQS, ≤CSL	2.14	No	Total HPAHs	31500	J	µg/kg dw	Yes	1500	No	Yes	0.28	1.6
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2-4	2	4	>SQS, ≤CSL	2.14	No	BEHP	1600		µg/kg dw	Yes	75	No	Yes	0.96	1.6

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-2.5-3	2.5	3	>SQS, ≤CSL	1.39	No	Acenaphthene	570		µg/kg dw	Yes	41	No	Yes	0.72	2.6
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Acenaphthene	2100		µg/kg dw	Yes	160	Yes	Yes	2.8	10
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Anthracene	8800		µg/kg dw	Yes	680	No	Yes	0.57	3.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Benzo(a)anthracene	7100		µg/kg dw	Yes	550	Yes	Yes	2	5
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Benzo(a)pyrene	3000		µg/kg dw	Yes	230	Yes	Yes	1.1	2.3
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Benzo(g,h,i)perylene	730		µg/kg dw	Yes	56	No	Yes	0.72	1.8
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Chrysene	7800		µg/kg dw	Yes	600	Yes	Yes	1.3	5.5
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Dibenzo(a,h)anthracene	180		µg/kg dw	Yes	14	No	Yes	0.42	1.2
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Dibenzofuran	650		µg/kg dw	Yes	50	No	Yes	0.86	3.3
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Fluoranthene	24000		µg/kg dw	Yes	1800	Yes	Yes	1.5	11
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Fluorene	1800		µg/kg dw	Yes	140	Yes	Yes	1.8	6.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Indeno(1,2,3-cd)pyrene	930		µg/kg dw	Yes	72	No	Yes	0.82	2.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Phenanthrene	12000		µg/kg dw	Yes	920	Yes	Yes	1.9	9.2
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Pyrene	14000		µg/kg dw	Yes	1100	No	Yes	0.79	1.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Total benzofluoranthenes	6400		µg/kg dw	Yes	490	Yes	Yes	1.1	2.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Total HPAHs	64000		µg/kg dw	Yes	4900	No	Yes	0.92	5.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	Total LPAHs	25000		µg/kg dw	Yes	1900	Yes	Yes	2.4	5.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3-3.5	3	3.5	>CSL	1.3	No	BEHP	780		µg/kg dw	Yes	60	No	Yes	0.77	1.3
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3.5-4	3.5	4	>CSL	2.29	No	Acenaphthene	1500		µg/kg dw	Yes	66	Yes	Yes	1.2	4.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3.5-4	3.5	4	>CSL	2.29	No	Benzo(a)anthracene	2700		µg/kg dw	Yes	120	No	Yes	0.44	1.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3.5-4	3.5	4	>CSL	2.29	No	Chrysene	3100		µg/kg dw	Yes	140	No	Yes	0.3	1.3
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3.5-4	3.5	4	>CSL	2.29	No	Fluoranthene	10000		µg/kg dw	Yes	440	No	Yes	0.37	2.8
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-3.5-4	3.5	4	>CSL	2.29	No	Total HPAHs	25000		µg/kg dw	Yes	1100	No	Yes	0.21	1.1
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-4-6	4	6	>SQS, ≤CSL	1.46	No	Total PCBs	880		µg/kg dw	Yes	60	No	Yes	0.92	5
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-6-8	6	8	>SQS, ≤CSL	2.25	No	Total PCBs	400		µg/kg dw	Yes	18	No	Yes	0.28	1.5
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	No	-	LDW-SC23-8-10.2	8	10.2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC24	1267861	205130	1.2	4	4	1	No	No	-	LDW-SC24-0-1	0	1	>SQS, ≤CSL	1.99	No	Total PCBs	280		µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC24	1267861	205130	1.2	4	4	1	No	No	-	LDW-SC24-1-2	1	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC24	1267861	205130	1.2	4	4	1	No	No	-	LDW-SC24-2-4	2	4	≤SQS												
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0000A	0	2	>CSL	1.99	No	Arsenic	280		mg/kg dw	Yes		Yes	Yes	3	4.9
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0000A	0	2	>CSL	1.99	No	Copper	800		mg/kg dw	Yes		Yes	Yes	2.1	2.1
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0000A	0	2	>CSL	1.99	No	Zinc	1600		mg/kg dw	Yes		Yes	Yes	1.7	3.9
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0000A	0	2	>CSL	1.99	No	Total PCBs	250		µg/kg dw	Yes	13	No	Yes	0.2	1.1
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0000A	0	2	>CSL	1.99	No	BEHP	1200		µg/kg dw	Yes	60	No	Yes	0.77	1.3
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Arsenic	620		mg/kg dw	Yes		Yes	Yes	6.7	11
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Copper	720		mg/kg dw	Yes		Yes	Yes	1.8	1.8
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Lead	630		mg/kg dw	Yes		Yes	Yes	1.2	1.4
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Mercury	1.4		mg/kg dw	Yes		Yes	Yes	2.4	3.4
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Zinc	1400		mg/kg dw	Yes		Yes	Yes	1.5	3.4
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Benzo(g,h,i)perylene	720		µg/kg dw	Yes	49	No	Yes	0.63	1.6
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Chrysene	1700		µg/kg dw	Yes	120	No	Yes	0.26	1.1
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Dibenzo(a,h)anthracene	220		µg/kg dw	Yes	15	No	Yes	0.45	1.3
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Fluoranthene	3400		µg/kg dw	Yes	230	No	Yes	0.19	1.4
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Indeno(1,2,3-cd)pyrene	850		µg/kg dw	Yes	58	No	Yes	0.66	1.7
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Total HPAHs	15100		µg/kg dw	Yes	1000	No	Yes	0.19	1
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	Total PCBs	750		µg/kg dw	Yes	51	No	Yes	0.78	4.3
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	No	-	SD-DR054-0020	2	4	>CSL	1.46	No	BEHP	710		µg/kg dw	Yes	49	No	Yes	0.63	1
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-0-1	0	1	>SQS, ≤CSL	1.94	No	Total PCBs	310		µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-1-2	1	2	>SQS, ≤CSL	1.47	No	Arsenic	91		mg/kg dw	Yes		No	Yes	0.98	1.6
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-1-2	1	2	>SQS, ≤CSL	1.47	No	Zinc	503		mg/kg dw	Yes		No	Yes	0.52	1.2
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-1-2	1	2	>SQS, ≤CSL	1.47	No	Total PCBs	360		µg/kg dw	Yes	24	No	Yes	0.37	2
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-2-4	2	4	>CSL	1.69	No	Arsenic	170		mg/kg dw	Yes		Yes	Yes	1.8	3
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-2-4	2	4	>CSL	1.69	No	Copper	541		mg/kg dw	Yes		Yes	Yes	1.4	1.4
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-2-4	2	4	>CSL	1.69	No	Zinc	750		mg/kg dw	Yes		No	Yes	0.78	1.8
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-2-4	2	4	>CSL	1.69	No	Total PCBs	430		µg/kg dw	Yes	25	No	Yes	0.38	2.1
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-4-6	4	6	>CSL	1.63	No	Arsenic	250		mg/kg dw	Yes		Yes	Yes	2.7	4.4

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-4-6	4	6	>CSL	1.63	No	Copper	663		mg/kg dw	Yes		Yes	Yes	1.7	1.7
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-4-6	4	6	>CSL	1.63	No	Zinc	1420		mg/kg dw	Yes		Yes	Yes	1.5	3.5
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-4-6	4	6	>CSL	1.63	No	Total PCBs	800	J	µg/kg dw	Yes	49	No	Yes	0.75	4.1
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	No	-	LDW-SC25-8-9.1	8	9.1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-0-1	0	1	>SQS, ≤CSL	1.4	No	Total PCBs	280		µg/kg dw	Yes	20	No	Yes	0.31	1.7
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-1-2	1	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-2-4	2	4	>CSL	2.08	No	Arsenic	67		mg/kg dw	Yes		No	Yes	0.72	1.2
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-2-4	2	4	>CSL	2.08	No	Copper	544		mg/kg dw	Yes		Yes	Yes	1.4	1.4
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-2-4	2	4	>CSL	2.08	No	Mercury	0.69	J	mg/kg dw	Yes		Yes	Yes	1.2	1.7
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-2-4	2	4	>CSL	2.08	No	Total PCBs	310		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Arsenic	1890		mg/kg dw	Yes		Yes	Yes	20	33
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Copper	1950		mg/kg dw	Yes		Yes	Yes	5	5
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Lead	1350		mg/kg dw	Yes		Yes	Yes	2.5	3
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Mercury	4.34		mg/kg dw	Yes		Yes	Yes	7.4	11
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Zinc	3700		mg/kg dw	Yes		Yes	Yes	3.9	9
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	1,2-Dichlorobenzene	73		µg/kg dw	Yes	3.9	Yes	Yes	1.7	1.7
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Pentachlorophenol	800		µg/kg dw	Yes		Yes	Yes	1.2	2.2
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Acenaphthene	900		µg/kg dw	Yes	48	No	Yes	0.84	3
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Benzo(a)anthracene	3700		µg/kg dw	Yes	200	No	Yes	0.74	1.8
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Benzo(a)pyrene	2800		µg/kg dw	Yes	150	No	Yes	0.71	1.5
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Benzo(g,h,i)perylene	1000		µg/kg dw	Yes	53	No	Yes	0.68	1.7
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Chrysene	3900		µg/kg dw	Yes	210	No	Yes	0.46	1.9
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Dibenzo(a,h)anthracene	400	J	µg/kg dw	Yes	21	No	Yes	0.64	1.8
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Dibenzofuran	360		µg/kg dw	Yes	19	No	Yes	0.33	1.3
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Fluoranthene	10000		µg/kg dw	Yes	530	No	Yes	0.44	3.3
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Indeno(1,2,3-cd)pyrene	1000		µg/kg dw	Yes	53	No	Yes	0.6	1.6
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Phenanthrene	5600		µg/kg dw	Yes	300	No	Yes	0.63	3
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Total benzofluoranthenes	5200		µg/kg dw	Yes	280	No	Yes	0.62	1.2
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Total HPAHs	38000	J	µg/kg dw	Yes	2000	No	Yes	0.38	2.1
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Total LPAHs	8500	J	µg/kg dw	Yes	450	No	Yes	0.58	1.2
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	Total PCBs	2300		µg/kg dw	Yes	120	Yes	Yes	1.8	10
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-6-8	6	8	>CSL	1.88	No	BEHP	3800		µg/kg dw	Yes	200	Yes	Yes	2.6	4.3
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	No	-	LDW-SC26-11.1-12.1	11.1	12.1	>SQS, ≤CSL	0.912	No	Total PCBs	140		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-0-0.5	0	0.5	>SQS, ≤CSL	1.54	No	Total PCBs	250		µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-0-2	0	2	>CSL	2.24	No	Mercury	0.52		mg/kg dw	Yes		No	Yes	0.88	1.3
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-0-2	0	2	>CSL	2.24	No	Total PCBs	3300		µg/kg dw	Yes	150	Yes	Yes	2.3	13
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-0.5-1	0.5	1	>CSL	1.8	No	Total PCBs	2000		µg/kg dw	Yes	110	Yes	Yes	1.7	9.2
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-1-1.5	1	1.5	>CSL	1.22	No	Total PCBs	3200		µg/kg dw	Yes	260	Yes	Yes	4	22
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-1.5-2	1.5	2	>CSL	1.82	No	Total PCBs	1510		µg/kg dw	Yes	83	Yes	Yes	1.3	6.9
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-2-2.5	2	2.5	>SQS, ≤CSL	2.14	No	Total PCBs	840		µg/kg dw	Yes	39	No	Yes	0.6	3.3
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-2.5-3	2.5	3	>SQS, ≤CSL	2.27	No	Total PCBs	290		µg/kg dw	Yes	13	No	Yes	0.2	1.1
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-3-3.5	3	3.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-3.5-4	3.5	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	No	-	LDW-SC27-4-4.5	4	4.5	≤SQS												

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concentration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-0-1	0	1	>CSL	2.59	No	Arsenic	114		mg/kg dw	Yes		Yes	Yes	1.2	2
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-0-1	0	1	>CSL	2.59	No	Benzyl alcohol	110		µg/kg dw	Yes		Yes	Yes	1.5	1.9
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-0-1	0	1	>CSL	2.59	No	Total PCBs	440		µg/kg dw	Yes	17	No	Yes	0.26	1.4
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-1-2	1	2	>SQS, ≤CSL	2.07	No	Total PCBs	360	J	µg/kg dw	Yes	17	No	Yes	0.26	1.4
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-2-4	2	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Arsenic	760		mg/kg dw	Yes		Yes	Yes	8.2	13
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Copper	1480		mg/kg dw	Yes		Yes	Yes	3.8	3.8
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Lead	583		mg/kg dw	Yes		Yes	Yes	1.1	1.3
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Mercury	0.72		mg/kg dw	Yes		Yes	Yes	1.2	1.8
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Zinc	1880		mg/kg dw	Yes		Yes	Yes	2	4.6
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	1,2-Dichlorobenzene	160		µg/kg dw	Yes	9.9	Yes	Yes	4.3	4.3
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Pentachlorophenol	410		µg/kg dw	Yes		No	Yes	0.59	1.1
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Fluoranthene	4100		µg/kg dw	Yes	250	No	Yes	0.21	1.6
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Phenanthrene	1700		µg/kg dw	Yes	110	No	Yes	0.23	1.1
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	Total PCBs	3200		µg/kg dw	Yes	200	Yes	Yes	3.1	17
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-5.5-7.5	5.5	7.5	>CSL	1.61	No	BEHP	1000		µg/kg dw	Yes	62	No	Yes	0.79	1.3
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	No	-	LDW-SC28-12-12.6	12	12.6	>SQS, ≤CSL	1.31	No	Total PCBs	540		µg/kg dw	Yes	41	No	Yes	0.63	3.4
LDW Subsurface Sediment 2006	LDW-SC29	1268061	204054	1.4	2	3	3	No	No	-	LDW-SC29-0-1	0	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC29	1268061	204054	1.4	2	3	3	No	No	-	LDW-SC29-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC29	1268061	204054	1.4	2	3	3	No	No	-	LDW-SC29-2-3.6	2	3.6	≤SQS												
Glacier NW	SCDMMU3	1268206	204169	1.4	2	3	1	Yes	Yes	2005	SCDMMU3	0	5.6	>CSL	2.27	No	Arsenic	181		mg/kg dw	Yes		Yes	Yes	1.9	3.2
Glacier NW	SCDMMU3	1268206	204169	1.4	2	3	1	Yes	Yes	2005	SCDMMU3	0	5.6	>CSL	2.27	No	Zinc	765		mg/kg dw	Yes		No	Yes	0.8	1.9
Glacier NW	SCDMMU3	1268206	204169	1.4	2	3	1	Yes	Yes	2005	SCDMMU3	0	5.6	>CSL	2.27	No	Total PCBs	630		µg/kg dw	Yes	28	No	Yes	0.43	2.3
Lone Star 92	C-1	1268275	203789	1.5	3	3	1	Yes	Yes	1992	C-1	0	4	>SQS, ≤CSL	2	No	Arsenic	87		mg/kg dw	Yes		No	Yes	0.94	1.5
Lone Star 92	C-1	1268275	203789	1.5	3	3	1	Yes	Yes	1992	C-1	0	4	>SQS, ≤CSL	2	No	Total PCBs	300		µg/kg dw	Yes	15	No	Yes	0.23	1.3
Glacier NW	SCDMMU1	1268338	203745	1.5	3	3	2	Yes	Yes	2005	SCDMMU1	0	2.7	>CSL, ND												
Glacier NW	SCDMMU2	1268280	203995	1.5	2	3	1	Yes	Yes	2005	SCDMMU2	0	2.2	>CSL, ND												
Glacier NW	SCDMMU2R	1268280	203995	1.5	2	3	1	Yes	Yes	2005	SCDMMU2R-Z	3	4	>CSL	2.38	No	Arsenic	63.3		mg/kg dw	Yes		No	Yes	0.68	1.1
Glacier NW	SCDMMU2R	1268280	203995	1.5	2	3	1	Yes	Yes	2005	SCDMMU2R-Z	3	4	>CSL	2.38	No	Mercury	0.6		mg/kg dw	Yes		Yes	Yes	1	1.5
Hardie Gypsum-1	1	1268851	203302	1.6	6	not dredged	1	Yes	Yes	1999	1	0	4	>SQS, ≤CSL, ND												
Hardie Gypsum-1	2	1268883	203173	1.6	4	4	1	Yes	Yes	1999	2	0	4	>SQS, ≤CSL	2.3	No	Total PCBs	290		µg/kg dw	Yes	13	No	Yes	0.2	1.1
Hardie Gypsum-2	2b	1268892	203155	1.6	4	4	1	Yes	Yes	1999	2b	0	3	>SQS, ≤CSL, ND												
Hardie Gypsum-2	A	1268872	203206	1.6	4	4	1	Yes	Yes	1999	A	0	3	≤SQS												
Hardie Gypsum-2	B	1268916	203178	1.6	4	4	1	Yes	Yes	1999	B	0	3	>SQS, ≤CSL, ND												
Lone Star-Hardie Gypsum	c-3	1268925	203167	1.6	4	4	1	Yes	Yes	1995	c-3	0	4.6	>SQS, ≤CSL, ND												
Lone Star-Hardie Gypsum	c-4	1268760	203523	1.6	4	6	3	Yes	Yes	1995	c-4	0	4	>SQS, ≤CSL, ND												
Lone Star-Hardie Gypsum	c-4	1268760	203523	1.6	4	6	3	Yes	Yes	1995	c-5	4	12	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC30	1268784	203576	1.6	4	6	3	No	No	-	LDW-SC30-0-2.5	0	2.5	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC30	1268784	203576	1.6	4	6	3	No	No	-	LDW-SC30-2.5-4	2.5	4	≤SQS												
Hardie Gypsum-1	3 (HG-1)	1268962	202989	1.7	4	4	1	Yes	Yes	1999	4	0	4	>SQS, ≤CSL, ND												
Hardie Gypsum-2	3 (HG-2)	1268958	202981	1.7	4	4	1	Yes	Yes	1999	4	0	3	>SQS, ≤CSL, ND												
Hardie Gypsum-1	4 (HG-1)	1268987	202873	1.7	4	not dredged	1	Yes	Yes	1999	4	0	4	>SQS, ≤CSL	2	No	Hexachlorobenzene	13		µg/kg dw	Yes	0.65	No	Yes	0.28	1.7
Hardie Gypsum-1	4 (HG-1)	1268987	202873	1.7	4	not dredged	1	Yes	Yes	1999	4	0	4	>SQS, ≤CSL	2	No	Total PCBs	300		µg/kg dw	Yes	15	No	Yes	0.23	1.3
Hardie Gypsum-2	4 (HG-2)	1268974	202866	1.7	4	not dredged	1	Yes	Yes	1999	4	0	3	>SQS, ≤CSL, ND												
Hardie Gypsum-1	5 (HG-1)	1268997	202773	1.7	4	not dredged	1	Yes	Yes	1999	5	0	4	>SQS, ≤CSL, ND												
Hardie Gypsum-2	5.2 (HG-2)	1269023	202728	1.7	4	not dredged	1	Yes	Yes	1999	5	0	3	≤SQS												
Hardie Gypsum-2	C	1268981	203013	1.7	4	4	1	Yes	Yes	1999	C	0	3	>SQS, ≤CSL	1.9	No	Phenanthrene	2200		µg/kg dw	Yes	120	No	Yes	0.25	1.2
Lone Star-Hardie Gypsum	c-1	1269036	202783	1.7	4	not dredged	1	Yes	Yes	1995	c-1	0	4	>SQS, ≤CSL, ND												
Lone Star-Hardie Gypsum	c-2	1268972	202971	1.7	4	4	1	Yes	Yes	1995	c-2	0	5	>SQS, ≤CSL, ND												
Hardie Gypsum-2	D	1269020	202886	1.7	4	not dredged	1	Yes	Yes	1999	D	0	3	>SQS, ≤CSL	1.8	No	Mercury	0.43		mg/kg dw	Yes		No	Yes	0.73	1
Hardie Gypsum-2	D	1269020	202886	1.7	4	not dredged	1	Yes	Yes	1999	D	0	3	>SQS, ≤CSL	1.8	No	Total PCBs	1010		µg/kg dw	Yes	56	No	Yes	0.86	4.7
EPA SI	DR101	1269108	202682	1.7	6	6	1	No	No	-	SD-DR101-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR101	1269108	202682	1.7	6	6	1	No	No	-	SD-DR101-0020	2	4	>SQS, ≤CSL	2.34	No	BEHP	1400		µg/kg dw	Yes	60	No	Yes	0.77	1.3
Hardie Gypsum-2	E	1269034	202730	1.7	4	not dredged	1	Yes	Yes	1999	E	0	3	>SQS, ≤CSL	1.5	No	Total PCBs	590		µg/kg dw	Yes	39	No	Yes	0.6	3.3
LDW Subsurface Sediment 2006	LDW-SC31	1268935	203092	1.7	4	4	1	No	No	-	LDW-SC31-0-1	0	1	>SQS, ≤CSL	2.52	No	Total PCBs	370		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC31	1268935	203092	1.7	4	4	1	No	No	-	LDW-SC31-1-2.8	1	2.8	>SQS, ≤CSL	2.18	No	Total PCBs	330		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC31	1268935	203092	1.7	4	4	1	No	No	-	LDW-SC31-2.8-4	2.8	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-0-1	0	1	>SQS, ≤CSL	1.81	No	Total PCBs	1010		µg/kg dw	Yes	56	No	Yes	0.86	4.7
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	Acenaphthene	1400		µg/kg dw	Yes	120	Yes	Yes	2.1	7.5
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	Dibenzofuran	1200		µg/kg dw	Yes	100	Yes	Yes	1.7	6.7

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concentration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	Fluoranthene	2500		µg/kg dw	Yes	220	No	Yes	0.18	1.4
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	Fluorene	1900		µg/kg dw	Yes	160	Yes	Yes	2	7
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	Phenanthrene	3700		µg/kg dw	Yes	320	No	Yes	0.67	3.2
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	Total LPAHs	7500		µg/kg dw	Yes	650	No	Yes	0.83	1.8
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	Total PCBs	1720		µg/kg dw	Yes	150	Yes	Yes	2.3	13
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-1-2	1	2	>CSL	1.16	No	BEHP	650		µg/kg dw	Yes	56	No	Yes	0.72	1.2
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-2-4	2	4	>CSL	1.47	No	Acenaphthene	300		µg/kg dw	Yes	20	No	Yes	0.35	1.3
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-2-4	2	4	>CSL	1.47	No	Total PCBs	2450		µg/kg dw	Yes	170	Yes	Yes	2.6	14
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	No	-	LDW-SC32-5.2-8	5.2	8	>SQS, ≤CSL, ND												
PSDDA99	S1	1268863	202577	1.8	6	6	3	Yes	No	-	S1	0	4	>SQS, ≤CSL, ND												
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-CS-0803	0	3	>CSL	2.59	No	Benzo(a)anthracene	6800		µg/kg dw	Yes	260	No	Yes	0.96	2.4
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-CS-0803	0	3	>CSL	2.59	No	Benzo(a)pyrene	3400		µg/kg dw	Yes	130	No	Yes	0.62	1.3
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-CS-0803	0	3	>CSL	2.59	No	Chrysene	16000		µg/kg dw	Yes	620	Yes	Yes	1.3	5.6
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-CS-0803	0	3	>CSL	2.59	No	Fluoranthene	47000		µg/kg dw	Yes	1800	Yes	Yes	1.5	11
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-CS-0803	0	3	>CSL	2.59	No	Pyrene	34000		µg/kg dw	Yes	1300	No	Yes	0.93	1.3
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-CS-0803	0	3	>CSL	2.59	No	Total benzofluoranthenes	14200		µg/kg dw	Yes	548	Yes	Yes	1.2	2.4
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-CS-0803	0	3	>CSL	2.59	No	Total HPAHs	123000		µg/kg dw	Yes	4750	No	Yes	0.9	4.9
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	Yes	2009	T115-S1-ZA-0803	3	4	>SQS, ≤CSL, ND												
T115	S1-02	1268725	202252	1.8	2	3	1	Yes	Yes	2009	T115-S1-02-ZA-0803	3	4	>SQS, ≤CSL	1.98	No	Chrysene	2600	J	µg/kg dw	Yes	130	No	Yes	0.28	1.2
T115	S1-02	1268725	202252	1.8	2	3	1	Yes	Yes	2009	T115-S1-02-ZA-0803	3	4	>SQS, ≤CSL	1.98	No	Fluoranthene	7400	J	µg/kg dw	Yes	370	No	Yes	0.31	2.3
T115	S1-02	1268725	202252	1.8	2	3	1	Yes	Yes	2009	T115-S1-02-ZA-0803	3	4	>SQS, ≤CSL	1.98	No	Total HPAHs	19500	J	µg/kg dw	Yes	985	No	Yes	0.19	1
T115	S1-02	1268725	202252	1.8	2	3	1	Yes	Yes	2009	T115-S1-02-ZB-0803	4	4.7	>SQS, ≤CSL, ND												
PSDDA99	S2	1268952	202446	1.8	6	6	3	Yes	No	-	S2	0	4	>SQS, ≤CSL, ND												
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	Yes	2009	T115-S2-CS-0803	0	3	>CSL	1.84	No	BEHP	6700	J	µg/kg dw	Yes	360	Yes	Yes	4.6	7.7
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	Yes	2009	T115-S2-01-ZA-0803	3	4	>SQS, ≤CSL	2.23	No	Total PCBs	300		µg/kg dw	Yes	13	No	Yes	0.2	1.1
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	Yes	2009	T115-S2-01-ZB-0803	4	5	>SQS, ≤CSL	1.89	No	Total PCBs	260		µg/kg dw	Yes	14	No	Yes	0.22	1.2
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	Yes	2009	T115-S2-01-ZC-0803	5	6	>SQS, ≤CSL	5.25	Yes	Total PCBs	180		µg/kg dw	Yes		No	Yes	0.18	1.4
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	Yes	2009	T115-S2-02-ZA-0803	3	4	>SQS, ≤CSL	1.6	No	BEHP	1000	J	µg/kg dw	Yes	63	No	Yes	0.81	1.3
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	Yes	2009	T115-S2-02-ZB-0803	4	5	>CSL	5.02	Yes	Chrysene	1500		µg/kg dw	Yes		No	Yes	0.54	1.1
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	Yes	2009	T115-S2-02-ZB-0803	4	5	>CSL	5.02	Yes	Pyrene	4600		µg/kg dw	Yes		Yes	Yes	1.4	1.8
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	Yes	2009	T115-S2-02-ZB-0803	4	5	>CSL	5.02	Yes	Total PCBs	320	J	µg/kg dw	Yes		No	Yes	0.32	2.5
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	Yes	2009	T115-S2-02-ZC-0803	5	6	>SQS, ≤CSL, ND												
PSDDA99	S3	1268980	202348	1.8	6	6	3	Yes	No	-	S3	0	4	>SQS, ≤CSL, ND												
PSDDA99	S4	1269020	202252	1.8	6	6	3	Yes	No	-	S4	0	4	>SQS, ≤CSL, ND												
PSDDA99	S5	1269042	202166	1.8	6	6	3	Yes	No	-	S5	0	4	>SQS, ≤CSL, ND												
PSDDA99	B1	1269154	202036	1.9	6	6	3	Yes	No	-	B1	4	8	>SQS, ≤CSL	1.5	No	Total PCBs	220		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-0-1.5	0	1.5	>CSL	1.88	No	Lead	772		mg/kg dw	Yes		Yes	Yes	1.5	1.7
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-0-1.5	0	1.5	>CSL	1.88	No	Total PCBs	1450		µg/kg dw	Yes	77	Yes	Yes	1.2	6.4
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-1.5-4	1.5	4	>SQS, ≤CSL	1.33	No	Total PCBs	530	J	µg/kg dw	Yes	40	No	Yes	0.62	3.3
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-4-6	4	6	>SQS, ≤CSL	2.13	No	Acenaphthene	710		µg/kg dw	Yes	33	No	Yes	0.58	2.1
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-4-6	4	6	>SQS, ≤CSL	2.13	No	Fluoranthene	5000		µg/kg dw	Yes	230	No	Yes	0.19	1.4
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-4-6	4	6	>SQS, ≤CSL	2.13	No	Fluorene	510		µg/kg dw	Yes	24	No	Yes	0.3	1
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-4-6	4	6	>SQS, ≤CSL	2.13	No	Total PCBs	340		µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	No	-	LDW-SC201-8-10	8	10	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-0-1	0	1	>SQS, ≤CSL	3.27	No	Benzyl alcohol	66		µg/kg dw	Yes		No	Yes	0.9	1.2
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-0-1	0	1	>SQS, ≤CSL	3.27	No	BEHP	1800		µg/kg dw	Yes	55	No	Yes	0.71	1.2
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-0-1	0	1	>SQS, ≤CSL	3.27	No	Butyl benzyl phthalate	380		µg/kg dw	Yes	12	No	Yes	0.19	2.4
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-1-2	1	2	>CSL	2.91	No	BEHP	2600		µg/kg dw	Yes	89	Yes	Yes	1.1	1.9
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-1-2	1	2	>CSL	2.91	No	Butyl benzyl phthalate	400		µg/kg dw	Yes	14	No	Yes	0.22	2.9
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-2-4	2	4	>CSL	2.59	No	Butyl benzyl phthalate	140		µg/kg dw	Yes	5.4	No	Yes	0.084	1.1
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-2-4	2	4	>CSL	2.59	No	Dimethyl phthalate	8800		µg/kg dw	Yes	340	Yes	Yes	6.4	6.4
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	No	-	LDW-SC203-4-6	4	6	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-0-0.5	0	0.5	>SQS, ≤CSL	1.76	No	Total PCBs	490		µg/kg dw	Yes	28	No	Yes	0.43	2.3
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-0-2	0	2	>CSL	3.34	No	Pentachlorophenol	730		µg/kg dw	Yes		Yes	Yes	1.1	2
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-0-2	0	2	>CSL	3.34	No	Total PCBs	3100		µg/kg dw	Yes	93	Yes	Yes	1.4	7.8
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-0.5-1	0.5	1	>SQS, ≤CSL	2.14	No	Total PCBs	790		µg/kg dw	Yes	37	No	Yes	0.57	3.1
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-1-1.5	1	1.5	>CSL	2.53	No	Total PCBs	4700		µg/kg dw	Yes	190	Yes	Yes	2.9	16
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-1.5-2	1.5	2	>CSL	2.42	No	Total PCBs	2500	J	µg/kg dw	Yes	100	Yes	Yes	1.5	8.3
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-2-2.5	2	2.5	>SQS, ≤CSL	1.35	No	Total PCBs	210		µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-2-4	2	4	>SQS, ≤CSL	1.62	No	Total PCBs	420		µg/kg dw	Yes	26	No	Yes	0.4	2.2

Table G-1 Detected SMS Contaminants Exceeding the SQS in Cores — River Miles 0 to 1.9

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-2.5-3	2.5	3	>SQS, ≤CSL	1.98	No	Total PCBs	940		µg/kg dw	Yes	47	No	Yes	0.72	3.9
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-4-6	4	6	>SQS, ≤CSL	2.1	No	Acenaphthene	1000		µg/kg dw	Yes	48	No	Yes	0.84	3
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-4-6	4	6	>SQS, ≤CSL	2.1	No	Dibenzofuran	380		µg/kg dw	Yes	18	No	Yes	0.31	1.2
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-4-6	4	6	>SQS, ≤CSL	2.1	No	Fluorene	630		µg/kg dw	Yes	30	No	Yes	0.38	1.3
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-4-6	4	6	>SQS, ≤CSL	2.1	No	Total PCBs	280		µg/kg dw	Yes	13	No	Yes	0.2	1.1
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	No	-	LDW-SC33-8-10	8	10	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	No	-	LDW-SC34-0-1	0	1	>SQS, ≤CSL	2.9	No	Butyl benzyl phthalate	440		µg/kg dw	Yes	15	No	Yes	0.23	3.1
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	No	-	LDW-SC34-1-2	1	2	>CSL	3.02	No	Benzyl alcohol	210		µg/kg dw	Yes		Yes	Yes	2.9	3.7
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	No	-	LDW-SC34-1-2	1	2	>CSL	3.02	No	BEHP	3900		µg/kg dw	Yes	130	Yes	Yes	1.7	2.8
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	No	-	LDW-SC34-1-2	1	2	>CSL	3.02	No	Butyl benzyl phthalate	400		µg/kg dw	Yes	13	No	Yes	0.2	2.7
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	No	-	LDW-SC34-2-4	2	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC35	1269260	201604	1.9	3	4	3	No	No	-	LDW-SC35-0-2	0	2	>SQS, ≤CSL	1.86	No	Total PCBs	370	J	µg/kg dw	Yes	20	No	Yes	0.31	1.7
LDW Subsurface Sediment 2006	LDW-SC35	1269260	201604	1.9	3	4	3	No	No	-	LDW-SC35-2-4	2	4	≤SQS												
PSDDA99	S10	1269353	201769	1.9	6	6	3	Yes	No	-	S10	0	4	>SQS, ≤CSL, ND												
PSDDA99	S6	1269111	202083	1.9	6	6	3	Yes	No	-	S6	0	4	>SQS, ≤CSL, ND												
PSDDA99	S7	1269130	201979	1.9	outside of AOPCs	outside of AOPCs	3	Yes	No	-	S7	0	4	>SQS, ≤CSL, ND												
PSDDA99	S8	1269220	201915	1.9	6	6	3	Yes	No	-	S8	0	4	>SQS, ≤CSL, ND												
PSDDA99	S9	1269264	201827	1.9	6	6	3	Yes	No	-	S9	0	4	>SQS, ≤CSL, ND												

Notes

a. Datum: NAD 1983 Washington State Plane North (feet).

b. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 2R/2R-CAD, 3R, 4R, 5R/5R-T, and 6R.

c. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 3C, 4C, 5C, and 6C.
Note that if a removal alternative is dredged, but the corresponding combined alternative is not dredged, then the combined alternative is actively remediated with capping or ENR.

d. The column titled "Collected for Dredge Material Characterization" identifies whether cores were collected to support a proposed dredging project. The "yes" entries in this column match the dredging footnotes in the stick diagrams. Much of the information about dredging comes from open water disposal suitability determinations written prior to dredging, not from reports confirming the dredging itself. In those instances where there is no confirmation that the dredging occurred, the "historically dredge" column is populated with "no," and the dredge year is blank. This matches the entries in the FS database.

e. Maximum SMS exceedance status for sample. Delineation matches color coding in stick diagrams.

f. Cells are populated only if sample has detected exceedances of the SQS. Then the TOC and AET substitution describe whether non-polar organic compounds are compared to the SQS/CSL (organic carbon normalized concentration) or the LAET/2LAET (dry weight concentration).

AET = apparent effects threshold; AOPC = area of potential concern; BEHP = bis(2-ethylhexyl)phthalate; CSL = cleanup screening level; LAET = lowest apparent effects threshold (2LAET = 2nd lowest); ND = not detected; oc = organic carbon; PAHs = polycyclic aromatic hydrocarbons; PCB = polychlorinated biphenyl; SMS = Sediment Management Standards; SQS = sediment quality standard; SVOCs = semivolatile organic compounds; TOC = total organic carbon.

Table G-2 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 2.0 to 4.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
PSDDA99	S11	1269400	201666	2.0	4	4	3	Yes	No	-	S11	0	4	>SQS, ≤CSL	2	No	Total PCBs	720		µg/kg dw	Yes	36	No	Yes	0.55	3
PSDDA99	S12	1269510	201597	2.0	4	4	3	Yes	No	-	S12	0	4	>SQS, ≤CSL	2.4	No	Total PCBs	680		µg/kg dw	Yes	28	No	Yes	0.43	2.3
PSDDA99	B2	1269979	201124	2.1	5	not dredged	3	Yes	No	-	B2	4	8	>SQS, ≤CSL	2.1	No	Total PCBs	380		µg/kg dw	Yes	18	No	Yes	0.28	1.5
EPA SI	DR106	1270217	201545	2.1	6	not dredged	3	No	No	-	SD-DR106-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR106	1270217	201545	2.1	6	not dredged	3	No	No	-	SD-DR106-0020	2	4	>SQS, ≤CSL, ND												
EPA SI	DR112	1270202	201166	2.1	4	4	2	No	No	-	SD-DR112-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR112	1270202	201166	2.1	4	4	2	No	No	-	SD-DR112-0020	2	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC202	1269986	201491	2.1	6	not dredged	3	No	No	-	LDW-SC202-0-1	0	1	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC202	1269986	201491	2.1	6	not dredged	3	No	No	-	LDW-SC202-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC202	1269986	201491	2.1	6	not dredged	3	No	No	-	LDW-SC202-2-4	2	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC36	1269990	201489	2.1	6	not dredged	3	No	No	-	LDW-SC36-0-1	0	1	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC36	1269990	201489	2.1	6	not dredged	3	No	No	-	LDW-SC36-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC36	1269990	201489	2.1	6	not dredged	3	No	No	-	LDW-SC36-2-4	2	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-0-1	0	1	>CSL	2.25	No	Arsenic	150		mg/kg dw	Yes		Yes	Yes	1.6	2.6
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-0-1	0	1	>CSL	2.25	No	Total PCBs	450		µg/kg dw	Yes	20	No	Yes	0.31	1.7
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Arsenic	121		mg/kg dw	Yes		Yes	Yes	1.3	2.1
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Mercury	0.45	J	mg/kg dw	Yes		No	Yes	0.76	1.1
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Zinc	490		mg/kg dw	Yes		No	Yes	0.51	1.2
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Benzo(a) anthracene	3100		µg/kg dw	Yes	120	No	Yes	0.44	1.1
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Benzo(a)pyrene	5300		µg/kg dw	Yes	200	No	Yes	0.95	2
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Benzo(g,h,i) perylene	1000		µg/kg dw	Yes	37	No	Yes	0.47	1.2
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Chrysene	4800		µg/kg dw	Yes	180	No	Yes	0.39	1.6
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Dibenzo(a,h) anthracene	360		µg/kg dw	Yes	13	No	Yes	0.39	1.1
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Fluoranthene	4500		µg/kg dw	Yes	170	No	Yes	0.14	1.1
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Indeno(1,2,3-cd)pyrene	1500		µg/kg dw	Yes	56	No	Yes	0.64	1.6
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Total benzofluoranthenes	10200		µg/kg dw	Yes	380	No	Yes	0.84	1.7
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Total HPAHs	40000		µg/kg dw	Yes	1500	No	Yes	0.28	1.6
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-1-2	1	2	>CSL	2.67	No	Total PCBs	950	J	µg/kg dw	Yes	36	No	Yes	0.55	3
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Arsenic	2000		mg/kg dw	Yes		Yes	Yes	22	35
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Copper	2940		mg/kg dw	Yes		Yes	Yes	7.5	7.5
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Lead	3520	J	mg/kg dw	Yes		Yes	Yes	6.6	7.8
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Zinc	4720		mg/kg dw	Yes		Yes	Yes	4.9	12
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	1,2,4-Trichlorobenzene	46		µg/kg dw	Yes	2.1	Yes	Yes	1.2	2.6
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	1,2-Dichlorobenzene	150		µg/kg dw	Yes	6.7	Yes	Yes	2.9	2.9
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Acenaphthene	620		µg/kg dw	Yes	28	No	Yes	0.49	1.8
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Benzo(a) anthracene	4500		µg/kg dw	Yes	200	No	Yes	0.74	1.8
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Benzo(a)pyrene	4000		µg/kg dw	Yes	180	No	Yes	0.86	1.8
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Benzo(g,h,i) perylene	830		µg/kg dw	Yes	37	No	Yes	0.47	1.2
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Chrysene	5000		µg/kg dw	Yes	220	No	Yes	0.48	2
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Dibenzofuran	570		µg/kg dw	Yes	25	No	Yes	0.43	1.7
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Fluoranthene	13000		µg/kg dw	Yes	580	No	Yes	0.48	3.6
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Fluorene	750		µg/kg dw	Yes	33	No	Yes	0.42	1.4
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Indeno(1,2,3-cd)pyrene	1200		µg/kg dw	Yes	54	No	Yes	0.61	1.6
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Phenanthrene	7500		µg/kg dw	Yes	330	No	Yes	0.69	3.3
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Total benzofluoranthenes	9100		µg/kg dw	Yes	410	No	Yes	0.91	1.8
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Total HPAHs	47000		µg/kg dw	Yes	2100	No	Yes	0.4	2.2

Table G-2 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 2.0 to 4.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Total LPAHs	10500	J	µg/kg dw	Yes	470	No	Yes	0.6	1.3
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-2-4	2	4	>CSL	2.24	No	Total PCBs	550		µg/kg dw	Yes	25	No	Yes	0.38	2.1
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	No	-	LDW-SC37-5.3-6.9	5.3	6.9	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	No	-	LDW-SC38-0-1	0	1	>SQS, ≤CSL	1.95	No	Total PCBs	450		µg/kg dw	Yes	23	No	Yes	0.35	1.9
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	No	-	LDW-SC38-1-2	1	2	>SQS, ≤CSL	1.37	No	Total PCBs	710		µg/kg dw	Yes	52	No	Yes	0.8	4.3
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	No	-	LDW-SC38-2-3	2	3	>CSL	1.5	No	Mercury	0.45		mg/kg dw	Yes		No	Yes	0.76	1.1
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	No	-	LDW-SC38-2-3	2	3	>CSL	1.5	No	Acenaphthene	810	J	µg/kg dw	Yes	54	No	Yes	0.95	3.4
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	No	-	LDW-SC38-2-3	2	3	>CSL	1.5	No	Dibenzofuran	250	J	µg/kg dw	Yes	17	No	Yes	0.29	1.1
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	No	-	LDW-SC38-2-3	2	3	>CSL	1.5	No	Total PCBs	3400		µg/kg dw	Yes	230	Yes	Yes	3.5	19
LDW Subsurface Sediment 2006	LDW-SC38b	1269744	200959	2.1	5	6	3	No	No	-	LDW-SC38-3-3.3	3	3.3	>SQS, ≤CSL, ND												
EPA SI	DR137	1270252	200448	2.2	6	not dredged	3	No	No	-	SD-DR137-0000A-CC	0	2	>SQS, ≤CSL	2.46	No	Total PCBs	470	J	µg/kg dw	Yes	19	No	Yes	0.29	1.6
EPA SI	DR137	1270252	200448	2.2	6	not dredged	3	No	No	-	SD-DR137-0020-CC	2	4	>SQS, ≤CSL	2.62	No	Total PCBs	730	J	µg/kg dw	Yes	28	No	Yes	0.43	2.3
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	No	-	LDW-SC39-0-1	0	1	>SQS, ≤CSL	1.02	No	Total PCBs	208		µg/kg dw	Yes	20	No	Yes	0.31	1.7
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	No	-	LDW-SC39-1-2	1	2	>CSL	0.633	No	Total PCBs	440		µg/kg dw	Yes	70	Yes	Yes	1.1	5.8
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	No	-	LDW-SC39-2-4	2	4	>SQS, ≤CSL	1.56	No	Total PCBs	220		µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	No	-	LDW-SC39-4-6	4	6	≤SQS												
PSDDA99	S13	1270426	200645	2.2	outside of AOPCs	outside of AOPCs	3	Yes	No	-	S13	0	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC40	1270303	200332	2.3	2	3	2	No	No	-	LDW-SC40-0-1.3	0	1.3	>SQS, ≤CSL	0.747	No	Total PCBs	160	J	µg/kg dw	Yes	21	No	Yes	0.32	1.8
LDW Subsurface Sediment 2006	LDW-SC40	1270303	200332	2.3	2	3	2	No	No	-	LDW-SC40-1.3-2	1.3	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC40	1270303	200332	2.3	2	3	2	No	No	-	LDW-SC40-2-4	2	4	≤SQS												
Hurlen-Boyer	C5 (Hurlen-Boyer)	1270986	199683	2.4	4	4	1	Yes	No	-	C5	0	3.3	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	No	-	LDW-SC41-0-1	0	1	>SQS, ≤CSL	2.39	No	Total PCBs	370	J	µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	No	-	LDW-SC41-1-2	1	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	No	-	LDW-SC41-2-4	2	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	No	-	LDW-SC41-4-6	4	6	>SQS, ≤CSL	1.89	No	Total PCBs	510		µg/kg dw	Yes	27	No	Yes	0.42	2.3
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	No	-	LDW-SC41-6-7.9	6	7.9	>SQS, ≤CSL	1.38	No	Total PCBs	190		µg/kg dw	Yes	14	No	Yes	0.22	1.2
PSDDA99	S14	1270894	200131	2.4	6	6	3	Yes	No	-	S14	0	4	>SQS, ≤CSL, ND												
Hurlen-Boyer	C6 (Hurlen-Boyer)	1271160	199554	2.5	4	4	2	Yes	No	-	C6	0	3.8	>SQS, ≤CSL	1.52	No	Total PCBs	238		µg/kg dw	Yes	16	No	Yes	0.25	1.3
EPA SI	DR171	1271310	199597	2.5	6	6	3	No	No	-	SD-DR171-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR171	1271310	199597	2.5	6	6	3	No	No	-	SD-DR171-0020	2	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC42	1271361	199898	2.5	6	not dredged	1	No	No	-	LDW-SC42-0-1	0	1	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC42	1271361	199898	2.5	6	not dredged	1	No	No	-	LDW-SC42-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC42	1271361	199898	2.5	6	not dredged	1	No	No	-	LDW-SC42-2-4	2	4	>SQS, ≤CSL, ND												
PSDDA99	S15	1271295	199702	2.5	4	4	3	Yes	No	-	S15	0	4	>SQS, ≤CSL	1.9	No	Total PCBs	240		µg/kg dw	Yes	13	No	Yes	0.2	1.1
BoyerTowing	WRC-SS-B1	1271107	199533	2.5	4	not dredged	3	No	No	-	WRC-SS-B1A-B 1-2'	1	2	≤SQS												
BoyerTowing	WRC-SS-B2	1271101	199571	2.5	4	not dredged	3	No	No	-	WRC-SS-B2A-B 1-2'	1	2	≤SQS												
BoyerTowing	WRC-SS-B3	1271056	199592	2.5	4	not dredged	3	No	No	-	WRC-SS-B3A-B 1-2'	1	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC43	1271846	199289	2.6	2	3	3	No	No	-	LDW-SC43-0-2	0	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC43	1271846	199289	2.6	2	3	3	No	No	-	LDW-SC43-2-4	2	4	≤SQS												
PSDDA99	S16	1271930	199035	2.6	6	6	3	Yes	No	-	S16	0	4	>SQS, ≤CSL, ND												
Hurlen-Boyer	C1 (Hurlen-Boyer)	1271875	198851	2.7	4	4	2	Yes	No	-	C1	0	3.7	>SQS, ≤CSL, ND												
Hurlen-Boyer	C2	1271991	198746	2.7	4	4	1	Yes	No	-	C2	0	4.2	>SQS, ≤CSL	2.28	No	Fluoranthene	5200		µg/kg dw	Yes	230	No	Yes	0.19	1.4
Hurlen-Boyer	C2	1271991	198746	2.7	4	4	1	Yes	No	-	C2	0	4.2	>SQS, ≤CSL	2.28	No	Total HPAHs	22700		µg/kg dw	Yes	1000	No	Yes	0.19	1
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Acenaphthene	2300		µg/kg dw	Yes	93	Yes	Yes	1.6	5.8
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Benzo(a) anthracene	3800		µg/kg dw	Yes	150	No	Yes	0.56	1.4
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Chrysene	3200		µg/kg dw	Yes	130	No	Yes	0.28	1.2
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Dibenzofuran	710		µg/kg dw	Yes	29	No	Yes	0.5	1.9
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Fluoranthene	15000		µg/kg dw	Yes	610	No	Yes	0.51	3.8
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Fluorene	1100		µg/kg dw	Yes	45	No	Yes	0.57	2
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Phenanthrene	5900		µg/kg dw	Yes	240	No	Yes	0.5	2.4
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Total HPAHs	41000		µg/kg dw	Yes	1700	No	Yes	0.32	1.8
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	No	-	C3	0	3.3	>CSL	2.47	No	Total LPAHs	10000		µg/kg dw	Yes	400	No	Yes	0.51	1.1

Table G-2 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 2.0 to 4.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concentration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-0-0.5	0	0.5	>SQS, ≤CSL	1.68	No	Total PCBs	260		µg/kg dw	Yes	15	No	Yes	0.23	1.3
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-0-2	0	2	>SQS, ≤CSL	1.59	No	Total PCBs	510		µg/kg dw	Yes	32	No	Yes	0.49	2.7
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-0.5-1	0.5	1	>SQS, ≤CSL	1.68	No	Total PCBs	880	J	µg/kg dw	Yes	52	No	Yes	0.8	4.3
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-1-1.5	1	1.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-1.5-2	1.5	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-2-2.5	2	2.5	>SQS, ≤CSL	1.94	No	Total PCBs	270		µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-2-3.2	2	3.2	>SQS, ≤CSL	1.9	No	Total PCBs	450		µg/kg dw	Yes	24	No	Yes	0.37	2
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-2.5-3	2.5	3	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-3-3.5	3	3.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	No	-	LDW-SC44-3.2-4	3.2	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	No	-	LDW-SC46-0-1	0	1	>SQS, ≤CSL	1.81	No	Fluoranthene	3900		µg/kg dw	Yes	220	No	Yes	0.18	1.4
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	No	-	LDW-SC46-1-2	1	2	>SQS, ≤CSL	1.42	No	Benzyl alcohol	64	J	µg/kg dw	Yes		No	Yes	0.88	1.1
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	No	-	LDW-SC46-1-2	1	2	>SQS, ≤CSL	1.42	No	Hexachlorobenzene	10		µg/kg dw	Yes	0.7	No	Yes	0.3	1.8
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	No	-	LDW-SC46-1-2	1	2	>SQS, ≤CSL	1.42	No	Fluoranthene	2900		µg/kg dw	Yes	200	No	Yes	0.17	1.3
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	No	-	LDW-SC46-1-2	1	2	>SQS, ≤CSL	1.42	No	Total PCBs	185		µg/kg dw	Yes	13	No	Yes	0.2	1.1
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	No	-	LDW-SC46-2-4	2	4	>SQS, ≤CSL	1.94	No	Total PCBs	270		µg/kg dw	Yes	14	No	Yes	0.22	1.2
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	No	-	LDW-SC46-4-6.8	4	6.8	≤SQS												
Hurlen-Boyer	C4	1272268	198483	2.8	2	3	1	Yes	No	-	C4	0	3.3	>SQS, ≤CSL, ND												
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Benzo(a) anthracene	3600		µg/kg dw	Yes	180	No	Yes	0.67	1.6
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Benzo(a)pyrene	2300		µg/kg dw	Yes	120	No	Yes	0.57	1.2
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Benzo(g,h,i) perylene	980		µg/kg dw	Yes	49	No	Yes	0.63	1.6
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Chrysene	4000		µg/kg dw	Yes	200	No	Yes	0.43	1.8
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Dibenzo(a,h) anthracene	450		µg/kg dw	Yes	23	No	Yes	0.7	1.9
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Fluoranthene	8500		µg/kg dw	Yes	430	No	Yes	0.36	2.7
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Indeno(1,2,3-cd) pyrene	980		µg/kg dw	Yes	49	No	Yes	0.56	1.4
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Phenanthrene	3000		µg/kg dw	Yes	150	No	Yes	0.31	1.5
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Total HPAHs	31500		µg/kg dw	Yes	1600	No	Yes	0.3	1.7
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	Yes	1996	CMS4-5	0	3.9	>SQS, ≤CSL	2	No	Total PCBs	320		µg/kg dw	Yes	16	No	Yes	0.25	1.3
Slip4-Crowley	DMMU 2	1273000	198628	2.8	6	6	3	Yes	Yes	1996	CMS4-1	0	2.8	>SQS, ≤CSL	2.4	No	Total PCBs	860		µg/kg dw	Yes	36	No	Yes	0.55	3
Slip4-Crowley	DMMU 3	1273126	198726	2.8	6	6	3	Yes	Yes	1996	CMS4-2	0	4.3	>SQS, ≤CSL	2.7	No	Total PCBs	640		µg/kg dw	Yes	24	No	Yes	0.37	2
Slip4-Crowley	DMMU 4	1273220	198831	2.8	6	6	3	Yes	Yes	1996	CMS4-3	0	3.9	>SQS, ≤CSL	2.3	No	Total PCBs	980		µg/kg dw	Yes	43	No	Yes	0.66	3.6
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	No	-	LDW-SC45-0-1	0	1	>SQS, ≤CSL	1.48	No	Total PCBs	230	J	µg/kg dw	Yes	16	No	Yes	0.25	1.3
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	No	-	LDW-SC45-1-2	1	2	>SQS, ≤CSL	1.4	No	Total PCBs	270		µg/kg dw	Yes	19	No	Yes	0.29	1.6
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	No	-	LDW-SC45-2-4	2	4	>SQS, ≤CSL	6.88	Yes	Total PCBs	570		µg/kg dw	Yes		No	Yes	0.57	4.4
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	No	-	LDW-SC45-5-6	5	6	≤SQS												
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	No	-	SC06A	0	2	>SQS, ≤CSL	2.39	No	Total PCBs	350	N	µg/kg dw	Yes	15	No	Yes	0.23	1.3
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	No	-	SC06B	2	4	>SQS, ≤CSL	2.34	No	Total PCBs	990	N	µg/kg dw	Yes	42	No	Yes	0.65	3.5
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	No	-	SC06C	4	6	>SQS, ≤CSL	1.59	No	Total PCBs	770	J	µg/kg dw	Yes	48	No	Yes	0.74	4
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	No	-	SC06D	6	8	≤SQS												
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	No	-	SC06E	8	10	≤SQS												
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	No	-	SC08A	0	2	≤SQS												
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	No	-	SC08B	2	4	≤SQS												
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	No	-	SC08C	4	6	≤SQS												
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	No	-	SC08D	6	8	≤SQS												
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	No	-	SC10A	0	2	≤SQS												
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	No	-	SC10B	2	4	≤SQS												
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	No	-	SC10C	4	6	≤SQS												
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	No	-	SC10D	6	8	≤SQS												
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	No	-	SC10E	8	10	≤SQS												
USACE 1990	DU9008XX	1273003	198124	2.9	6	6	3	Yes	No	- -	DUWO&M90S008	0	7	>CSL	2.5	No	Total PCBs	3300		µg/kg dw	Yes	130	Yes	Yes	2	11
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	No	-	SC09A	0	2	≤SQS												
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	No	-	SC09B	2	4	≤SQS												
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	No	-	SC09C	4	6	≤SQS												
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	No	-	SC09D	6	8	≤SQS												
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	No	-	SC09E	8	10	≤SQS												
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	No	-	SC11A	0	2	≤SQS												
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	No	-	SC11B	2	4	≤SQS												
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	No	-	SC11C	4	6	≤SQS												
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	No	-	SC11D	6	8	≤SQS												
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	No	-	SC11E	8	10	≤SQS												
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	No	-	SC11F	10	12	≤SQS												
EPA SI	DR224	1273359	197554	3.0	6	not dredged	1	No	No	-	SD-DR224-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR224	1273359	197554	3.0	6	not dredged	1	No	No	-	SD-DR224-0020	2	3.33	>SQS, ≤CSL, ND												

Table G-2 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 2.0 to 4.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	No	-	LDW-SC47-0-1	0	1	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	No	-	LDW-SC47-1-2	1	2	>CSL	1.75	No	Total PCBs	2000		µg/kg dw	Yes	110	Yes	Yes	1.7	9.2
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	No	-	LDW-SC47-2-3	2	3	>SQS, ≤CSL	1.61	No	Total PCBs	490	J	µg/kg dw	Yes	30	No	Yes	0.46	2.5
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	No	-	LDW-SC47-3-4	3	4	≤SQS												
PSDDA99	S17	1273435	197587	3.0	6	6	1	Yes	No	-	S17	0	4	>SQS, ≤CSL, ND												
USACE 1990	DU9007XX	1273696	197475	3.1	2	4	1	Yes	No	- -	DUWO&M90S007	0	5	>CSL	2.1	No	Total PCBs	2000		µg/kg dw	Yes	100	Yes	Yes	1.5	8.3
PSDDA99	S18	1274190	196895	3.2	6	6	3	Yes	No	-	S18	0	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC48	1274533	196659	3.3	6	6	3	No	No	-	LDW-SC48-0-1	0	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC48	1274533	196659	3.3	6	6	3	No	No	-	LDW-SC48-1-2	1	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC48	1274533	196659	3.3	6	6	3	No	No	-	LDW-SC48-2-4	2	4	≤SQS												
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	No	-	SB5-SED-2.5	0	2.5	>SQS, ≤CSL	1.48	No	Total PCBs	712		µg/kg dw	Yes	48.1	No	Yes	0.74	4
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	No	-	SB5-SED-5	2.5	5	>CSL	1.29	No	Total PCBs	1720		µg/kg dw	Yes	133	Yes	Yes	2	11
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	No	-	SB5-SED-7.5	5	7.5	>SQS, ≤CSL	1.99	No	Total PCBs	830		µg/kg dw	Yes	41.7	No	Yes	0.64	3.5
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	No	-	SB5-SED-50	47.5	50	≤SQS												
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	No	-	SB5-SED-75	72.5	75	>SQS, ≤CSL	0.31	Yes	BEHP	1360	J	µg/kg dw	Yes		No	Yes	0.72	1
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	No	-	SB5-SED-75	72.5	75	>SQS, ≤CSL	0.31	Yes	Butyl benzyl phthalate	365		µg/kg dw	Yes		No	Yes	0.41	5.8
SouthParkMarina	1 & 2	1274844	196140	3.4	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1994	Comp 1	0	4	>CSL, ND												
SouthParkMarina	3 & 4	1274723	196251	3.4	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1994	Comp 2	0	4	>CSL, ND												
USACE 1990	DU9005XX	1274822	196338	3.4	6	6	3	Yes	Yes	1990	DUWO&M90S005	0	7	>SQS, ≤CSL, ND												
USACE 1991	DU9125XX	1274809	196315	3.4	6	6	3	Yes	Yes	1992	DUWO&M91S017	0	4	>SQS, ≤CSL		Yes	Total PCBs	136		µg/kg dw	Yes		No	Yes	0.14	1
PSDDA98	1	1275291	195913	3.5	6	6	3	Yes	Yes	1999	S1	0	2	>SQS, ≤CSL, ND												
USACE 1990	DU9004XX	1275227	195934	3.5	6	6	3	Yes	Yes	1990	DUWO&M90S004	0	7	>SQS, ≤CSL, ND												
USACE 1991	DU9124XX	1275229	195938	3.5	6	6	3	Yes	Yes	1992	DUWO&M91S016	0	4	>SQS, ≤CSL		Yes	Total PCBs	198		µg/kg dw	Yes		No	Yes	0.2	1.5
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	No	-	LDW-SC49-0-1	0	1	>CSL	1.97	No	Benzoic acid	750	J	µg/kg dw	Yes		Yes	Yes	1.2	1.2
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	No	-	LDW-SC49-0-1	0	1	>CSL	1.97	No	Benzyl alcohol	200		µg/kg dw	Yes		Yes	Yes	2.7	3.5
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	No	-	LDW-SC49-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	No	-	LDW-SC49-2-4	2	4	>SQS, ≤CSL	2.05	No	Total PCBs	420		µg/kg dw	Yes	20	No	Yes	0.31	1.7
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	No	-	LDW-SC49-4-6	4	6	>SQS, ≤CSL	2.03	No	Total PCBs	780		µg/kg dw	Yes	38	No	Yes	0.58	3.2
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	No	-	LDW-SC49-6-8	6	8	>SQS, ≤CSL	2.71	No	Total PCBs	810		µg/kg dw	Yes	30	No	Yes	0.46	2.5
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	No	-	LDW-SC49-8-10	8	10	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-0-1	0	1	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-1-2	1	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-2-3	2	3	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-3-4	3	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-4-5	4	5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-5-6	5	6	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-6-7	6	7	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-7-8	7	8	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-8-9	8	9	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-9-10	9	10	>SQS, ≤CSL		Yes	Hexachloro-butadiene	13		µg/kg dw	Yes		No	Yes	0.11	1.2
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-10-11	10	11	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	No	-	LDW-SC49V-11-12	11	12	≤SQS												
T117BoundaryDefinition	T117-SE-91-SC	1275230	195820	3.5	6	not dredged	3	No	No	-	T117-SE91-SC-02	0	2	≤SQS												
T117BoundaryDefinition	T117-SE-93-SC	1275303	195783	3.5	6	not dredged	3	No	No	-	T117-SE93-SC-02	0	2	≤SQS												
T117BoundaryDefinition	T117-SE-94-SC	1275365	195781	3.5	6	6	3	No	No	-	T117-SE94-SC-02	0	2	≤SQS												
T117BoundaryDefinition	T117-SE-COMP1-SC	1275216	195870	3.5	6	not dredged	3	No	No	-	T117-SC-COMP1	0	4	≤SQS												
T117BoundaryDefinition	T117-SE-COMP2and3-SC	1275238	195806	3.5	6	not dredged	3	No	No	-	T117-SC-COMP3	0	2	>SQS, ≤CSL	2.34	No	Total PCBs	980		µg/kg dw	Yes	41.9	No	Yes	0.64	3.5
T117BoundaryDefinition	T117-SE-COMP2and3-SC	1275238	195806	3.5	6	not dredged	3	No	No	-	T117-SC-COMP2	2	4	>SQS, ≤CSL, ND												
T117BoundaryDefinition	T117-SE-COMP4-SC	1275267	195801	3.5	6	not dredged	3	No	No	-	T117-SC-COMP4	0	2	≤SQS												
USACE 1990	DU9002XX	1275794	195492	3.6	4	4	1	Yes	Yes	1990	DUWO&M90S002	0	7	>SQS, ≤CSL	2.7	No	Total PCBs	1100		µg/kg dw	Yes	41	No	Yes	0.63	3.4
USACE 1990	DU9003XX	1275515	195674	3.6	6	6	3	Yes	Yes	1990	DUWO&M90S003	0	7	>SQS, ≤CSL	2.8	No	Pentachlorophenol	400		µg/kg dw	Yes		No	Yes	0.58	1.1
USACE 1990	DU9003XX	1275515	195674	3.6	6	6	3	Yes	Yes	1990	DUWO&M90S003	0	7	>SQS, ≤CSL	2.8	No	Total PCBs	720		µg/kg dw	Yes	26	No	Yes	0.4	2.2
USACE 1991	DU9123XX	1275519	195678	3.6	6	6	3	Yes	Yes	1992	DUWO&M91S015	0	4	>SQS, ≤CSL		Yes	Total PCBs	260		µg/kg dw	Yes		No	Yes	0.26	2

Table G-2 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 2.0 to 4.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	No	-	T117-SE15-SC-01	0	1	>SQS, ≤CSL	2	No	Total PCBs	310		µg/kg dw	Yes	16	No	Yes	0.25	1.3
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	No	-	T117-SE15-SC-12	1	2	>SQS, ≤CSL	1.9	No	Total PCBs	320		µg/kg dw	Yes	17	No	Yes	0.26	1.4
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	No	-	T117-SE15-SC-24	2	4	>SQS, ≤CSL	1.5	No	Total PCBs	216		µg/kg dw	Yes	14	No	Yes	0.22	1.2
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	No	-	T117-SE15-SC-46	4	6	≤SQS												
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	No	-	T117-SE15-SC-68	6	8	≤SQS												
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	No	-	T117-SE15-SC-810	8	10	≤SQS												
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	No	-	T117-SE23-SC-01	0	1	≤SQS												
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	No	-	T117-SE23-SC-12	1	2	≤SQS												
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	No	-	T117-SE23-SC-24	2	4	≤SQS												
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	No	-	T117-SE23-SC-46	4	6	>SQS, ≤CSL	1.3	No	Total PCBs	220		µg/kg dw	Yes	17	No	Yes	0.26	1.4
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	No	-	T117-SE23-SC-68	6	8	≤SQS												
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	No	-	T117-SE23-SC-810	8	10	≤SQS												
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	No	-	T117-SE35-SC-01	0	1	≤SQS												
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	No	-	T117-SE35-SC-12	1	2	>SQS, ≤CSL	1.9	No	Total PCBs	480	J	µg/kg dw	Yes	25	No	Yes	0.38	2.1
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	No	-	T117-SE35-SC-24	2	4	>SQS, ≤CSL	2	No	Total PCBs	920		µg/kg dw	Yes	46	No	Yes	0.71	3.8
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	No	-	T117-SE35-SC-46	4	6	>SQS, ≤CSL	2.6	No	Total PCBs	480	J	µg/kg dw	Yes	18	No	Yes	0.28	1.5
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	No	-	T117-SE35-SC-68	6	8	>SQS, ≤CSL	1.5	No	Total PCBs	210		µg/kg dw	Yes	14	No	Yes	0.22	1.2
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	No	-	T117-SE35-SC-810	8	10	≤SQS												
PSDDA98	2 (98)	1275779	195125	3.7	6	6	1	Yes	Yes	1999	S2	0	2	>SQS, ≤CSL, ND												
USACE 1991	DU9121XX	1275843	194878	3.7	5	5	1	Yes	Yes	1992	DUWO&M91S013	0	4	>SQS, ≤CSL	1.7	No	Total PCBs	260		µg/kg dw	Yes	15	No	Yes	0.23	1.3
USACE 1991	DU9122XX	1275714	195358	3.7	6	6	1	Yes	Yes	1992	DUWO&M91S014	0	3	>SQS, ≤CSL, ND												
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	No	-	T117-SE42-SC-01	0	1	>SQS, ≤CSL	1.3	No	Total PCBs	470		µg/kg dw	Yes	36	No	Yes	0.55	3
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	No	-	T117-SE42-SC-12	1	2	≤SQS												
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	No	-	T117-SE42-SC-24	2	4	≤SQS												
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	No	-	T117-SE42-SC-46	4	6	≤SQS												
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	No	-	T117-SE42-SC-68	6	8	≤SQS												
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	No	-	T117-SE42-SC-810	8	10	>SQS, ≤CSL, ND												
EPA SI	DR220	1276032	194669	3.8	2	3	1	No	No	-	SD-DR220-0000A	0	2	>SQS, ≤CSL	2.42	No	Total PCBs	830		µg/kg dw	Yes	34	No	Yes	0.52	2.8
EPA SI	DR220	1276032	194669	3.8	2	3	1	No	No	-	SD-DR220-0020	2	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	No	-	LDW-SC50-0-1	0	1	>CSL	0.63	No	Arsenic	707		mg/kg dw	Yes		Yes	Yes	7.6	12
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	No	-	LDW-SC50-0-1	0	1	>CSL	0.63	No	Total PCBs	510		µg/kg dw	Yes	81	Yes	Yes	1.2	6.8
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	No	-	LDW-SC50-0-1	0	1	>CSL	0.63	No	BEHP	680		µg/kg dw	Yes	110	Yes	Yes	1.4	2.3
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	No	-	LDW-SC50-1-2	1	2	>CSL	0.816	No	Arsenic	281		mg/kg dw	Yes		Yes	Yes	3	4.9
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	No	-	LDW-SC50-1-2	1	2	>CSL	0.816	No	Total PCBs	780		µg/kg dw	Yes	96	Yes	Yes	1.5	8
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	No	-	LDW-SC50-2-2.8	2	2.8	>CSL	1.18	No	Arsenic	161		mg/kg dw	Yes		Yes	Yes	1.7	2.8
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	No	-	LDW-SC50-2.8-4	2.8	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Benzyl alcohol	180		µg/kg dw	Yes		Yes	Yes	2.5	3.2
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Acenaphthene	350		µg/kg dw	Yes	22	No	Yes	0.39	1.4
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Benzo(g,h,i) perylene	590		µg/kg dw	Yes	37	No	Yes	0.47	1.2
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Chrysene	1900		µg/kg dw	Yes	120	No	Yes	0.26	1.1
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Fluoranthene	4000		µg/kg dw	Yes	250	No	Yes	0.21	1.6
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Indeno(1,2,3-cd)pyrene	690		µg/kg dw	Yes	43	No	Yes	0.49	1.3
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Phenanthrene	2300		µg/kg dw	Yes	140	No	Yes	0.29	1.4
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	Total HPAHs	16100		µg/kg dw	Yes	1000	No	Yes	0.19	1
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-0.5	0	0.5	>CSL	1.61	No	BEHP	970		µg/kg dw	Yes	60	No	Yes	1.3	0.77
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-2	0	2	>CSL	1.47	No	Acenaphthene	380		µg/kg dw	Yes	26	No	Yes	0.46	1.6
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-2	0	2	>CSL	1.47	No	Dibenzofuran	230		µg/kg dw	Yes	16	No	Yes	0.28	1.1
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0-2	0	2	>CSL	1.47	No	Total PCBs	1290		µg/kg dw	Yes	88	Yes	Yes	1.4	7.3
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-0.5-1	0.5	1	>CSL	1.64	No	BEHP	1800		µg/kg dw	Yes	110	Yes	Yes	2.3	1.4
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-1-1.5	1	1.5	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-1.5-2	1.5	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-2-3.8	2	3.8	>SQS, ≤CSL	1.73	No	Total PCBs	700		µg/kg dw	Yes	40	No	Yes	0.62	3.3
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	No	-	LDW-SC51-3.8-5.8	3.8	5.8	≤SQS												
PSDDA98	3	1276037	194297	3.9	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1999	S3	0	2	>SQS, ≤CSL, ND												

Table G-2 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 2.0 to 4.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
8801 E Marginal (formerly KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	No	-	AN042-SC-080211-A	0	1	>CSL	1.55	No	Total PCBs	1500		µg/kg dw	Yes	97	Yes	Yes	1.5	8.1
8801 E Marginal (formerly KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	No	-	AN042-SC-080211-A	0	1	>CSL	1.55	No	Butyl benzyl phthalate	130		µg/kg dw	Yes	8.4	No	Yes	0.13	1.7
8801 E Marginal (formerly KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	No	-	AN042-SC-080211-B	1	2	>CSL	2.1	No	Total PCBs	1400		µg/kg dw	Yes	67	Yes	Yes	1	5.6
8801 E Marginal (formerly KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	No	-	AN042-SC-080211-C	2	3	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	No	-	AN042-SC-080211-D	3	4	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	No	-	AN042-SC-080211-E	4	5	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	No	-	AN042-SC-080211-F	5	5.8	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-A	0	1	>SQS, ≤CSL	1.06	No	Total PCBs	270		µg/kg dw	Yes	25	No	Yes	0.38	2.1
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-A	0	1	>SQS, ≤CSL	1.06	No	Butyl benzyl phthalate	57		µg/kg dw	Yes	5.4	No	Yes	0.084	1.1
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-B	1	2	>CSL	2.86	No	Cadmium	16.9		mg/kg dw	Yes		Yes	Yes	2.5	3.3
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-B	1	2	>CSL	2.86	No	Chromium	514	J	mg/kg dw	Yes		Yes	Yes	1.9	2
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-B	1	2	>CSL	2.86	No	Lead	2530	J	mg/kg dw	Yes		Yes	Yes	4.8	5.6
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-B	1	2	>CSL	2.86	No	Mercury	1.51		mg/kg dw	Yes		Yes	Yes	2.6	3.7
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-B	1	2	>CSL	2.86	No	Zinc	1250		mg/kg dw	Yes		Yes	Yes	1.3	3
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-B	1	2	>CSL	2.86	No	2,4-Dimethyl-phenol	54	J	µg/kg dw	Yes		Yes	Yes	1.9	1.9
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-B	1	2	>CSL	2.86	No	Total PCBs	1800		µg/kg dw	Yes	63	No	Yes	0.97	5.3
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-C	2	3	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-D	3	4	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-E	4	5	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	No	-	AN043-SC-080211-F	5	6	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	No	-	AN044-SC-080211-A	0	1	>CSL	2.3	No	Total PCBs	3000		µg/kg dw	Yes	130	Yes	Yes	2	11
8801 E Marginal (formerly KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	No	-	AN044-SC-080211-A	0	1	>CSL	2.3	No	Butyl benzyl phthalate	240		µg/kg dw	Yes	10	No	Yes	0.16	2
8801 E Marginal (formerly KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	No	-	AN044-SC-080211-B	1	2	>SQS, ≤CSL	2.79	No	Total PCBs	470		µg/kg dw	Yes	17	No	Yes	0.26	1.4
8801 E Marginal (formerly KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	No	-	AN044-SC-080211-C	2	3.5	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	No	-	AN044-SC-080211-D	3.5	4.5	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	No	-	AN044-SC-080211-E	4.5	5.5	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	No	-	AN044-SC-080211-F	5.5	6.5	≤SQS												
USACE 1990	DU9001XX	1276182	193931	3.9	5	5	1	Yes	Yes	1990	DUWO&M90S001	0	5	>SQS, ≤CSL	2.8	No	Pentachloro-phenol	420		µg/kg dw	Yes		No	Yes	0.61	1.2
USACE 1991	DU9119XX	1276190	193943	3.9	5	5	1	Yes	Yes	1992	DUWO&M91S011	0	3	≤SQS												
USACE 1991	DU9120XX	1276091	194345	3.9	6	6	1	Yes	Yes	1992	DUWO&M91S012	0	3	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	No	-	LDW-SC52-0-1	0	1	>CSL	2.37	No	Mercury	0.67		mg/kg dw	Yes		Yes	Yes	1.1	1.6
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	No	-	LDW-SC52-0-1	0	1	>CSL	2.37	No	2-Methylphenol	160		µg/kg dw	Yes		Yes	Yes	2.5	2.5
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	No	-	LDW-SC52-0-1	0	1	>CSL	2.37	No	Total PCBs	3000	J	µg/kg dw	Yes	130	Yes	Yes	2	11
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	No	-	LDW-SC52-0-1	0	1	>CSL	2.37	No	Butyl benzyl phthalate	610		µg/kg dw	Yes	26	No	Yes	0.41	5.3
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	No	-	LDW-SC52-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	No	-	LDW-SC52-2-4	2	4	≤SQS												
PSDDA98	4	1276167	193767	4.0	6	6	1	Yes	Yes	1999	S4	0	2	>SQS, ≤CSL, ND												

Table G-2 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 2.0 to 4.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
8801 E Marginal (formerly KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	No	-	AN041-SC-080211-A	0	1	>CSL	1.58	No	Total PCBs	1060		µg/kg dw	Yes	67.1	Yes	Yes	1	5.6
8801 E Marginal (formerly KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	No	-	AN041-SC-080211-B	1	2	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	No	-	AN041-SC-080211-C	2	3	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	No	-	AN041-SC-080211-D	3	4	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	No	-	AN041-SC-080211-E	4	5	≤SQS												
8801 E Marginal (formerly KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	No	-	AN041-SC-080211-F	5	6	≤SQS												
DuwamYachtClub	C1	1276029	193283	4.0	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C1	0	1.7	>SQS, ≤CSL, ND												
USACE 1991	DU9118XX	1276200	193467	4.0	6	6	3	Yes	Yes	1992	DUWO&M91S010	0	3	>SQS, ≤CSL	1.2	No	Total PCBs	214		µg/kg dw	Yes	18	No	Yes	0.28	1.5
RhônePoulenc2004	SB-13	1276396	193642	4.0	4	not dredged	2	No	No	-	Lower SB-13	0.33	0.69	>SQS, ≤CSL	1.5	No	Dibenzo(a,h) anthracene	300	J	µg/kg dw	Yes	20	No	Yes	0.61	1.7
RhônePoulenc2004	SH-01	1276626	193525	4.0	3	not dredged	3	No	No	-	Lower SH-01	0.33	0.82	>CSL	0.66	No	Pentachloro-phenol	840	J	µg/kg dw	Yes		Yes	Yes	1.2	2.3
RhônePoulenc2004	SH-01	1276626	193525	4.0	3	not dredged	3	No	No	-	Lower SH-01	0.33	0.82	>CSL	0.66	No	Dibenzo(a,h) anthracene	210	J	µg/kg dw	Yes	32	No	Yes	0.97	2.7
RhônePoulenc2004	SH-01	1276626	193525	4.0	3	not dredged	3	No	No	-	Lower SH-01	0.33	0.82	>CSL	0.66	No	Total PCBs	130		µg/kg dw	Yes	20	No	Yes	0.31	1.7
RhônePoulenc2004	SH-01	1276626	193525	4.0	3	not dredged	3	No	No	-	Lower SH-01	0.33	0.82	>CSL	0.66	No	Diethyl phthalate	2700		µg/kg dw	Yes	410	Yes	Yes	3.7	6.7
RhônePoulenc2004	SH-02	1276644	193476	4.0	3	not dredged	3	No	No	-	Lower SH-02	0.33	0.82	>SQS, ≤CSL	1.45	No	Dibenzo(a,h) anthracene	380	J	µg/kg dw	Yes	26	No	Yes	0.79	2.2
RhônePoulenc2004	SH-02	1276644	193476	4.0	3	not dredged	3	No	No	-	Lower SH-02	0.33	0.82	>SQS, ≤CSL	1.45	No	Total PCBs	300		µg/kg dw	Yes	21	No	Yes	0.32	1.8
RhônePoulenc2004	SH-02	1276644	193476	4.0	3	not dredged	3	No	No	-	Lower SH-02	0.33	0.82	>SQS, ≤CSL	1.45	No	Di-n-octyl phthalate	2000		µg/kg dw	Yes	140	No	Yes	0.031	2.4

Notes

a. datum: NAD 1983 Washington State Plane North (Feet).

b. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 2R/2R-CAD, 3R, 4R, 5R/5R-T, and 6R.

c. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 3C, 4C, 5C, and 6C.

Note that if a removal alternative is dredged, but the corresponding combined alternative is not dredged, then the combined alternative is actively remediated with capping or ENR

d. The column titled "Collected for Dredge Material Characterization" identifies whether cores were collected to support a proposed dredging project. The "yes" entries in this column match the dredging footnotes in the stick diagrams. Much of the information about dredging comes from open water disposal suitability determinations written prior to dredging not from reports confirming the dredging itself. In those instances where there is no confirmation that the dredging occurred, the "historically dredge" column is populated with "no," and the dredge year is blank. This matches the entries in the FS database

e. Maximum SMS exceedance status for sample. Delineation matches color coding in stick diagrams.

f. Cells are populated only if sample has detected exceedances of the SQS. Then the TOC and AET substitution describe whether non-polar organic compounds are compared to the SQS/CSL (organic carbon normalized concentration) or the LAET/2LAET (dry weight concentration)

AET = apparent effects threshold; AOPC = area of potential concern; BEHP = bis(2-ethylhexyl)phthalate; CSL = cleanup screening level; LAET = lowest apparent effects threshold (2LAET = 2nd lowest); ND = not detected; oc = organic carbon; PAHs = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl; SMS = Sediment Management Standards; SQS = sediment quality standard; SVOCs = semivolatile organic compounds; TOC = total organic carbon

Table G-3 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 4.1 to 5.0

Core Information											Sample Information							Detected SMS Contaminants Exceeding the SQS										
Study	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
PSDDA98	5	1276295	193292	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	S5	0	2	>SQS, ≤CSL, ND												
DuwamYachtClub	C2	1276060	193153	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C2	0	1.8	>SQS, ≤CSL, ND												
DuwamYachtClub	C3	1276097	193033	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C3	0	1.7	>SQS, ≤CSL, ND												
DuwamYachtClub	C4	1276116	192985	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C4	0	1.8	>SQS, ≤CSL, ND												
DuwamYachtClub	C5	1276185	192853	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C5	0	1.7	>SQS, ≤CSL, ND												
DuwamYachtClub	C6	1276095	192761	4.1	6	not dredged	3	Yes	Yes	1999	C6	0	2.2	>SQS, ≤CSL, ND												
LDW Turning Basin 08	D08	1276400	192844	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D08-C	0	4.2	≤SQS												
LDW Turning Basin 08	D09 (08)	1276360	192966	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D09-C	0	5.2	≤SQS												
LDW Turning Basin 09	D09 (09)	1276360	192966	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR09R-B-D09-C	0	4.4	≤SQS												
LDW Turning Basin 08	D10	1276350	193086	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D10-C	0	4.9	≤SQS												
LDW Turning Basin 08	D11 (08)	1276330	193196	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D11-C	0	5.1	≤SQS												
LDW Turning Basin 09	D11 (09)	1276330	193196	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR09R-B-D11-C	0	4.2	≤SQS												
LDW Turning Basin 08	D12	1276281	193320	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D12-C	0	3.2	≤SQS												
LDW Turning Basin 08	D14	1276335	193122	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D14-C	5.2	6.2	≤SQS												
EPA SI	DR284	1276300	192823	4.1	outside of AOPCs	outside of AOPCs	3	No	No	-	SD-DR284-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR284	1276300	192823	4.1	outside of AOPCs	outside of AOPCs	3	No	No	-	SD-DR284-0020	2	4	>SQS, ≤CSL, ND												
USACE 1991	DU9115XX	1276329	192919	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91S007	0	4	>SQS, ≤CSL, ND												
USACE 1991	DU9116XX	1276287	193084	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91S008	0	4	>SQS, ≤CSL	1.9	No	Total PCBs	600		µg/kg dw	Yes	30	No	Yes	0.46	2.5
USACE 1991	DU9117XX	1276242	193271	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91S009	0	4	>SQS, ≤CSL, ND												
RhônePoulenc2004	SB-12	1276488	193172	4.1	3	not dredged	3	No	No	-	Lower SB-12	0.33	0.69	>CSL	1.79	No	Benzoic acid	1300	J	µg/kg dw	Yes		Yes	Yes	2	2
RhônePoulenc2004	SB-12	1276488	193172	4.1	3	not dredged	3	No	No	-	Lower SB-12	0.33	0.69	>CSL	1.79	No	Dibenzo(a,h)anthracene	380	J	µg/kg dw	Yes	21	No	Yes	0.64	1.8
RhônePoulenc2004	SH-03	1276647	193427	4.1	3	not dredged	3	No	No	-	Lower SH-03	0.33	0.82	>CSL, ND												
RhônePoulenc2004	SH-04	1276680	193285	4.1	3	6	3	No	No	-	Lower SH-04	0.33	0.82	>CSL	0.61	No	Pentachlorophenol	930	J	µg/kg dw	Yes		Yes	Yes	1.3	2.6
RhônePoulenc2004	SH-04	1276680	193285	4.1	3	6	3	No	No	-	Lower SH-04	0.33	0.82	>CSL	0.61	No	Dibenzo(a,h)anthracene	230	J	µg/kg dw	Yes	38	Yes	Yes	1.2	3.2
RhônePoulenc2004	SH-04	1276680	193285	4.1	3	6	3	No	No	-	Lower SH-04	0.33	0.82	>CSL	0.61	No	Total PCBs	2500		µg/kg dw	Yes	410	Yes	Yes	6.3	34
RhônePoulenc2004	SH-05	1276691	193156	4.1	3	5	3	No	No	-	Lower SH-05	0.33	0.82	≤SQS												
RhônePoulenc2004	SH-06	1276761	192921	4.1	2	3	1	No	No	-	Lower SH-06	0.33	0.82	>CSL, ND												
LDW Turning Basin 08	ST21	1276490	192863	4.1	2	3	1	Yes	Yes	2010	DR08-B-ST21-C0-2	0	2	≤SQS												
LDW Turning Basin 08	ST21	1276490	192863	4.1	2	3	1	Yes	Yes	2010	DR08-B-ST21-C2-5	2	5	≤SQS												
LDW Turning Basin 08	ST22	1276450	192975	4.1	6	6	3	Yes	Yes	2010	DR08-B-ST22-C0-2	0	2	≤SQS												
LDW Turning Basin 08	ST22	1276450	192975	4.1	6	6	3	Yes	Yes	2010	DR08-B-ST22-C2-5	2	5	>CSL	2.7	No	Mercury	1.8		mg/kg dw	Yes		Yes	Yes	3.1	4.4
LDW Turning Basin 08	ST23	1276430	193096	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-ST23-C0-2	0	2	≤SQS												
LDW Turning Basin 08	ST23	1276430	193096	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-ST23-C2-5	2	5	≤SQS												
LDW Turning Basin 08	ST28	1276250	193065	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-ST28-C0-2	0	2	≤SQS												
LDW Turning Basin 08	ST28	1276250	193065	4.1	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-ST28-C2-5	2	5	≤SQS												
PSDDA96	6 (96)	1276510	192364	4.2	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1999	S3	0	4	>SQS, ≤CSL, ND												
PSDDA98	6 (98)	1276452	192612	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	S6	0	2	>SQS, ≤CSL, ND												
PSDDA98	7 (98)	1276534	192326	4.2	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1999	S7	0	3	>SQS, ≤CSL, ND												
LDW Turning Basin 08	D04 (08)	1276510	192418	4.2	outside of AOPCs	outside of AOPCs	1	Yes	Yes	2010	DR08-B-D04-C	0	4.7	≤SQS												
LDW Turning Basin 09	D04 (09)	1276510	192418	4.2	outside of AOPCs	outside of AOPCs	1	Yes	Yes	2010	DR09R-B-D04-C	0	5.5	≤SQS												
LDW Turning Basin 08	D05	1276490	192506	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D05-C	0	4.9	≤SQS												
LDW Turning Basin 08	D06 (08)	1276470	192610	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D06-C	0	4.4	≤SQS												
LDW Turning Basin 09	D06 (09)	1276470	192610	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR09R-B-D06-C	0	5.3	≤SQS												
LDW Turning Basin 08	D07	1276440	192730	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D07-C	0	4.5	≤SQS												
LDW Turning Basin 08	D13	1276491	192512	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-B-D13-C	4.9	5.9	≤SQS												
LDW Turning Basin 09	D15	1276467	192514	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR09-B-D15-C0-3	0	2.5	≤SQS												
LDW Turning Basin 09	D15	1276467	192514	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR09-B-D15-Z	2.5	3.5	>SQS, ≤CSL, ND												
Delta Marine	DMMU 1	1276241	192572	4.2	6	not dredged	1	Yes	Yes	2008	DMMU 1	0	7	>SQS, ≤CSL, ND												
Delta Marine	DMMU 3	1276355	192576	4.2	6	6	1	Yes	Yes	2008	DMMU 3	1	7	>SQS, ≤CSL, ND												
Delta Marine	DMMU 4	1276391	192408	4.2	6	6	1	Yes	Yes	2008	DMMU 4	1.3	7.5	>SQS, ≤CSL, ND												
EPA SI	DR246	1276783	192615	4.2	4	4	1	No	No	-	SD-DR246-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR246	1276783	192615	4.2	4	4	1	No	No	-	SD-DR246-0020	2	4	>SQS, ≤CSL, ND												
USACE 1991	DU9111XX	1276455	192388	4.2	6	6	3	Yes	Yes	1992	DUWO&M91S003	0	3	>SQS, ≤CSL, ND												
USACE 1991	DU9112XX	1276485	192405	4.2	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1992	DUWO&M91S004	0	3	>SQS, ≤CSL	1.4	No	BEHP	1000		µg/kg dw	Yes	70	No	Yes	0.9	1.5
USACE 1991	DU9113XX	1276409	192563	4.2	6	6	3	Yes	Yes	1992	DUWO&M91S005	0	5	>SQS, ≤CSL, ND												
USACE 1991	DU9114XX	1276360	192762	4.2	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91S006	0	4	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC53	1277459	192928	4.2	2	3	1	No	No	-	LDW-SC53-0-2	0	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC53	1277459	192928	4.2	2	3	1	No	No	-	LDW-SC53-2-4	2	4	>SQS, ≤CSL, ND												
RhônePoulenc2004	SB-1	1277485	192933	4.2	3	3	1	No	No	-	Lower SB-01	0.33	0.69	>SQS, ≤CSL	2.5	SQS	Benzo(g,h,i)perylene	860		µg/kg dw	Yes	34	No	Yes	0.44	1.1
RhônePoulenc2004	SB-1	1277485	192933	4.2	3	3	1	No	No	-	Lower SB-01	0.33	0.69	>SQS, ≤CSL	2.5	SQS	Dibenzo(a,h)anthracene	630	J	µg/kg dw	Yes	25	No	Yes	0.76	2.1
RhônePoulenc2004	SB-1	1277485	192933	4.2	3	3	1	No	No	-	Lower SB-01	0.33	0.69	>SQS, ≤CSL	2.5	SQS	Indeno(1,2,3-cd)pyrene	970		µg/kg dw	Yes	39	No	Yes	0.44	1.1
RhônePoulenc2004	SB-1	1277485	192933	4.2	3	3	1	No	No	-	Lower SB-01	0.33	0.69	>SQS, ≤CSL	2.5	SQS	BEHP	1600		µg/kg dw	Yes	64	No	Yes	0.82	1.4
RhônePoulenc2004	SB-11	1276515	192835	4.2	2	3	1	No	No	-	Lower SB-11	0.33	0.69	>CSL	2.26	SQS	Benzoic acid	1200	J	µg/kg dw	Yes		Yes	Yes	1.8	1.8
RhônePoulenc2004	SB-11	1276515	192835	4.2	2	3	1	No	No	-	Lower SB-11	0.33	0.69	>CSL	2.26	SQS	Dibenzo(a,h)anthracene	320	J	µg/kg dw	Yes	14	No	Yes	0.42	1.2
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	No	-	Lower SB-16	0.33	0.69	>CSL	3.71	SQS	Benzoic acid	2000	J	µg/kg dw	Yes		Yes	Yes	3.1	3.1
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	No	-	Lower SB-17	0.33	0.69	>CSL	3.32	SQS	Benzoic acid	1800	J	µg/kg dw	Yes		Yes	Yes	2.8	2.8
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	No	-	Lower SB-16	0.33	0.69	>CSL	3.71	SQS	Phenol	480		µg/kg dw	Yes		No	Yes	0.4	1.1
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	No	-	Lower SB-16	0.33	0.69	>CSL	3.71	SQS	Dibenzo(a,h)anthracene	630	J	µg/kg dw	Yes	17	No	Yes	0.52	1.4
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	No	-	Lower SB-17	0.33	0.69	>CSL	3.32	SQS	Dibenzo(a,h)anthracene	660	J	µg/kg dw	Yes	20	No	Yes	0.61	1.7
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	No	-	Lower SB-16	0.33	0.69	>CSL	3.71	SQS	BEHP	1800		µg/kg dw	Yes	49	No	Yes	0.63	1
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	No	-	Lower SB-17	0.33	0.69	>CSL	3.32	SQS	BEHP	1800		µg/kg dw	Yes	54	No	Yes	0.69	1.1
RhônePoulenc2004	SB-2	1277003	192646	4.2	4	4	1	No	No	-	Lower SB-02	0.33	0.69	>SQS, ≤CSL	2.32	SQS	Dibenzo(a,h)anthracene	380	J	µg/kg dw	Yes	16	No	Yes	0.48	1.3
RhônePoulenc2004	SB-2	1277003	192646	4.2	4	4	1	No	No	-	Lower SB-15	0.33	0.69	>SQS, ≤CSL	2.29	SQS	Dibenzo(a,h)anthracene	410	J	µg/kg dw	Yes	18	No	Yes	0.55	1.5
RhônePoulenc2004	SB-3	1277422	192973	4.2	2	3	2	No	No	-	Lower SB-03	0.33	0.69	>CSL	2.94	SQS	Benzoic acid	2000	J	µg/kg dw	Yes		Yes	Yes	3.1	3.1
RhônePoulenc2004	SB-3	1277422	192973	4.2	2	3	2	No	No	-	Lower SB-03	0.33	0.69	>CSL	2.94	SQS	Phenol	3100		µg/kg dw	Yes		Yes	Yes	2.6	7.4
RhônePoulenc2004	SB-3	1277422	192973	4.2	2	3	2	No	No	-	Lower SB-03	0.33	0.69	>CSL	2.94	SQS	Dibenzo(a,h)anthracene	540	J	µg/kg dw	Yes	18	No	Yes	0.55	1.5
RhônePoulenc2004	SB-3	1277422	192973	4.2	2	3	2	No	No	-	Lower SB-03	0.33	0.69	>CSL	2.94	SQS	BEHP	2100		µg/kg dw	Yes	71	No	Yes	0.91	1.5
RhônePoulenc2004	SB-4	1277315	192933	4.2	2	3	2	No	No	-	Lower SB-04	0.33	0.69	>CSL	3.44	SQS	Benzoic acid	1700	J	µg/kg dw	Yes		Yes	Yes	2.6	2.6
RhônePoulenc2004	SB-4	1277315	192933	4.2	2	3	2	No	No	-	Lower SB-04	0.33	0.69	>CSL	3.44	SQS	Dibenzo(a,h)anthracene	490	J	µg/kg dw	Yes	14	No	Yes	0.42	1.2
RhônePoulenc2004	SB-4	1277315	192933	4.2	2	3	2	No	No	-	Lower SB-04	0.33	0.69	>CSL	3.44	SQS	BEHP	1700		µg/kg dw	Yes	49	No	Yes	0.63	1
RhônePoulenc2004	SB-5	1277209	192892	4.2	2	3	2	No	No	-	Lower SB-05	0.33	0.69	>CSL	2.9	SQS	Benzoic acid	1800	J	µg/kg dw	Yes		Yes	Yes	2.8	2.8
RhônePoulenc2004	SB-5	1277209	192892	4.2	2	3	2	No	No	-	Lower SB-05	0.33	0.69	>CSL	2.9	SQS	Dibenzo(a,h)anthracene	420	J	µg/kg dw	Yes	14	No	Yes	0.42	1.2
RhônePoulenc2004	SB-5	1277209	192892	4.2	2	3	2	No	No	-	Lower SB-05	0.33	0.69	>CSL	2.9	SQS	BEHP	1600		µg/kg dw	Yes	55	No	Yes	0.71	1.2
RhônePoulenc2004	SB-6	1277116	192857	4.2	4	4	2	No	No	-	Lower SB-06	0.33	0.69	>CSL	2.98	SQS	Benzoic acid	1800	J	µg/kg dw	Yes		Yes	Yes	2.8	2.8
RhônePoulenc2004	SB-6	1277116	192857	4.2	4	4	2	No	No	-	Lower SB-06	0.33	0.69	>CSL	2.98	SQS	Dibenzo(a,h)anthracene	420	J	µg/kg dw	Yes	14	No	Yes	0.42	1.2
RhônePoulenc2004	SB-7	1276950	192774	4.2	4	4	2	No	No	-	Lower SB-07	0.33	0.69	>CSL	2.92	SQS	Benzoic acid	1700	J	µg/kg dw	Yes		Yes	Yes	2.6	2.6
RhônePoulenc2004	SB-7	1276950	192774	4.2	4	4	2	No	No	-	Lower SB-07	0.33	0.69	>CSL	2.92	SQS	Dibenzo(a,h)anthracene	410	J	µg/kg dw	Yes	14	No	Yes	0.42	1.2
RhônePoulenc2004	SB-7	1276950	192774	4.2	4	4	2	No	No	-	Lower SB-07	0.33	0.69	>CSL	2.92	SQS	BEHP	1400		µg/kg dw	Yes	48	No	Yes	0.62	1
RhônePoulenc2004	SB-8	1276869	192749	4.2	2	3	2	No	No	-	Lower SB-08	0.33	0.69	>CSL	2.48	SQS	Benzoic acid	1500	J	µg/kg dw	Yes		Yes	Yes	2.3	2.3
RhônePoulenc2004	SB-8	1276869	192749	4.2	2	3	2	No	No	-	Lower SB-08	0.33	0.69	>CSL	2.48	SQS	Dibenzo(a,h)anthracene	410	J	µg/kg dw	Yes	17	No	Yes	0.52	1.4
RhônePoulenc2004	SH-07	1276783	192891	4.2	2	3	1	No	No	-	Lower SH-07	0.33	0.82	>CSL	0.473	SQS	Benzoic acid	930	J	µg/kg dw	Yes		Yes	Yes	1.4	1.4
RhônePoulenc2004	SH-08	1276796	192834	4.2	2	3	1	No	No	-	Lower SH-08	0.33	0.82	>SQS, ≤CSL	1.1	SQS	Dibenzo(a,h)anthracene	310	J	µg/kg dw	Yes	28	No	Yes	0.85	2.3
RhônePoulenc2004	SH-09	1276766	192833	4.2	3	3	1	No	No	-	Lower SH-09	0.33	0.82	>CSL, ND												

Table G-3 Detected SMS Contaminants Exceeding the SQS in Cores – River Miles 4.1 to 5.0

Core Information											Sample Information						Detected SMS Contaminants Exceeding the SQS									
Study	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area is First Dredged[b]	FS Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?[d]	Historically Dredged?[d]	Dredge Year[d]	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	SMS Assignment for Sample (maximum exceedance status in sample)[e]	TOC[f]	AET Substitution?[f]	SMS Contaminant	Concen-tration	Qualifier	Unit	Detected	OC-Normalized Concentration (mg/kg oc), if applicable	Exceeds CSL/2LAET?	Exceeds SQS/LAET?	Exceedance Factor CSL	Exceedance Factor SQS
LDW Turning Basin 08	ST31	1276320	192713	4.2	6	6	1	Yes	Yes	2010	DR08-B-ST31-C0-2	0	2	≤SQS												
LDW Turning Basin 08	ST31	1276320	192713	4.2	6	6	1	Yes	Yes	2010	DR08-B-ST31-C2-5	2	5	≤SQS												
PSDDA96	4 (96)	1276677	192025	4.3	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1999	S1	0	4	>SQS, ≤CSL, ND												
PSDDA96	5 (96)	1276557	192210	4.3	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1999	S2	0	4	>SQS, ≤CSL, ND												
LDW Turning Basin 08	D03 (08)	1276540	192295	4.3	outside of AOPCs	outside of AOPCs	1	Yes	Yes	2010	DR08-B-D03-C	0	4.3	≤SQS												
LDW Turning Basin 09	D03 (09)	1276540	192295	4.3	outside of AOPCs	outside of AOPCs	1	Yes	Yes	2010	DR09R-B-D03-C	0	3.7	≤SQS												
USACE 1991	DU9109XX	1276581	191917	4.3	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91S001	0	5	>SQS, ≤CSL, ND												
USACE 1991	DU9110XX	1276557	192034	4.3	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1992	DUWO&M91S002	0	5	>CSL	0.6	No	BEHP	980		µg/kg dw	Yes	160	Yes	Yes	2.1	3.4
LDW Subsurface Sediment 2006	LDW-SC54	1276355	192181	4.3	6	6	1	No	No	-	LDW-SC54-0-2	0	2	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC54	1276355	192181	4.3	6	6	1	No	No	-	LDW-SC54-2-4	2	4	≤SQS												
PSDDA98	Average Of 8-9	1276772	191322	4.4	outside of AOPCs	outside of AOPCs	1	Yes	Yes	1999	C1	0	2	>SQS, ≤CSL, ND												
LDW Turning Basin 08	D02 (08)	1276735	191454	4.4	outside of AOPCs	outside of AOPCs	1	Yes	Yes	2010	DR08-A-D02-S	0	0.62	≤SQS												
LDW Turning Basin 09	D02 (09)	1276735	191454	4.4	outside of AOPCs	outside of AOPCs	1	Yes	Yes	2010	DR09R-A-D02-C	0	11.6	>CSL		No	Benzyl alcohol	150	J	µg/kg dw	Yes		Yes	Yes	2.1	2.6
Turning-basin	DTB-01SD	1276666	191599	4.4	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2004	DTB-01SD	0	4.8	≤SQS												
Turning-basin	DTB-02SD	1276813	191026	4.5	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2004	DTB-02SD	0	6.1	≤SQS												
USACE 1991	DU9105MC	1276829	190964	4.5	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91C002	0	4	>SQS, ≤CSL, ND												
PSDDA98	Average Of 10-12	1277162	190420	4.6	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C2	0	4	>SQS, ≤CSL	2.5	No	Phenanthrene	3400		µg/kg dw	Yes	140	No	Yes	0.29	1.4
PSDDA98	Average Of 10-12	1277162	190420	4.6	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C3	4	11	>SQS, ≤CSL, ND												
PSDDA96	C1 (96)	1276974	190762	4.6	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1999	C1	0	4	>SQS, ≤CSL, ND												
LDW Turning Basin 08	D01 (08)	1277173	190473	4.6	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR08-A-D01-S	0	0.62	≤SQS												
LDW Turning Basin 09	D01 (09)	1277173	190473	4.6	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2010	DR09R-A-D01-C	0	12.9	≤SQS												
EPA SI	DR269	1276822	190328	4.6	outside of AOPCs	outside of AOPCs	3	No	No	-	SD-DR269-0000A	0	2	>SQS, ≤CSL, ND												
EPA SI	DR269	1276822	190328	4.6	outside of AOPCs	outside of AOPCs	3	No	No	-	SD-DR269-0020	2	4	>SQS, ≤CSL, ND												
Turning-basin	DTB-03SD	1276961	190722	4.6	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2004	DTB-03SD	0	6.5	≤SQS												
Turning-basin	DTB-04SD	1277106	190448	4.6	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2004	DTB-04SD	0	13	>SQS, ≤CSL, ND												
Turning-basin	DTB-05SD	1277259	190358	4.7	outside of AOPCs	outside of AOPCs	3	Yes	Yes	2004	DTB-05SD	0	8.8	≤SQS												
USACE 1991	DU9101MC	1277266	190358	4.7	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91C001	0	4	>SQS, ≤CSL, ND												
USACE 1991	DU9101MC	1277266	190358	4.7	outside of AOPCs	outside of AOPCs	3	Yes	Yes	1992	DUWO&M91C003	4	14	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC56	1277575	190022	4.7	3	3	1	No	No	-	LDW-SC56-0-2	0	2	>SQS, ≤CSL	1.67	No	Total PCBs	330		µg/kg dw	Yes	20	No	Yes	0.31	1.7
LDW Subsurface Sediment 2006	LDW-SC56	1277575	190022	4.7	3	3	1	No	No	-	LDW-SC56-2-4	2	4	≤SQS												
LDW Subsurface Sediment 2006	LDW-SC55	1278267	190390	4.9	2	3	0	No	No	-	LDW-SC55-0-1	0	1	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC55	1278267	190390	4.9	2	3	0	No	No	-	LDW-SC55-1-2	1	2	>SQS, ≤CSL, ND												
LDW Subsurface Sediment 2006	LDW-SC55	1278267	190390	4.9	2	3	0	No	No	-	LDW-SC55-2-3	2	3	>SQS, ≤CSL, ND												
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-8	0	0.98	>CSL	0.29	Yes	1,4-Dichlorobenzene	750	J	µg/kg dw	Yes		Yes	Yes	6.3	6.8
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-8	0	0.98	>CSL	0.29	Yes	n-Nitrosodiphenylamine	33		µg/kg dw	Yes		No	Yes	0.83	1.2
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-8	0	0.98	>CSL	0.29	Yes	Indeno(1,2,3-cd)pyrene	630	J	µg/kg dw	Yes		No	Yes	0.91	1.1
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-8	0	0.98	>CSL	0.29	Yes	BEHP	1400		µg/kg dw	Yes		No	Yes	0.74	1.1
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-8	0	0.98	>CSL	0.29	Yes	Butyl benzyl phthalate	130		µg/kg dw	Yes		No	Yes	0.14	2.1
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-9	0.98	2	>CSL, ND												
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-10	2	3	>CSL, ND												
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	No	-	L6725-11	3	3.9	>CSL, ND												

Notes

a. Datum: NAD 1983 Washington State Plane North (Feet).

b. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 2R/2R-CAD, 3R, 4R, 5R/5R-T, and 6R.

c. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 3C, 4C, 5C, and 6C.
Note that if a removal alternative is dredged, but the corresponding combined alternative is not dredged, then the combined alternative is actively remediated with capping or ENR.

d. The column titled "Collected for Dredge Material Characterization" identifies whether cores were collected to support a proposed dredging project. The "yes" entries in this column match the dredging footnotes in the stick diagrams. Much of the information about dredging comes from open water disposal suitability determinations written prior to dredging, not from reports confirming the dredging itself. In those instances where there is no confirmation that the dredging occurred, the "historically dredge" column is populated with "no", and the dredge year is blank. This matches the entries in the FS database.

e. Maximum SMS exceedance status for sample. Delineation matches color coding in stick diagrams.

f. Cells are populated only if sample has detected exceedances of the SQS. Then the TOC and AET substitution describe whether non-polar organic compounds are compared to the SQS/CSL (organic carbon normalized concentration) or the LAET/2LAET (dry weight concentration).

AET = apparent effects threshold; AOPC = area of potential concern; BEHP = bis(2-ethylhexyl)phthalate; CSL = cleanup screening level; LAET = lowest apparent effects threshold (2LAET = 2nd lowest); ND = not detected; oc = organic carbon; PAHs = polycyclic aromatic hydrocarbons;

PCB = polychlorinated biphenyl; SMS = Sediment Management Standards; SQS = sediment quality standard; SVOCs = semivolatile organic compounds; TOC = total organic carbon.

Table G-4 Dioxins/Furans and cPAHs in Cores – River Miles 0 to 1.9

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	LDW-SC1-0-0.5	0	0.5	620	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	LDW-SC1-0-2	0	2	500		Yes			
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	LDW-SC1-0.5-1	0.5	1	350	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	LDW-SC1-1-1.5	1	1.5	420		Yes			
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	LDW-SC1-1.5-2	1.5	2	470		Yes			
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	LDW-SC1-2-4	2	4	75	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC1	1266315	211282	0.0	3	not dredged	3	No	LDW-SC1-4-6	4	6						
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	LDW-SC2-0-2	0	2	69		Yes			
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	LDW-SC2-2-4	2	4	110	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	LDW-SC2-4-6	4	6	48	U	No			
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	LDW-SC2-8-10	8	10						
LDW Subsurface Sediment 2006	LDW-SC2	1267032	211196	0.1	3	not dredged	2	No	LDW-SC2-10.7-12	10.7	12	48	U	No			
LDW Subsurface Sediment 2006	LDW-SC3	1266432	210649	0.2	outside of AOPCs	outside of AOPCs	3	No	LDW-SC3-0-2	0	2	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC3	1266432	210649	0.2	outside of AOPCs	outside of AOPCs	3	No	LDW-SC3-2-4	2	4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	LDW-SC4-0-1	0	1	300	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	LDW-SC4-1-2	1	2	360	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	LDW-SC4-2-4	2	4	70		Yes			
LDW Subsurface Sediment 2006	LDW-SC4	1266932	210598	0.2	4	not dredged	1	No	LDW-SC4-4-6	4	6						
LDW Subsurface Sediment 2006	LDW-SC5	1266048	210543	0.2	4	not dredged	2	No	LDW-SC5-0-1	0	1	880		Yes			
LDW Subsurface Sediment 2006	LDW-SC5	1266048	210543	0.2	4	not dredged	2	No	LDW-SC5-1-2.2	1	2.2	1900		Yes			
LDW Subsurface Sediment 2006	LDW-SC5	1266048	210543	0.2	4	not dredged	2	No	LDW-SC5-2.2-4	2.2	4	330		Yes			
EPA SI	DR068	1266404	209574	0.3	2	3	1	No	SD-DR068-0000A	0	2	590		Yes			
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-0-0.5	0	0.5						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-0.5-1	0.5	1						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-1-1.5	1	1.5						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-1.5-2	1.5	2						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-2-2.5	2	2.5						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-2-4.5	2	4.5	490	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-2.5-3	2.5	3						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-3-3.5	3	3.5						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-3.5-4	3.5	4						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-4-4.5	4	4.5						
LDW Subsurface Sediment 2006	LDW-SC6	1266285	209838	0.3	4	4	1	No	LDW-SC6-6-8	6	8	48		Yes			
Duw/Diag-2	DUD250	1266871	209564	0.4	5	not dredged	3	No	L8542-12	0	3	329	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	LDW-SC7-0-1	0	1	420	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	LDW-SC7-1-1.7	1	1.7	67	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC7	1266850	209606	0.4	5	not dredged	3	No	LDW-SC7-1.7-4	1.7	4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	LDW-SC8-0-1	0	1	540		Yes			
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	LDW-SC8-1-2	1	2	540		Yes			
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	LDW-SC8-2-4	2	4	250	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	LDW-SC8-4-6	4	6	320		Yes			
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	LDW-SC8-6-8	6	8	300		Yes			
LDW Subsurface Sediment 2006	LDW-SC8	1266614	209589	0.4	5	not dredged	3	No	LDW-SC8-8-10	8	10	290		Yes			
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	L8542-27	0	3	1560	J	Yes			
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	L10112-8	3	6						
Duw/Diag-2	DUD258	1267170	208772	0.5	3	not dredged	3	No	L10112-9	6	9						
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	LDW-SC10-0-1	0	1	210	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	LDW-SC10-1-2	1	2	570		Yes			
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	LDW-SC10-2-4	2	4	820	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	LDW-SC10-4-5	4	5	75	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC10	1267168	208777	0.5	3	not dredged	3	No	LDW-SC10-6-8	6	8						
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	LDW-SC11-0-0.8	0	0.8	4400		Yes			
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	LDW-SC11-0.8-2	0.8	2	17	U	No			
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	LDW-SC11-2-3.4	2	3.4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC11	1265909	208291	0.5	2	3	1	No	LDW-SC11-3.4-4.1	3.4	4.1	17	U	No			
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	LDW-SC9-0-1	0	1	190		Yes			
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	LDW-SC9-1-2.6	1	2.6	230	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC9	1266865	208920	0.5	5	5	3	No	LDW-SC9-2.6-4	2.6	4	52	J	Yes			

Table G-4 Dioxins/Furans and cPAHs in Cores – River Miles 0 to 1.9

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
EPA SI	DR044	1266577	208216	0.6	4	5	2	No	SD-DR044-0000A	0	2	61		Yes			
EPA SI	DR044	1266577	208216	0.6	4	5	2	No	SD-DR044-0020	2	4	140		Yes			
Duw/Diag-2	DUD206	1267277	208630	0.6	outside of AOPCs	outside of AOPCs	3	No	L8542-28	0	3	38.2	J	Yes			
Duw/Diag-2	DUD260	1267150	208575	0.6	3	not dredged	0	No	L8542-29	0	3	454	J	Yes			
Duw/Diag-2	DUD260	1267150	208575	0.6	6	not dredged	0	No	L8542-30	3	6	38	UJ	No			
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-0-0.5	0	0.5						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-0-2	0	2	290	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-0.5-1	0.5	1						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-1-1.5	1	1.5						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-1.5-2	1.5	2						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-2-2.5	2	2.5						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-2-4	2	4	190	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-2.5-3	2.5	3						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-3-3.5	3	3.5						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-3.5-4	3.5	4						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-4-6.7	4	6.6						
LDW Subsurface Sediment 2006	LDW-SC12	1266578	208218	0.6	4	5	2	No	LDW-SC12-6.7-8.7	6.6	8.7						
EPA SI	DR021	1267822	206718	0.9	2	not dredged	1	No	SD-DR021-0000A	0	2	690		Yes			
EPA SI	DR021	1267822	206718	0.9	2	not dredged	1	No	SD-DR021-0020	2	4	760		Yes			
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	LDW-SC13-0-0.5	0	0.5						
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	LDW-SC13-0-2	0	2	540	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	LDW-SC13-0.5-1	0.5	1						
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	LDW-SC13-1-1.5	1	1.5						
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	LDW-SC13-1.5-2	1.5	2						
LDW Subsurface Sediment 2006	LDW-SC13	1267585	207097	0.9	5	not dredged	3	No	LDW-SC13-2-4	2	4	1200		Yes			
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	LDW-SC14-0-1.4	0	1.4	330	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	LDW-SC14-1.4-2	1.4	2	110	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	LDW-SC14-2-4.1	2	4.1	140		Yes			
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	LDW-SC14-4.1-6	4.1	6	190	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	LDW-SC14-6-8.7	6	8.6						
LDW Subsurface Sediment 2006	LDW-SC14	1267399	207054	0.9	3	5	2	No	LDW-SC14-10-11	10	11						
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	LDW-SC15-0-1	0	1	510		Yes			
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	LDW-SC15-1-2	1	2	430		Yes			
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	LDW-SC15-2-4	2	4	550		Yes			
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	LDW-SC15-4-6	4	6						
LDW Subsurface Sediment 2006	LDW-SC15	1267822	206822	0.9	3	6	2	No	LDW-SC15-8-10	8	10						
Lehigh NW	C2 (Lehigh NW)	1267920	206336	1.0	2	3	1	Yes	C-2	0	4	370		Yes			
Lehigh NW	C3 (Lehigh NW)	1267936	206274	1.0	2	3	1	Yes	C-3S	3.8	5	390		Yes			
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	LDW-SC16-0-2	0	2	660		Yes			
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	LDW-SC16-2-4	2	4	380	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	LDW-SC16-4-6	4	6	1300		Yes			
LDW Subsurface Sediment 2006	LDW-SC16	1267960	206670	1.0	4	4	1	No	LDW-SC16-8-10	8	10	130	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	LDW-SC17-0-1	0	1	1800		Yes			
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	LDW-SC17-1-2	1	2	2000	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	LDW-SC17-2-4	2	4	1400		Yes			
LDW Subsurface Sediment 2006	LDW-SC17	1268446	206551	1.0	2	3	2	No	LDW-SC17-6-8.2	6	8.6	2400		Yes			
LDW Subsurface Sediment 2006	LDW-SC18	1267927	206334	1.0	2	3	1	No	LDW-SC18-0-1	0	1	510		Yes			
LDW Subsurface Sediment 2006	LDW-SC18	1267927	206334	1.0	2	3	1	No	LDW-SC18-1-2	1	2	41	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC18	1267927	206334	1.0	2	3	1	No	LDW-SC18-2-4	2	4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	LDW-SC19-0-1	0	1	480	J	Yes	22.8	J	Yes
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	LDW-SC19-1-2	1	2	580	J	Yes	20.1	J	Yes
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	LDW-SC19-2-4	2	4	310		Yes	20.5	J	Yes
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	LDW-SC19-4-6	4	6						
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	LDW-SC19-6-7	6	7						
LDW Subsurface Sediment 2006	LDW-SC19	1266968	206222	1.0	5	6	2	No	LDW-SC19-9-11.9	9	11.9						

Table G-4 Dioxins/Furans and cPAHs in Cores – River Miles 0 to 1.9

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	LDW-SC20-0-2	0	2	140	J	Yes	38.7	J	Yes
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	LDW-SC20-2-4	2	4	61	J	Yes	27.1		Yes
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	LDW-SC20-4-6	4	6				194	J	Yes
LDW Subsurface Sediment 2006	LDW-SC20	1267735	206178	1.0	2	3	2	No	LDW-SC20-8-10	8	10				5.6	J	Yes
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	LDW-SC21-0-1	0	1	420	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	LDW-SC21-1-2	1	2	310		Yes			
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	LDW-SC21-2-4	2	4	500	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	LDW-SC21-4-6.2	4	6.2						
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	LDW-SC21-6.2-8	6.2	8						
LDW Subsurface Sediment 2006	LDW-SC21	1267488	206168	1.0	2	3	1	No	LDW-SC21-10-11.3	10	11.3						
Lehigh NW	A1	1268045	206036	1.1	6	6	1	Yes	C-1	0	4.4	450		Yes			
LDW Subsurface Sediment 2006	LDW-SC22	1268174	205908	1.1	3	not dredged	3	No	LDW-SC22-0-1.1	0	1.1	130		Yes			
LDW Subsurface Sediment 2006	LDW-SC22	1268174	205908	1.1	3	not dredged	3	No	LDW-SC22-1.1-2	1.1	2	120		Yes			
LDW Subsurface Sediment 2006	LDW-SC22	1268174	205908	1.1	3	not dredged	3	No	LDW-SC22-2-4	2	4	18	U	No			
EPA SI	DR025	1268230	205416	1.2	6	6	2	No	SD-DR025-0000A	0	2	610		Yes			
EPA SI	DR025	1268230	205416	1.2	6	6	2	No	SD-DR025-0020	2	4	470		Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-0-0.5	0	0.5	590	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-0.5-1	0.5	1	460	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-1-1.5	1	1.5	570	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-1.5-2	1.5	2	510	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-2-2.5	2	2.5	1200		Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-2-4	2	4	3600	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-2.5-3	2.5	3	170	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-3-3.5	3	3.5	4600		Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-3.5-4	3.5	4	1900		Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-4-6	4	6	290		Yes			
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-6-8	6	8						
LDW Subsurface Sediment 2006	LDW-SC23	1268229	205418	1.2	6	6	2	No	LDW-SC23-8-10.2	8	10.2						
LDW Subsurface Sediment 2006	LDW-SC24	1267861	205130	1.2	4	4	1	No	LDW-SC24-0-1	0	1	500		Yes			
LDW Subsurface Sediment 2006	LDW-SC24	1267861	205130	1.2	4	4	1	No	LDW-SC24-1-2	1	2	83	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC24	1267861	205130	1.2	4	4	1	No	LDW-SC24-2-4	2	4	23	J	Yes			
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	SD-DR054-0000A	0	2	1200		Yes			
EPA SI	DR054	1268074	204727	1.3	2	3	1	No	SD-DR054-0020	2	4	2000		Yes			
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	LDW-SC25-0-1	0	1	720		Yes			
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	LDW-SC25-1-2	1	2	860	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	LDW-SC25-2-4	2	4	980	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	LDW-SC25-4-6	4	6						
LDW Subsurface Sediment 2006	LDW-SC25	1267979	204751	1.3	2	3	1	No	LDW-SC25-8-9.1	8	9.1						
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	LDW-SC26-0-1	0	1	490		Yes	15.9	J	Yes
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	LDW-SC26-1-2	1	2	370		Yes	13.1	J	Yes
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	LDW-SC26-2-4	2	4	570		Yes	22.4	J	Yes
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	LDW-SC26-6-8	6	8	4000	J	Yes	136	J	Yes
LDW Subsurface Sediment 2006	LDW-SC26	1268157	204480	1.4	2	3	1	No	12.1	11.1	12.1						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-0-0.5	0	0.5						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-0-2	0	2	330		Yes			
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-0.5-1	0.5	1						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-1-1.5	1	1.5						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-1.5-2	1.5	2						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-2-2.5	2	2.5						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-2.5-3	2.5	3						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-3-3.5	3	3.5						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-3.5-4	3.5	4						
LDW Subsurface Sediment 2006	LDW-SC27	1268519	204443	1.4	3	6	3	No	LDW-SC27-4-4.5	4	4.5						
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	LDW-SC28-0-1	0	1	420	J	Yes	19.9	J	Yes
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	LDW-SC28-1-2	1	2	230	J	Yes	14.8		Yes
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	LDW-SC28-2-4	2	4	260	J	Yes	18.5	J	Yes
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	LDW-SC28-5.5-7.5	5.5	7.5	1400		Yes			
LDW Subsurface Sediment 2006	LDW-SC28	1268253	204225	1.4	2	3	1	No	LDW-SC28-12-12.6	12	12.6	180		Yes			

Table G-4 Dioxins/Furans and cPAHs in Cores – River Miles 0 to 1.9

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
LDW Subsurface Sediment 2006	LDW-SC29	1268061	204054	1.4	2	3	3	No	LDW-SC29-0-1	0	1	60	J	Yes	54.1	J	Yes
LDW Subsurface Sediment 2006	LDW-SC29	1268061	204054	1.4	2	3	3	No	LDW-SC29-1-2	1	2	150	J	Yes	1.03	J	Yes
LDW Subsurface Sediment 2006	LDW-SC29	1268061	204054	1.4	2	3	3	No	LDW-SC29-2-3.6	2	3.6	18	U	No	0.147	J	Yes
Glacier NW	SCDMMU3	1268206	204169	1.4	2	3	1	Yes	SCDMMU3	0	5.6	620		Yes			
Lone Star 92	C-1	1268275	203789	1.5	3	3	1	Yes	C-1	0	4	590		Yes			
Glacier NW	SCDMMU1	1268338	203745	1.5	3	3	2	Yes	SCDMMU1	0	2.7	310		Yes			
Glacier NW	SCDMMU2	1268280	203995	1.5	2	3	1	Yes	SCDMMU2	0	2.2	280		Yes			
Glacier NW	SCDMMU2R	1268280	203995	1.5	2	3	1	Yes	SCDMMU2R-Z	3	4						
Hardie Gypsum-1	1	1268851	203302	1.6	6	not dredged	1	Yes	1	0	4	140		Yes			
Hardie Gypsum-1	2	1268883	203173	1.6	4	4	1	Yes	2	0	4	220		Yes			
Hardie Gypsum-2	2b	1268892	203155	1.6	4	4	1	Yes	2b	0	3	240		Yes			
Hardie Gypsum-2	A	1268872	203206	1.6	4	4	1	Yes	A	0	3	160		Yes			
Hardie Gypsum-2	B	1268916	203178	1.6	4	4	1	Yes	B	0	3	310		Yes			
Lone Star-Hardie Gypsum	c-3	1268925	203167	1.6	4	4	1	Yes	c-3	0	4.6	430		Yes			
Lone Star-Hardie Gypsum	c-4	1268760	203523	1.6	4	6	3	Yes	c-4	0	4	82		Yes			
Lone Star-Hardie Gypsum	c-4	1268760	203523	1.6	4	6	3	Yes	c-5	4	12	16	U	No			
LDW Subsurface Sediment 2006	LDW-SC30	1268784	203576	1.6	4	6	3	No	LDW-SC30-0-2.5	0	2.5	30	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC30	1268784	203576	1.6	4	6	3	No	LDW-SC30-2.5-4	2.5	4	17	U	No			
Hardie Gypsum-1	3 (HG-1)	1268962	202989	1.7	4	4	1	Yes	4	0	4						
Hardie Gypsum-2	3 (HG-2)	1268958	202981	1.7	4	4	1	Yes	4	0	3						
Hardie Gypsum-1	4 (HG-1)	1268987	202873	1.7	4	not dredged	1	Yes	4	0	4	240		Yes			
Hardie Gypsum-2	4 (HG-2)	1268974	202866	1.7	4	not dredged	1	Yes	4	0	3	230		Yes			
Hardie Gypsum-1	5	1268997	202773	1.7	4	not dredged	1	Yes	5	0	4	130		Yes			
Hardie Gypsum-2	5.2	1269023	202728	1.7	4	not dredged	1	Yes	5	0	3	240		Yes			
Hardie Gypsum-2	C	1268981	203013	1.7	4	4	1	Yes	C	0	3	700		Yes			
Lone Star-Hardie Gypsum	c-1	1269036	202783	1.7	4	not dredged	1	Yes	c-1	0	4	200		Yes			
Lone Star-Hardie Gypsum	c-2	1268972	202971	1.7	4	4	1	Yes	c-2	0	5	310		Yes			
Hardie Gypsum-2	D	1269020	202886	1.7	4	not dredged	1	Yes	D	0	3	100		Yes			
EPA SI	DR101	1269108	202682	1.7	6	6	1	No	SD-DR101-0000A	0	2	74		Yes			
EPA SI	DR101	1269108	202682	1.7	6	6	1	No	SD-DR101-0020	2	4	44		Yes			
Hardie Gypsum-2	E	1269034	202730	1.7	4	not dredged	1	Yes	E	0	3	46		Yes			
LDW Subsurface Sediment 2006	LDW-SC31	1268935	203092	1.7	4	4	1	No	LDW-SC31-0-1	0	1	330		Yes			
LDW Subsurface Sediment 2006	LDW-SC31	1268935	203092	1.7	4	4	1	No	LDW-SC31-1-2.8	1	2.8	290	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC31	1268935	203092	1.7	4	4	1	No	LDW-SC31-2.8-4	2.8	4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	LDW-SC32-0-1	0	1	230	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	LDW-SC32-1-2	1	2	660		Yes			
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	LDW-SC32-2-4	2	4	170		Yes			
LDW Subsurface Sediment 2006	LDW-SC32	1269345	202959	1.7	5	not dredged	3	No	LDW-SC32-5.2-8	5.2	8	48	U	No			
PSDDA99	S1	1268863	202577	1.8	6	6	3	Yes	S1	0	4	130		Yes			
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	T115-S1-CS-0803	0	3	5900		Yes	19.2	J	Yes
T115	S1-01	1268671	202394	1.8	5	not dredged	3	Yes	T115-S1-ZA-0803	3	4	72	J	Yes	12.5	J	Yes
T115	S1-02	1268725	202252	1.8	2	3	1	Yes	0803	3	4	940	J	Yes	14	J	Yes
T115	S1-02	1268725	202252	1.8	2	3	1	Yes	T115-S1-02-ZB-0803	4	4.7	360	J	Yes	38.9	J	Yes
PSDDA99	S2	1268952	202446	1.8	6	6	3	Yes	S2	0	4	170		Yes			
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	T115-S2-CS-0803	0	3	1100	J	Yes	23.3	J	Yes
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	0803	3	4	650		Yes	31.4	J	Yes
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	T115-S2-01-ZB-0803	4	5	370		Yes	27.1	J	Yes
T115	S2-01	1268765	202119	1.8	2	3	1	Yes	T115-S2-01-ZC-0803	5	6	730		Yes	22.6	J	Yes
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	0803	3	4	1200	J	Yes	23.7	J	Yes
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	T115-S2-02-ZB-0803	4	5	1300		Yes	28.5	J	Yes
T115	S2-02	1268791	202044	1.8	2	3	1	Yes	T115-S2-02-ZC-0803	5	6	1400		Yes	22.3	J	Yes
PSDDA99	S3	1268980	202348	1.8	6	6	3	Yes	S3	0	4	190		Yes			
PSDDA99	S4	1269020	202252	1.8	6	6	3	Yes	S4	0	4	250		Yes			
PSDDA99	S5	1269042	202166	1.8	6	6	3	Yes	S5	0	4	190		Yes			
PSDDA99	B1	1269154	202036	1.9	6	6	3	Yes	B1	4	8	140		Yes			

Table G-4 Dioxins/Furans and cPAHs in Cores – River Miles 0 to 1.9

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	LDW-SC201-0-1.5	0	1.5	280	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	LDW-SC201-1.5-4	1.5	4	130	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	LDW-SC201-4-6	4	6	750		Yes			
LDW Subsurface Sediment 2006	LDW-SC201	1269268	202052	1.9	3	not dredged	3	No	LDW-SC201-8-10	8	10	93	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	LDW-SC203-0-1	0	1	510	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	LDW-SC203-1-2	1	2	660		Yes			
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	LDW-SC203-2-4	2	4	290		Yes			
LDW Subsurface Sediment 2006	LDW-SC203	1268832	202013	1.9	2	3	1	No	LDW-SC203-4-6	4	6	280		Yes			
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-0-0.5	0	0.5						
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-0-2	0	2	350	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-0.5-1	0.5	1						
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-1-1.5	1	1.5						
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-1.5-2	1.5	2						
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-2-2.5	2	2.5						
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-2-4	2	4	120	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-2.5-3	2.5	3						
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-4-6	4	6	430		Yes			
LDW Subsurface Sediment 2006	LDW-SC33	1269267	202053	1.9	3	not dredged	3	No	LDW-SC33-8-10	8	10	120	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	LDW-SC34-0-1	0	1	360	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	LDW-SC34-1-2	1	2	600		Yes			
LDW Subsurface Sediment 2006	LDW-SC34	1268831	202016	1.9	2	3	1	No	LDW-SC34-2-4	2	4	230	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC35	1269260	201604	1.9	3	4	3	No	LDW-SC35-0-2	0	2	290	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC35	1269260	201604	1.9	3	4	3	No	LDW-SC35-2-4	2	4	310	J	Yes			
PSDDA99	S10	1269353	201769	1.9	6	6	3	Yes	S10	0	4	280	J	Yes			
PSDDA99	S6	1269111	202083	1.9	6	6	3	Yes	S6	0	4	270		Yes			
PSDDA99	S7	1269130	201979	1.9	outside of AOPCs	outside of AOPCs	3	Yes	S7	0	4	170		Yes			
PSDDA99	S8	1269220	201915	1.9	6	6	3	Yes	S8	0	4	160		Yes			
PSDDA99	S9	1269264	201827	1.9	6	6	3	Yes	S9	0	4	190		Yes			

Notes

a. datum: NAD 1983 Washington State Plane North (Feet).

b. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 2R/2R-CAD, 3R, 4R, 5R/5R-T, and 6R.

c. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 3C, 4C, 5C, and 6C.
Note that if a removal alternative is dredged, but the corresponding combined alternative is not dredged, then the combined alternative is actively remediated with capping or ENR.

AOPC = area of potential concern; cPAHs = carcinogenic polycyclic aromatic hydrocarbons

Table G-5 Dioxins/Furans and cPAHs in Cores – River Miles 2.0 to 4.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area Is First Dredged[b]	FS Combined-Technologies Alternative when Area Is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
PSDDA99	S11	1269400	201666	2.0	4	4	3	Yes	S11	0	4	86		Yes			
PSDDA99	S12	1269510	201597	2.0	4	4	3	Yes	S12	0	4	74		Yes			
PSDDA99	B2	1269979	201124	2.1	5	not dredged	3	Yes	B2	4	8	73		Yes			
EPA SI	DR106	1270217	201545	2.1	6	not dredged	3	No	SD-DR106-0000A	0	2	130		Yes			
EPA SI	DR106	1270217	201545	2.1	6	not dredged	3	No	SD-DR106-0020	2	4	260		Yes			
EPA SI	DR112	1270202	201166	2.1	4	4	2	No	SD-DR112-0000A	0	2	350		Yes			
EPA SI	DR112	1270202	201166	2.1	4	4	2	No	SD-DR112-0020	2	4	580		Yes			
LDW Subsurface Sediment 2006	LDW-SC202	1269986	201491	2.1	6	not dredged	3	No	LDW-SC202-0-1	0	1	89	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC202	1269986	201491	2.1	6	not dredged	3	No	LDW-SC202-1-2	1	2	38	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC202	1269986	201491	2.1	6	not dredged	3	No	LDW-SC202-2-4	2	4	35	UJ	No			
LDW Subsurface Sediment 2006	LDW-SC36	1269990	201489	2.1	6	not dredged	3	No	LDW-SC36-0-1	0	1	110	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC36	1269990	201489	2.1	6	not dredged	3	No	LDW-SC36-1-2	1	2	39	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC36	1269990	201489	2.1	6	not dredged	3	No	LDW-SC36-2-4	2	4	34	UJ	No			
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	LDW-SC37-0-1	0	1	2800		Yes			
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	LDW-SC37-1-2	1	2	7000		Yes			
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	LDW-SC37-2-4	2	4	5600		Yes			
LDW Subsurface Sediment 2006	LDW-SC37	1270691	201436	2.1	3	3	2	No	LDW-SC37-5.3-6.9	5.3	6.9	53	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	LDW-SC38-0-1	0	1	19	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	LDW-SC38-1-2	1	2	19	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC38a	1269747	200937	2.1	5	6	3	No	LDW-SC38-2-3	2	3	74	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC38b	1269744	200959	2.1	5	6	3	No	LDW-SC38-3-3.3	3	3.3	19	J	Yes			
EPA SI	DR137	1270252	200448	2.2	6	not dredged	3	No	SD-DR137-0000A-CC	0	2	60		Yes			
EPA SI	DR137	1270252	200448	2.2	6	not dredged	3	No	SD-DR137-0020-CC	2	4	290	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	LDW-SC39-0-1	0	1	260	J	Yes	7.91	J	Yes
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	LDW-SC39-1-2	1	2	76	J	Yes	12.4	J	Yes
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	LDW-SC39-2-4	2	4	60	J	Yes	13.1	J	Yes
LDW Subsurface Sediment 2006	LDW-SC39	1270056	200657	2.2	4	6	3	No	LDW-SC39-4-6	4	6						
PSDDA99	S13	1270426	200645	2.2	outside of AOPCs	outside of AOPCs	3	Yes	S13	0	4	140		Yes			
LDW Subsurface Sediment 2006	LDW-SC40	1270303	200332	2.3	2	3	2	No	LDW-SC40-0-1.3	0	1.3	51		Yes	6.71	J	Yes
LDW Subsurface Sediment 2006	LDW-SC40	1270303	200332	2.3	2	3	2	No	LDW-SC40-1.3-2	1.3	2	18	U	No	0.485	J	Yes
LDW Subsurface Sediment 2006	LDW-SC40	1270303	200332	2.3	2	3	2	No	LDW-SC40-2-4	2	4	18	U	No	0.355	J	Yes
Hurlen-Boyer	C5 (Hurlen-Boyer)	1270986	199683	2.4	4	4	1	Yes	C5	0	3.3	440		Yes			
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	LDW-SC41-0-1	0	1	290	J	Yes	13.8		Yes
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	LDW-SC41-1-2	1	2	78	J	Yes	12.5	J	Yes
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	LDW-SC41-2-4	2	4	270	J	Yes	14	J	Yes
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	LDW-SC41-4-6	4	6	470		Yes			
LDW Subsurface Sediment 2006	LDW-SC41	1271171	200294	2.4	4	4	1	No	LDW-SC41-6-7.9	6	7.9						
PSDDA99	S14	1270894	200131	2.4	6	6	3	Yes	S14	0	4	100	J	Yes			
Hurlen-Boyer	C6 (Hurlen-Boyer)	1271160	199554	2.5	4	4	2	Yes	C6	0	3.8	570		Yes			
EPA SI	DR171	1271310	199597	2.5	6	6	3	No	SD-DR171-0000A	0	2	290		Yes			
EPA SI	DR171	1271310	199597	2.5	6	6	3	No	SD-DR171-0020	2	4	250		Yes			
LDW Subsurface Sediment 2006	LDW-SC42	1271361	199898	2.5	6	not dredged	1	No	LDW-SC42-0-1	0	1	150		Yes			
LDW Subsurface Sediment 2006	LDW-SC42	1271361	199898	2.5	6	not dredged	1	No	LDW-SC42-1-2	1	2	550		Yes			
LDW Subsurface Sediment 2006	LDW-SC42	1271361	199898	2.5	6	not dredged	1	No	LDW-SC42-2-4	2	4	440		Yes			
PSDDA99	S15	1271295	199702	2.5	4	4	3	Yes	S15	0	4	180		Yes			
BoyerTowing	WRC-SS-B1	1271107	199533	2.5	4	not dredged	3	No	WRC-SS-B1A-B 1-2'	1	2	17.2	U	No			
BoyerTowing	WRC-SS-B2	1271101	199571	2.5	4	not dredged	3	No	WRC-SS-B2A-B 1-2'	1	2	17	U	No			
BoyerTowing	WRC-SS-B3	1271056	199592	2.5	4	not dredged	3	No	WRC-SS-B3A-B 1-2'	1	2	20	U	No			
LDW Subsurface Sediment 2006	LDW-SC43	1271846	199289	2.6	2	3	3	No	LDW-SC43-0-2	0	2	20	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC43	1271846	199289	2.6	2	3	3	No	LDW-SC43-2-4	2	4	17	U	No			
PSDDA99	S16	1271930	199035	2.6	6	6	3	Yes	S16	0	4	180		Yes			

Table G-5 Dioxins/Furans and cPAHs in Cores – River Miles 2.0 to 4.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area Is First Dredged[b]	FS Combined-Technologies Alternative when Area Is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
Hurlen-Boyer	C1 (Hurlen-Boyer)	1271875	198851	2.7	4	4	2	Yes	C1	0	3.7	780		Yes			
Hurlen-Boyer	C2	1271991	198746	2.7	4	4	1	Yes	C2	0	4.2	2400		Yes			
Hurlen-Boyer	C3	1272106	198645	2.7	2	3	1	Yes	C3	0	3.3	2800		Yes			
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-0-0.5	0	0.5						
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-0-2	0	2	100	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-0.5-1	0.5	1						
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-1-1.5	1	1.5						
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-1.5-2	1.5	2						
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-2-2.5	2	2.5						
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-2-3.2	2	3.2	120		Yes			
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-2.5-3	2.5	3						
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-3-3.5	3	3.5						
LDW Subsurface Sediment 2006	LDW-SC44	1272231	198926	2.7	3	3	3	No	LDW-SC44-3.2-4	3.2	4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	LDW-SC46-0-1	0	1	840	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	LDW-SC46-1-2	1	2	1200		Yes			
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	LDW-SC46-2-4	2	4	1100	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC46	1272121	198579	2.7	2	3	1	No	LDW-SC46-4-6.8	4	6.8						
Hurlen-Boyer	C4	1272268	198483	2.8	2	3	1	Yes	C4	0	3.3	340		Yes			
Slip4-Crowley	DMMU 1	1272885	198524	2.8	6	6	3	Yes	CMS4-5	0	3.9	3400		Yes			
Slip4-Crowley	DMMU 2	1273000	198628	2.8	6	6	3	Yes	CMS4-1	0	2.8	730		Yes			
Slip4-Crowley	DMMU 3	1273126	198726	2.8	6	6	3	Yes	CMS4-2	0	4.3	280		Yes			
Slip4-Crowley	DMMU 4	1273220	198831	2.8	6	6	3	Yes	CMS4-3	0	3.9	380		Yes			
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	LDW-SC45-0-1	0	1	240	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	LDW-SC45-1-2	1	2	170	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	LDW-SC45-2-4	2	4	1000	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC45	1272647	198588	2.8	5	not dredged	2	No	LDW-SC45-5-6	5	6						
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	SC06A	0	2						
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	SC06B	2	4						
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	SC06C	4	6						
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	SC06D	6	8						
Slip4-EarlyAction	SC06	1273260	198884	2.8	6	6	3	No	SC06E	8	10						
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	SC08A	0	2						
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	SC08B	2	4						
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	SC08C	4	6						
Slip4-EarlyAction	SC08	1273118	198766	2.8	6	6	3	No	SC08D	6	8						
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	SC10A	0	2						
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	SC10B	2	4						
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	SC10C	4	6						
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	SC10D	6	8						
Slip4-EarlyAction	SC10	1272980	198642	2.8	6	6	3	No	SC10E	8	10						
USACE 1990	DU9008XX	1273003	198124	2.9	6	6	3	Yes	DUWO&M90S008	0	7	10	U	No			
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	SC09A	0	2						
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	SC09B	2	4						
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	SC09C	4	6						
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	SC09D	6	8						
Slip4-EarlyAction	SC09	1273236	198729	2.9	6	6	3	No	SC09E	8	10						
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	SC11A	0	2						
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	SC11B	2	4						
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	SC11C	4	6						
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	SC11D	6	8						
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	SC11E	8	10						
Slip4-EarlyAction	SC11	1272966	198513	2.9	6	6	3	No	SC11F	10	12						

Table G-5 Dioxins/Furans and cPAHs in Cores – River Miles 2.0 to 4.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area Is First Dredged[b]	FS Combined-Technologies Alternative when Area Is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
EPA SI	DR224	1273359	197554	3.0	6	not dredged	1	No	SD-DR224-0000A	0	2	18	U	No			
EPA SI	DR224	1273359	197554	3.0	6	not dredged	1	No	SD-DR224-0020	2	3.33	18		Yes			
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	LDW-SC47-0-1	0	1	61	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	LDW-SC47-1-2	1	2	74	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	LDW-SC47-2-3	2	3	90	U	No			
LDW Subsurface Sediment 2006	LDW-SC47	1273347	197447	3.0	5	not dredged	3	No	LDW-SC47-3-4	3	4	18	UJ	No			
PSDDA99	S17	1273435	197587	3.0	6	6	1	Yes	S17	0	4	55		Yes			
USACE 1990	DU9007XX	1273696	197475	3.1	2	4	1	Yes	DUWO&M90S007	0	5	11		Yes			
PSDDA99	S18	1274190	196895	3.2	6	6	3	Yes	S18	0	4	54		Yes			
LDW Subsurface Sediment 2006	LDW-SC48	1274533	196659	3.3	6	6	3	No	LDW-SC48-0-1	0	1	40		Yes			
LDW Subsurface Sediment 2006	LDW-SC48	1274533	196659	3.3	6	6	3	No	LDW-SC48-1-2	1	2	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC48	1274533	196659	3.3	6	6	3	No	LDW-SC48-2-4	2	4	17	U	No			
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	SB5-SED-2.5	0	2.5	76.32		Yes			
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	SB5-SED-5	2.5	5	156.2		Yes			
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	SB5-SED-7.5	5	7.5	281.4	J	Yes			
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	SB5-SED-50	47.5	50	4.07	U	No			
South Park Bridge	SB-5	1274500	196550	3.3	6	not dredged	3	No	SB5-SED-75	72.5	75	4.07	U	No			
SouthParkMarina	1 & 2	1274844	196140	3.4	outside of AOPCs	outside of AOPCs	3	Yes	Comp 1	0	4	430	U	No			
SouthParkMarina	3 & 4	1274723	196251	3.4	outside of AOPCs	outside of AOPCs	3	Yes	Comp 2	0	4	430	U	No			
USACE 1990	DU9005XX	1274822	196338	3.4	6	6	3	Yes	DUWO&M90S005	0	7	10	U	No			
USACE 1991	DU9125XX	1274809	196315	3.4	6	6	3	Yes	DUWO&M91S017	0	4						
PSDDA98	1	1275291	195913	3.5	6	6	3	Yes	S1	0	2	33		Yes			
USACE 1990	DU9004XX	1275227	195934	3.5	6	6	3	Yes	DUWO&M90S004	0	7	10	U	No			
USACE 1991	DU9124XX	1275229	195938	3.5	6	6	3	Yes	DUWO&M91S016	0	4						
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	LDW-SC49-0-1	0	1	170	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	LDW-SC49-1-2	1	2	270		Yes			
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	LDW-SC49-2-4	2	4	120		Yes			
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	LDW-SC49-4-6	4	6						
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	LDW-SC49-6-8	6	8						
LDW Subsurface Sediment 2006	LDW-SC49a	1275477	195851	3.5	4	4	1	No	LDW-SC49-8-10	8	10						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-0-1	0	1						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-1-2	1	2						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-2-3	2	3						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-3-4	3	4						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-4-5	4	5						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-5-6	5	6						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-6-7	6	7						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-7-8	7	8						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-8-9	8	9						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-9-10	9	10						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-10-11	10	11						
LDW Subsurface Sediment 2006	LDW-SC49b	1275498	195853	3.5	4	4	1	No	LDW-SC49V-11-12	11	12						
T117BoundaryDefinition	T117-SE-91-SC	1275230	195820	3.5	6	not dredged	3	No	T117-SE91-SC-02	0	2						
T117BoundaryDefinition	T117-SE-93-SC	1275303	195783	3.5	6	not dredged	3	No	T117-SE93-SC-02	0	2						
T117BoundaryDefinition	T117-SE-94-SC	1275365	195781	3.5	6	6	3	No	T117-SE94-SC-02	0	2						
T117BoundaryDefinition	SC	1275216	195870	3.5	6	not dredged	3	No	T117-SC-COMP1	0	4						
T117BoundaryDefinition	COMP2and3-SC	1275238	195806	3.5	6	not dredged	3	No	T117-SC-COMP3	0	2	41.6	J	Yes			
T117BoundaryDefinition	COMP2and3-SC	1275238	195806	3.5	6	not dredged	3	No	T117-SC-COMP2	2	4	128		Yes			
T117BoundaryDefinition	SC	1275267	195801	3.5	6	not dredged	3	No	T117-SC-COMP4	0	2						
USACE 1990	DU9002XX	1275794	195492	3.6	4	4	1	Yes	DUWO&M90S002	0	7	10	U	No			
USACE 1990	DU9003XX	1275515	195674	3.6	6	6	3	Yes	DUWO&M90S003	0	7	10	U	No			
USACE 1991	DU9123XX	1275519	195678	3.6	6	6	3	Yes	DUWO&M91S015	0	4						

Table G-5 Dioxins/Furans and cPAHs in Cores – River Miles 2.0 to 4.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area Is First Dredged[b]	FS Combined-Technologies Alternative when Area Is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	T117-SE15-SC-01	0	1						
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	T117-SE15-SC-12	1	2						
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	T117-SE15-SC-24	2	4						
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	T117-SE15-SC-46	4	6						
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	T117-SE15-SC-68	6	8						
T117BoundaryDefinition	T117-SE-15-SC	1275420	195740	3.6	6	6	3	No	T117-SE15-SC-810	8	10						
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	T117-SE23-SC-01	0	1						
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	T117-SE23-SC-12	1	2						
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	T117-SE23-SC-24	2	4						
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	T117-SE23-SC-46	4	6						
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	T117-SE23-SC-68	6	8						
T117BoundaryDefinition	T117-SE-23-SC	1275568	195604	3.6	6	6	3	No	T117-SE23-SC-810	8	10						
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	T117-SE35-SC-01	0	1						
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	T117-SE35-SC-12	1	2						
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	T117-SE35-SC-24	2	4						
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	T117-SE35-SC-46	4	6						
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	T117-SE35-SC-68	6	8						
T117BoundaryDefinition	T117-SE-35-SC	1275664	195438	3.6	6	6	1	No	T117-SE35-SC-810	8	10						
PSDDA98	2 (98)	1275779	195125	3.7	6	6	1	Yes	S2	0	2	150		Yes			
USACE 1991	DU9121XX	1275843	194878	3.7	5	5	1	Yes	DUWO&M91S013	0	4	90		Yes			
USACE 1991	DU9122XX	1275714	195358	3.7	6	6	1	Yes	DUWO&M91S014	0	3	89		Yes			
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	T117-SE42-SC-01	0	1						
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	T117-SE42-SC-12	1	2						
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	T117-SE42-SC-24	2	4						
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	T117-SE42-SC-46	4	6						
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	T117-SE42-SC-68	6	8						
T117BoundaryDefinition	T117-SE-42-SC	1275667	195279	3.7	6	not dredged	3	No	T117-SE42-SC-810	8	10						
EPA SI	DR220	1276032	194669	3.8	2	3	1	No	SD-DR220-0000A	0	2	100		Yes			
EPA SI	DR220	1276032	194669	3.8	2	3	1	No	SD-DR220-0020	2	4	280		Yes			
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	LDW-SC50-0-1	0	1	360		Yes			
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	LDW-SC50-1-2	1	2	140	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	LDW-SC50-2-2.8	2	2.8	18	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC50a	1276043	194865	3.8	2	3	2	No	LDW-SC50-2.8-4	2.8	4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	LDW-SC51-0-0.5	0	0.5	2200		Yes			
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	LDW-SC51-0-2	0	2	690	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	LDW-SC51-0.5-1	0.5	1	540		Yes			
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	LDW-SC51-1-1.5	1	1.5	83	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	LDW-SC51-1.5-2	1.5	2	65	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	LDW-SC51-2-3.8	2	3.8	360		Yes			
LDW Subsurface Sediment 2006	LDW-SC51	1276135	194728	3.8	2	3	2	No	LDW-SC51-3.8-5.8	3.8	5.8						
PSDDA98	3	1276037	194297	3.9	outside of AOPCs	outside of AOPCs	1	Yes	S3	0	2	180		Yes			
KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	AN042-SC-080211-A	0	1	91	J	Yes			
KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	AN042-SC-080211-B	1	2	93	J	Yes			
KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	AN042-SC-080211-C	2	3	23	J	Yes			
KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	AN042-SC-080211-D	3	4	15	J	Yes			
KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	AN042-SC-080211-E	4	5	13	J	Yes			
KenworthPACCAR)	AN-042	1276319	193974	3.9	2	3	2	No	AN042-SC-080211-F	5	5.8						
KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	AN043-SC-080211-A	0	1	150	J	Yes			
KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	AN043-SC-080211-B	1	2	690	J	Yes			
KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	AN043-SC-080211-C	2	3	27	J	Yes			

Table G-5 Dioxins/Furans and cPAHs in Cores – River Miles 2.0 to 4.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	FS Removal-Emphasis Alternative when Area Is First Dredged[b]	FS Combined-Technologies Alternative when Area Is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	AN043-SC-080211-D	3	4						
KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	AN043-SC-080211-E	4	5						
KenworthPACCAR)	AN-043	1276265	194232	3.9	2	3	2	No	AN043-SC-080211-F	5	6						
KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	AN044-SC-080211-A	0	1	98		Yes			
KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	AN044-SC-080211-B	1	2	29	J	Yes			
KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	AN044-SC-080211-C	2	3.5						
KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	AN044-SC-080211-D	3.5	4.5						
KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	AN044-SC-080211-E	4.5	5.5						
KenworthPACCAR)	AN-044	1276246	194250	3.9	2	3	2	No	AN044-SC-080211-F	5.5	6.5						
USACE 1990	DU9001XX	1276182	193931	3.9	5	5	1	Yes	DUWO&M90S001	0	5	36		Yes			
USACE 1991	DU9119XX	1276190	193943	3.9	5	5	1	Yes	DUWO&M91S011	0	3						
USACE 1991	DU9120XX	1276091	194345	3.9	6	6	1	Yes	DUWO&M91S012	0	3	160		Yes			
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	LDW-SC52-0-1	0	1	160		Yes			
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	LDW-SC52-1-2	1	2	35	U	No			
LDW Subsurface Sediment 2006	LDW-SC52	1276280	194160	3.9	2	3	2	No	LDW-SC52-2-4	2	4	18	U	No			
PSDDA98	4	1276167	193767	4.0	6	6	1	Yes	S4	0	2	100		Yes			
KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	AN041-SC-080211-A	0	1	35	J	Yes			
KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	AN041-SC-080211-B	1	2	1.2	J	Yes			
KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	AN041-SC-080211-C	2	3	21	J	Yes			
KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	AN041-SC-080211-D	3	4	18	J	Yes			
KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	AN041-SC-080211-E	4	5	4.2	J	Yes			
KenworthPACCAR)	AN-041	1276367	193757	4.0	4	not dredged	2	No	AN041-SC-080211-F	5	6						
DuwamYachtClub	C1	1276029	193283	4.0	outside of AOPCs	outside of AOPCs	3	Yes	C1	0	1.7	130		Yes			
USACE 1991	DU9118XX	1276200	193467	4.0	6	6	3	Yes	DUWO&M91S010	0	3	96		Yes			
RhônePoulenc2004	SB-13	1276396	193642	4.0	4	not dredged	2	No	Lower SB-13	0.33	0.69	380	J	Yes			
RhônePoulenc2004	SH-01	1276626	193525	4.0	3	not dredged	3	No	Lower SH-01	0.33	0.82	310	J	Yes			
RhônePoulenc2004	SH-02	1276644	193476	4.0	3	not dredged	3	No	Lower SH-02	0.33	0.82	870	J	Yes			

Notes

a. datum: NAD 1983 Washington State Plane North (Feet).

b. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 2R/2R-CAD, 3R, 4R, 5R/5R-T, and 6R.

c. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 3C, 4C, 5C, and 6C. Note that if a removal alternative is dredged, but the corresponding combined alternative is not dredged, then the combined alternative is actively remediated with capping or ENR.

AOPC = area of potential concern; cPAHs = carcinogenic polycyclic aromatic hydrocarbons

Table G-6 Dioxins/Furans and cPAHs in Cores – River Miles 4.1 to 5.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
PSDDA98	5	1276295	193292	4.1	outside of AOPCs	outside of AOPCs	3	Yes	S5	0	2	130		Yes			
DuwamYachtClub	C2	1276060	193153	4.1	outside of AOPCs	outside of AOPCs	3	Yes	C2	0	1.8	130	J	Yes			
DuwamYachtClub	C3	1276097	193033	4.1	outside of AOPCs	outside of AOPCs	3	Yes	C3	0	1.7	160	J	Yes			
DuwamYachtClub	C4	1276116	192985	4.1	outside of AOPCs	outside of AOPCs	3	Yes	C4	0	1.8	180	J	Yes			
DuwamYachtClub	C5	1276185	192853	4.1	outside of AOPCs	outside of AOPCs	3	Yes	C5	0	1.7	170	J	Yes			
DuwamYachtClub	C6	1276095	192761	4.1	6	not dredged	3	Yes	C6	0	2.2	230		Yes			
LDW Turning Basin 08	D08	1276400	192844	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D08-C	0	4.2	93		Yes	2.89	J	Yes
LDW Turning Basin 08	D09 (08)	1276360	192966	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D09-C	0	5.2	88		Yes			
LDW Turning Basin 09	D09 (09)	1276360	192966	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR09R-B-D09-C	0	4.4						
LDW Turning Basin 08	D10	1276350	193086	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D10-C	0	4.9	84		Yes	2.59	J	Yes
LDW Turning Basin 08	D11 (08)	1276330	193196	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D11-C	0	5.1	69		Yes			
LDW Turning Basin 09	D11 (09)	1276330	193196	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR09R-B-D11-C	0	4.2						
LDW Turning Basin 08	D12	1276281	193320	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D12-C	0	3.2	68		Yes	2.79	J	Yes
LDW Turning Basin 08	D14	1276335	193122	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D14-C	5.2	6.2	99		Yes	4.3	J	Yes
EPA SI	DR284	1276300	192823	4.1	outside of AOPCs	outside of AOPCs	3	No	SD-DR284-0000A	0	2	220		Yes			
EPA SI	DR284	1276300	192823	4.1	outside of AOPCs	outside of AOPCs	3	No	SD-DR284-0020	2	4	190		Yes			
USACE 1991	DU9115XX	1276329	192919	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91S007	0	4	140		Yes			
USACE 1991	DU9116XX	1276287	193084	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91S008	0	4	94		Yes			
USACE 1991	DU9117XX	1276242	193271	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91S009	0	4	120		Yes			
RhônePoulenc2004	SB-12	1276488	193172	4.1	3	not dredged	3	No	Lower SB-12	0.33	0.69	880	J	Yes			
RhônePoulenc2004	SH-03	1276647	193427	4.1	3	not dredged	3	No	Lower SH-03	0.33	0.82	400	U	No			
RhônePoulenc2004	SH-04	1276680	193285	4.1	3	6	3	No	Lower SH-04	0.33	0.82	340	J	Yes			
RhônePoulenc2004	SH-05	1276691	193156	4.1	3	5	3	No	Lower SH-05	0.33	0.82						
RhônePoulenc2004	SH-06	1276761	192921	4.1	2	3	1	No	Lower SH-06	0.33	0.82	370	U	No			
LDW Turning Basin 08	ST21	1276490	192863	4.1	2	3	1	Yes	DR08-B-ST21-C0-2	0	2	130		Yes	3.03	J	Yes
LDW Turning Basin 08	ST21	1276490	192863	4.1	2	3	1	Yes	DR08-B-ST21-C2-5	2	5	160		Yes	5.67	J	Yes
LDW Turning Basin 08	ST22	1276450	192975	4.1	6	6	3	Yes	DR08-B-ST22-C0-2	0	2	77		Yes	2.26	J	Yes
LDW Turning Basin 08	ST22	1276450	192975	4.1	6	6	3	Yes	DR08-B-ST22-C2-5	2	5	140		Yes	8.11	J	Yes
LDW Turning Basin 08	ST23	1276430	193096	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-ST23-C0-2	0	2	98		Yes	4.57	J	Yes
LDW Turning Basin 08	ST23	1276430	193096	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-ST23-C2-5	2	5	160		Yes	4.62	J	Yes
LDW Turning Basin 08	ST28	1276250	193065	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-ST28-C0-2	0	2	91		Yes	6.5	J	Yes
LDW Turning Basin 08	ST28	1276250	193065	4.1	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-ST28-C2-5	2	5	75		Yes	8.63	J	Yes
PSDDA96	6 (96)	1276510	192364	4.2	outside of AOPCs	outside of AOPCs	1	Yes	S3	0	4						
PSDDA98	6 (98)	1276452	192612	4.2	outside of AOPCs	outside of AOPCs	3	Yes	S6	0	2	99		Yes			
PSDDA98	7 (98)	1276534	192326	4.2	outside of AOPCs	outside of AOPCs	1	Yes	S7	0	3	120		Yes			
LDW Turning Basin 08	D04 (08)	1276510	192418	4.2	outside of AOPCs	outside of AOPCs	1	Yes	DR08-B-D04-C	0	4.7	81		Yes	4.72	J	Yes
LDW Turning Basin 09	D04 (09)	1276510	192418	4.2	outside of AOPCs	outside of AOPCs	1	Yes	DR09R-B-D04-C	0	5.5						
LDW Turning Basin 08	D05	1276490	192506	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D05-C	0	4.9	64		Yes			
LDW Turning Basin 08	D06 (08)	1276470	192610	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D06-C	0	4.4	66		Yes	4.43	J	Yes
LDW Turning Basin 09	D06 (09)	1276470	192610	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DR09R-B-D06-C	0	5.3						
LDW Turning Basin 08	D07	1276440	192730	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D07-C	0	4.5	64		Yes			
LDW Turning Basin 08	D13	1276491	192512	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DR08-B-D13-C	4.9	5.9	62		Yes	3.46	J	Yes
LDW Turning Basin 09	D15	1276467	192514	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DR09-B-D15-C0-3	0	2.5	140	JN	Yes			
LDW Turning Basin 09	D15	1276467	192514	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DR09-B-D15-Z	2.5	3.5	87	JN	Yes			

Table G-6 Dioxins/Furans and cPAHs in Cores – River Miles 4.1 to 5.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
Delta Marine	DMMU 1	1276241	192572	4.2	6	not dredged	1	Yes	DMMU 1	0	7	110		Yes			
Delta Marine	DMMU 3	1276355	192576	4.2	6	6	1	Yes	DMMU 3	1	7	81		Yes	4.2	J	Yes
Delta Marine	DMMU 4	1276391	192408	4.2	6	6	1	Yes	DMMU 4	1.3	7.5	59		Yes	1.5	J	Yes
EPA SI	DR246	1276783	192615	4.2	4	4	1	No	SD-DR246-0000A	0	2	230		Yes			
EPA SI	DR246	1276783	192615	4.2	4	4	1	No	SD-DR246-0020	2	4	210		Yes			
USACE 1991	DU9111XX	1276455	192388	4.2	6	6	3	Yes	DUWO&M91S003	0	3	90		Yes			
USACE 1991	DU9112XX	1276485	192405	4.2	outside of AOPCs	outside of AOPCs	1	Yes	DUWO&M91S004	0	3	95		Yes			
USACE 1991	DU9113XX	1276409	192563	4.2	6	6	3	Yes	DUWO&M91S005	0	5	130		Yes			
USACE 1991	DU9114XX	1276360	192762	4.2	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91S006	0	4	120		Yes			
LDW Subsurface Sediment 2006	LDW-SC53	1277459	192928	4.2	2	3	1	No	LDW-SC53-0-2	0	2	1200	J	Yes			
LDW Subsurface Sediment 2006	LDW-SC53	1277459	192928	4.2	2	3	1	No	LDW-SC53-2-4	2	4	950		Yes			
RhônePoulenc2004	SB-1	1277485	192933	4.2	3	3	1	No	Lower SB-01	0.33	0.69	2000	J	Yes			
RhônePoulenc2004	SB-11	1276515	192835	4.2	2	3	1	No	Lower SB-11	0.33	0.69	330	J	Yes			
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	Lower SB-16	0.33	0.69	1700	J	Yes			
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	Lower SB-17	0.33	0.69	2100	J	Yes			
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	Lower SB-16	0.33	0.69	1700	J	Yes			
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	Lower SB-17	0.33	0.69	2100	J	Yes			
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	Lower SB-16	0.33	0.69	1700	J	Yes			
RhônePoulenc2004	SB-17	1277440	192982	4.2	2	3	1	No	Lower SB-17	0.33	0.69	2100	J	Yes			
RhônePoulenc2004	SB-2	1277003	192646	4.2	4	4	1	No	Lower SB-02	0.33	0.69	720	J	Yes			
RhônePoulenc2004	SB-2	1277003	192646	4.2	4	4	1	No	Lower SB-15	0.33	0.69	780	J	Yes			
RhônePoulenc2004	SB-3	1277422	192973	4.2	2	3	2	No	Lower SB-03	0.33	0.69	1500	J	Yes			
RhônePoulenc2004	SB-4	1277315	192933	4.2	2	3	2	No	Lower SB-04	0.33	0.69	1000	J	Yes			
RhônePoulenc2004	SB-5	1277209	192892	4.2	2	3	2	No	Lower SB-05	0.33	0.69	740	J	Yes			
RhônePoulenc2004	SB-6	1277116	192857	4.2	4	4	2	No	Lower SB-06	0.33	0.69	700	J	Yes			
RhônePoulenc2004	SB-7	1276950	192774	4.2	4	4	2	No	Lower SB-07	0.33	0.69	670	J	Yes			
RhônePoulenc2004	SB-8	1276869	192749	4.2	2	3	2	No	Lower SB-08	0.33	0.69	630	J	Yes			
RhônePoulenc2004	SH-07	1276783	192891	4.2	2	3	1	No	Lower SH-07	0.33	0.82	430	J	Yes			
RhônePoulenc2004	SH-08	1276796	192834	4.2	2	3	1	No	Lower SH-08	0.33	0.82	370	J	Yes			
RhônePoulenc2004	SH-09	1276766	192833	4.2	3	3	1	No	Lower SH-09	0.33	0.82	320	J	Yes			
LDW Turning Basin 08	ST31	1276320	192713	4.2	6	6	1	Yes	DR08-B-ST31-C0-2	0	2	130		Yes	1.19	J	Yes
LDW Turning Basin 08	ST31	1276320	192713	4.2	6	6	1	Yes	DR08-B-ST31-C2-5	2	5	100		Yes	9.33	J	Yes
PSDDA96	4 (96)	1276677	192025	4.3	outside of AOPCs	outside of AOPCs	1	Yes	S1	0	4						
PSDDA96	5 (96)	1276557	192210	4.3	outside of AOPCs	outside of AOPCs	1	Yes	S2	0	4						
LDW Turning Basin 08	D03 (08)	1276540	192295	4.3	outside of AOPCs	outside of AOPCs	1	Yes	DR08-B-D03-C	0	4.3	93		Yes	1.67	J	Yes
LDW Turning Basin 09	D03 (09)	1276540	192295	4.3	outside of AOPCs	outside of AOPCs	1	Yes	DR09R-B-D03-C	0	3.7						
USACE 1991	DU9109XX	1276581	191917	4.3	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91S001	0	5	160		Yes			
USACE 1991	DU9110XX	1276557	192034	4.3	outside of AOPCs	outside of AOPCs	1	Yes	DUWO&M91S002	0	5	53		Yes			
LDW Subsurface Sediment 2006	LDW-SC54	1276355	192181	4.3	6	6	1	No	LDW-SC54-0-2	0	2	130		Yes			
LDW Subsurface Sediment 2006	LDW-SC54	1276355	192181	4.3	6	6	1	No	LDW-SC54-2-4	2	4	150		Yes			
PSDDA98	Average of 8-9	1276772	191322	4.4	outside of AOPCs	outside of AOPCs	1	Yes	C1	0	2	91		Yes			
LDW Turning Basin 08	D02 (08)	1276735	191454	4.4	outside of AOPCs	outside of AOPCs	1	Yes	DR08-A-D02-S	0	0.62	110		Yes	2.77	J	Yes
LDW Turning Basin 09	D02 (09)	1276735	191454	4.4	outside of AOPCs	outside of AOPCs	1	Yes	DR09R-A-D02-D	0	11.6	19	J	Yes			
Turning-basin	DTB-01SD	1276666	191599	4.4	outside of AOPCs	outside of AOPCs	3	Yes	DTB-01SD	0	4.8	55	J	Yes			
Turning-basin	DTB-02SD	1276813	191026	4.5	outside of AOPCs	outside of AOPCs	3	Yes	DTB-02SD	0	6.1	64	J	Yes			

Table G-6 Dioxins/Furans and cPAHs in Cores – River Miles 4.1 to 5.0

Core Information									Sample Information			cPAHs			Dioxins/Furans		
Task	Core Location Name	X[a]	Y[a]	River Mile	Removal-Emphasis Alternative when Area is First Dredged[b]	Combined-Technologies Alternative when Area is First Dredged[c]	Recovery Category	Collected for Dredge Material Characterization?	Sample Name	Upper Sample Depth (ft recovered)	Lower Sample Depth (ft recovered)	Concentration (µg TEQ/kg dw)	Qualifier	Detected	Concentration (ng TEQ/kg dw)	Qualifier	Detected
USACE 1991	DU9105MC	1276829	190964	4.5	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91C002	0	4	82		Yes			
PSDDA98	Average of 10-12	1277162	190420	4.6	outside of AOPCs	outside of AOPCs	3	Yes	C2	0	4	1100		Yes			
PSDDA98	Average of 10-12	1277162	190420	4.6	outside of AOPCs	outside of AOPCs	3	Yes	C3	4	11	57		Yes			
PSDDA96	C1 (96)	1276974	190762	4.6	outside of AOPCs	outside of AOPCs	3	Yes	C1	0	4						
LDW Turning Basin 08	D01 (08)	1277173	190473	4.6	outside of AOPCs	outside of AOPCs	3	Yes	DR08-A-D01-S	0	0.62	41		Yes	1.99	J	Yes
LDW Turning Basin 09	D01 (09)	1277173	190473	4.6	outside of AOPCs	outside of AOPCs	3	Yes	DR09R-A-D01-C	0	12.9	6.6	J	Yes			
EPA SI	DR269	1276822	190328	4.6	outside of AOPCs	outside of AOPCs	3	No	SD-DR269-0000A	0	2	120		Yes			
EPA SI	DR269	1276822	190328	4.6	outside of AOPCs	outside of AOPCs	3	No	SD-DR269-0020	2	4	100		Yes			
Turning-basin	DTB-03SD	1276961	190722	4.6	outside of AOPCs	outside of AOPCs	3	Yes	DTB-03SD	0	6.5	47	J	Yes			
Turning-basin	DTB-04SD	1277106	190448	4.6	outside of AOPCs	outside of AOPCs	3	Yes	DTB-04SD	0	13	62	J	Yes			
Turning-basin	DTB-05SD	1277259	190358	4.7	outside of AOPCs	outside of AOPCs	3	Yes	DTB-05SD	0	8.8	29	J	Yes			
USACE 1991	DU9101MC	1277266	190358	4.7	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91C001	0	4	13	U	No			
USACE 1991	DU9101MC	1277266	190358	4.7	outside of AOPCs	outside of AOPCs	3	Yes	DUWO&M91C003	4	14	46		Yes			
LDW Subsurface Sediment 2006	LDW-SC56	1277575	190022	4.7	3	3	1	No	LDW-SC56-0-2	0	2	190		Yes			
LDW Subsurface Sediment 2006	LDW-SC56	1277575	190022	4.7	3	3	1	No	LDW-SC56-2-4	2	4	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC55	1278267	190390	4.9	2	3	0	No	LDW-SC55-0-1	0	1	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC55	1278267	190390	4.9	2	3	0	No	LDW-SC55-1-2	1	2	18	U	No			
LDW Subsurface Sediment 2006	LDW-SC55	1278267	190390	4.9	2	3	0	No	LDW-SC55-2-3	2	3	18	U	No			
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	L6725-8	0	0.98	1460	J	Yes			
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	L6725-9	0.98	2	170	J	Yes			
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	L6725-10	2	3	36	UJ	No			
Norfolk-cleanup2	NFK207	1278618	190161	4.9	5	6	0	No	L6725-11	3	3.9	36	UJ	No			

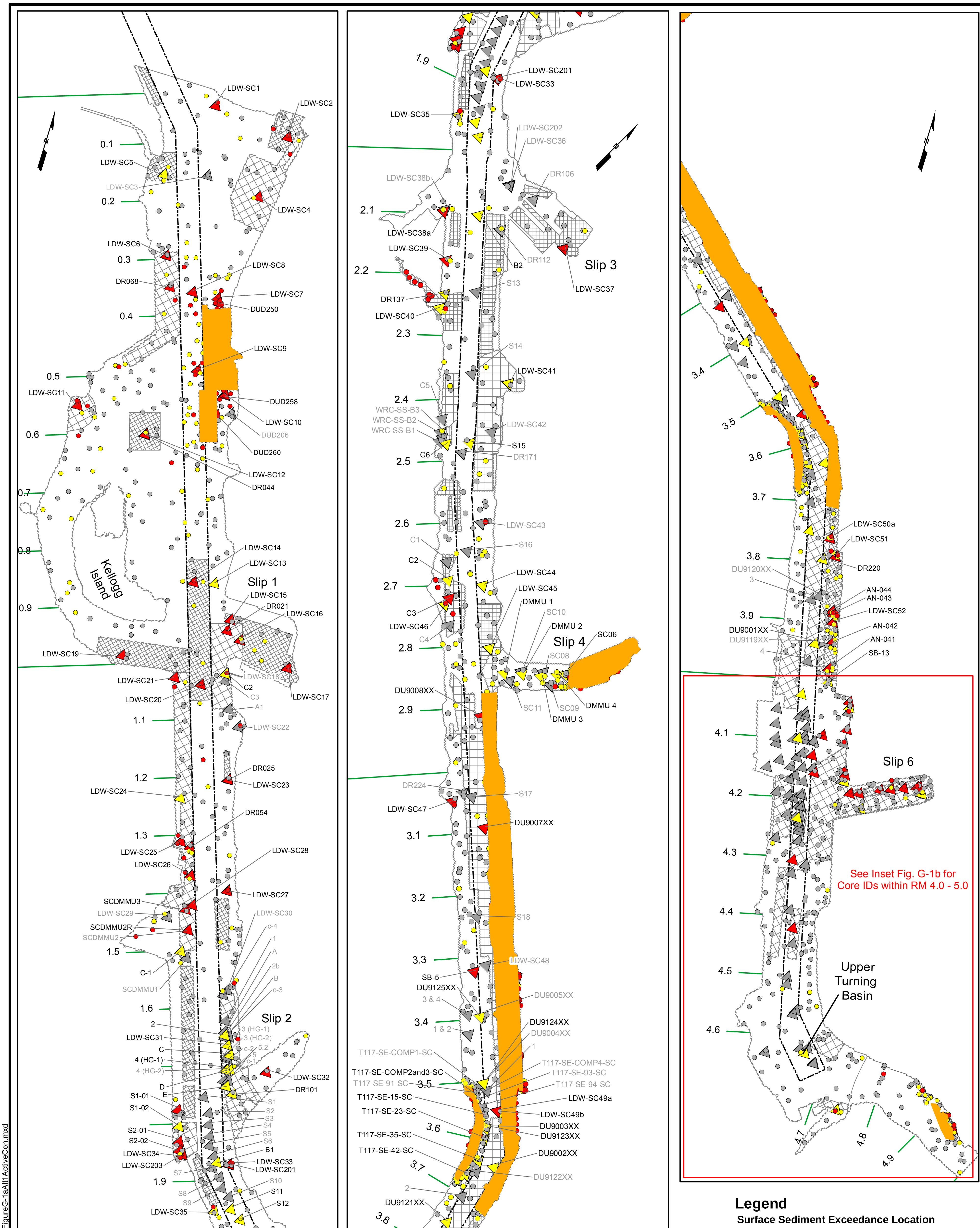
Notes

a. datum: NAD 1983 Washington State Plane North (Feet).

b. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 2R/2R-CAD, 3R, 4R, 5R/5R-T, and 6R.

c. Indicates lowest-numbered remedial alternative when the core is subject to dredging or to partial dredging/ capping for Alternatives 3C, 4C, 5C, and 6C. Note that if a removal alternative is dredged, but the corresponding combined alternative is not dredged, then the combined alternative is actively remediated with capping or ENR.

AOPC = area of potential concern; cPAHs = carcinogenic polycyclic aromatic hydrocarbons



Legend

Surface Sediment Exceedance Location

- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Subsurface Exceedance Location and ID

- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Technology Assignment

- Dredge, Cap, or Partial Dredge and Cap (Early Action Areas: 29 acres)
- Remaining Study Area (412 acres)

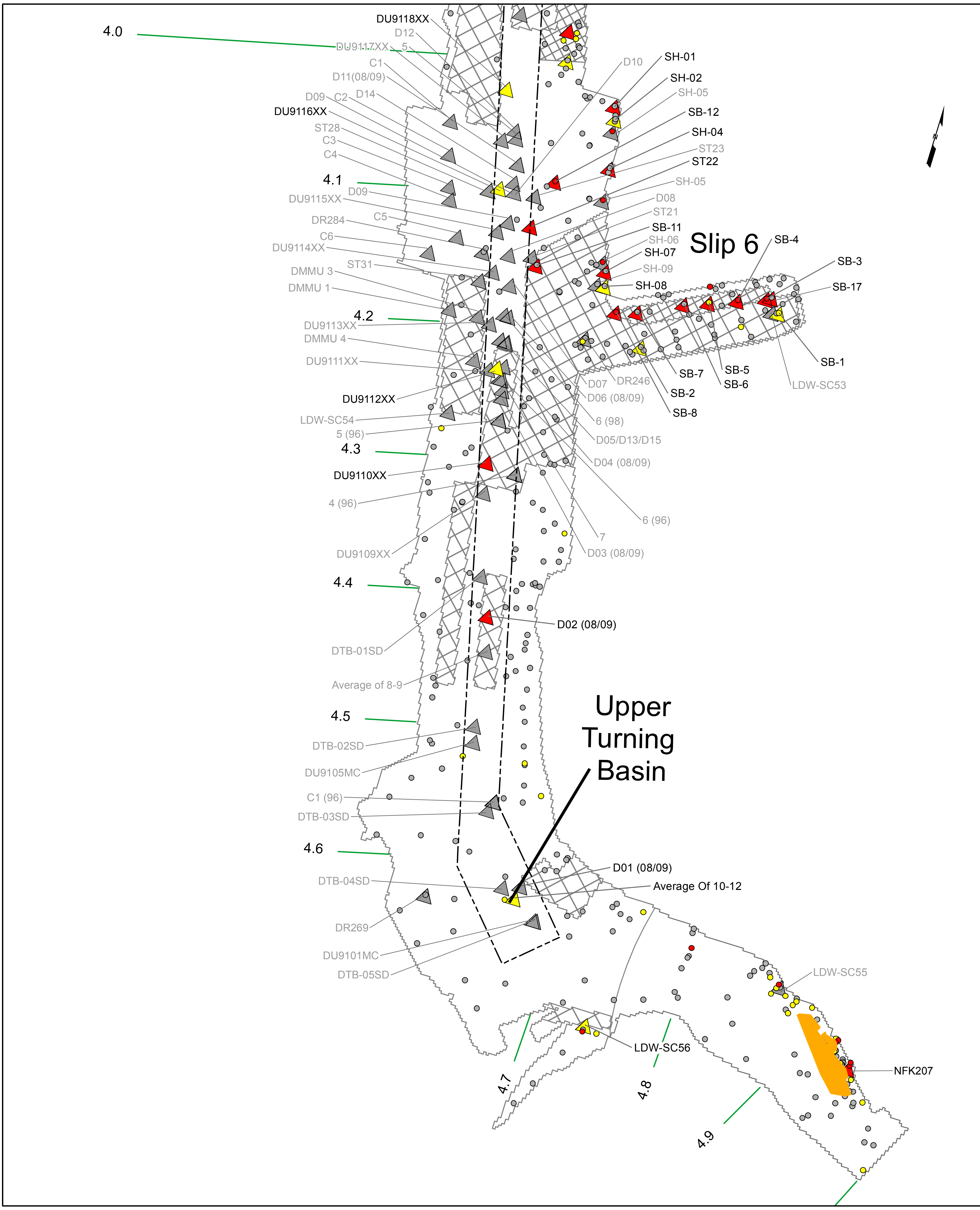
Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-1aAlt1ActiveCon.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			**Alternative 1 Technology Assignments and Waterway Conditions**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE G-1a**



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Technology Assignment
- Dredge, Cap, or Partial Dredge and Cap (Early Action Areas: 29 acres)
- Remaining Study Area (412 acres)

Legend

Surface Sediment Exceedance Location
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-1bAlt1ActiveConB.mxd

AECOM

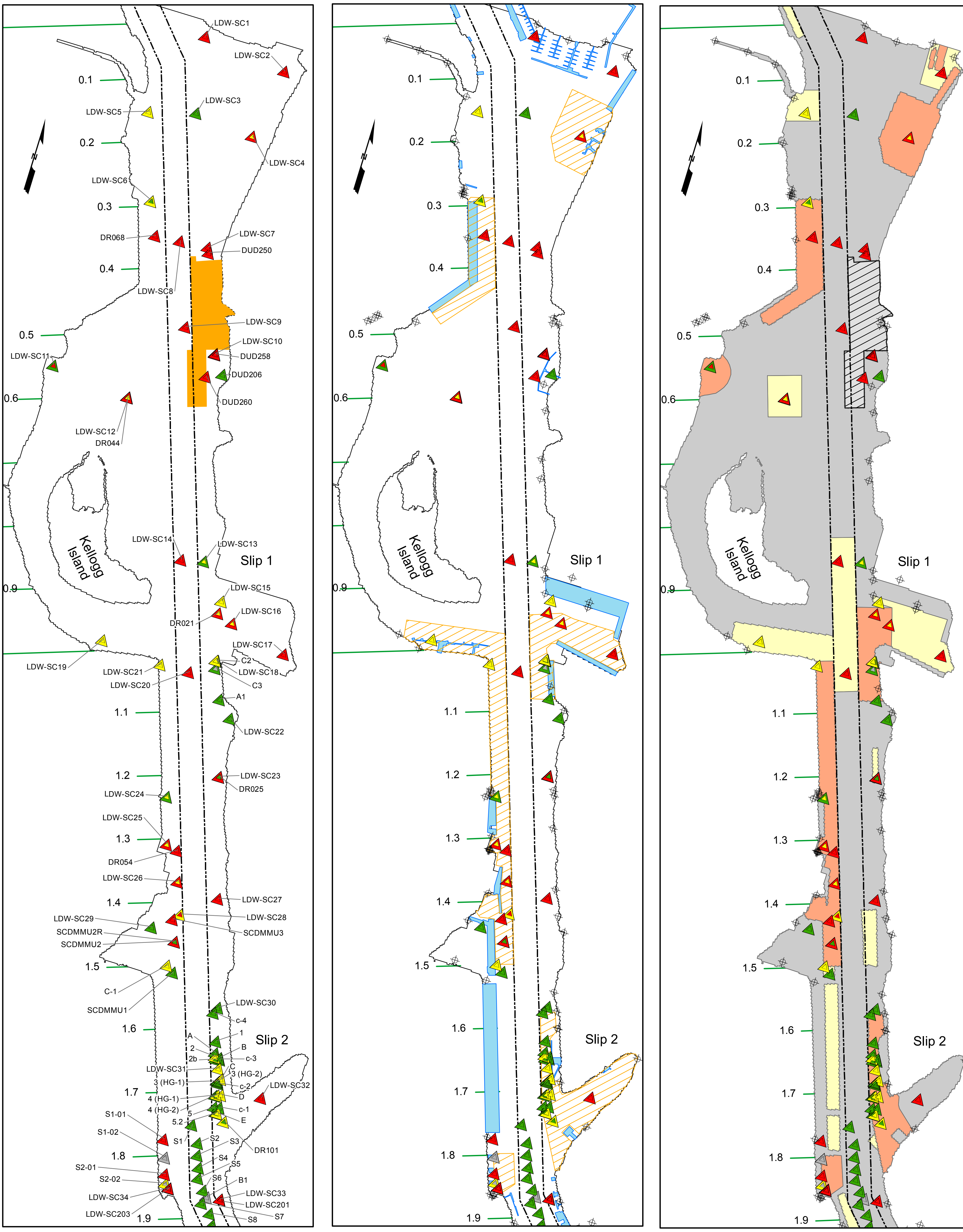
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 1 Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

FIGURE G-1b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge, Cap, or Partial Dredge and Cap
- Remaining Study Area (Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

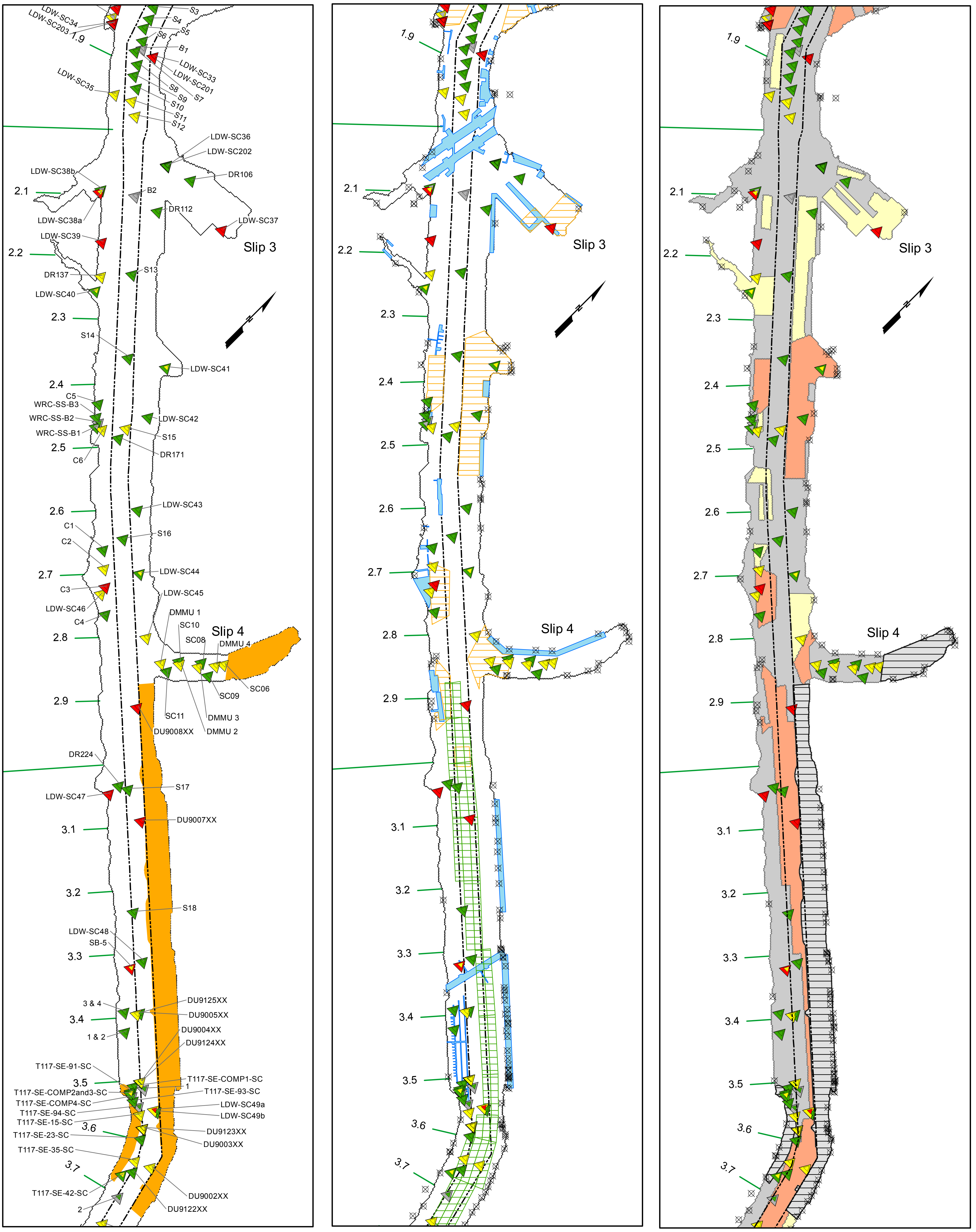
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 1 Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-2a

L:\Lower Duwamish FS\FS_Final_GIS\GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\G-2aCoreRecoveryNorth1.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 ft or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge, Cap, or Partial Dredge and Cap
- Remaining Study Area (Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

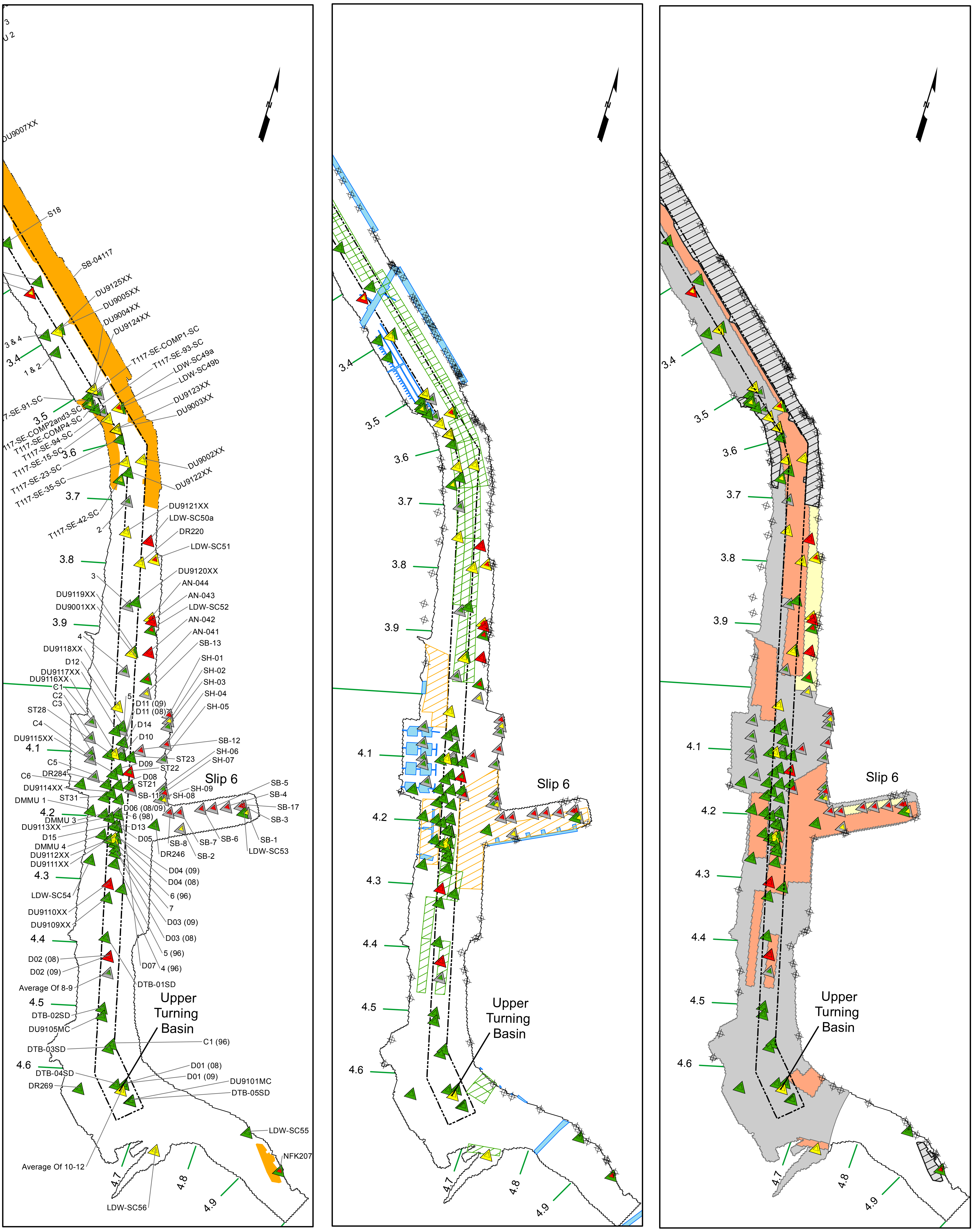
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			Alternative 1 Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-2b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-2bCoreRecoveryMid1.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge, Cap, or Partial Dredge and Cap
- Remaining Study Area (Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

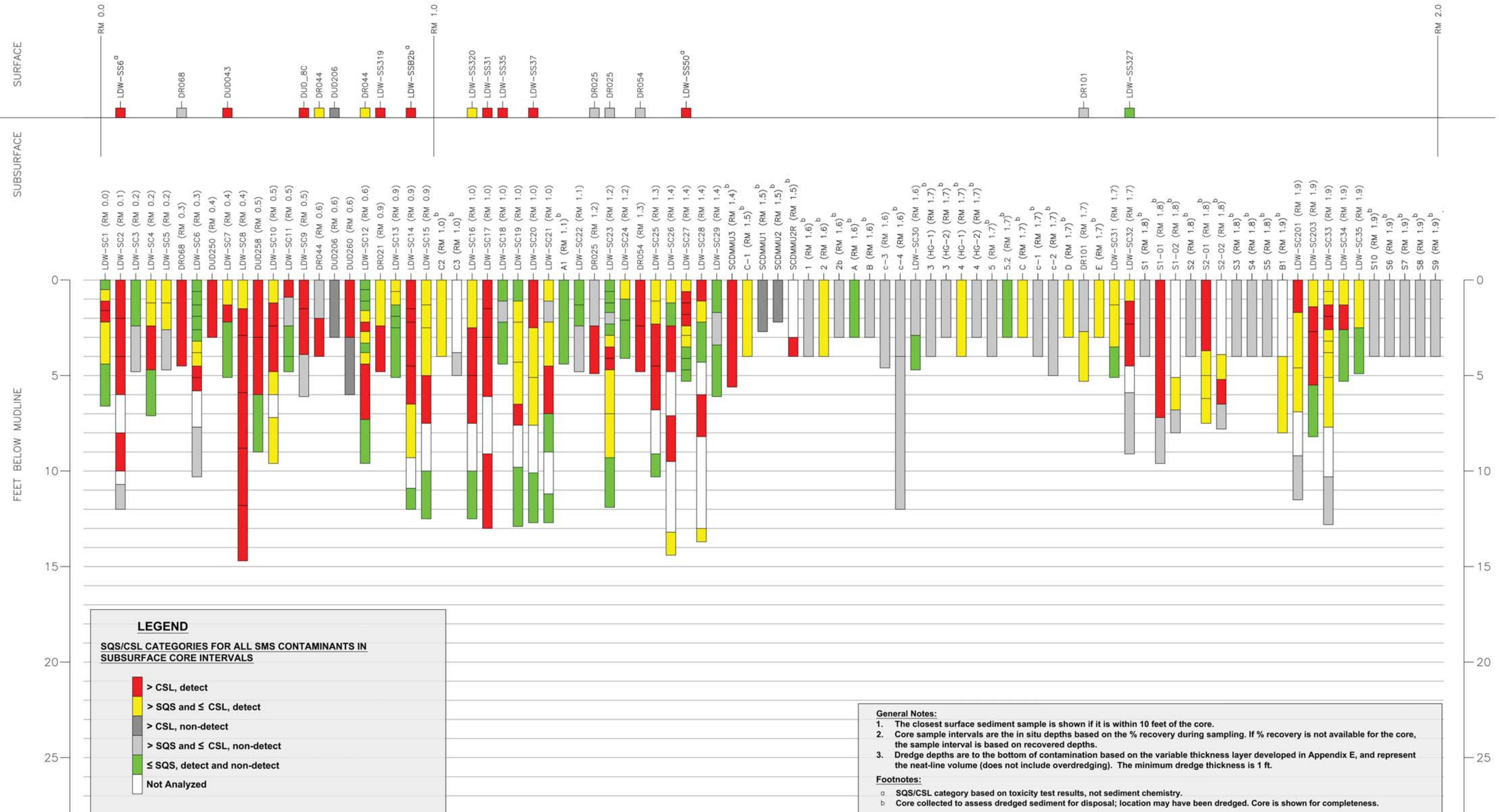
Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			**Alternative 1 Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE G-2c**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\NewG\FigureG-2cCoreRecoverySouth1.mxd



General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.

AECOM

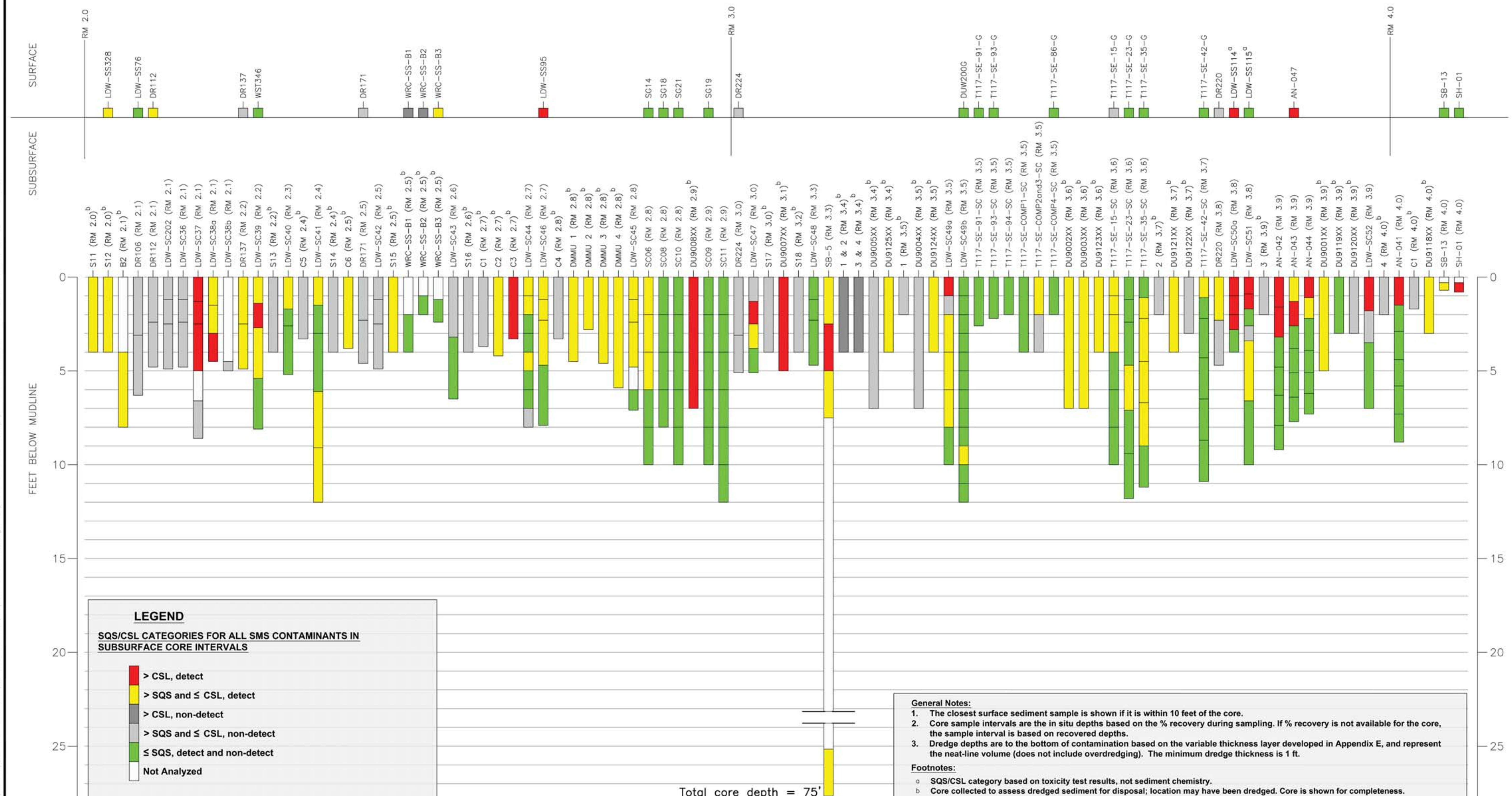
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 1 REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-3a



AECOM

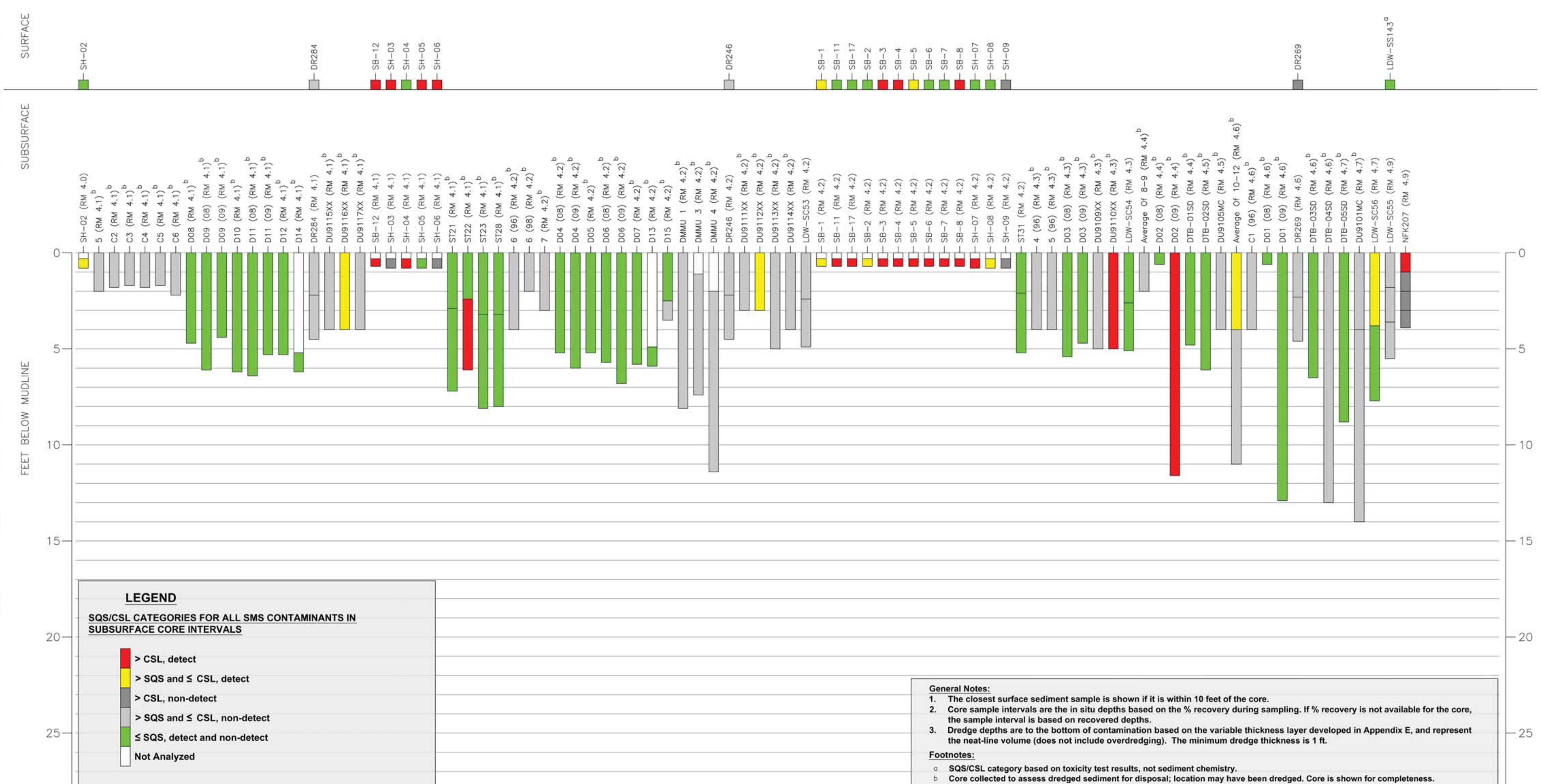
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 1 REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

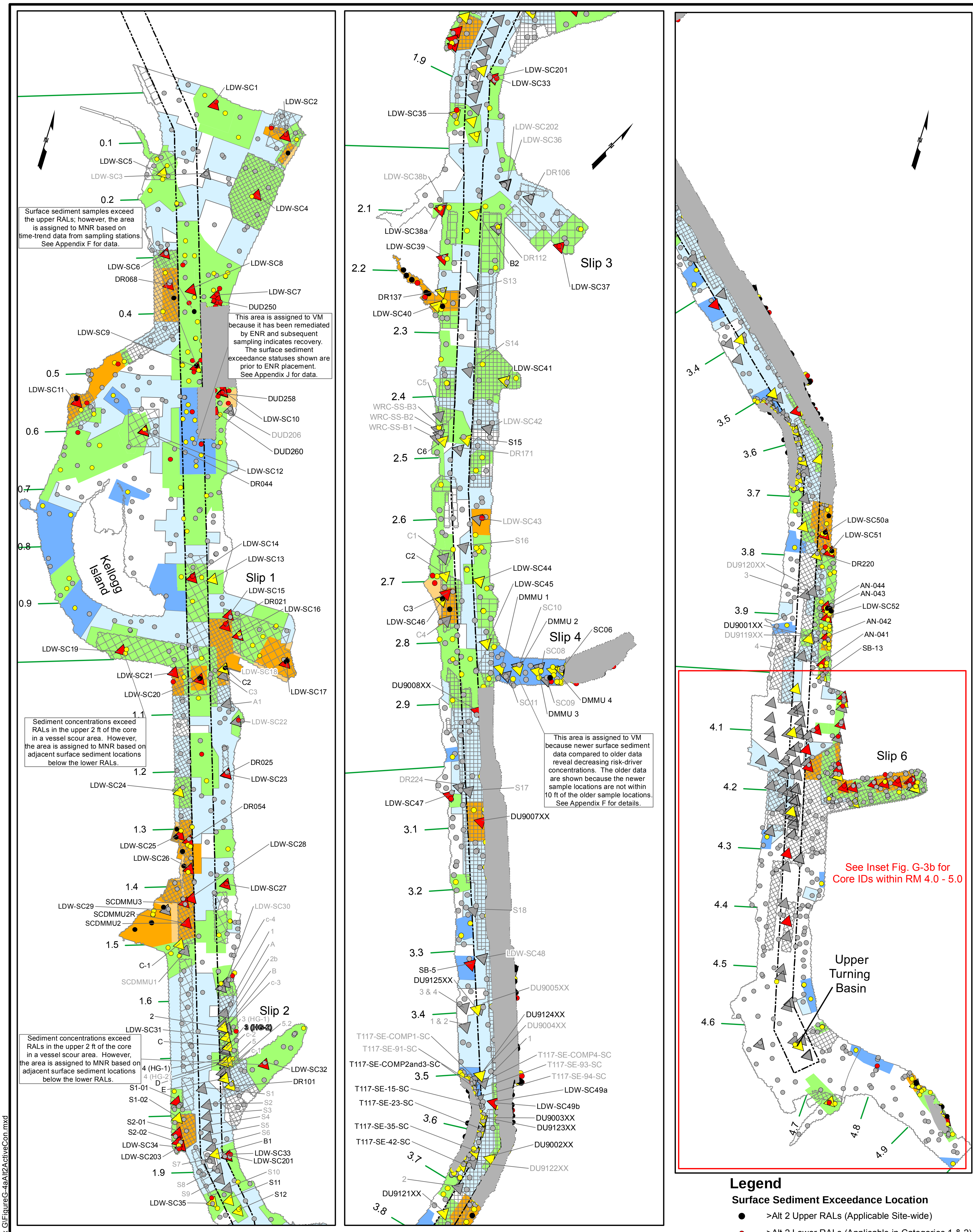
FIGURE G-3b



AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY 60150279-14.46	ALTERNATIVE 1 REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)
DATE: 10/31/12 DRWN: MO/SEA	FIGURE G-3c



Notes:

1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 2 upper RALs	2,200	5,500	50	93	3x CSL
Alt 2 lower RALs	1,300[a]	5,500	50	93	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (29 acres)
- Cap or Partial Dredge and Cap (3 acres)
- Monitored Natural Recovery (125 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

AOPC 2 (122 acres)

Early Action Area (29 acres)

Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 2 Upper RALs (Applicable Site-wide)
- >Alt 2 Lower RALs (Applicable in Categories 1 & 2)
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected

Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

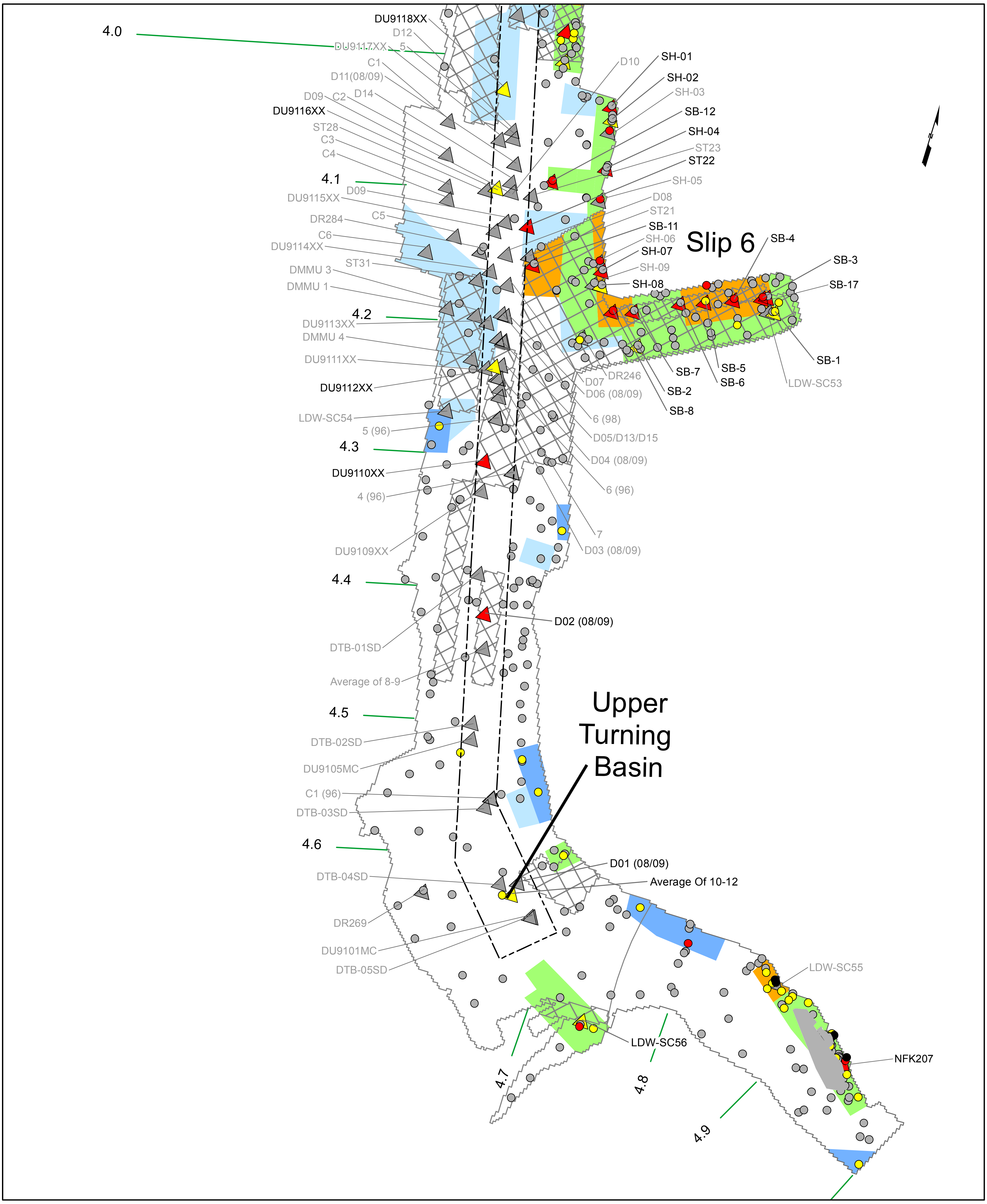
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 2 Removal Technology Assignments and Waterway Conditions

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-4a

L:\Lower Duwamish FS\FS Final GISOct2012\FS GIS MXDs Oct12\Appendix G\FigureG-4aAlt2ActiveCon.mxd



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 2 upper RALs	2,200	5,500	50	93	3x CSL
Alt 2 lower RALs	1,300[a]	5,500	50	93	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (29 acres)
- Cap or Partial Dredge and Cap (3 acres)
- Monitored Natural Recovery (125 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Feet
0 200 400 800

Legend

Surface Sediment Exceedance Location
- >Alt 2 Upper RALs (Applicable Site-wide)
- >Alt 2 Lower RALs (Applicable in Categories 1 & 2)
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected

Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-4bAlt2ActiveConCADB.mxd

AECOM

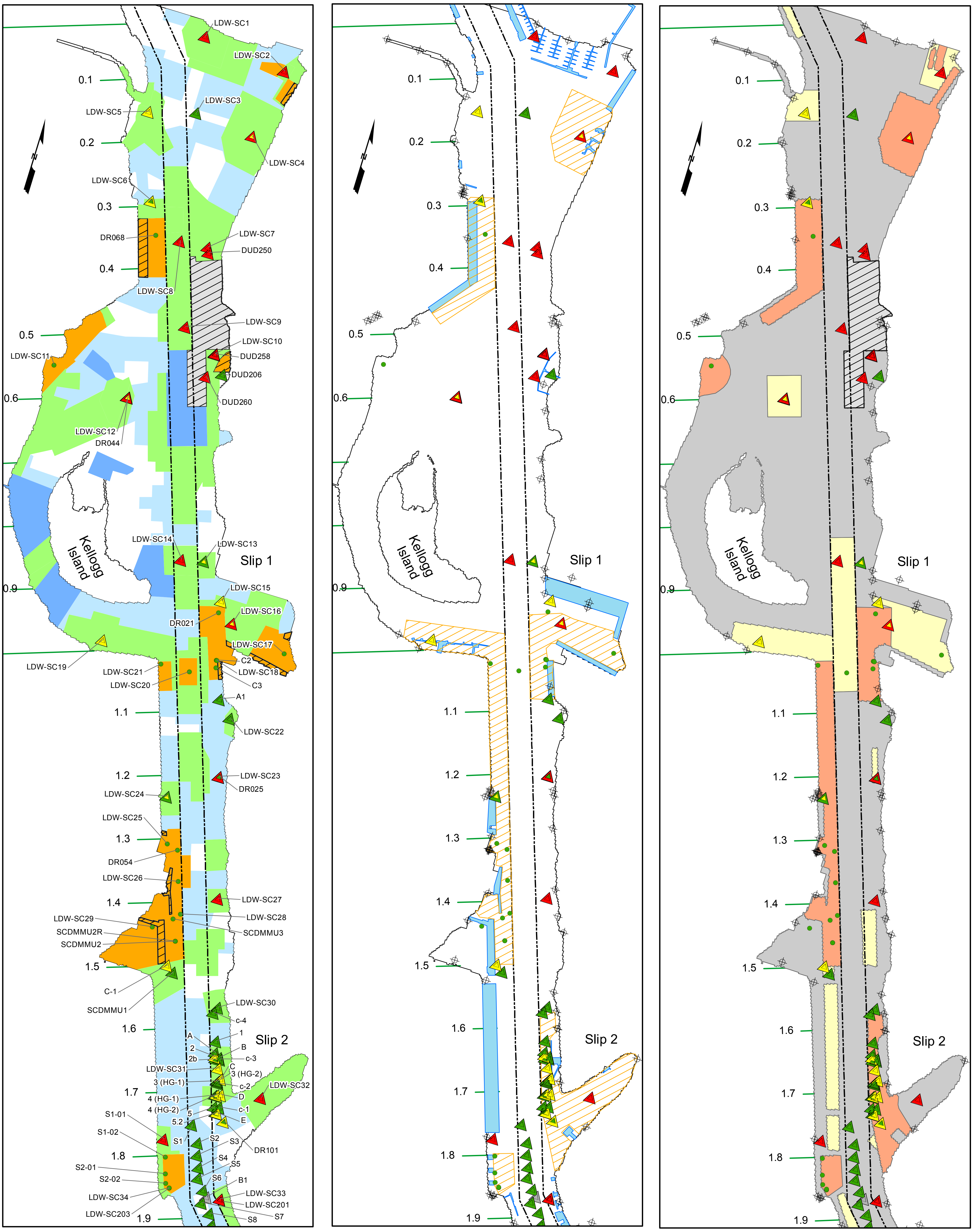
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 2 Removal Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-4b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

0 200 400 800 Feet

AECOM

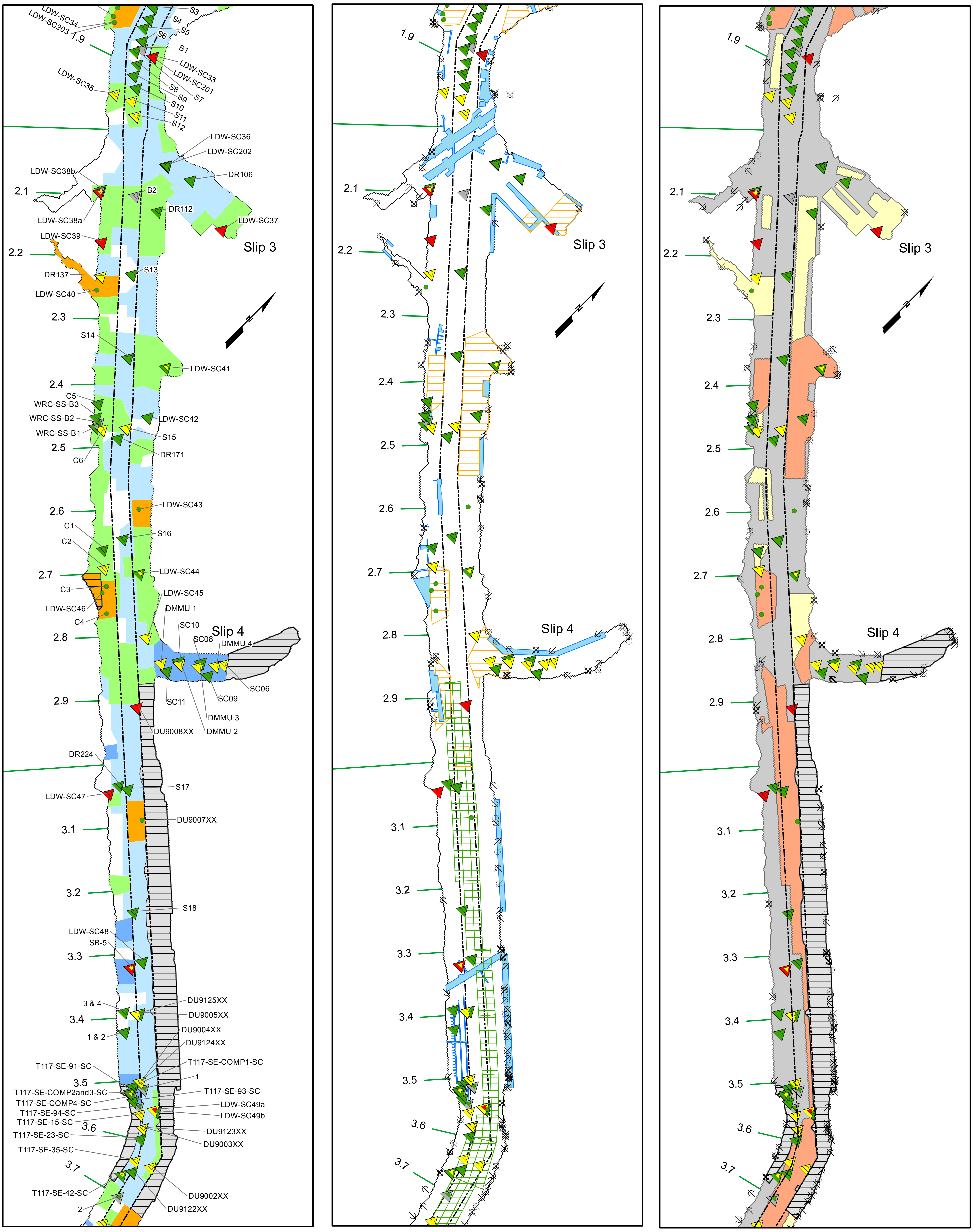
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 2 Removal Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0 | **FIGURE G-5a**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-5aCoreRecoveryNorth2R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

0 200 400 800 Feet

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core; Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

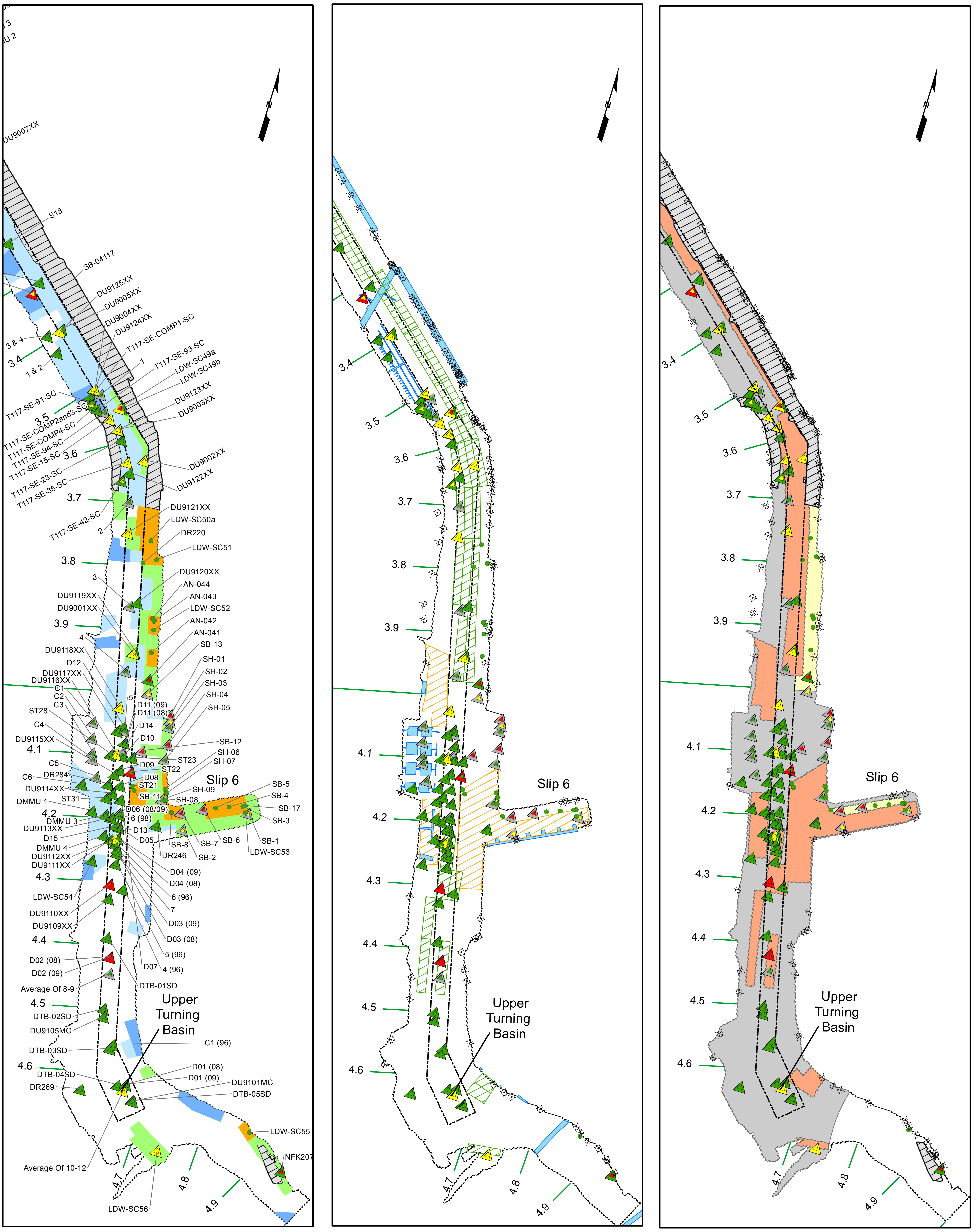
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 2 Removal Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-5b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-5bCoreRecoveryMid2R.mxd



Notes:

1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

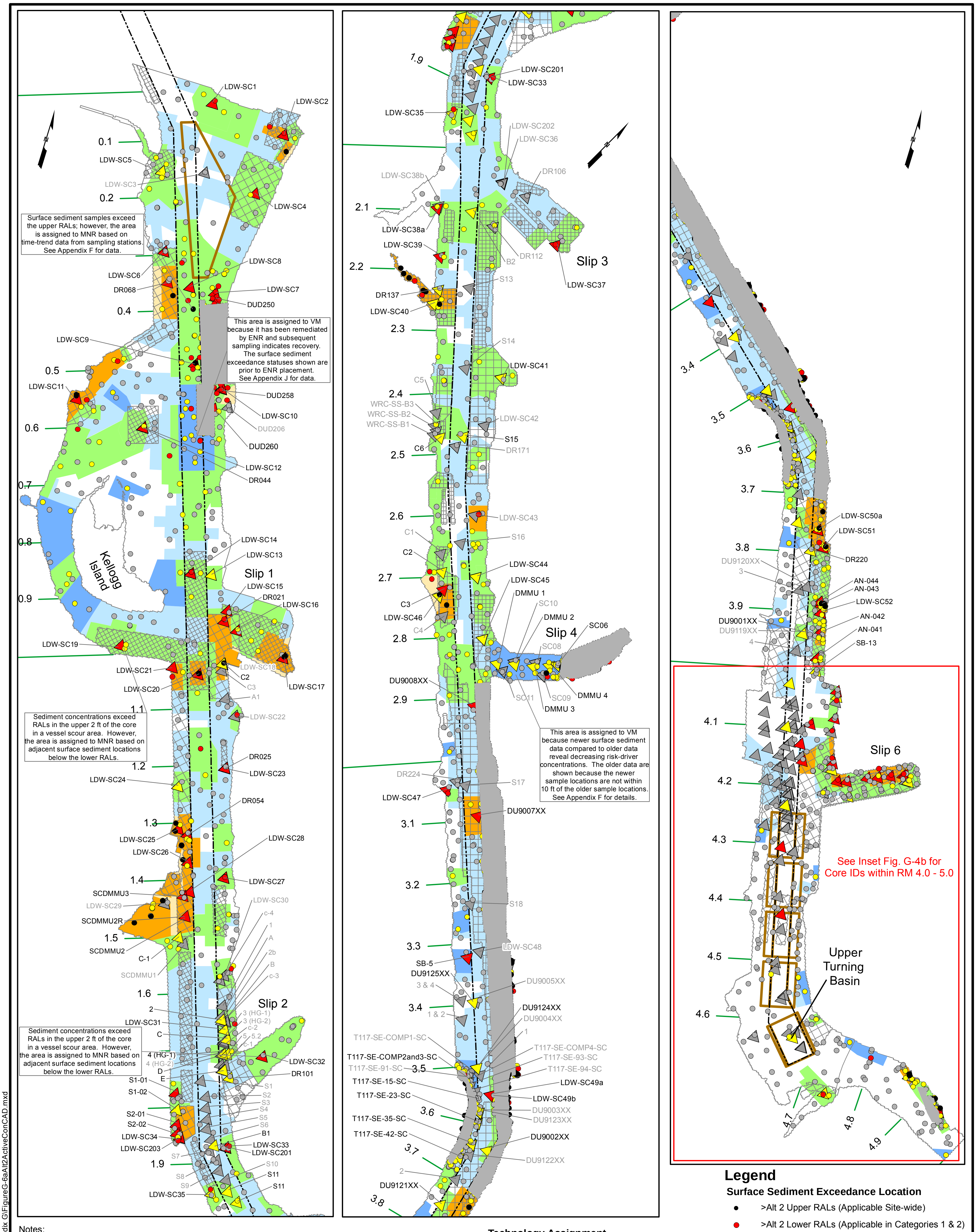
Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			Alternative 2 Removal Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-5c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-5cCoreRecoverySouth2R.mxd



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 2 upper RALs	2,200	5,500	50	93	3x CSL
Alt 2 lower RALs	1,300[a]	5,500	50	93	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (29 acres)
- Cap or Partial Dredge and Cap (3 acres)
- Monitored Natural Recovery (125 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)
- Contained Aquatic Disposal Area

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 2 Upper RALs (Applicable Site-wide)
- >Alt 2 Lower RALs (Applicable in Categories 1 & 2)
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

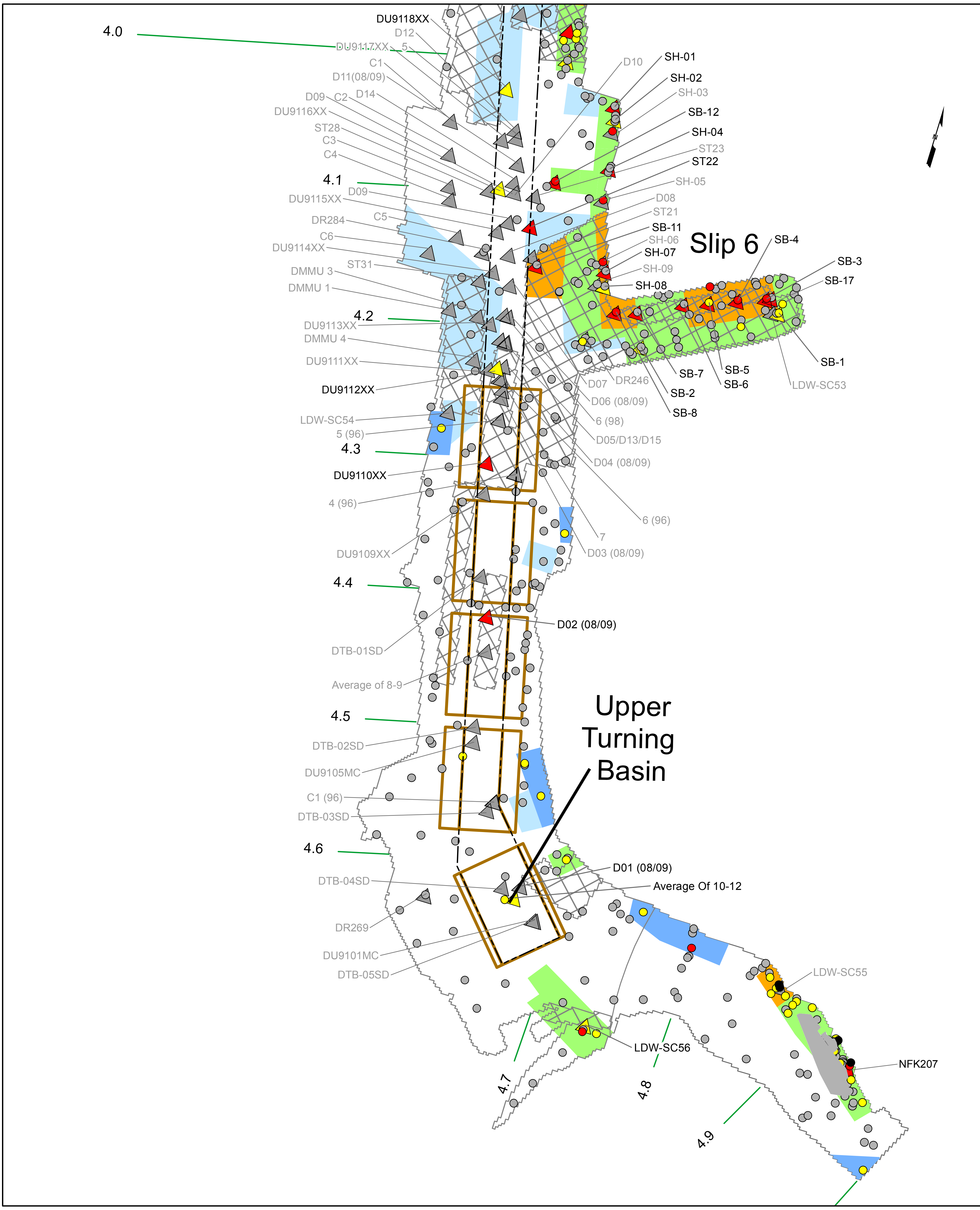
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 2 Removal with CAD Technology Assignments and Waterway Conditions

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-6a

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-6aAlt2ActiveConCAD.mxd



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 2 upper RALs	2,200	5,500	50	93	3x CSL
Alt 2 lower RALs	1,300[a]	5,500	50	93	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (29 acres)
- Cap or Partial Dredge and Cap (3 acres)
- Monitored Natural Recovery (125 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)
- Contained Aquatic Disposal Area

Feet
0 200 400 800

Legend

Surface Sediment Exceedance Location
- >Alt 2 Upper RALs (Applicable Site-wide)
- >Alt 2 Lower RALs (Applicable in Categories 1 & 2)
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-6bAlt2ActiveConCADB.mxd

AECOM

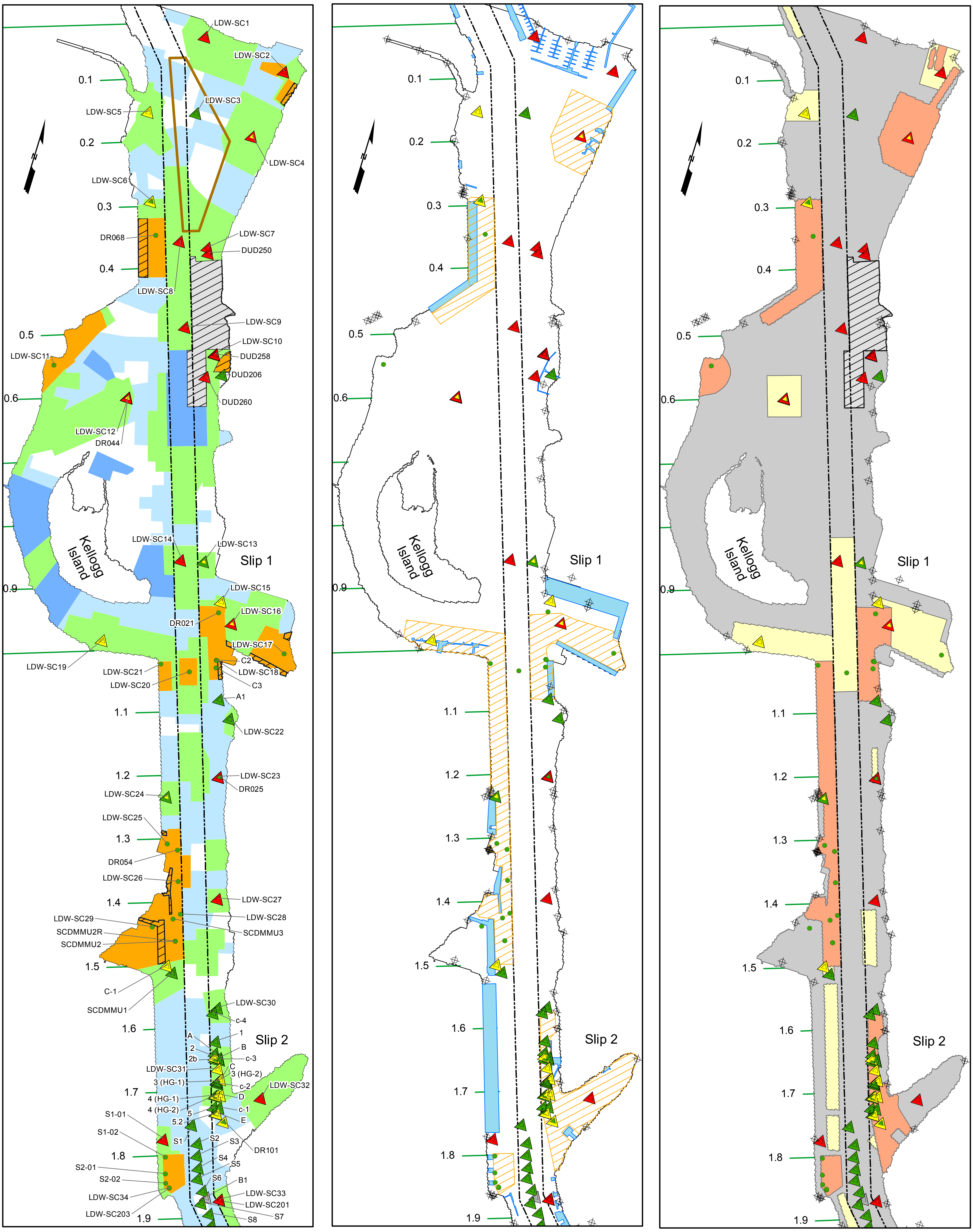
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 2 Removal with CAD Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

FIGURE G-6b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Contained Aquatic Disposal Area
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Feet
0 200 400 800

AECOM

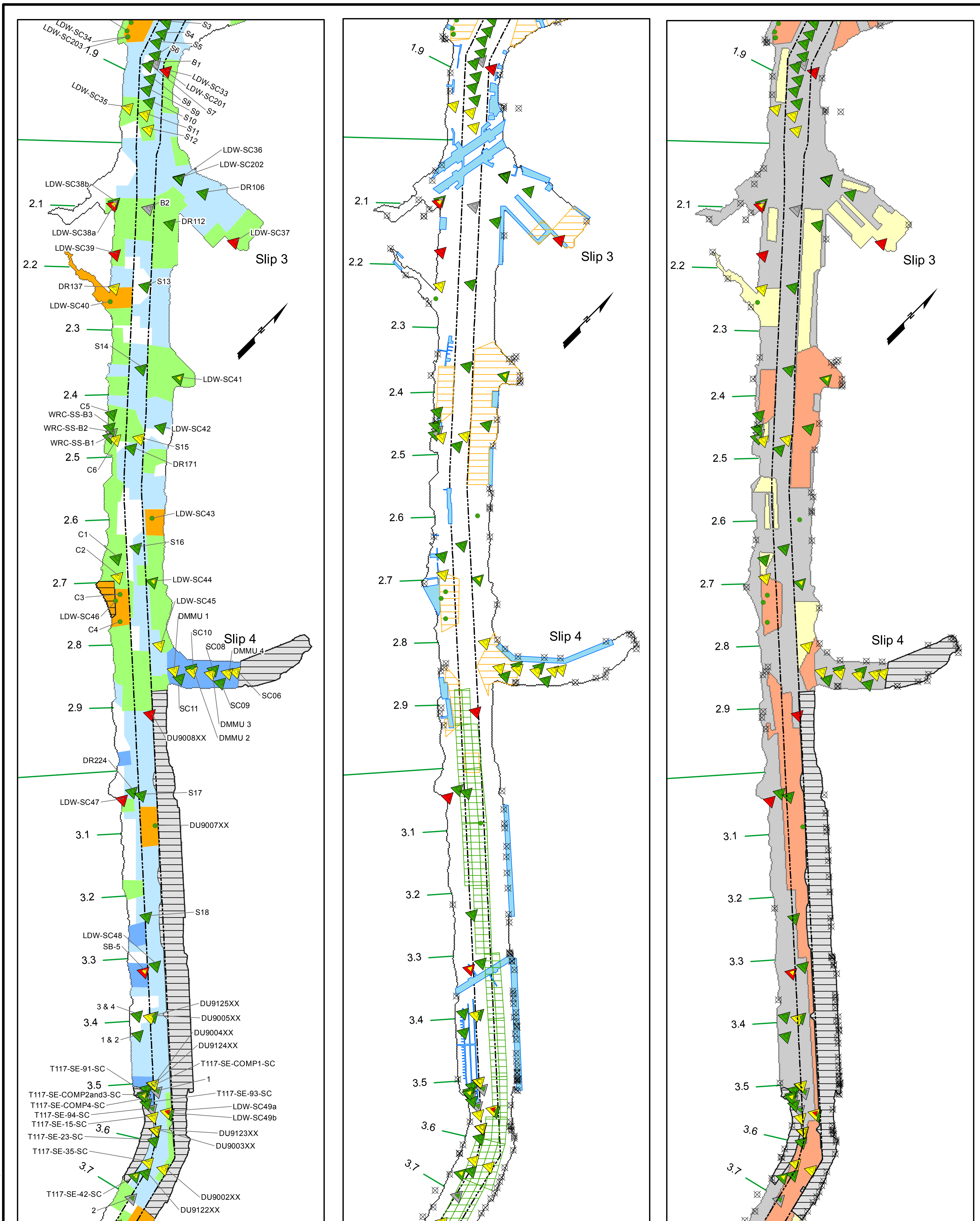
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 2 Removal with CAD Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-7a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-7aCoreRecoveryNorth2R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

AECOM

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core
Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

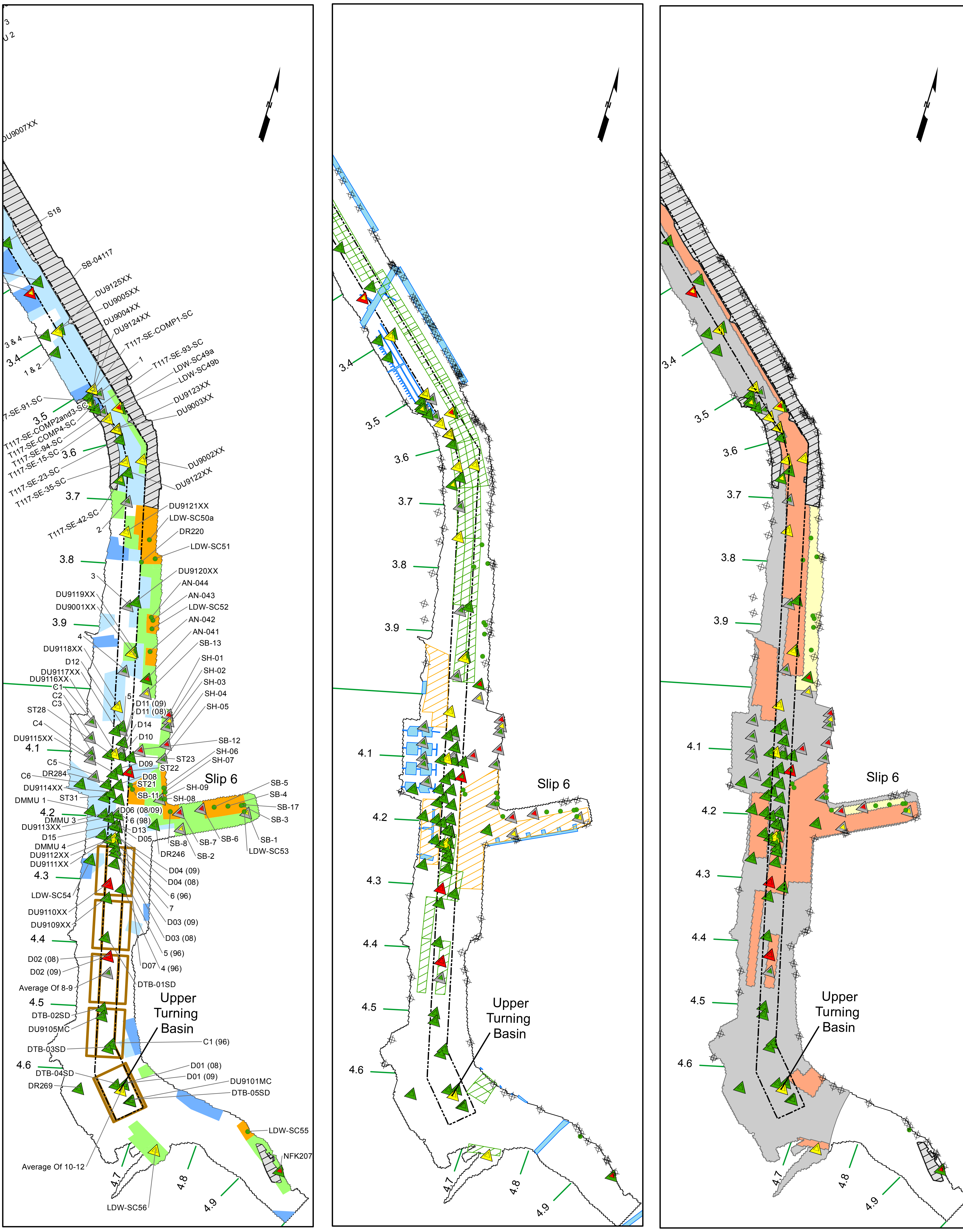
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Contained Aquatic Disposal Area
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 2 Removal with CAD Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-7b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-7bCoreRecoveryMid2R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation
Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Contained Aquatic Disposal Area
- Outfall Location

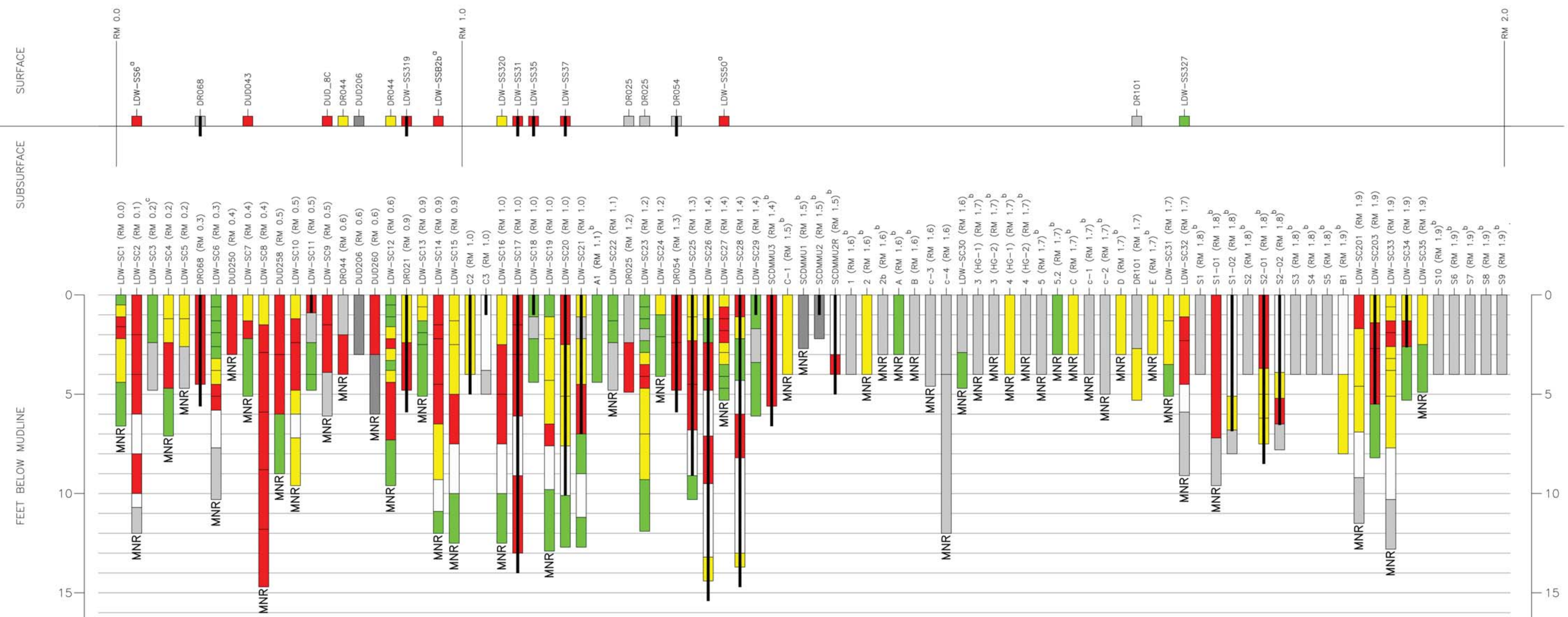
Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 2 Removal with CAD Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-7c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-7cCoreRecoverySouth2RCAD.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c Core located in CAD area. During construction, location would be dredged for CAD construction, backfilled with contaminated sediment, and capped.

AECOM

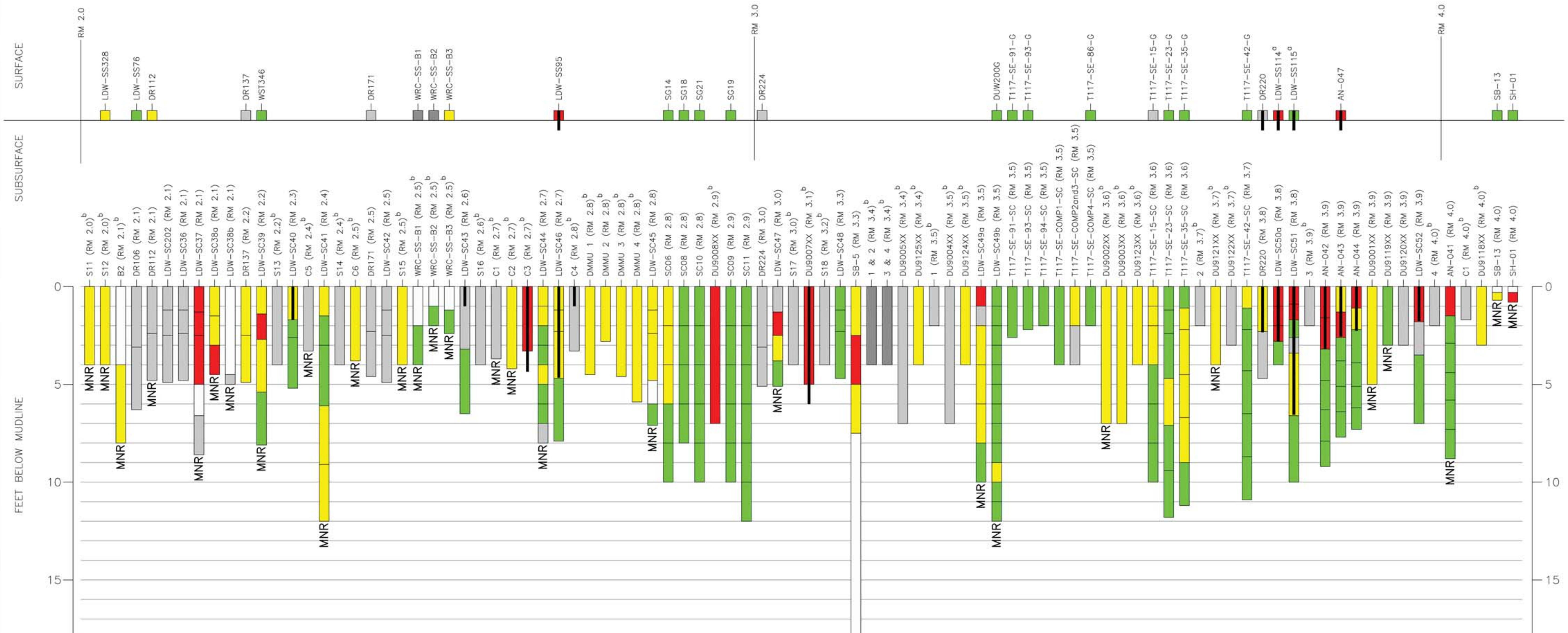
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVES 2 REMOVAL AND 2 REMOVAL WITH CAD REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-8a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c Core located in CAD area. During construction, location would be dredged for CAD construction, backfilled with contaminated sediment, and capped.

AECOM

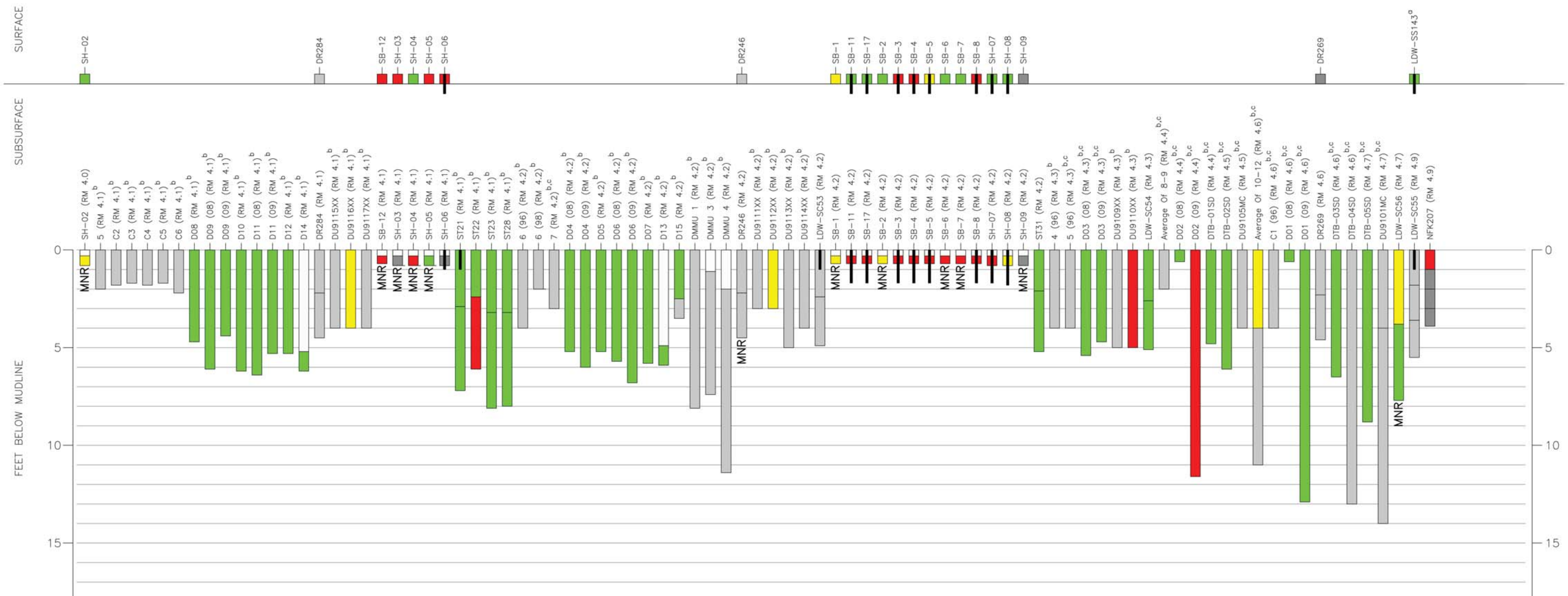
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVES 2 REMOVAL AND 2 REMOVAL WITH CAD REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-8b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c Core located in CAD area. During construction, location would be dredged for CAD construction, backfilled with contaminated sediment, and capped.

AECOM

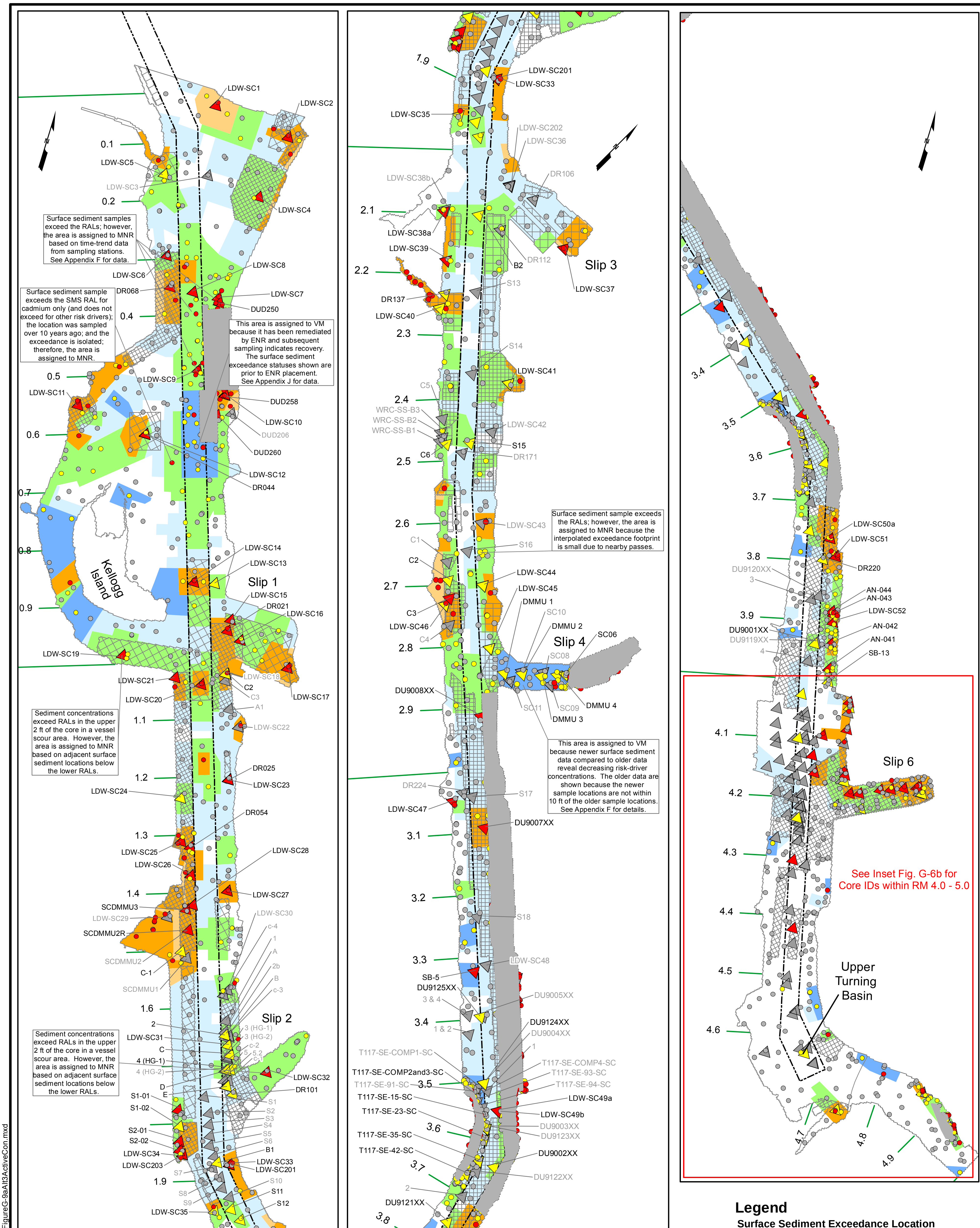
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVES 2 REMOVAL AND 2 REMOVAL WITH CAD REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-8c



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 3	1,300[a]	3,800 (site-wide), 900 (intertidal)	35 (site-wide), 28 (intertidal)	93 (site-wide), 28 (intertidal)	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (50 acres)
- Cap or Partial Dredge and Cap (8 acres)
- Monitored Natural Recovery (99 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

AOPC 2 (122 acres)

Early Action Area (29 acres)

Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 3 RALs
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

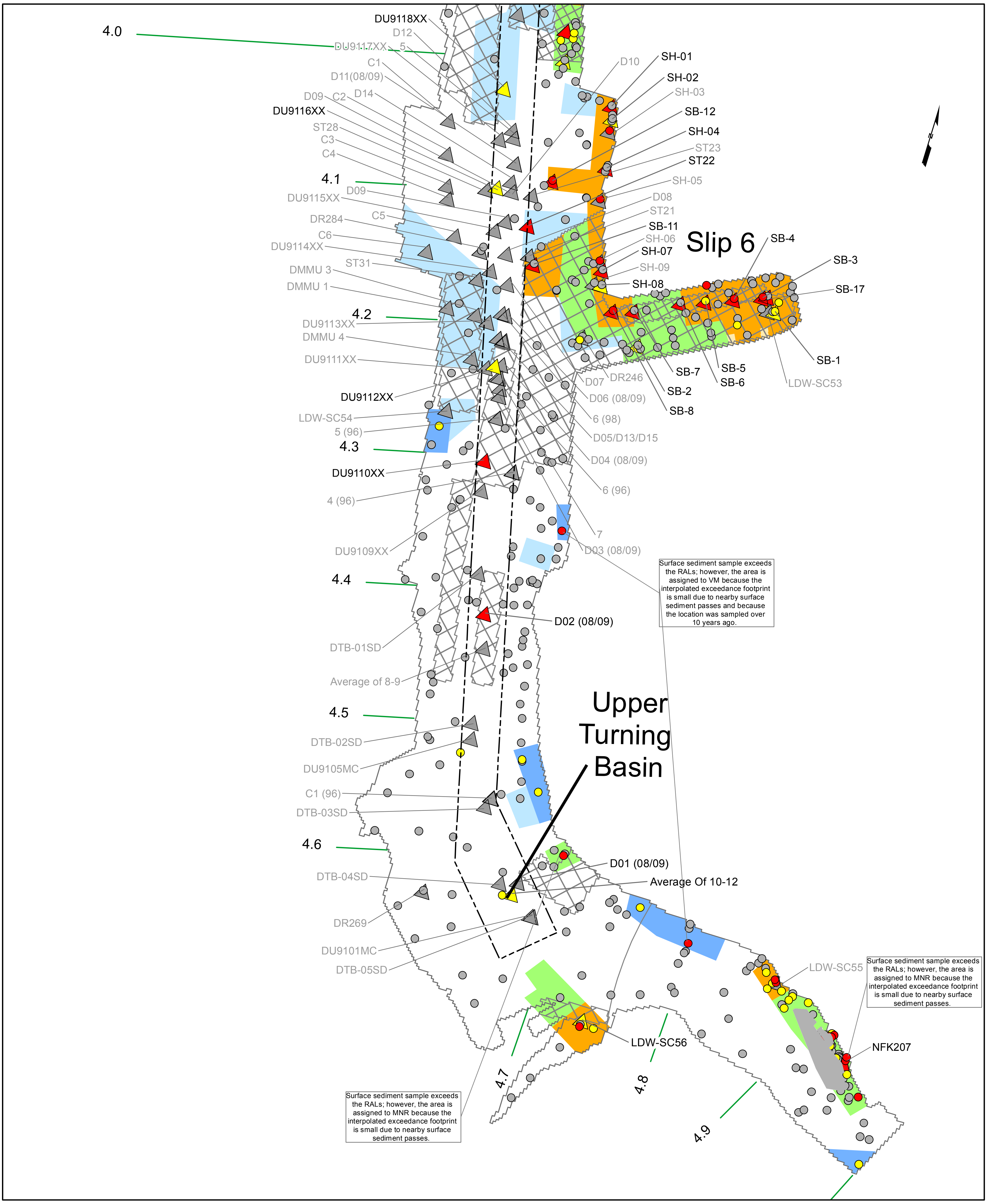
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 DWRN:MVI/sea Revision: 0

Alternative 3 Removal Technology Assignments and Waterway Conditions

FIGURE G-9a

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-9aAlt3ActiveCon.mxd



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 3	1,300[a]	3,800 (site-wide), 900 (intertidal)	35 (site-wide), 28 (intertidal)	93 (site-wide), 28 (intertidal)	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (50 acres)
- Cap or Partial Dredge and Cap (8 acres)
- Monitored Natural Recovery (99 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Feet
0 200 400 800

Legend

Surface Sediment Exceedance Location
- >Alt 3 RALs
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

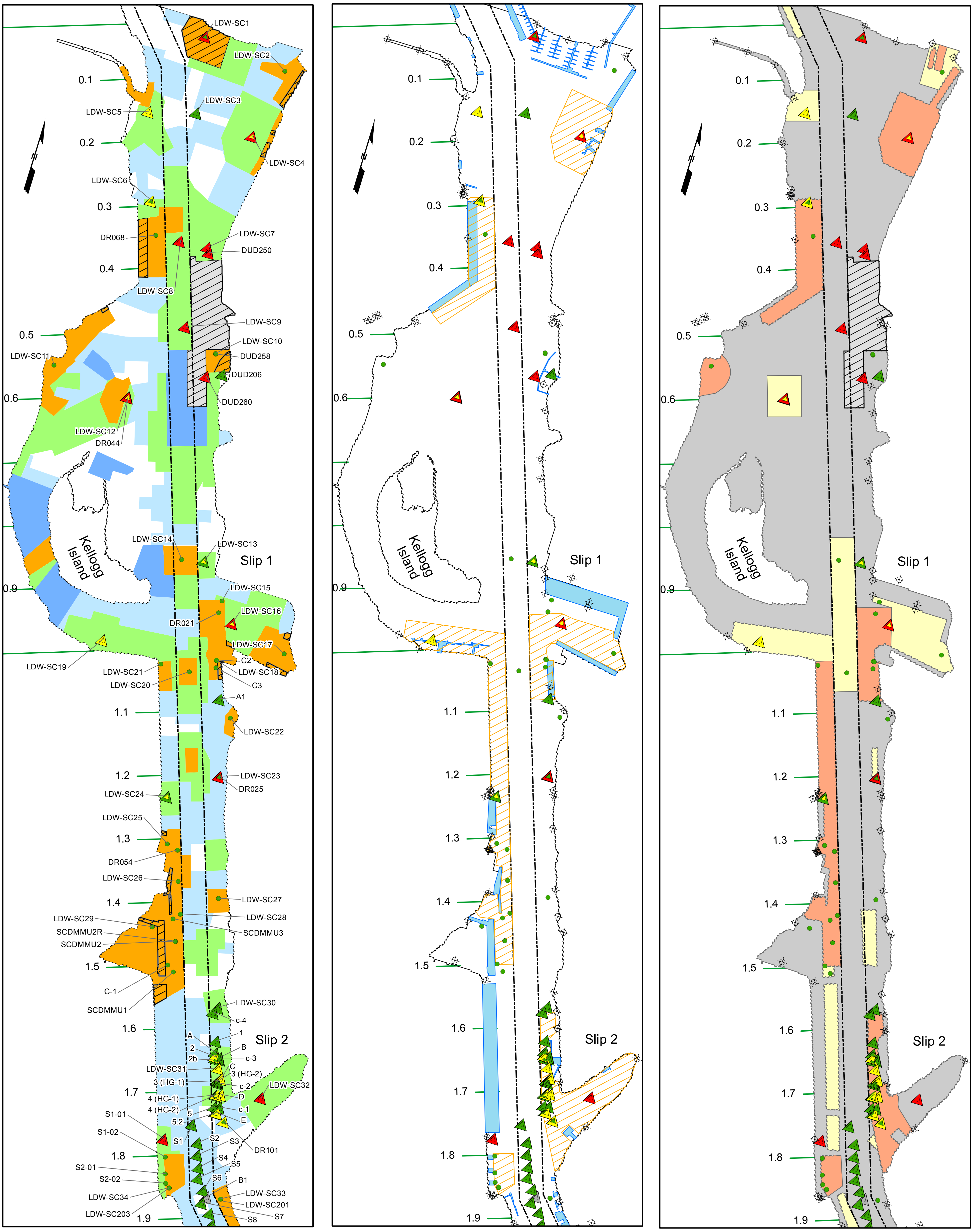
Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			Alternative 3 Removal Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-9b

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-9bAlt3ActiveConB.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Feet: 0 200 400 800

AECOM

Lower Duwamish Waterway Group — Port of Seattle / City of Seattle / King County / The Boeing Company

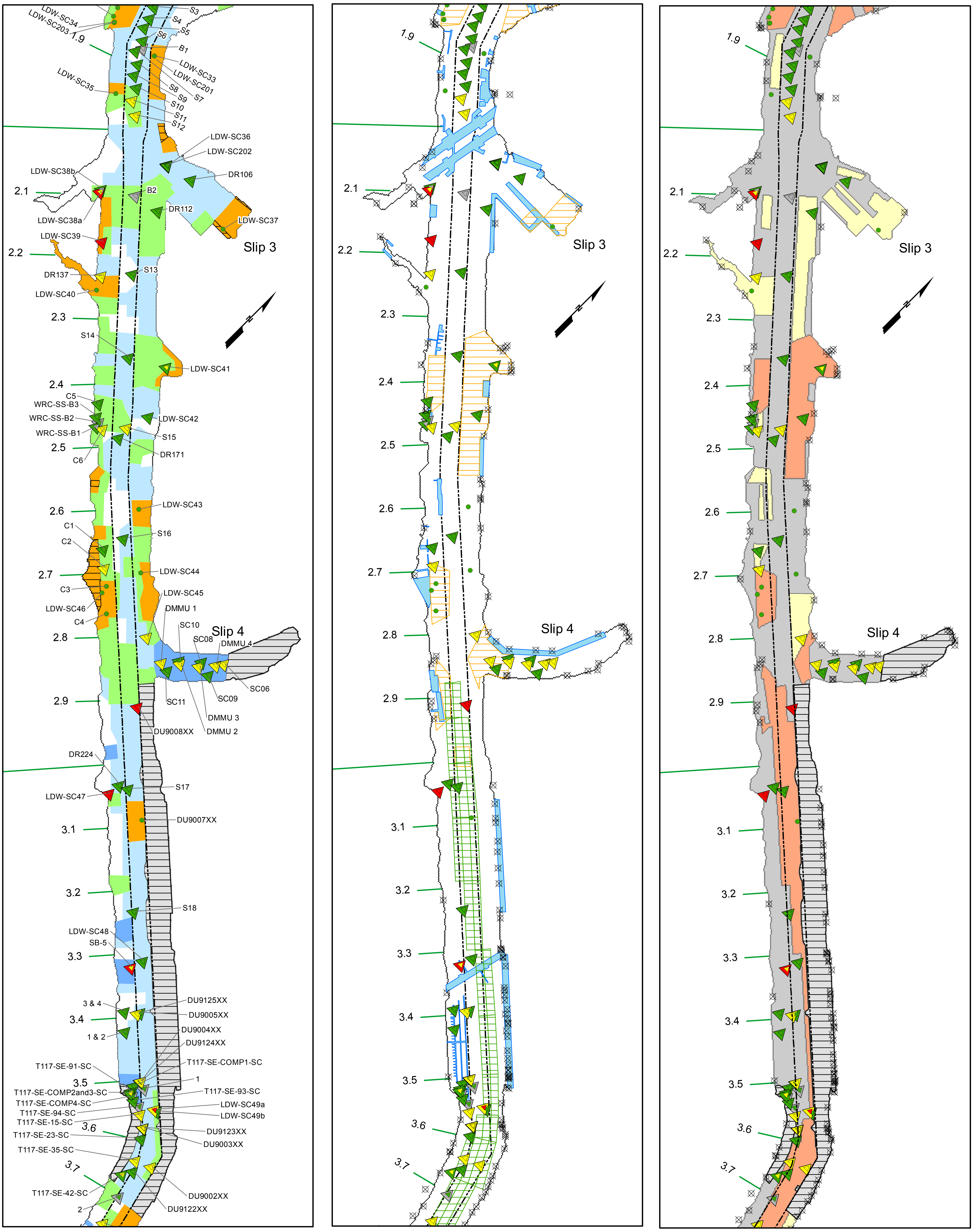
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 3 Removal Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-10a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-10aCoreRecoveryNorth3R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 ft or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

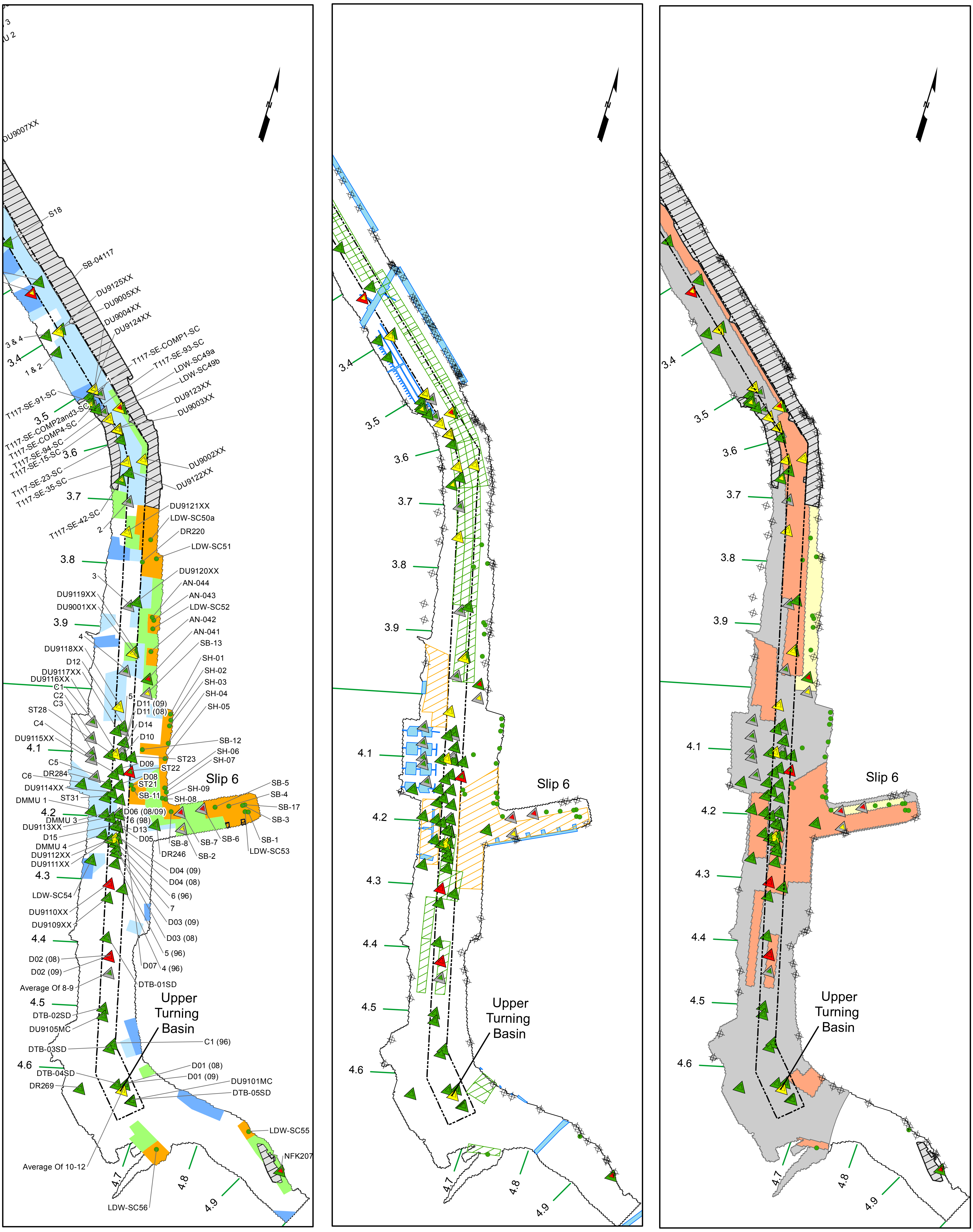
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 3 Removal Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-10b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-10bCoreRecoveryMid3R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

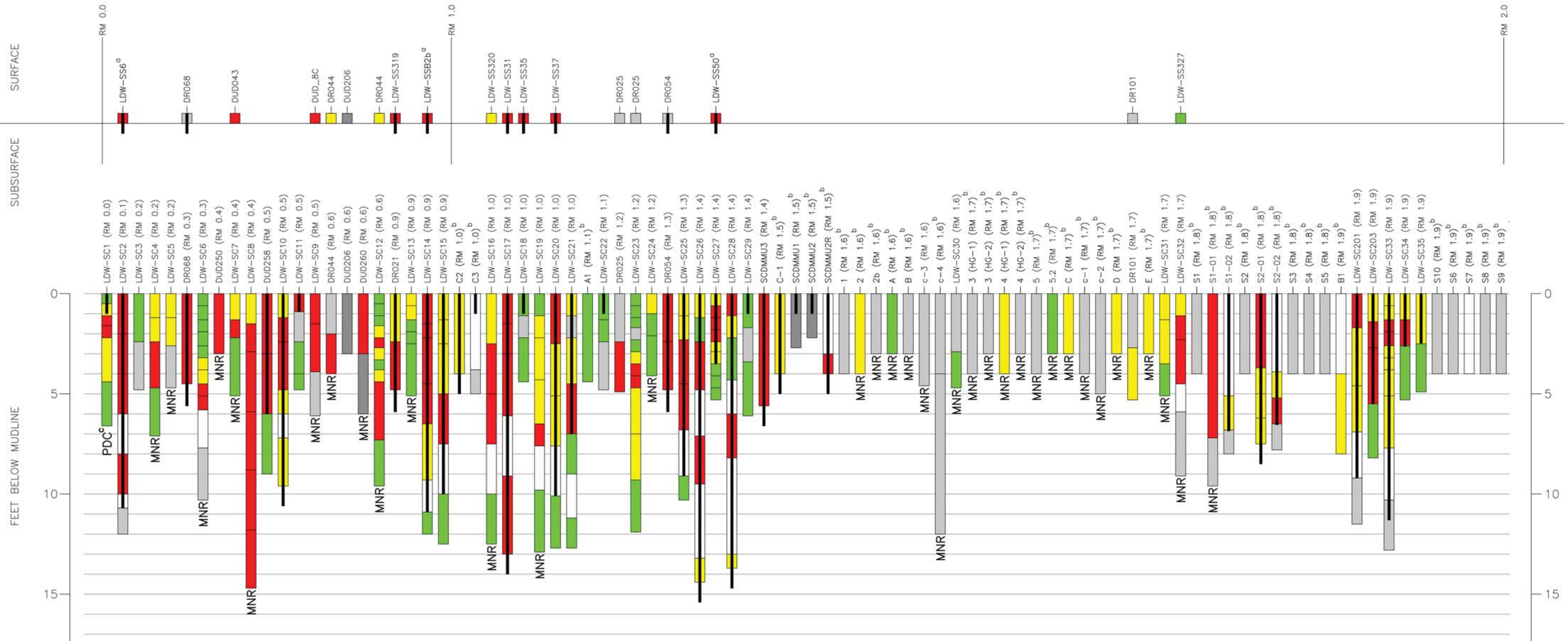
Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 3 Removal Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-10c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-10cCoreRecoverySouth3R.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

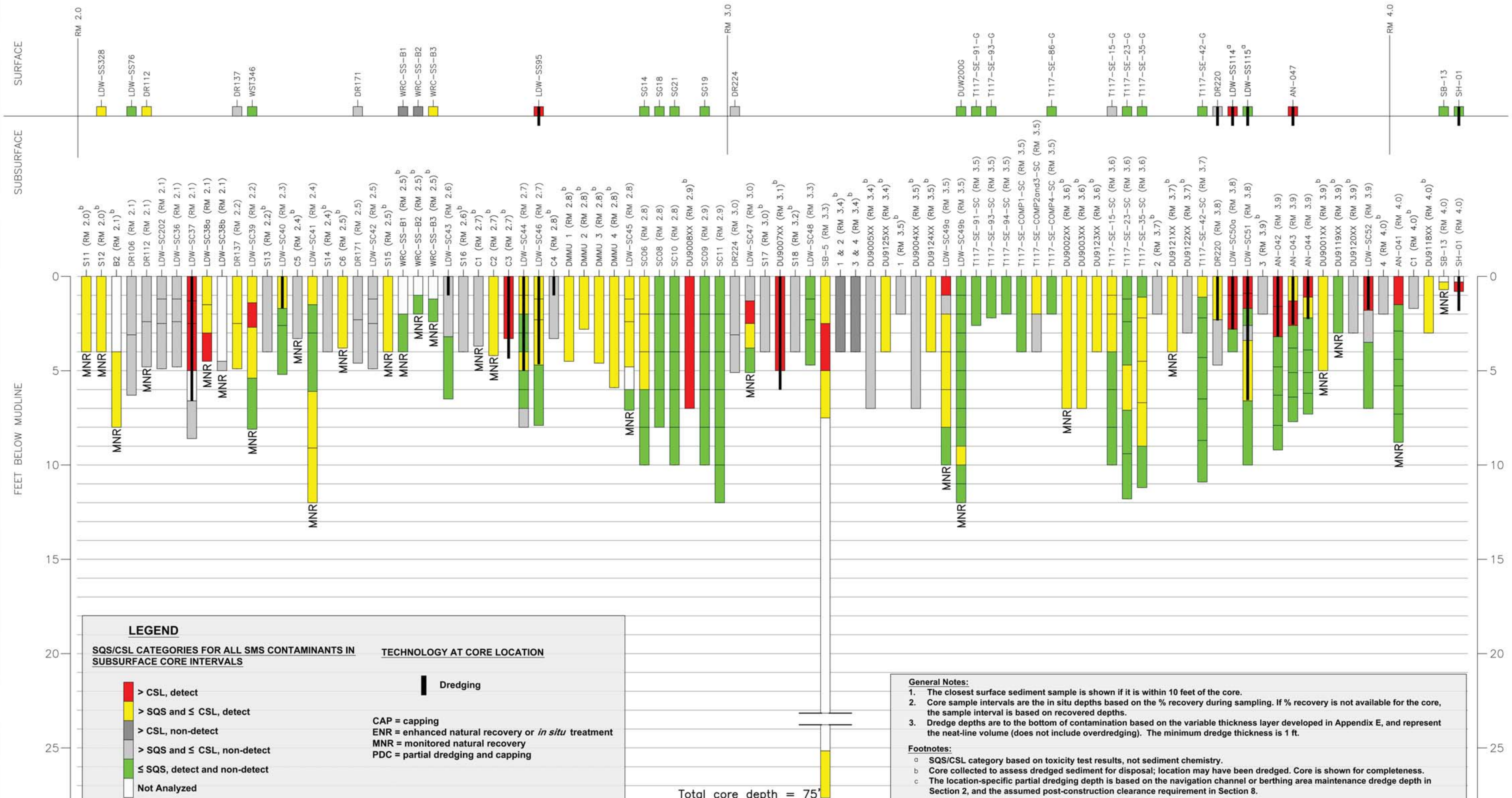
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 3 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-11a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

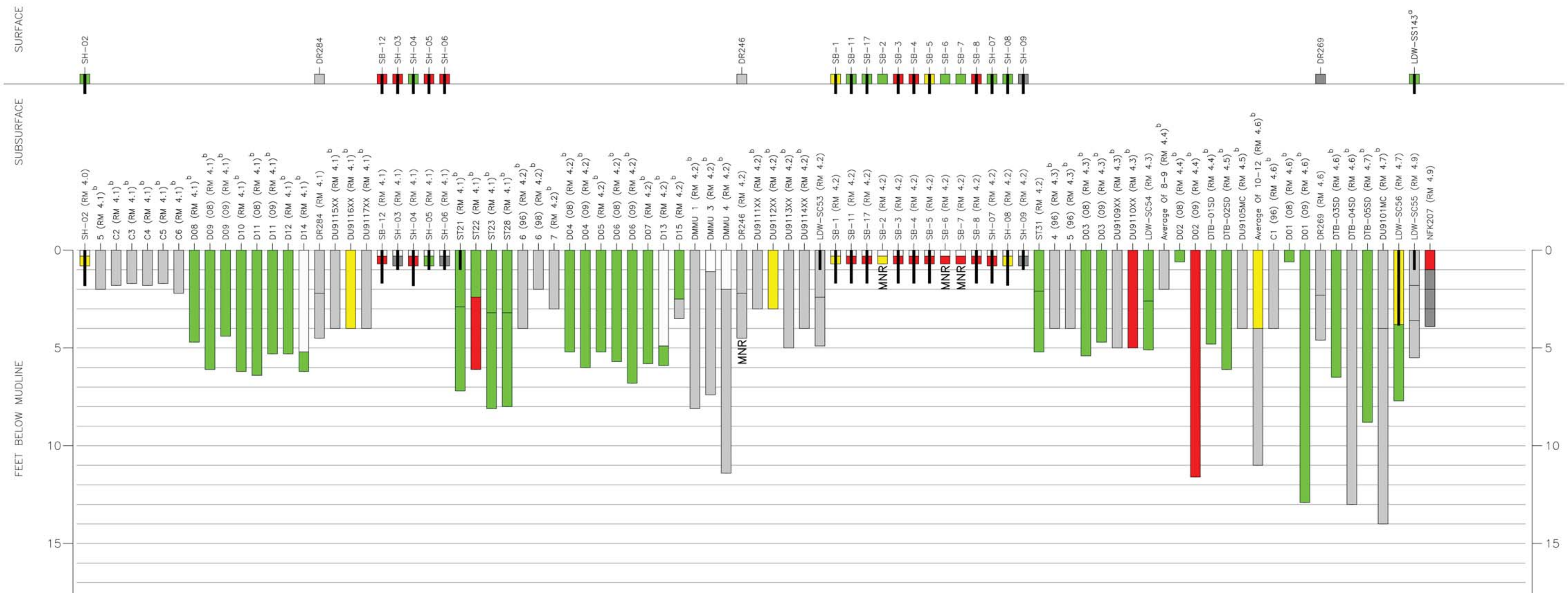
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 3 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-11b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

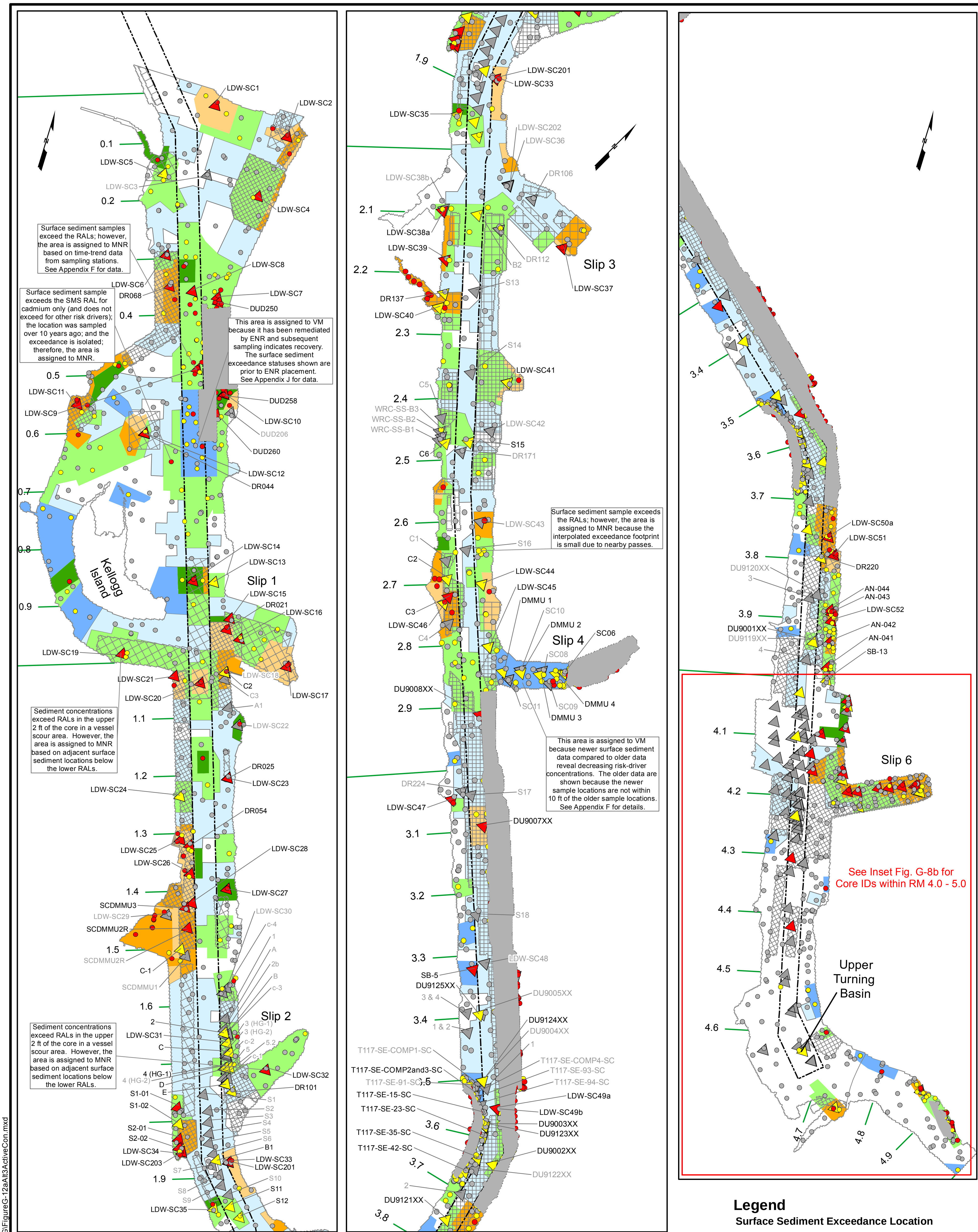
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 3 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-11c



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 3	1,300[a]	3,800 (site-wide), 900 (intertidal)	35 (site-wide), 28 (intertidal)	93 (site-wide), 28 (intertidal)	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (29 acres)
- Cap or Partial Dredge and Cap (19 acres)
- Monitored Natural Recovery (99 acres)
- ENR/*in situ* (10 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 3 RALs
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black

Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

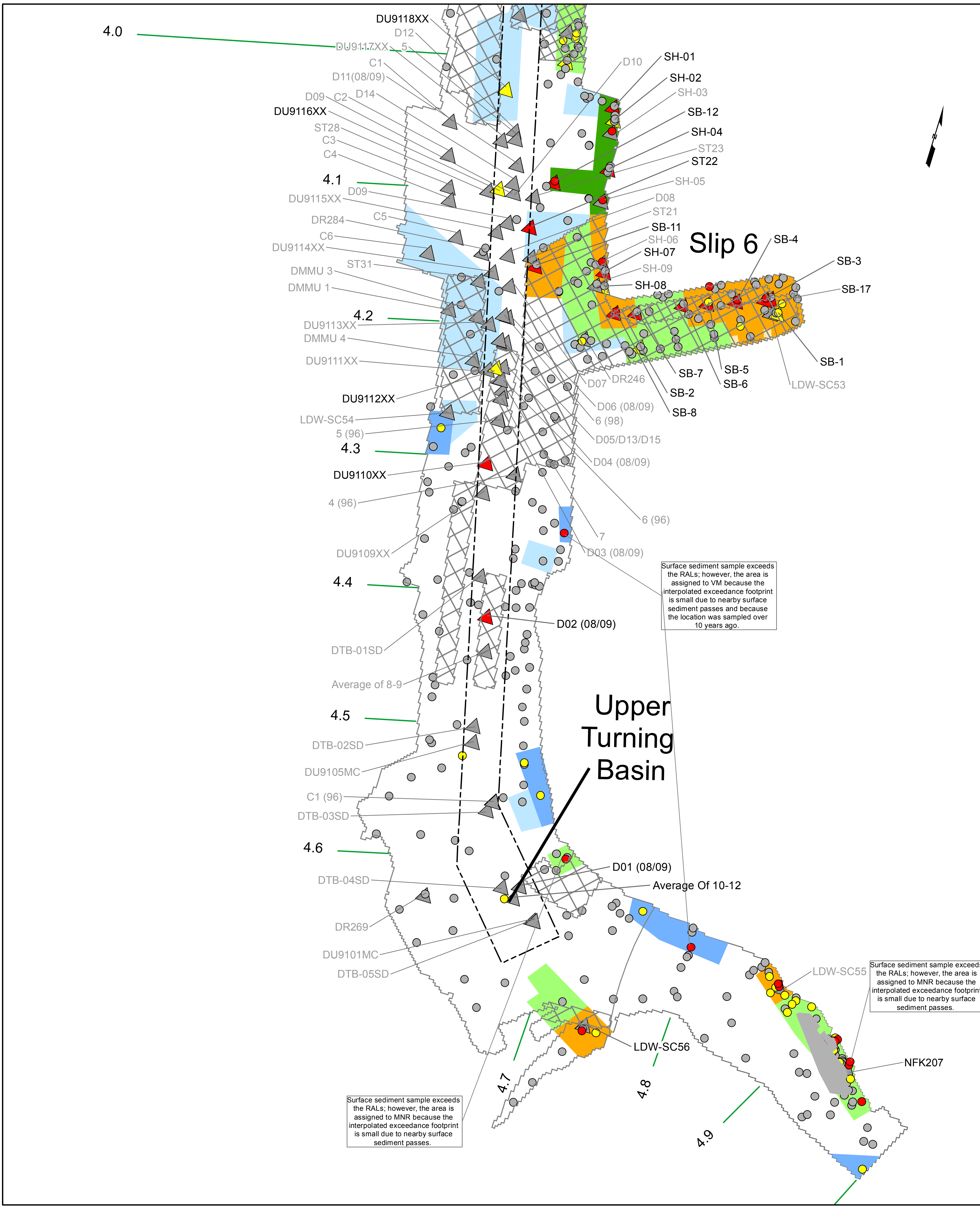
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 3 Combined Technology Assignments and Waterway Conditions

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-12a

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-12aAlt3ActiveCon.mxd



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 3	1,300[a]	3,800 (site-wide), 900 (intertidal)	35 (site-wide), 28 (intertidal)	93 (site-wide), 28 (intertidal)	CSL
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentrations of 1,300 µg/kg dw and 240 µg/kg dw are dry weight approximations of the 65 mg/kg oc (CSL) and 12 mg/kg oc (SQS) values assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (29 acres)
- Cap or Partial Dredge and Cap (19 acres)
- Monitored Natural Recovery (99 acres)
- ENR/*in situ* (10 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Legend

Surface Sediment Exceedance Location
- >Alt 3 RALs
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

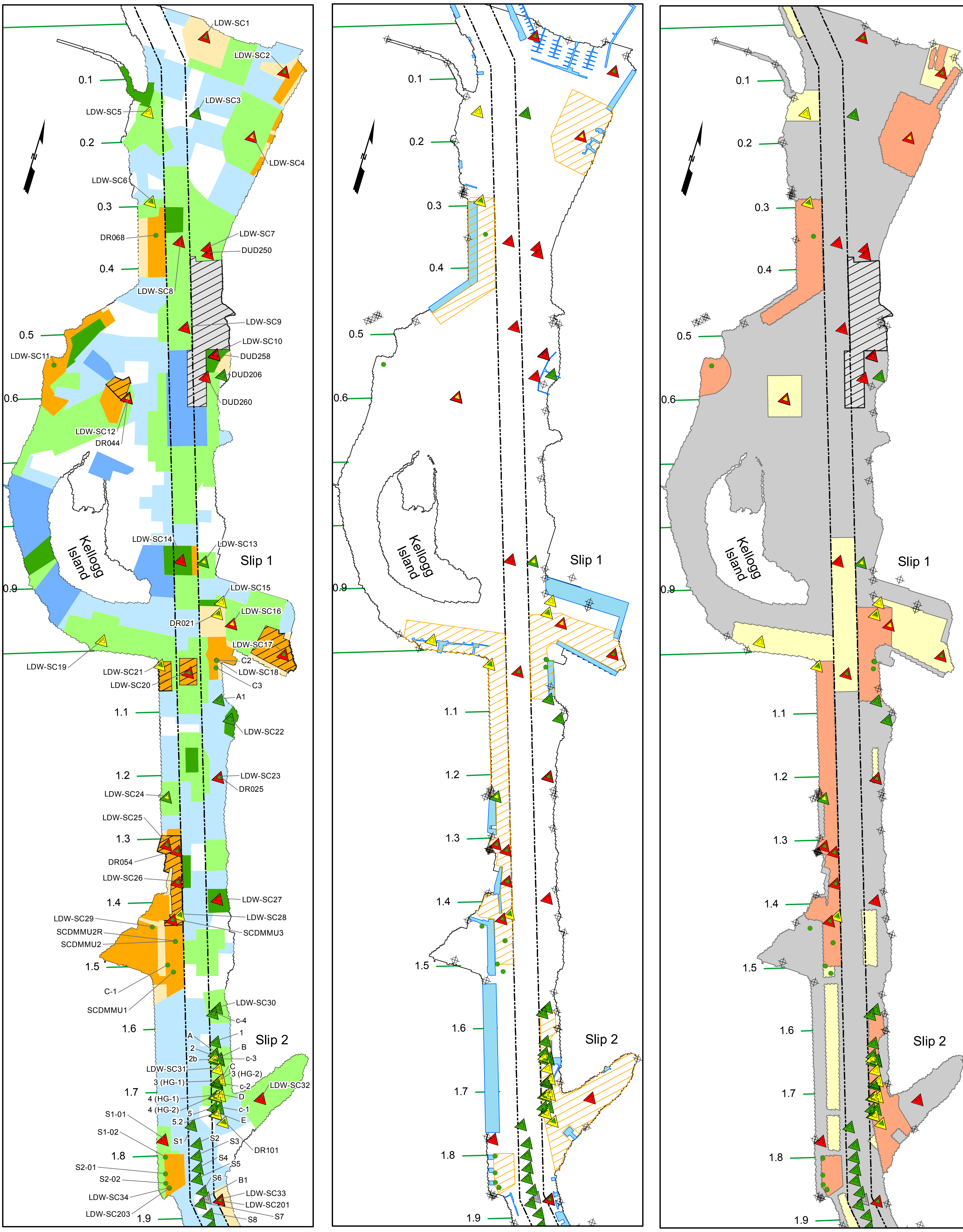
Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-12bAlt3CombinedConB.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			Alternative 3 Combined Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-12b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

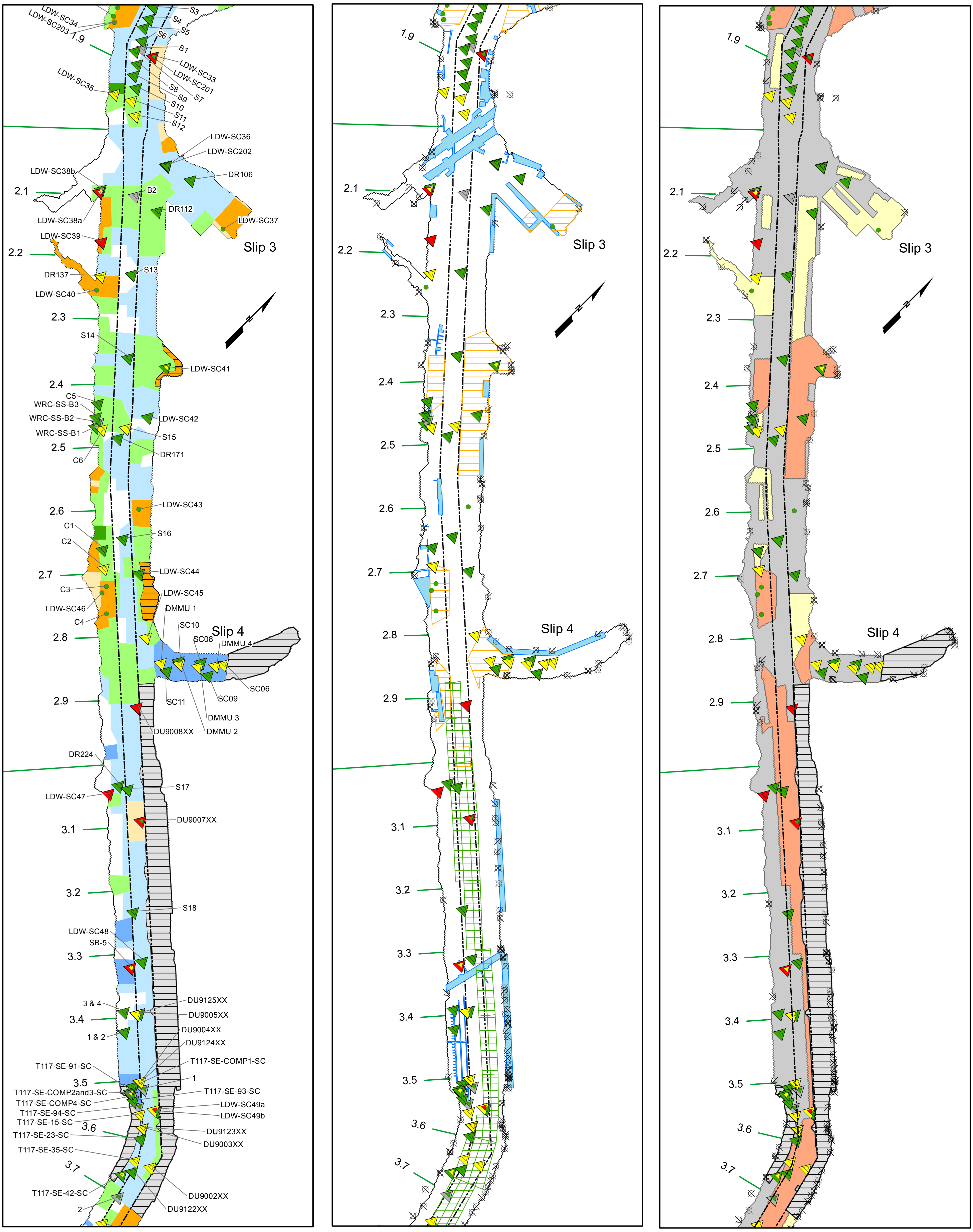
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	**Alternative 3 Combined Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)**
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	**FIGURE G-13a**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-13aCoreRecoveryNorth3C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation
Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

0 200 400 800 Feet

AECOM

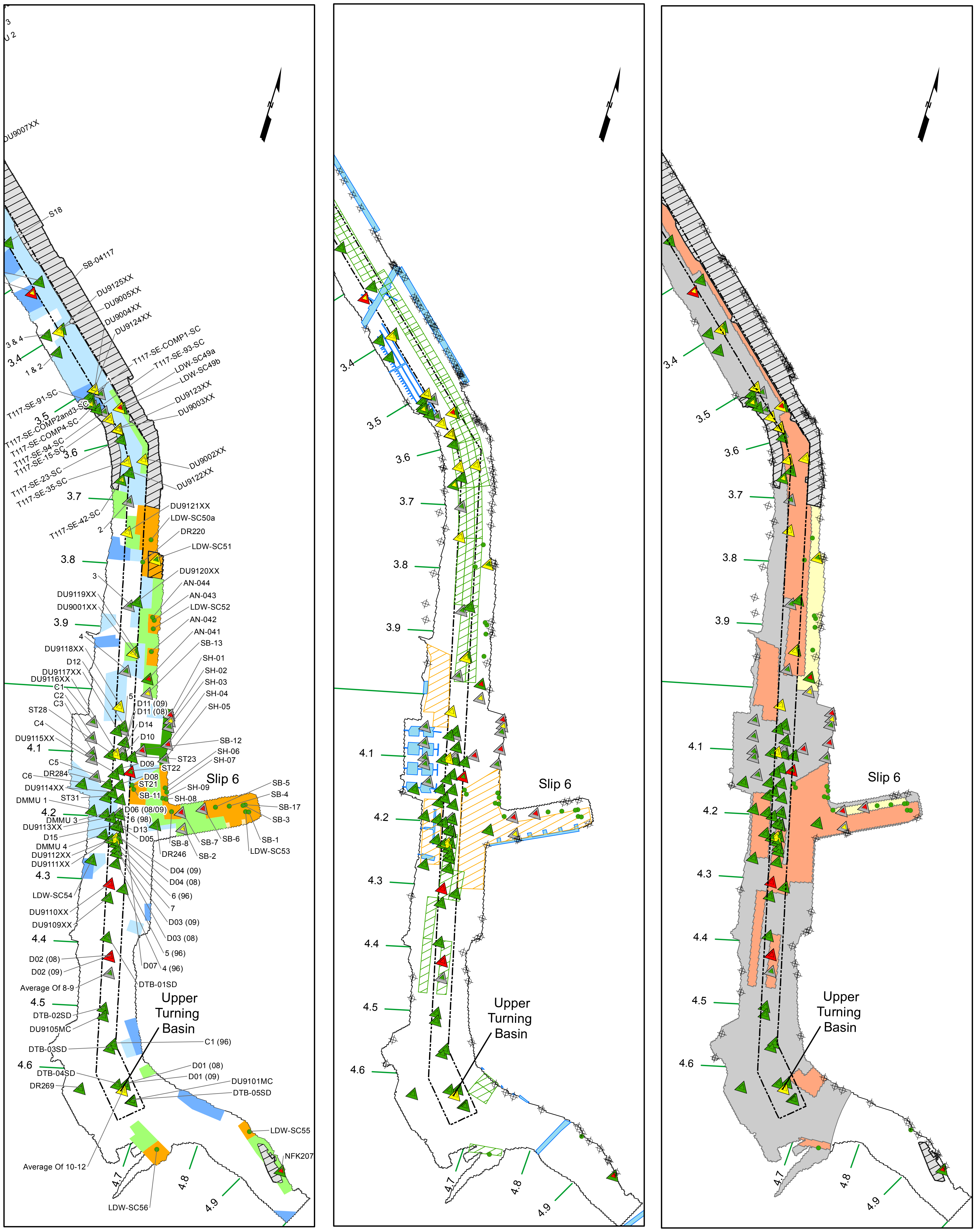
Lower Duwamish Waterway Group — Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 3 Combined Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-13b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-13bCoreRecoveryMid3C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

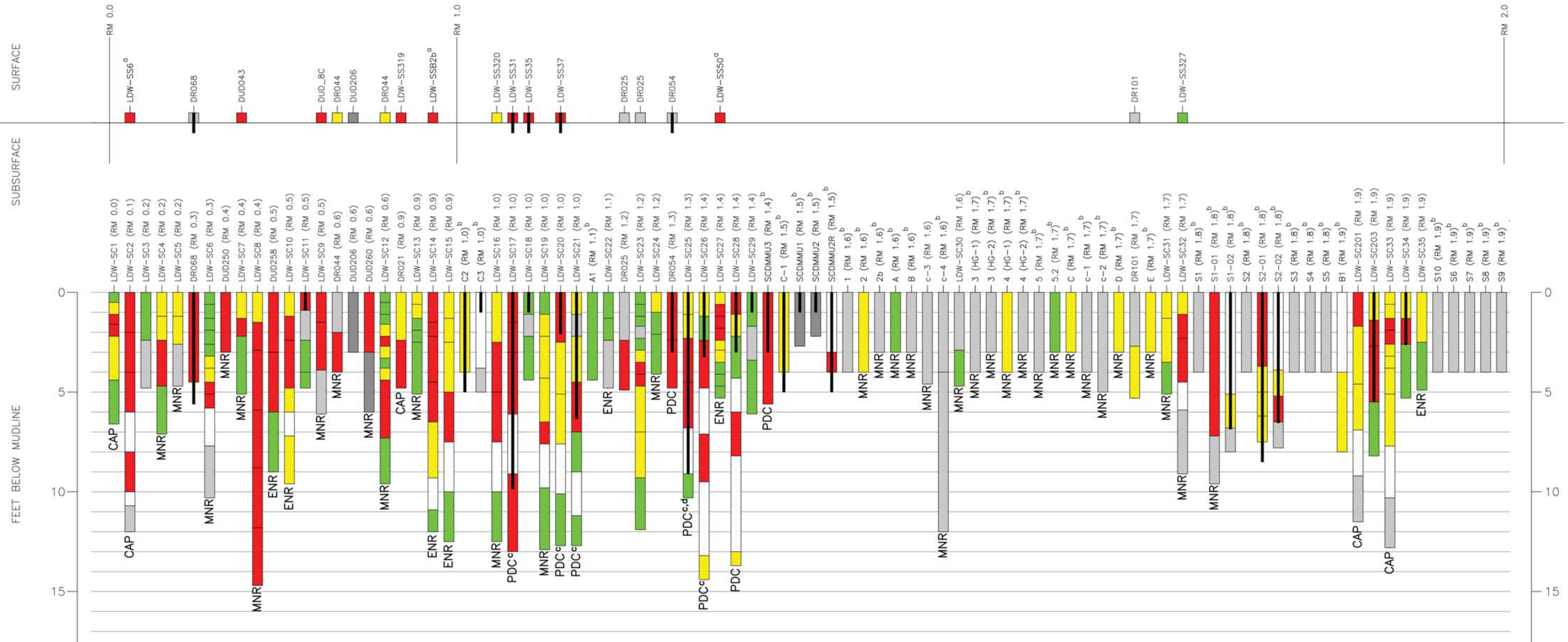
Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 3 Combined Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-13c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-13cCoreRecoverySouth3C.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.

AECOM

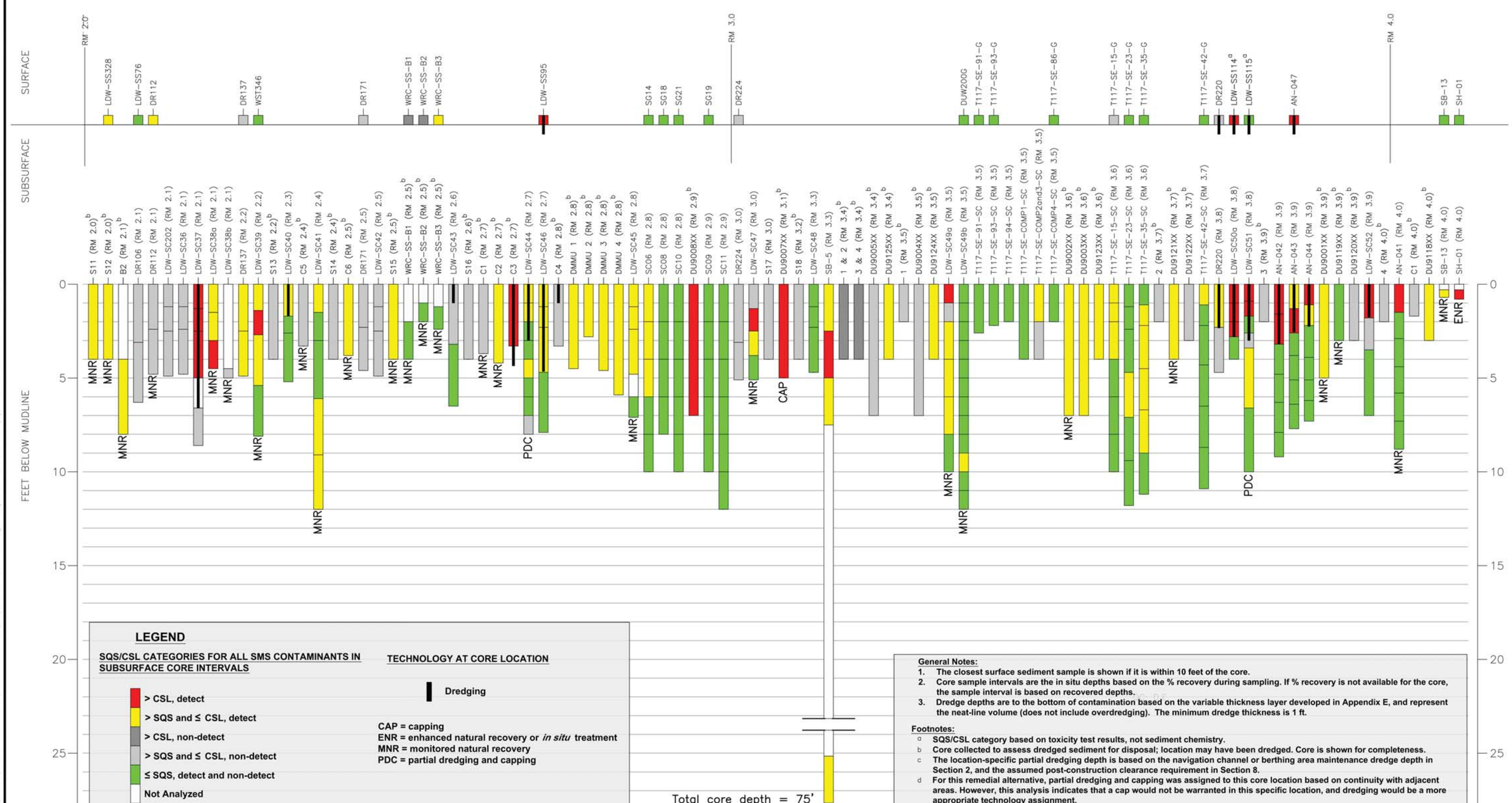
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
6015027-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 3 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-14a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.

AECOM

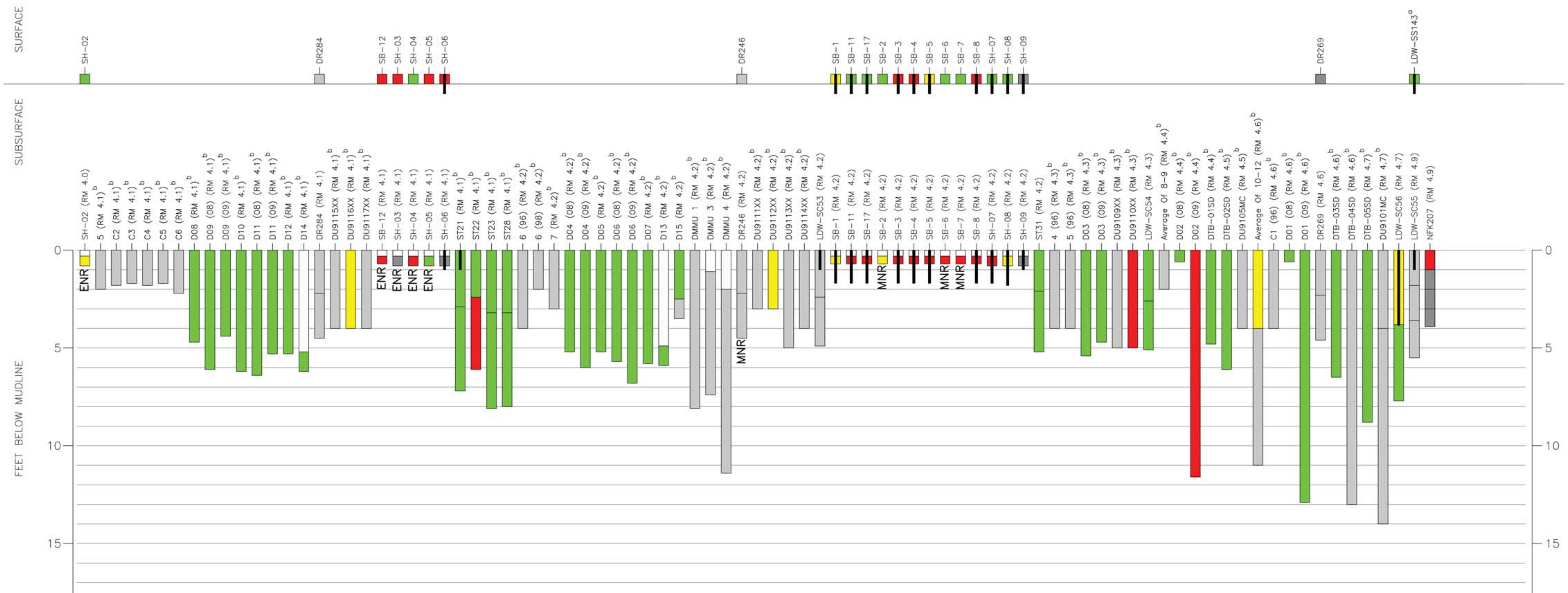
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
6015027-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 3 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-14b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a. SQS/CSL category based on toxicity test results, not sediment chemistry.
b. Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c. The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d. For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.

AECOM

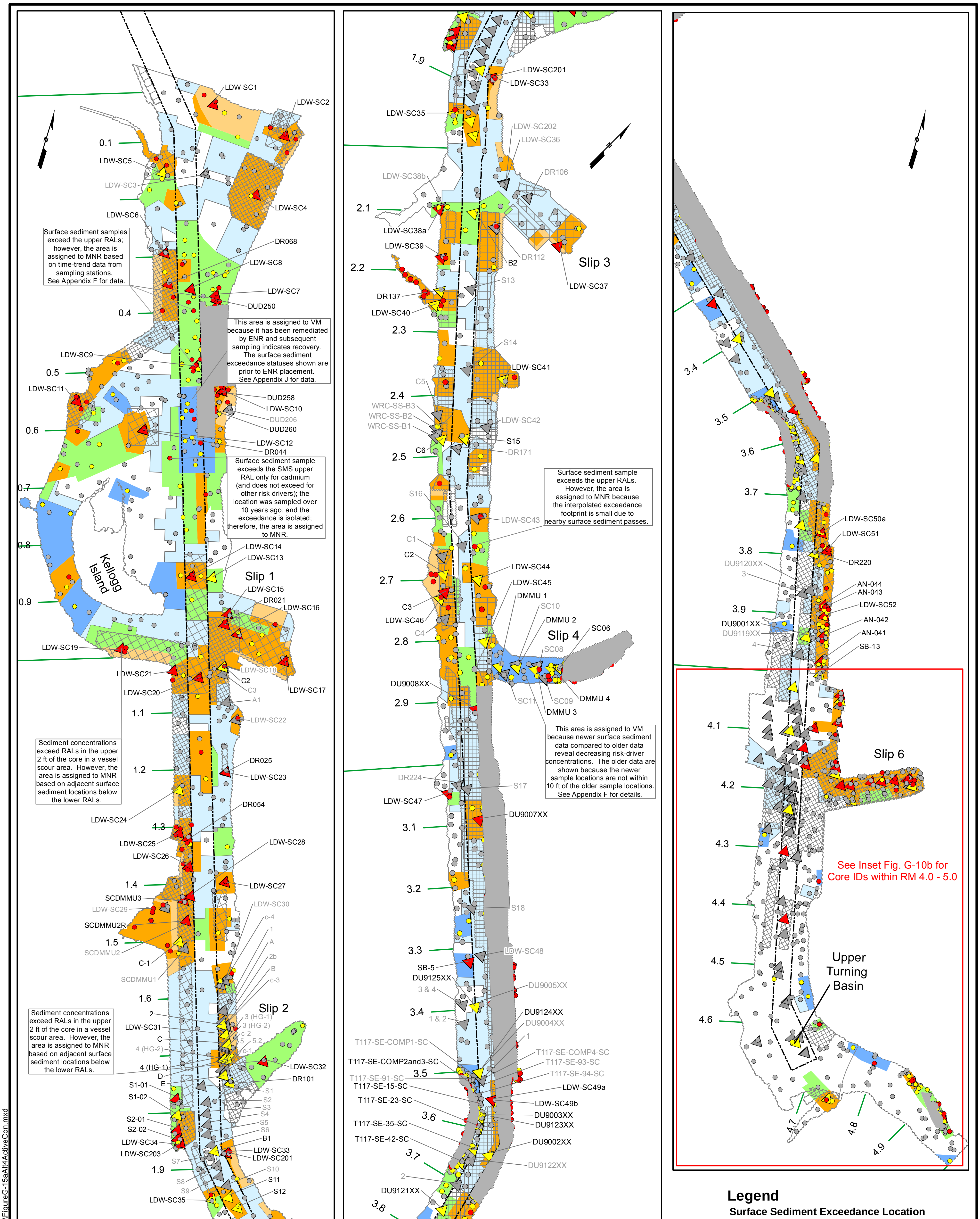
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
6015027-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 3 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-14c



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 4 upper RALs	700	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	CSL
Alt 4 lower RALs	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentration of 240 µg/kg dw as a dry weight approximation of the 12 mg/kg oc (SQS) value assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (93 acres)
- Cap or Partial Dredge and Cap (14 acres)
- Monitored Natural Recovery (50 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 4 Upper RALs (Applicable Site-wide)
- >Alt 4 Lower RALs (Applicable in Categories 1 & 2)
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-15aAlt4ActiveCon.mxd

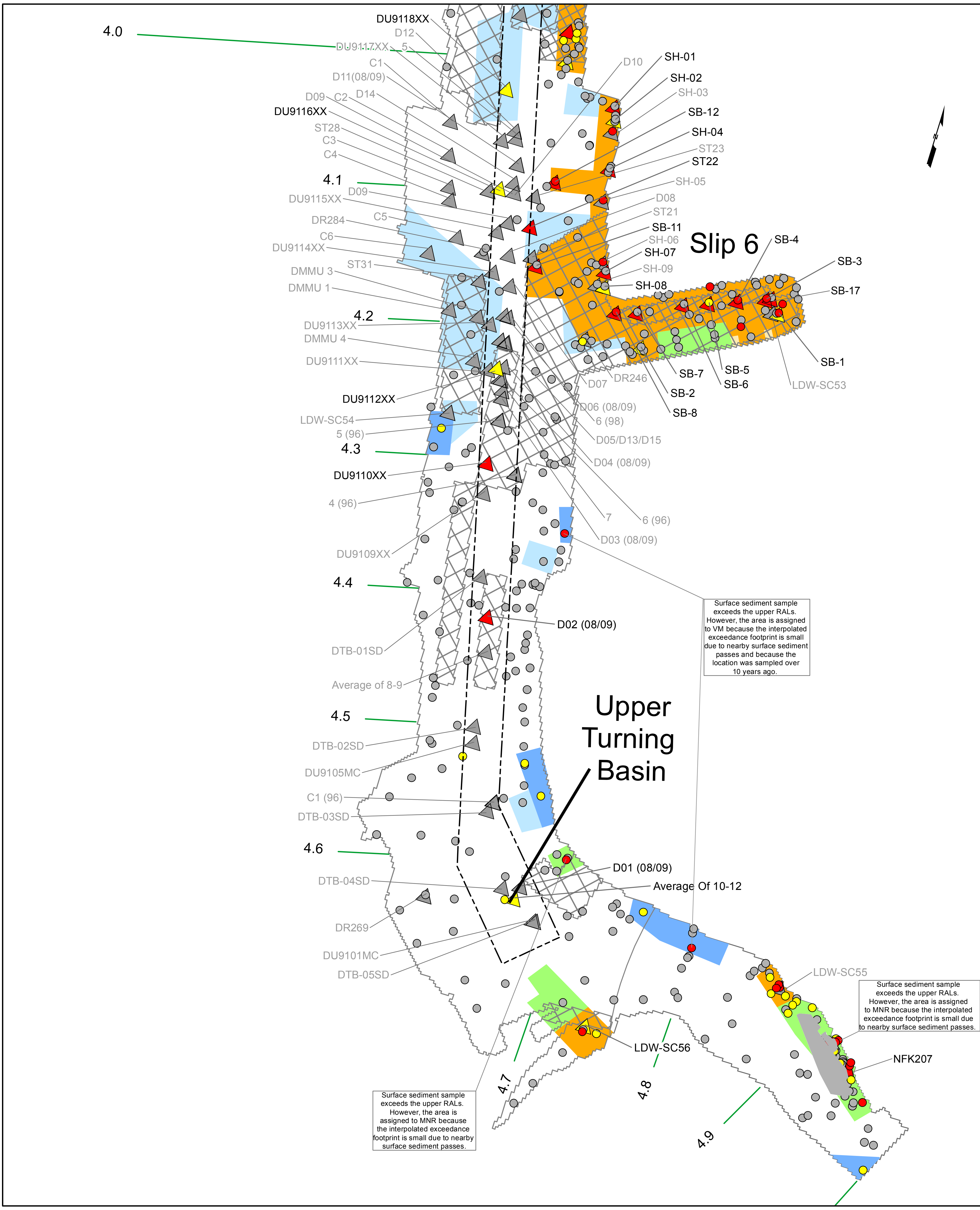
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.12

Alternative 4 Removal Technology Assignments and Waterway Conditions

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-15a



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 4 upper RALs	700	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	CSL
Alt 4 lower RALs	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentration of 240 µg/kg dw as a dry weight approximation of the 12 mg/kg oc (SQS) value assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (93 acres)
- Cap or Partial Dredge and Cap (14 acres)
- Monitored Natural Recovery (50 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

AOPC 2 (122 acres)

Early Action Area (29 acres)

Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 4 Upper RALs (Applicable Site-wide)
- >Alt 4 Lower RALs (Applicable in Categories 1 & 2)
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black

Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-15bAlt4ActiveConB.mxd

AECOM

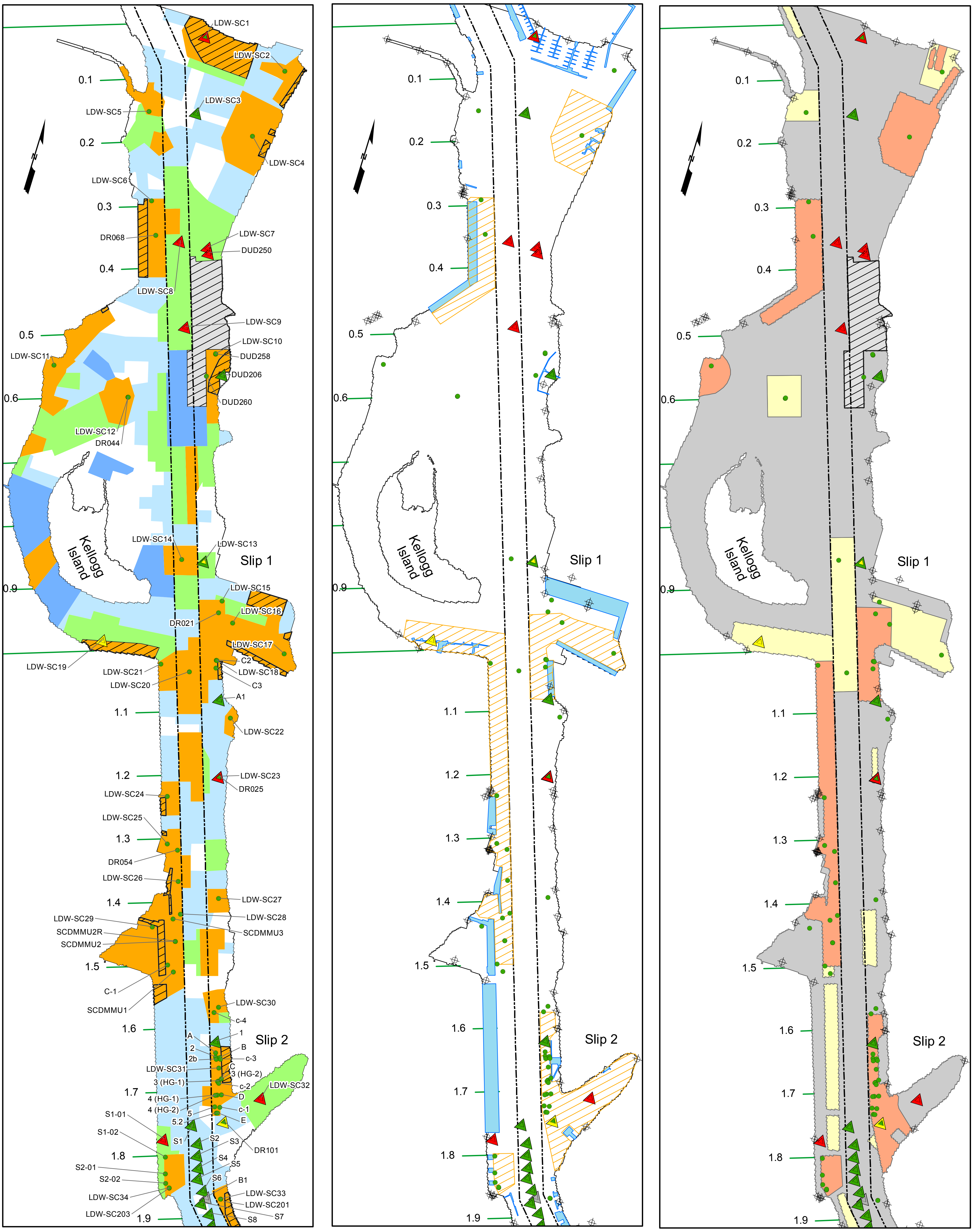
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 4 Removal Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

FIGURE G-15b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

0 200 400 800 Feet

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core
Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

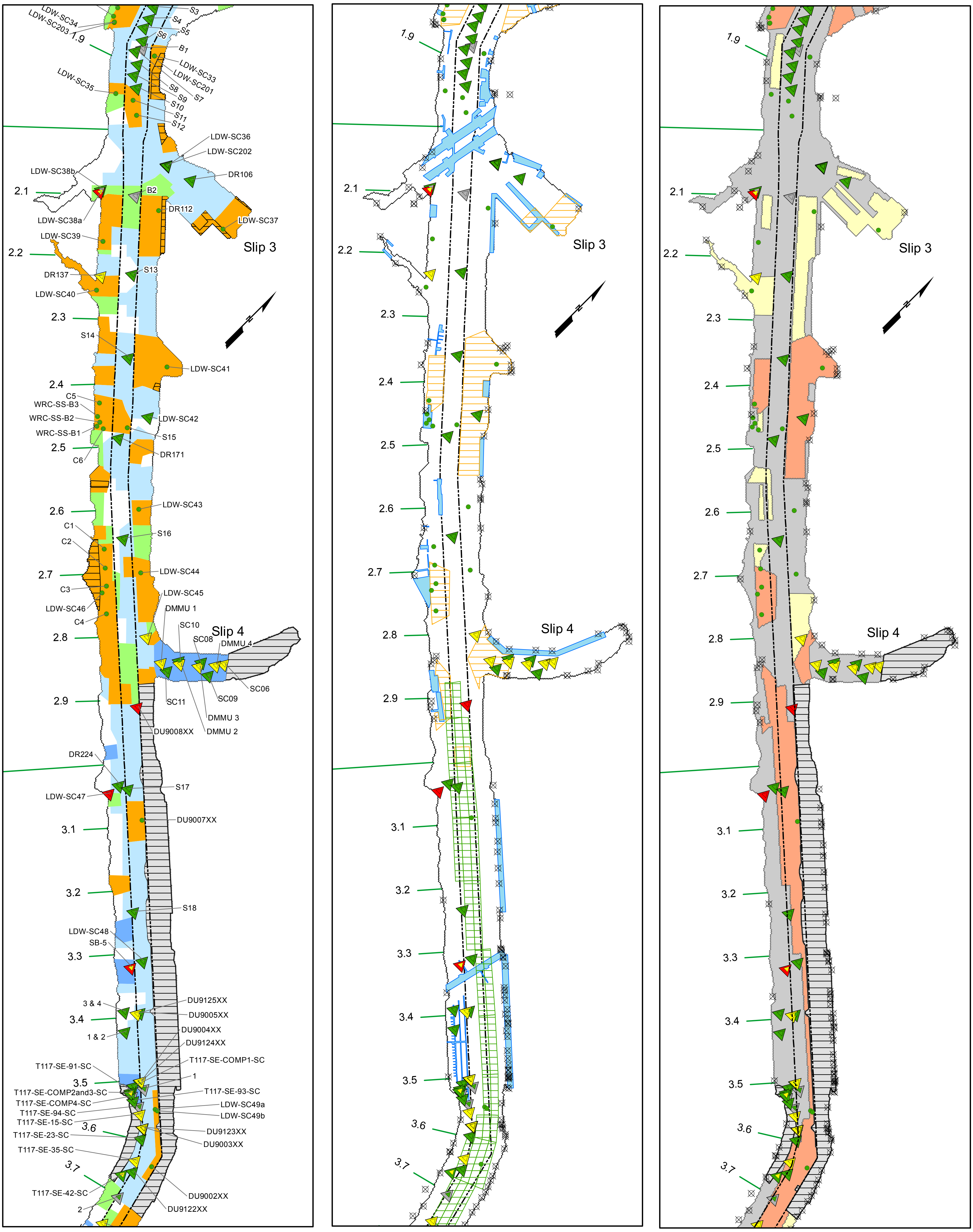
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 4 Removal Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-16a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-16aCoreRecoveryNorth4R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core | Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

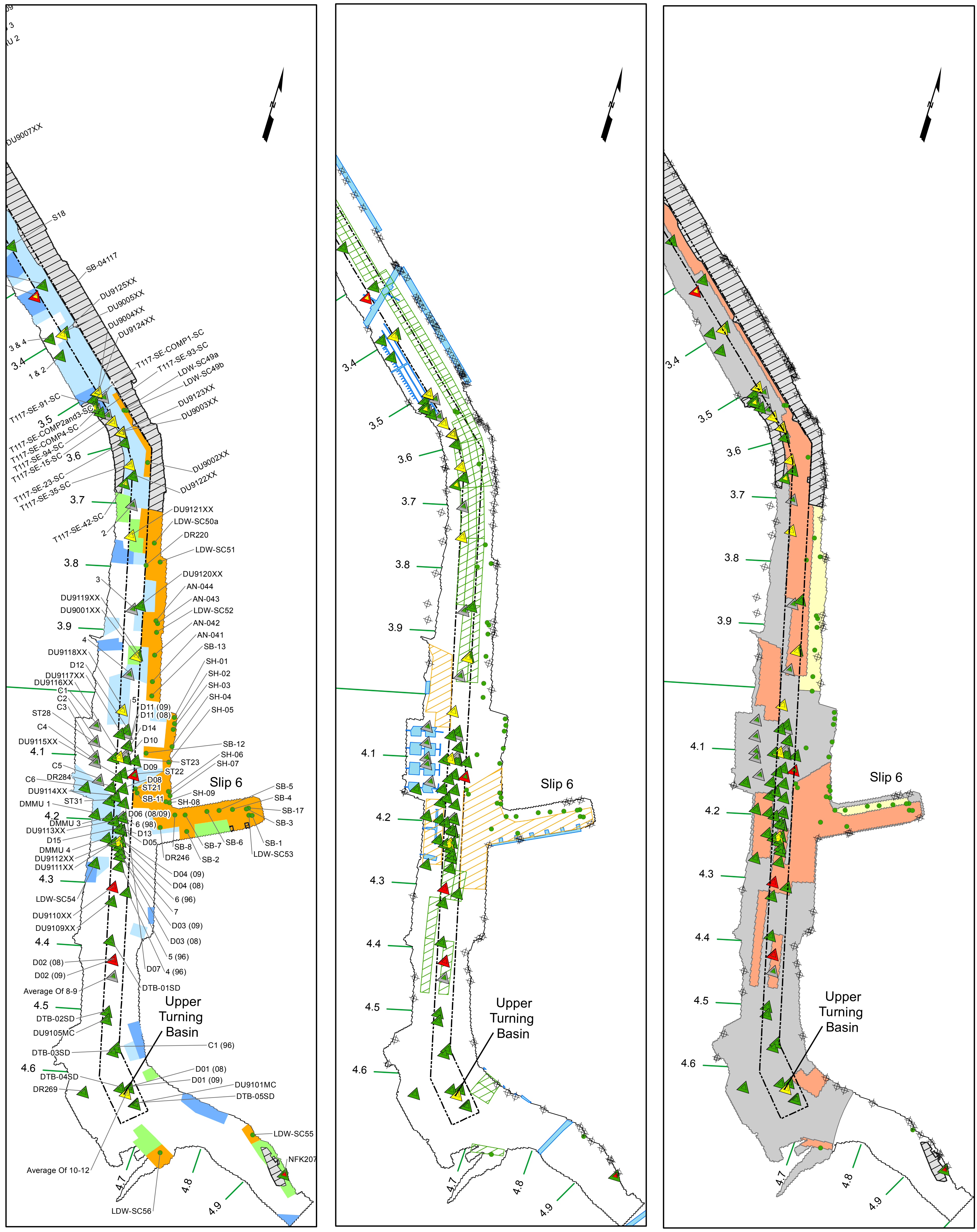
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 4 Removal Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-16b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-16bCoreRecoveryMid4R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

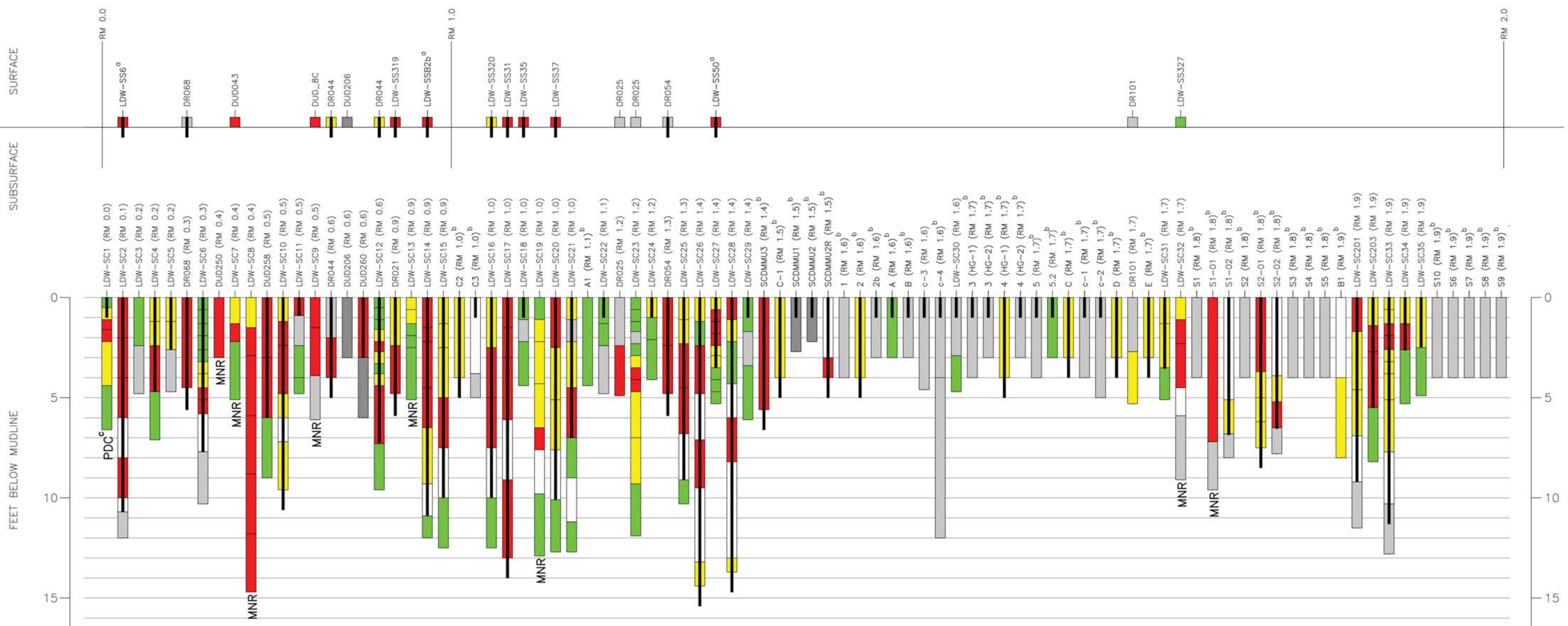
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 4 Removal Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-16c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-16cCoreRecoverySouth4R.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

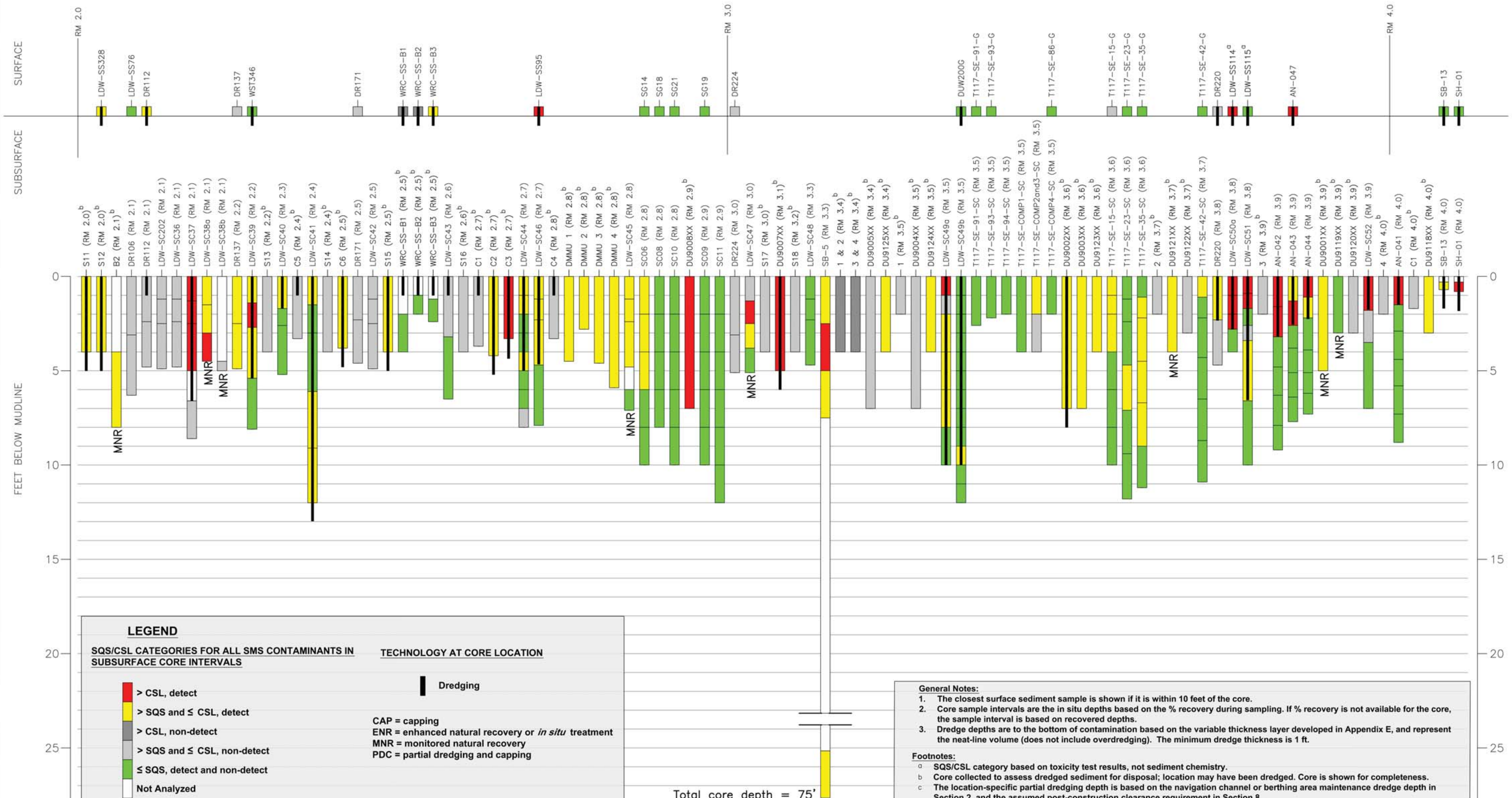
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 4 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-17a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

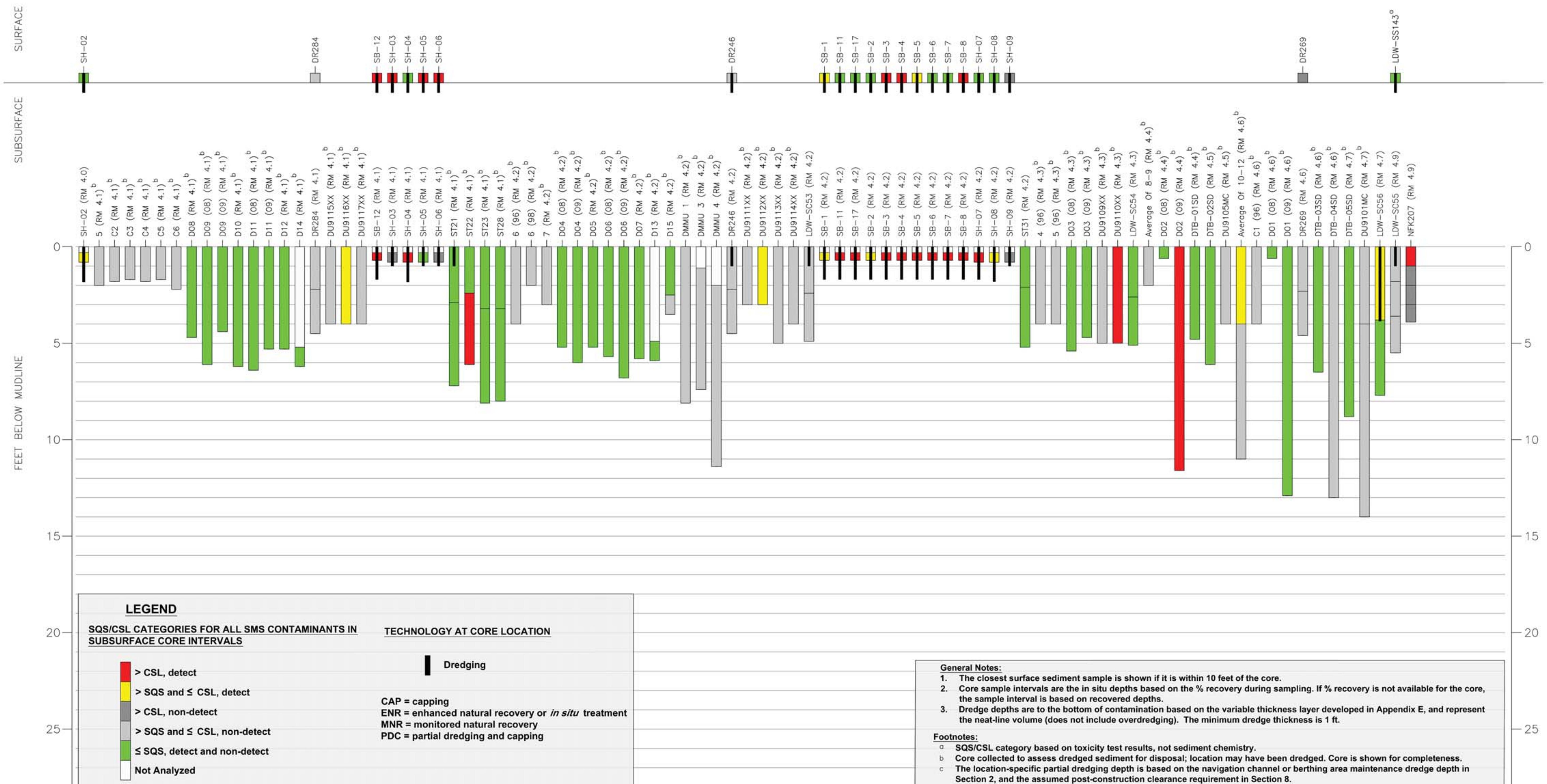
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 4 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-17b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

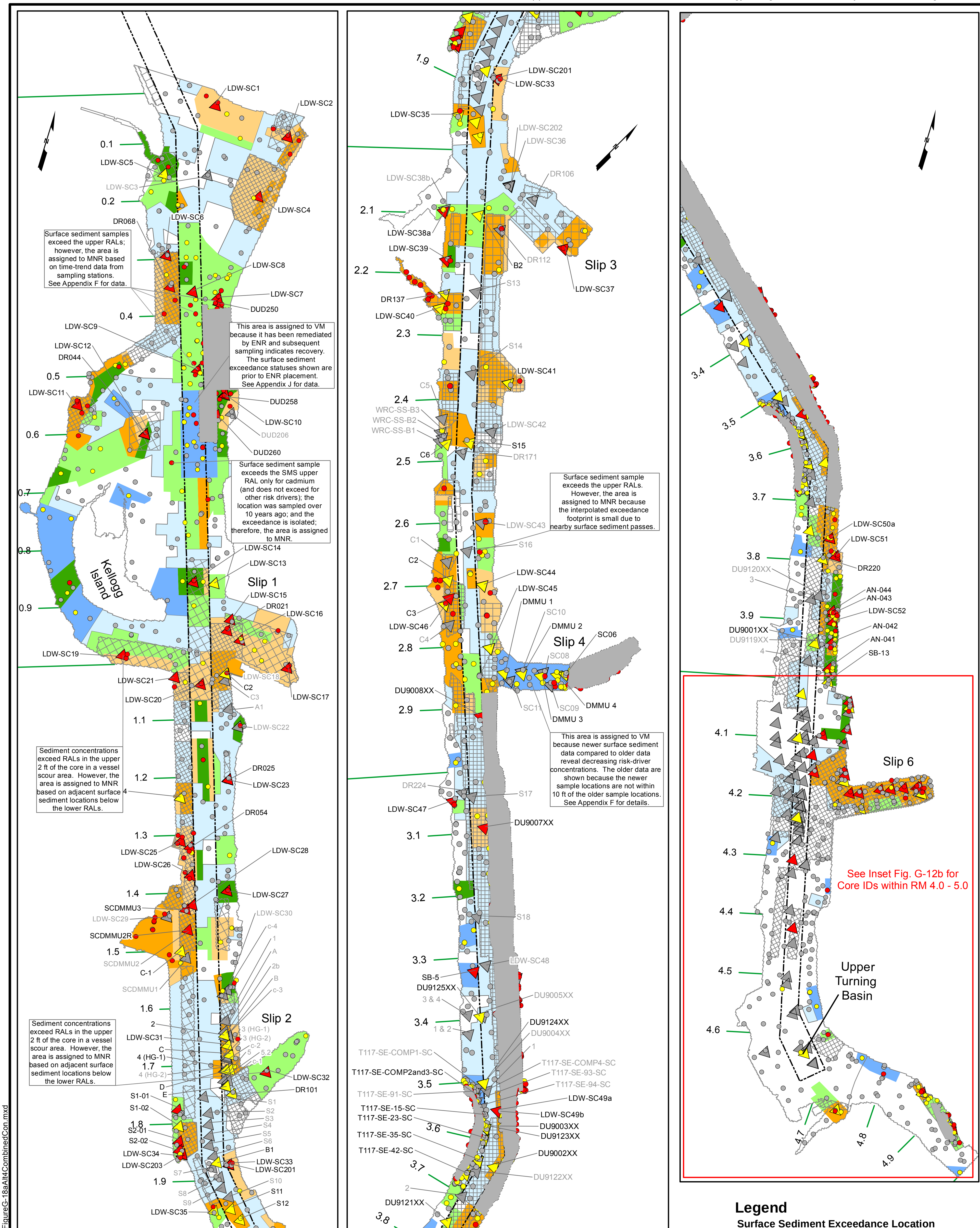
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 4 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-17c



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 4 upper RALs	700	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	CSL
Alt 4 lower RALs	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentration of 240 µg/kg dw as a dry weight approximation of the 12 mg/kg oc (SQS) value assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (52 acres)
- Cap or Partial Dredge and Cap (43 acres)
- Monitored Natural Recovery (45 acres)
- ENR/*in situ* (21 acres)
- Verification Monitoring (19 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (232 acres)

Feet
0 200 400 800

Legend

Surface Sediment Exceedance Location
- >Alt 4 Upper RALs (Applicable Site-wide)
- >Alt 4 Lower RALs (Applicable in Categories 1&2)
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black
Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-18aAlt4CombinedCon.mxd

AECOM

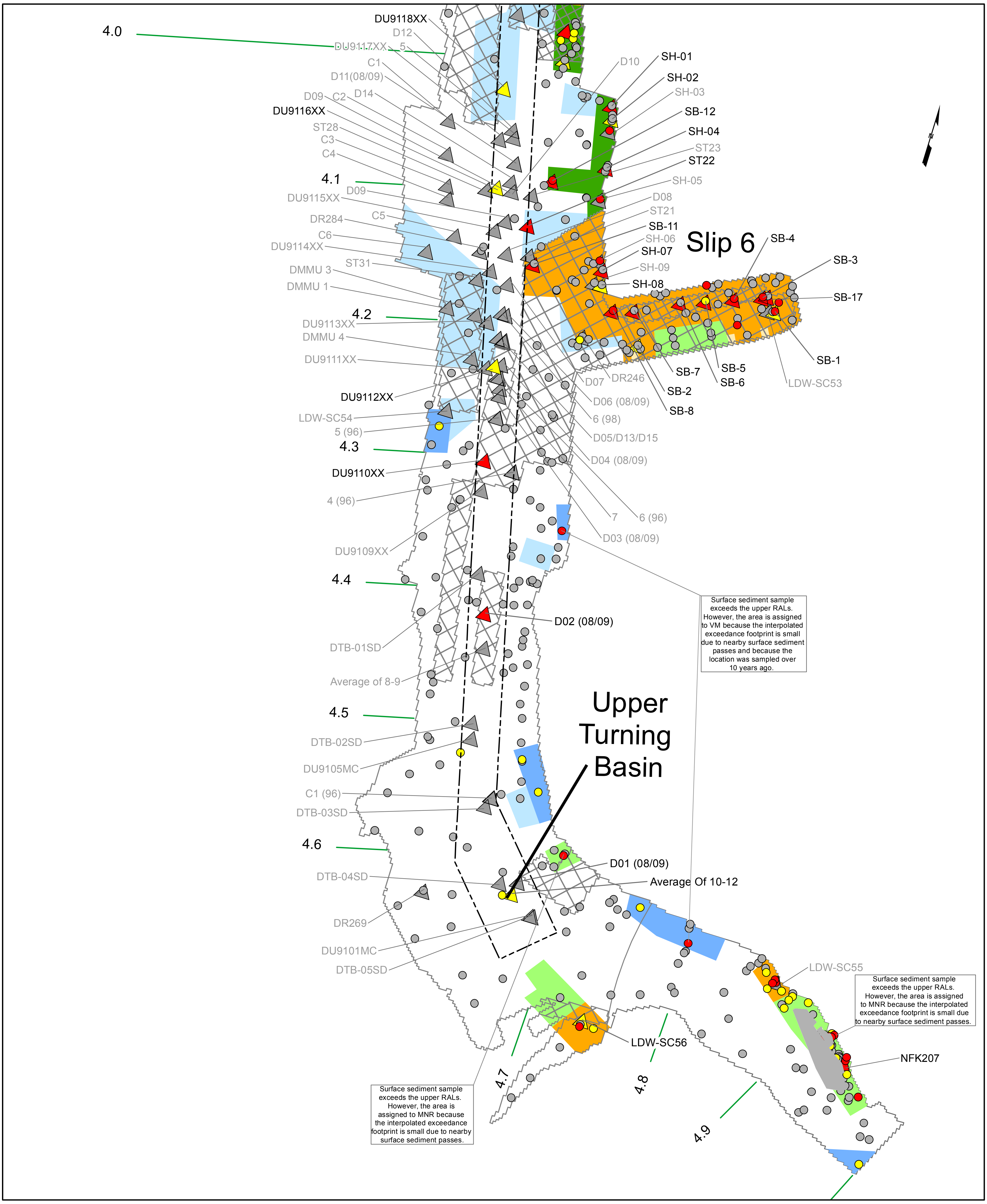
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 4 Combined Technology Assignments and Waterway Conditions

FIGURE G-18a



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 4 upper RALs	700	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	CSL
Alt 4 lower RALs	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 5 (defines AOPC 1)	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentration of 240 µg/kg dw as a dry weight approximation of the 12 mg/kg oc (SQS) value assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (50 acres)
- Cap or Partial Dredge and Cap (41 acres)
- Monitored Natural Recovery (50 acres)
- ENR/*in situ* (16 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 4 Upper RALs (Applicable Site-wide)
- >Alt 4 Lower RALs (Applicable in Categories 1&2)
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black

Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-18bAlt4CombinedConB.mxd

AECOM

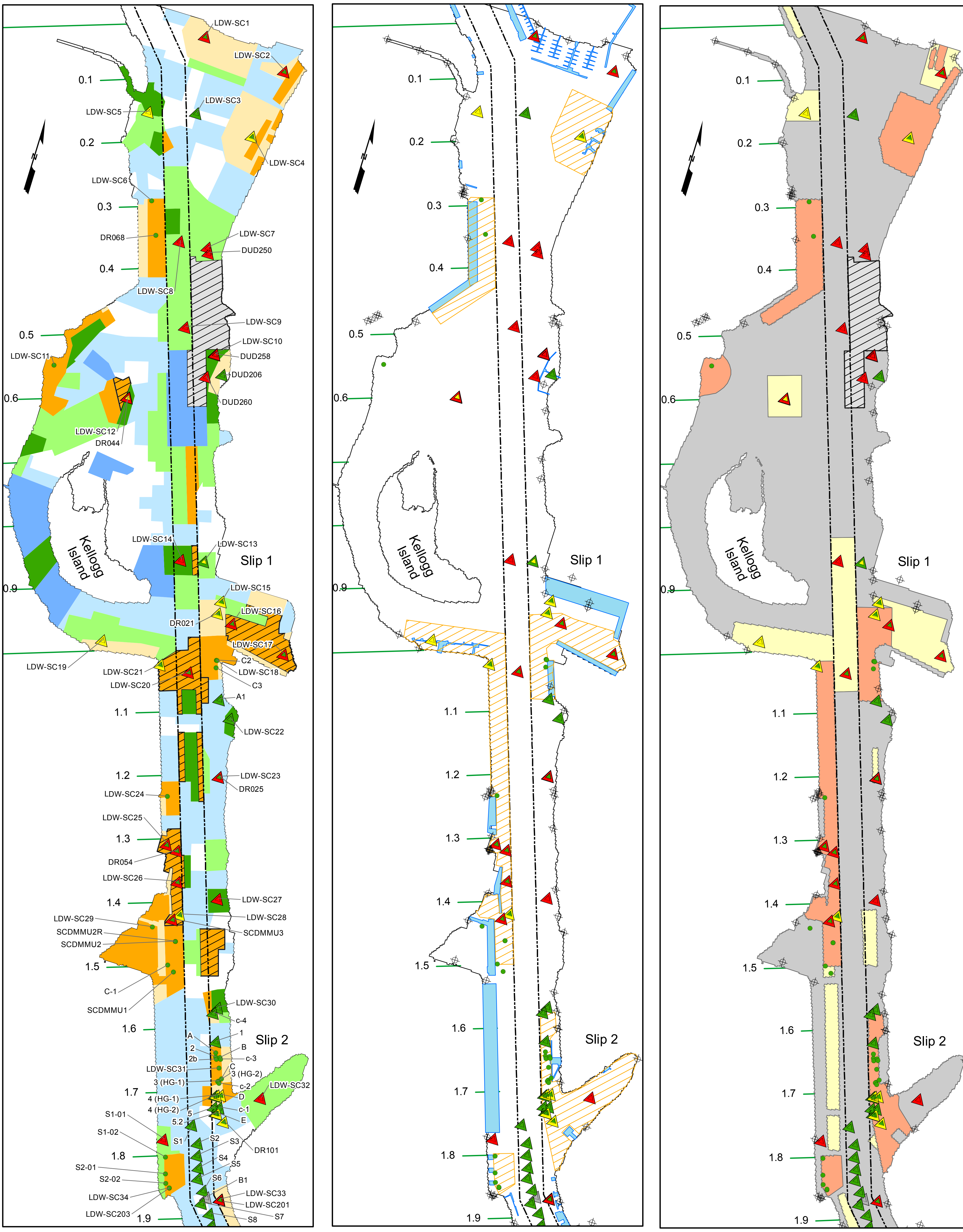
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 4 Combined Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-18b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core; Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group — Port of Seattle / City of Seattle / King County / The Boeing Company

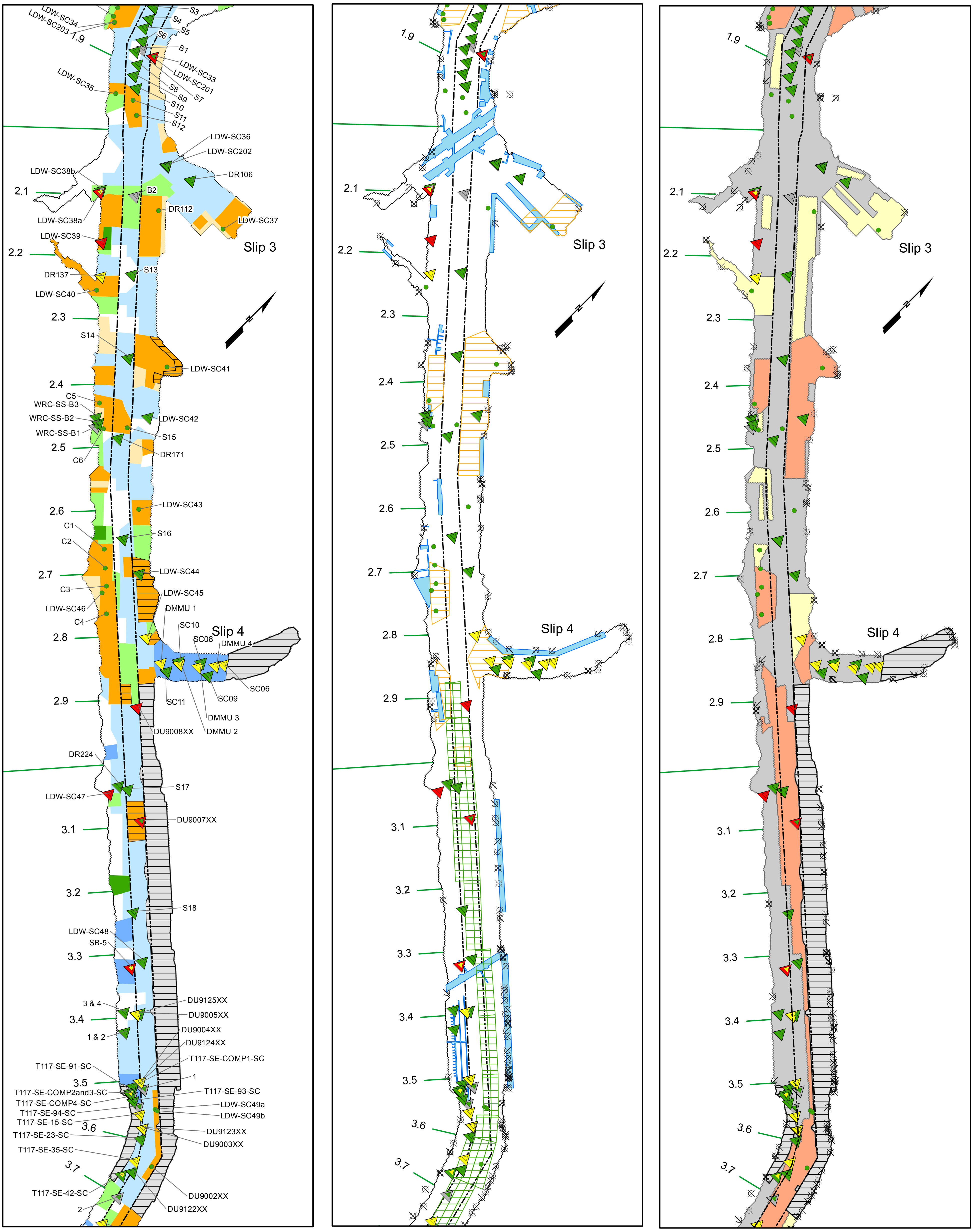
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 4 Combined Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-19a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-19aCoreRecoveryNorth4C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

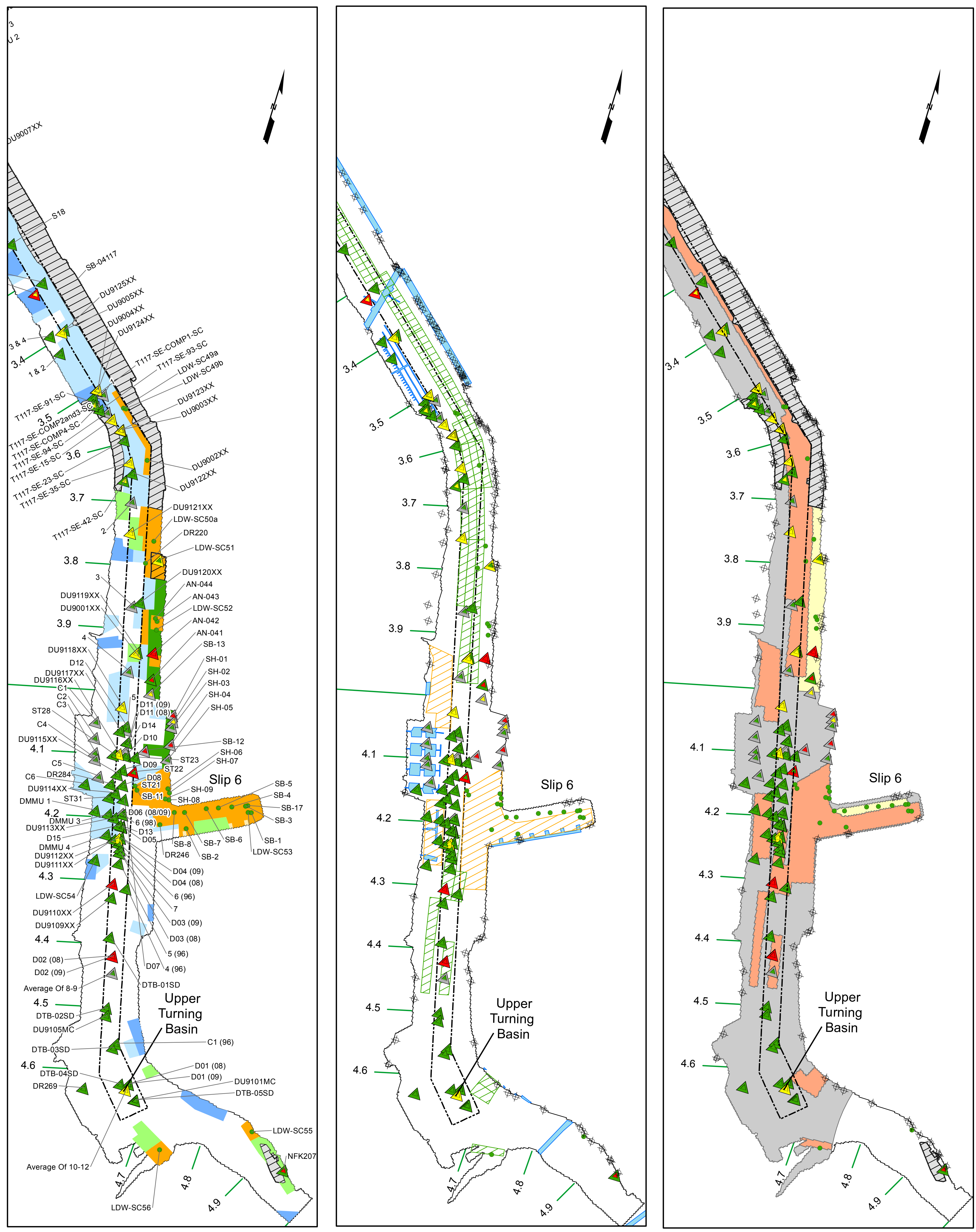
Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 4 Combined Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-19b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-19bCoreRecoveryMid4C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

AECOM

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

SMS Exceedance Status Following Remediation

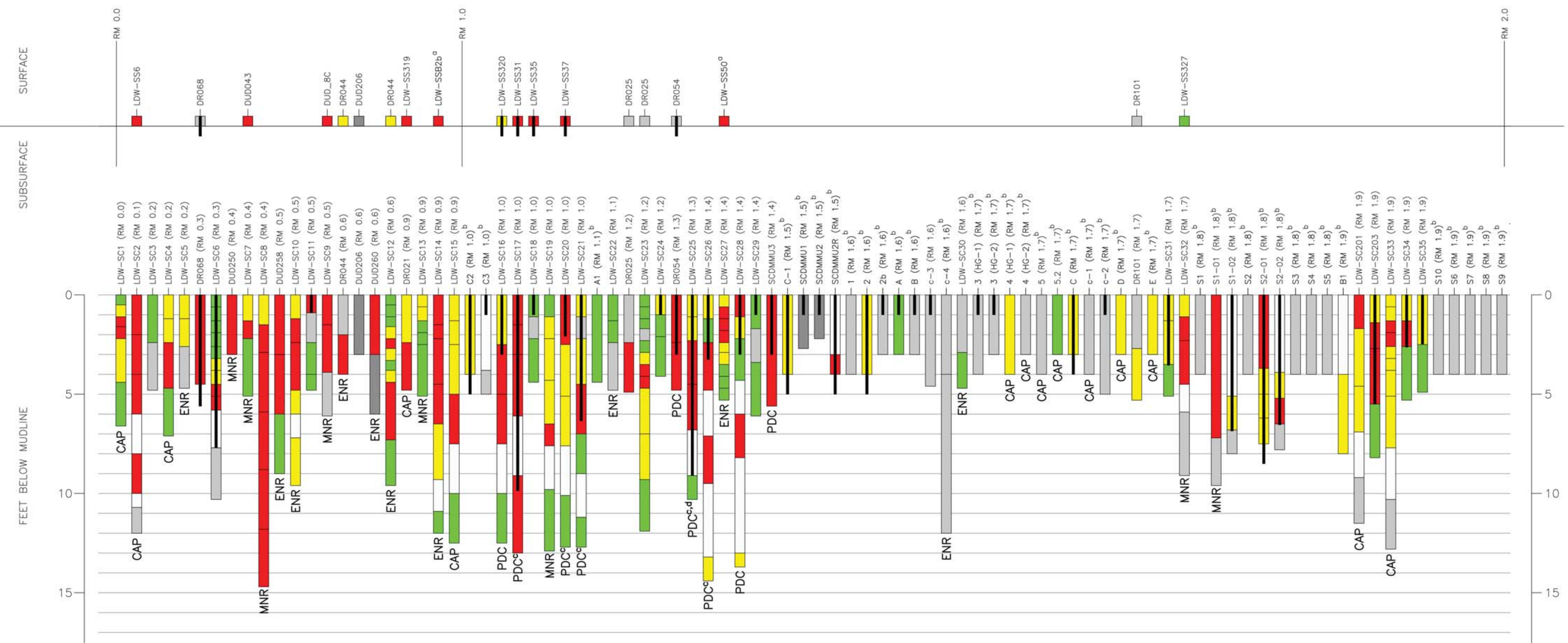
Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46			**Alternative 4 Combined Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE G-19c**

L:\Lower Duwamish FS\FS_Final_GIS\GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-19cCoreRecoverySouth4C.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.

AECOM

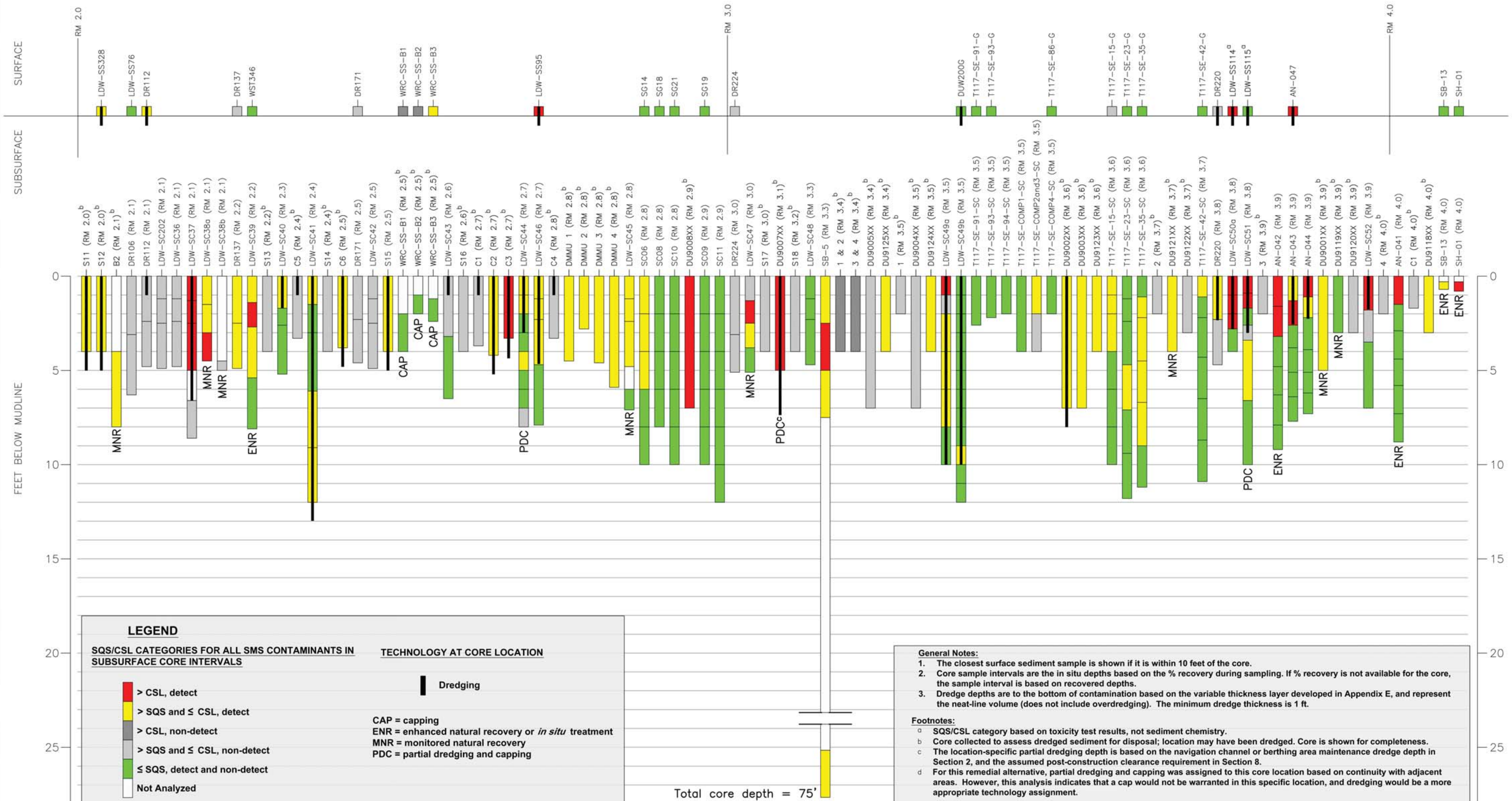
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 4 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-20a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.

AECOM

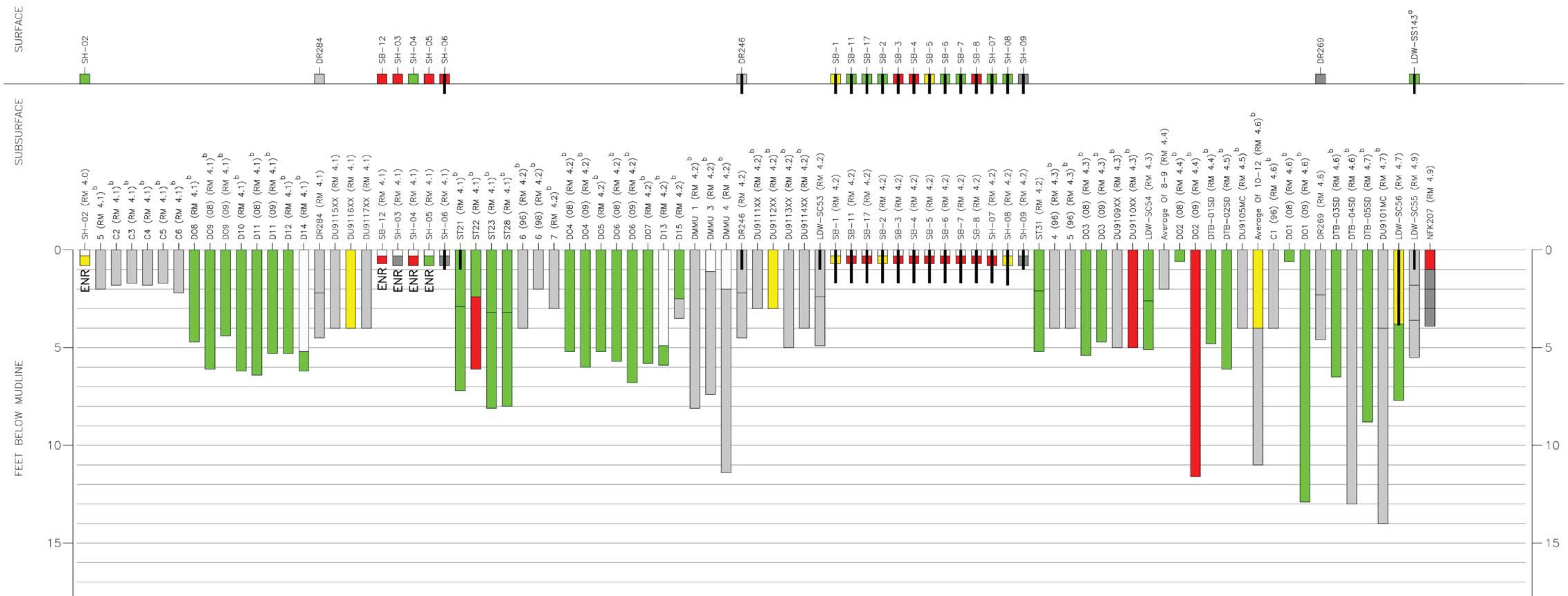
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 4 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-20b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
MNR = monitored natural recovery
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.

AECOM

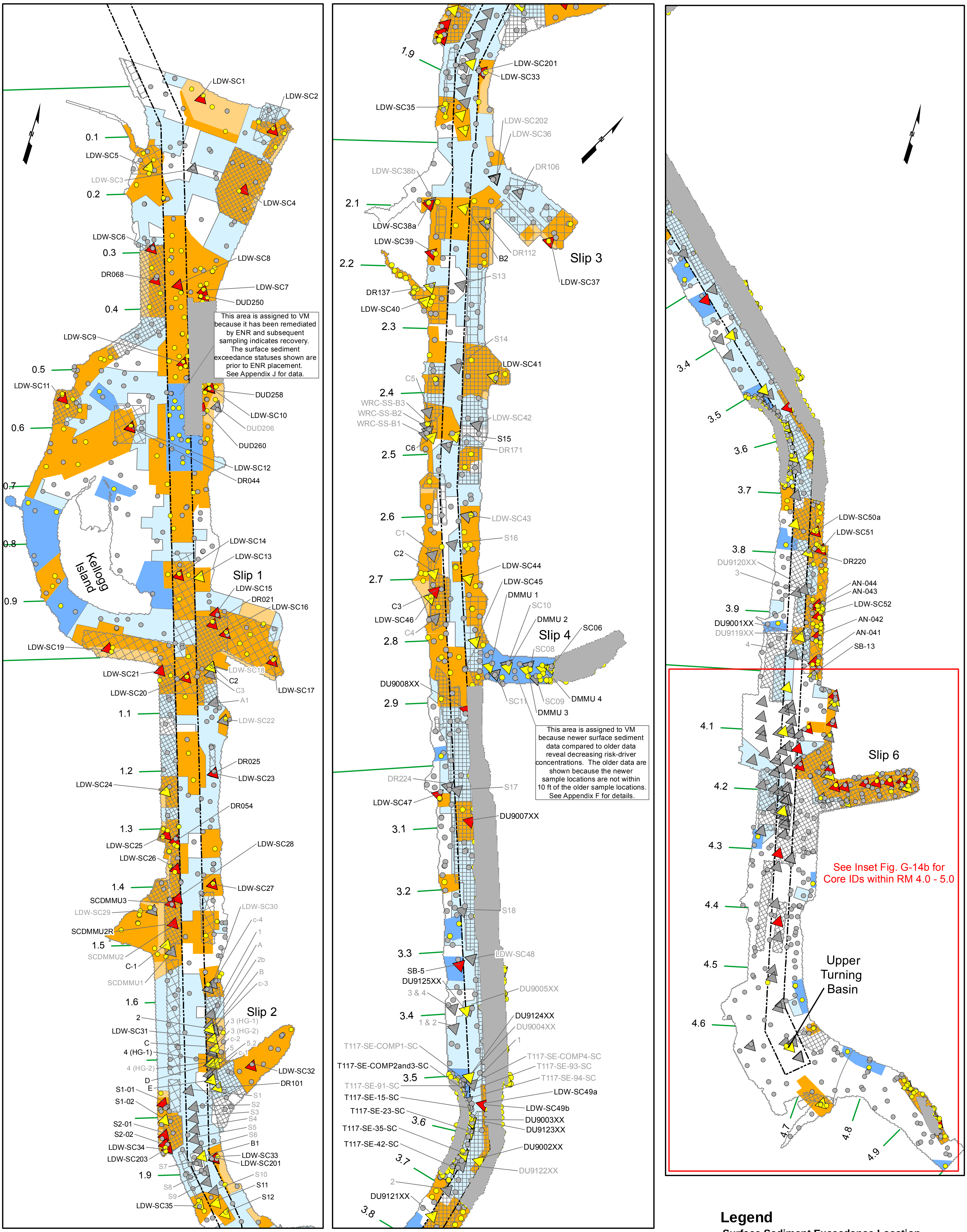
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 4 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-20c



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 5	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentration of 240 µg/kg dw as a dry weight approximation of the 12 mg/kg oc (SQS) value assuming 2% TOC.

0 200 400 800 Feet

Technology Assignment

AOPC 1
- Dredge (143 acres)
- Cap or Partial Dredge and Cap (14 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Legend

Surface Sediment Exceedance Location
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black
Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-21aAlt5ActiveCon.mxd

AECOM

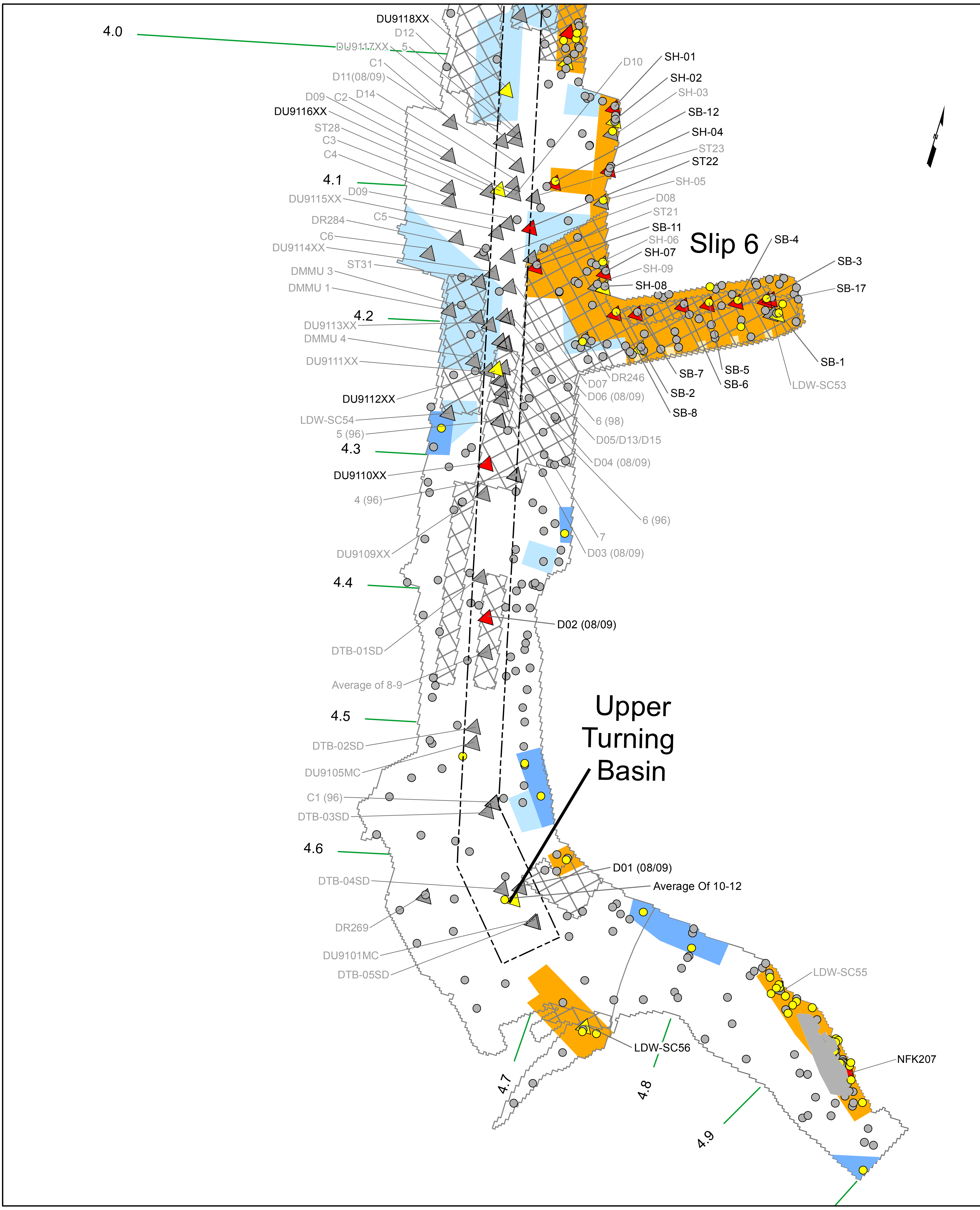
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 5 Removal and Alternative 5 Removal with Treatment Technology Assignments and Waterway Conditions

FIGURE G-21a



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 5	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentration of 240 µg/kg dw as a dry weight approximation of the 12 mg/kg oc (SQS) value assuming 2% TOC.

Technology Assignment

AOPC 1
- Dredge (143 acres)
- Cap or Partial Dredge and Cap (14 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Legend

Surface Sediment Exceedance Location
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

0 200 400 800 Feet

AECOM

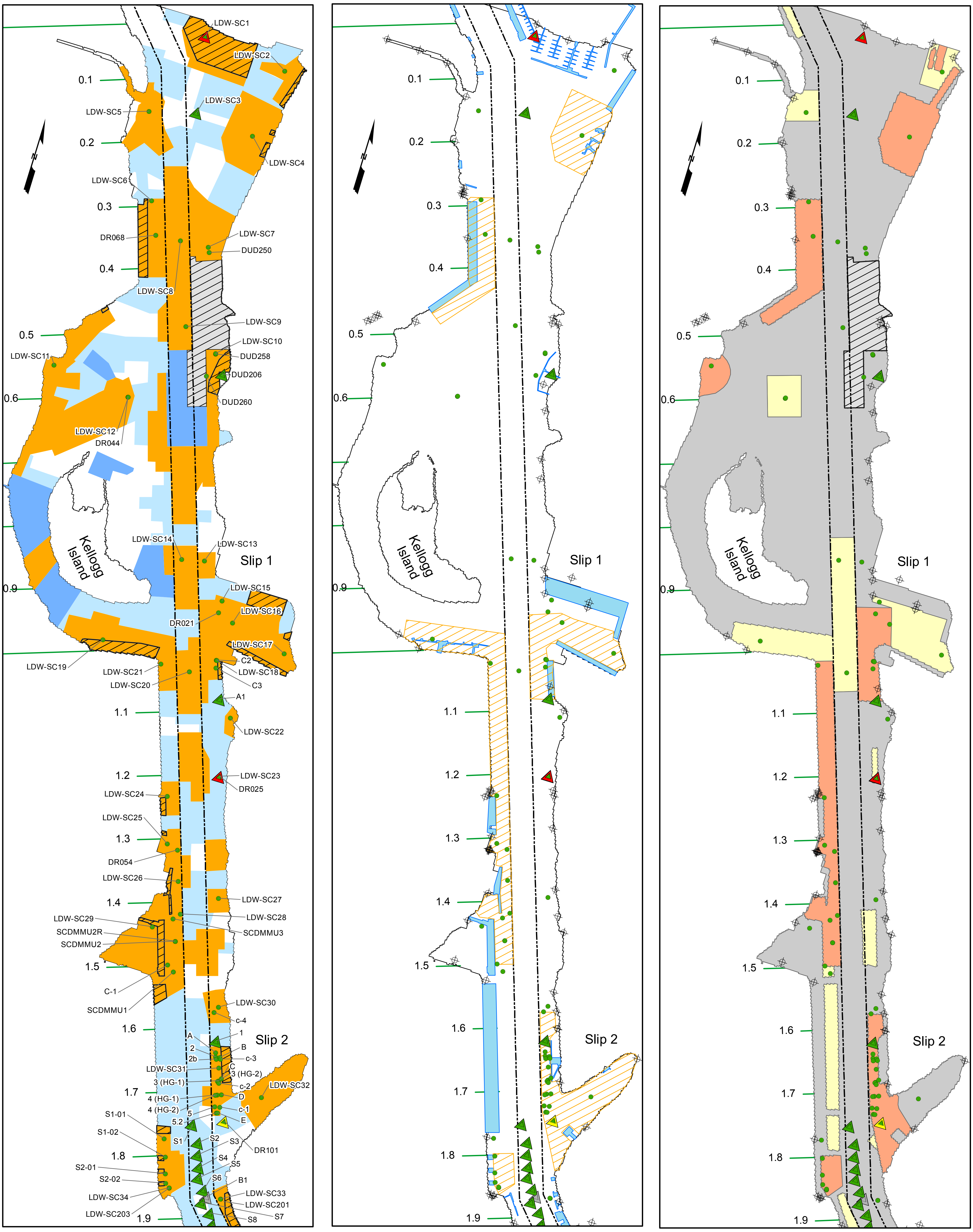
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 5 Removal and Alternative 5 Removal with Treatment Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

FIGURE G-21b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

0 200 400 800 Feet

AECOM

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

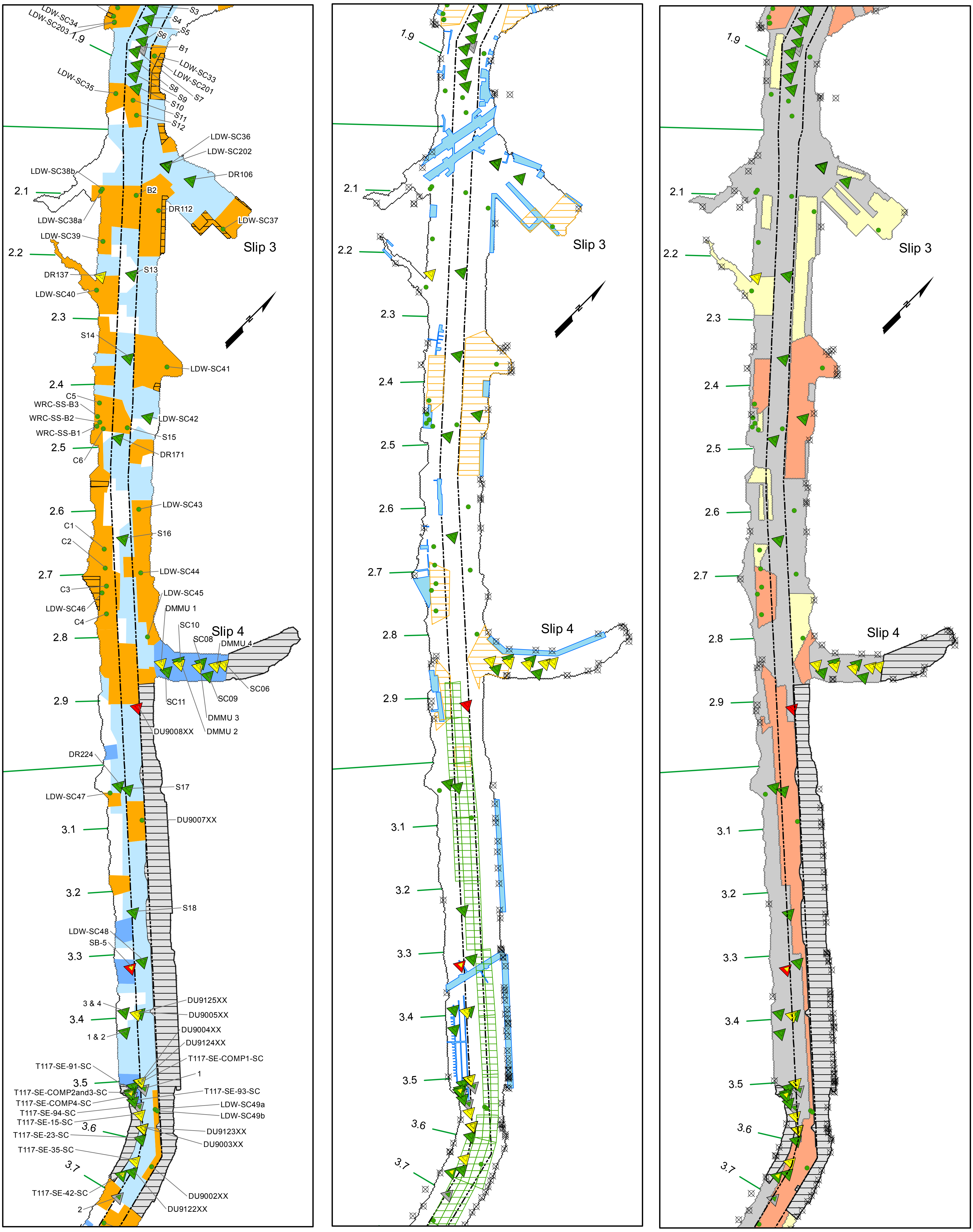
Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 5 Removal and Alternative 5 Removal with Treatment Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)
DATE: 10/31/12 · DWRN:MVI/sea · Revision: 0	FIGURE G-22a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-22aCoreRecoveryNorth5R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

0 200 400 800 Feet

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core
Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

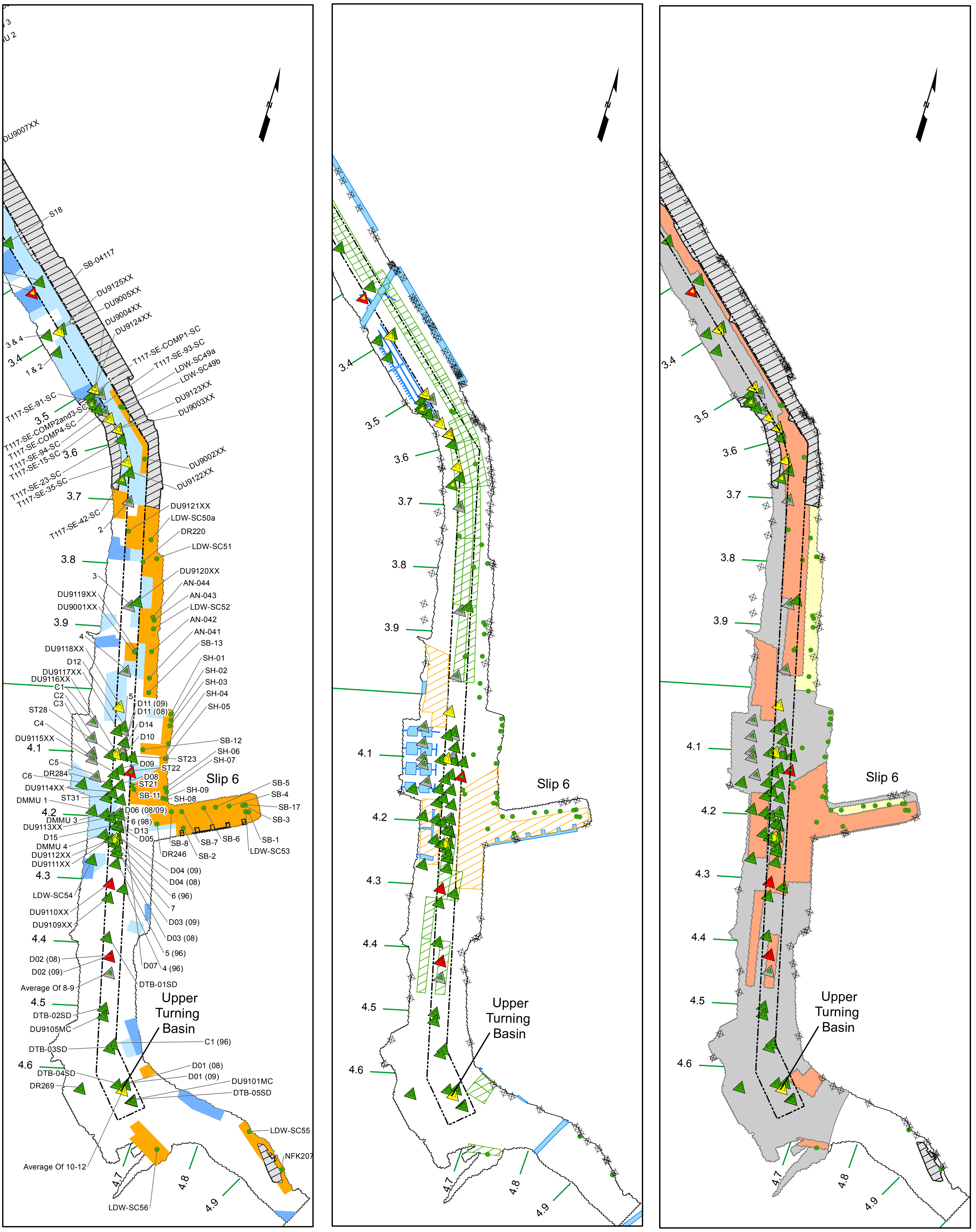
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 5 Removal and Alternative 5 Removal with Treatment Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-22b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-22bCoreRecoveryMid5R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet: 0, 200, 400, 800

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

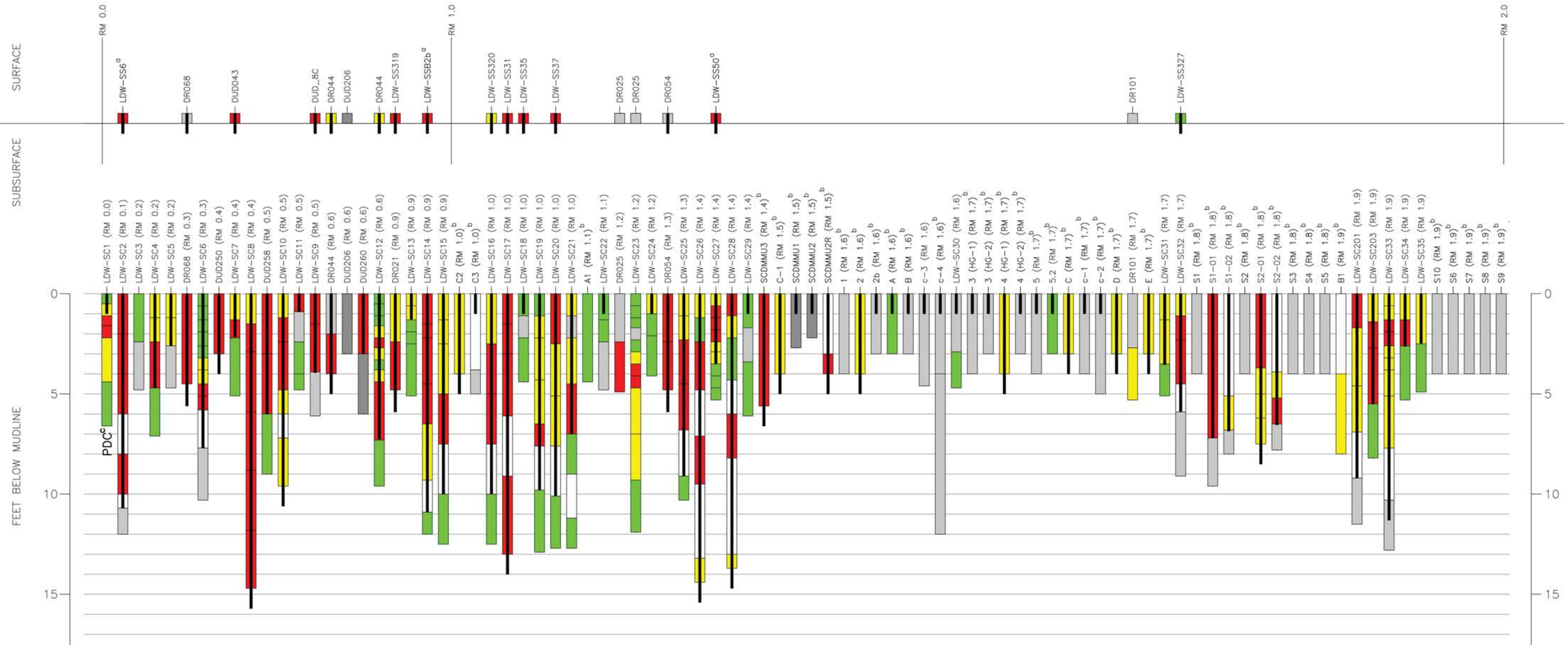
Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 5 Removal and Alternative 5 Removal with Treatment Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-22c

L:\Lower Duwamish FS\FS_Final_GIS\GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-22cCoreRecoverySouth5R.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

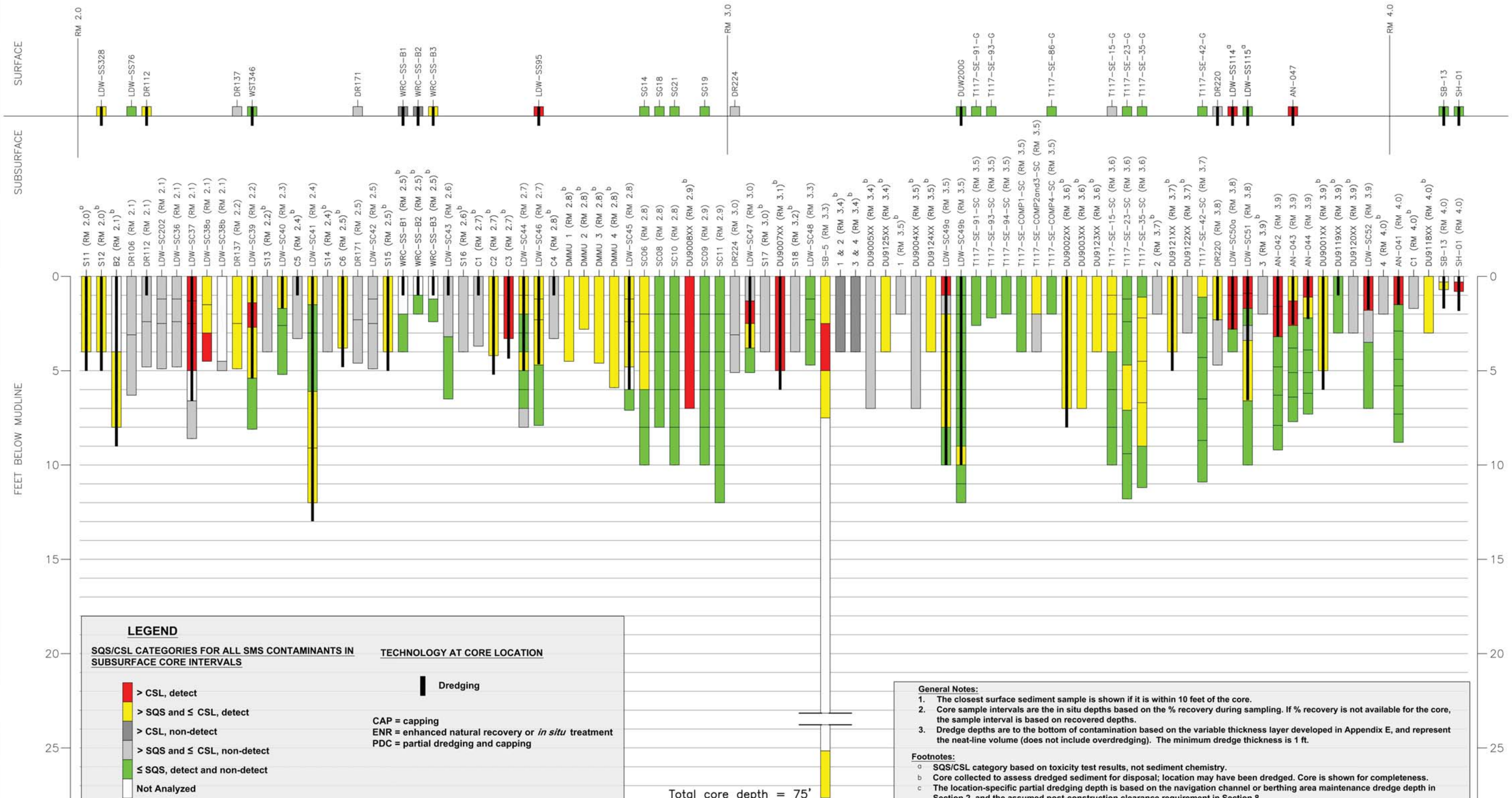
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 5 REMOVAL AND 5 REMOVAL WITH TREATMENT REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-23a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

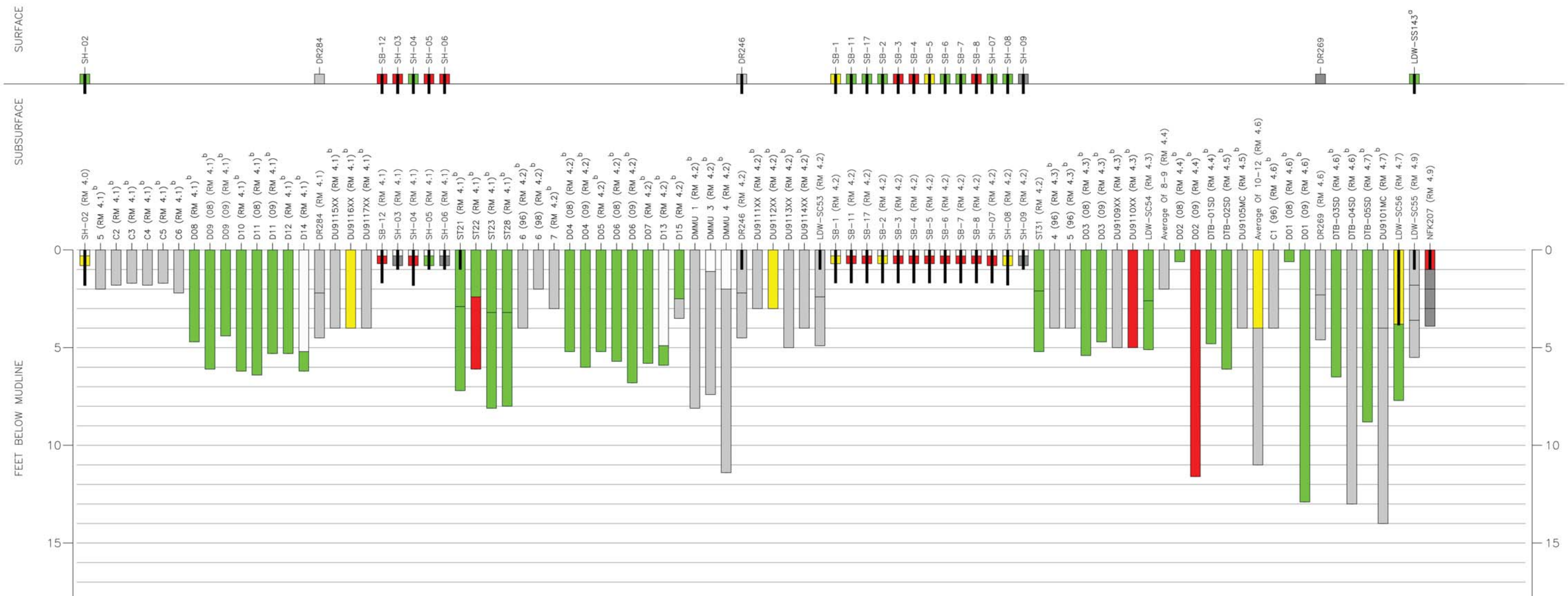
LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 5 REMOVAL AND 5 REMOVAL WITH TREATMENT REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-23b

File: G:\PROJECTS\CADD\Lower Duwamish\2011 slick maps\alt5R-103112.dwg Layout: ANSI_B(-LJ (2) User: oliveriam Plotted: Oct 31, 2012 - 10:28am



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

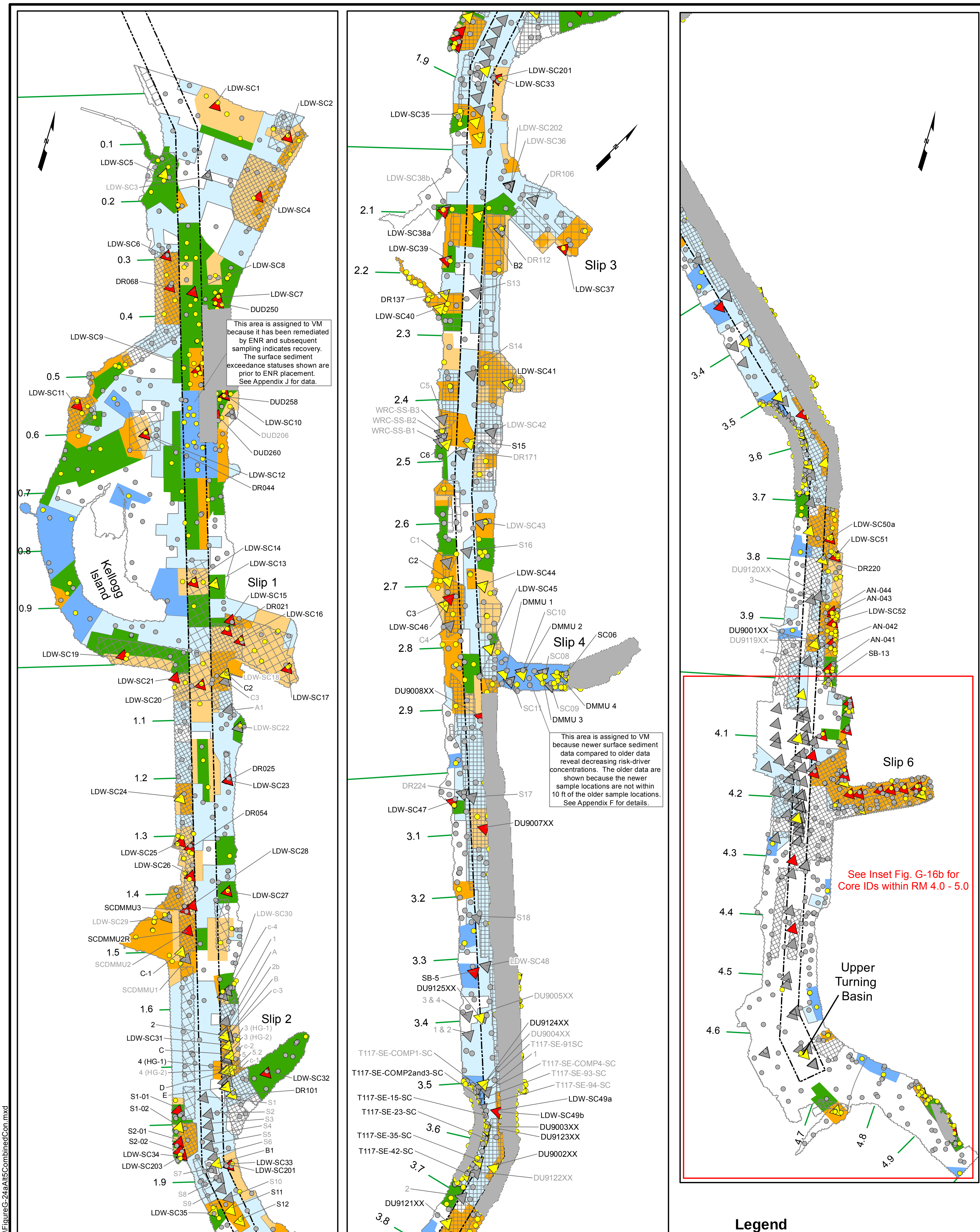
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 5 REMOVAL AND 5 REMOVAL WITH TREATMENT REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-23c



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 5	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

TOC.

Technology Assignment

AOPC 1
- Dredge (57 acres)
- Cap or Partial Dredge and Cap (47 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (53 acres)
- Verification Monitoring (23 acres)

AOCP 2 (122 acres)

Early Action Area (29 acres)

Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected — Station ID Labeled in Black
- Pass or Non-detect — Station ID Labeled in Grey

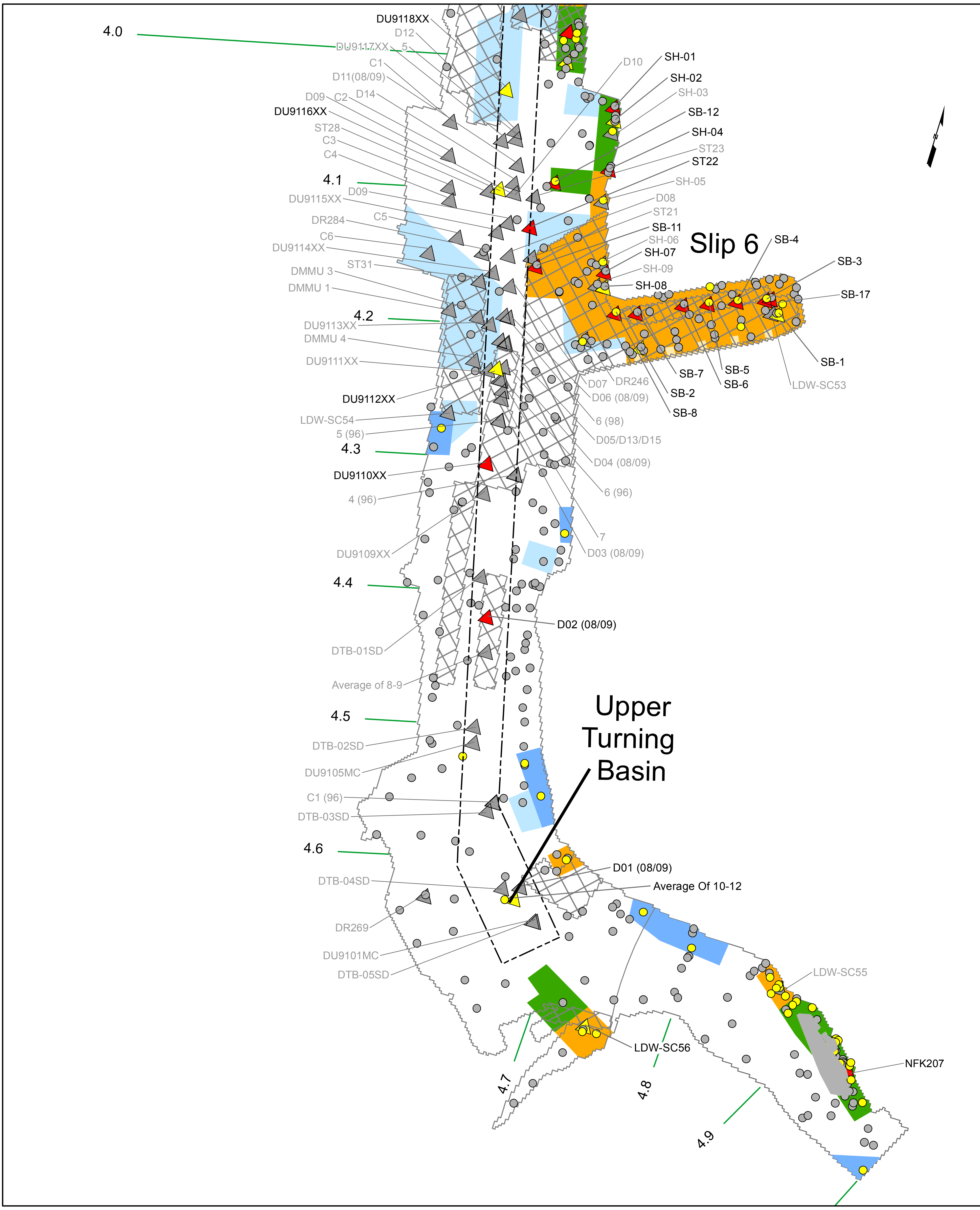
Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-24aAlt5CombinedCon.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	**Alternative 5 Combined Technology Assignments and Waterway Conditions**
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	**FIGURE G-24a**



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 5	240[a]	1,000 (site-wide), 900 (intertidal)	25	57 (site-wide), 28 (intertidal)	SQS
Alt 6 (defines AOPC 1+2)	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Note a. Total PCBs concentration of 240 µg/kg dw as a dry weight approximation of the 12 mg/kg oc (SQS) value assuming 2% TOC.

Technology Assignment

AOPC 1:
- Dredge (57 acres)
- Cap or Partial Dredge and Cap (47 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (53 acres)
- Verification Monitoring (23 acres)

- AOPC 2 (122 acres)
- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 5 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black

Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

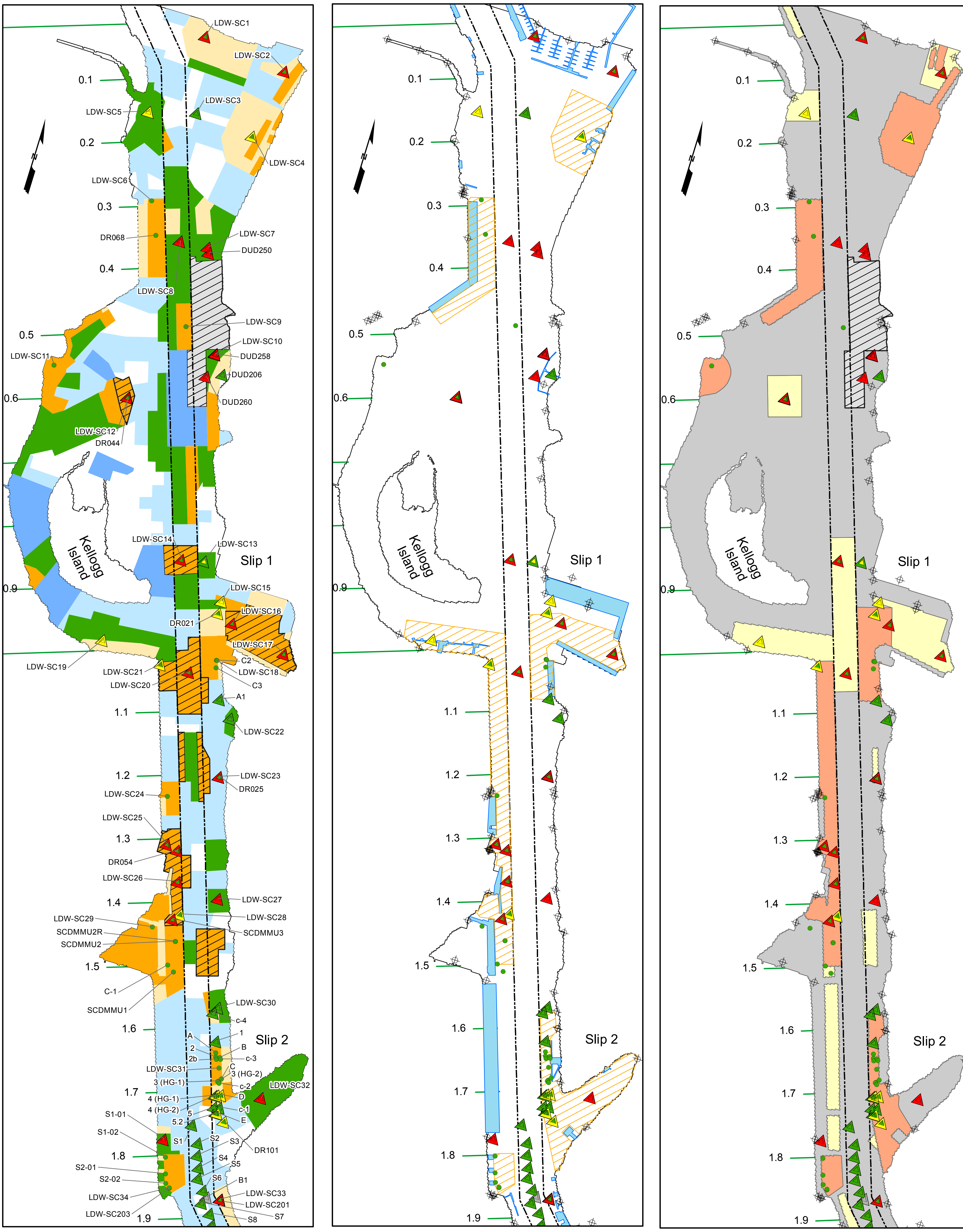
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 5 Combined Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-24b

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-24bAlt4CombinedConB.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

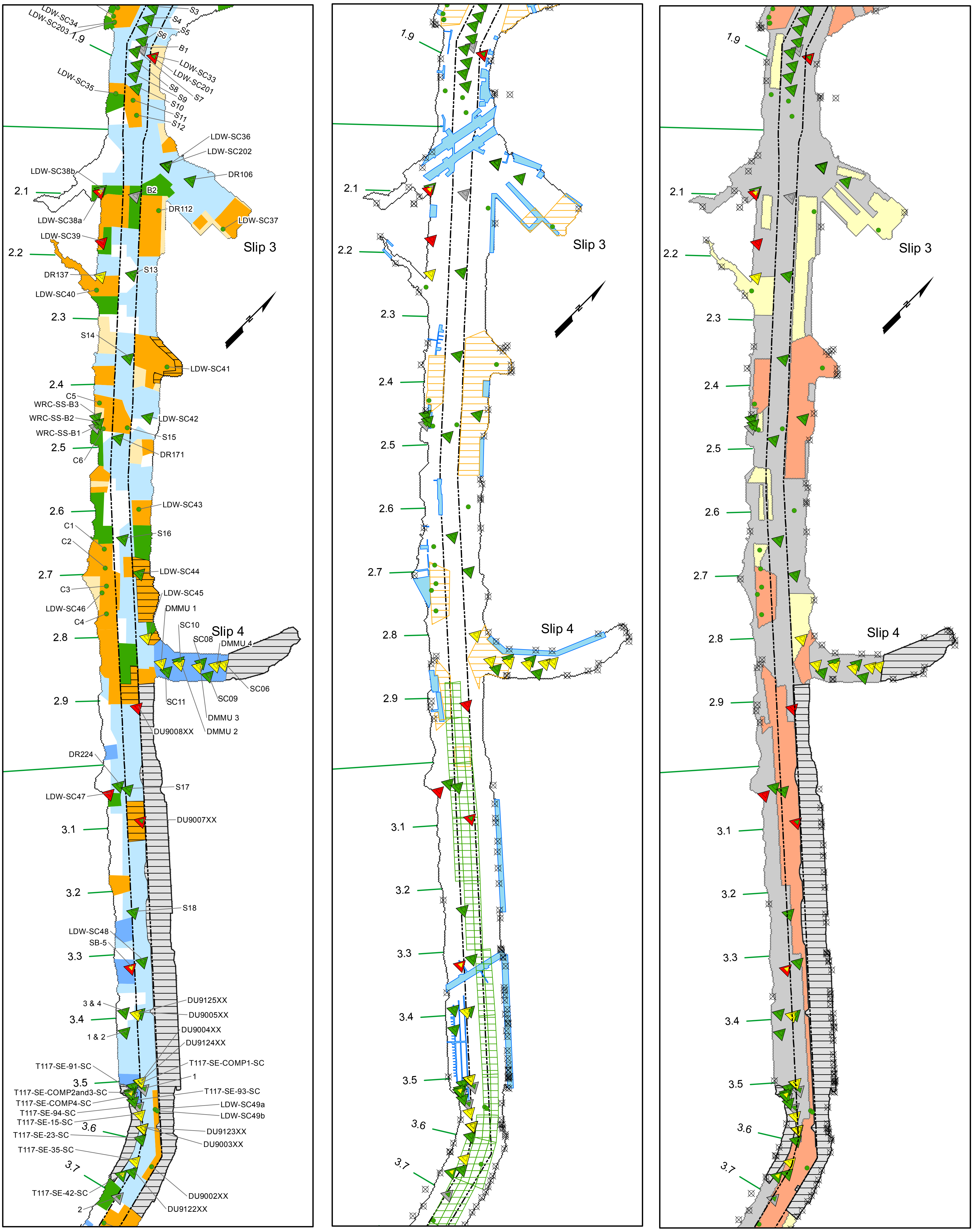
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 5 Combined Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-25a

L:\Lower Duwamish FS\FS_Final_GIS\GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\G-25aCoreRecoveryNorth5C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

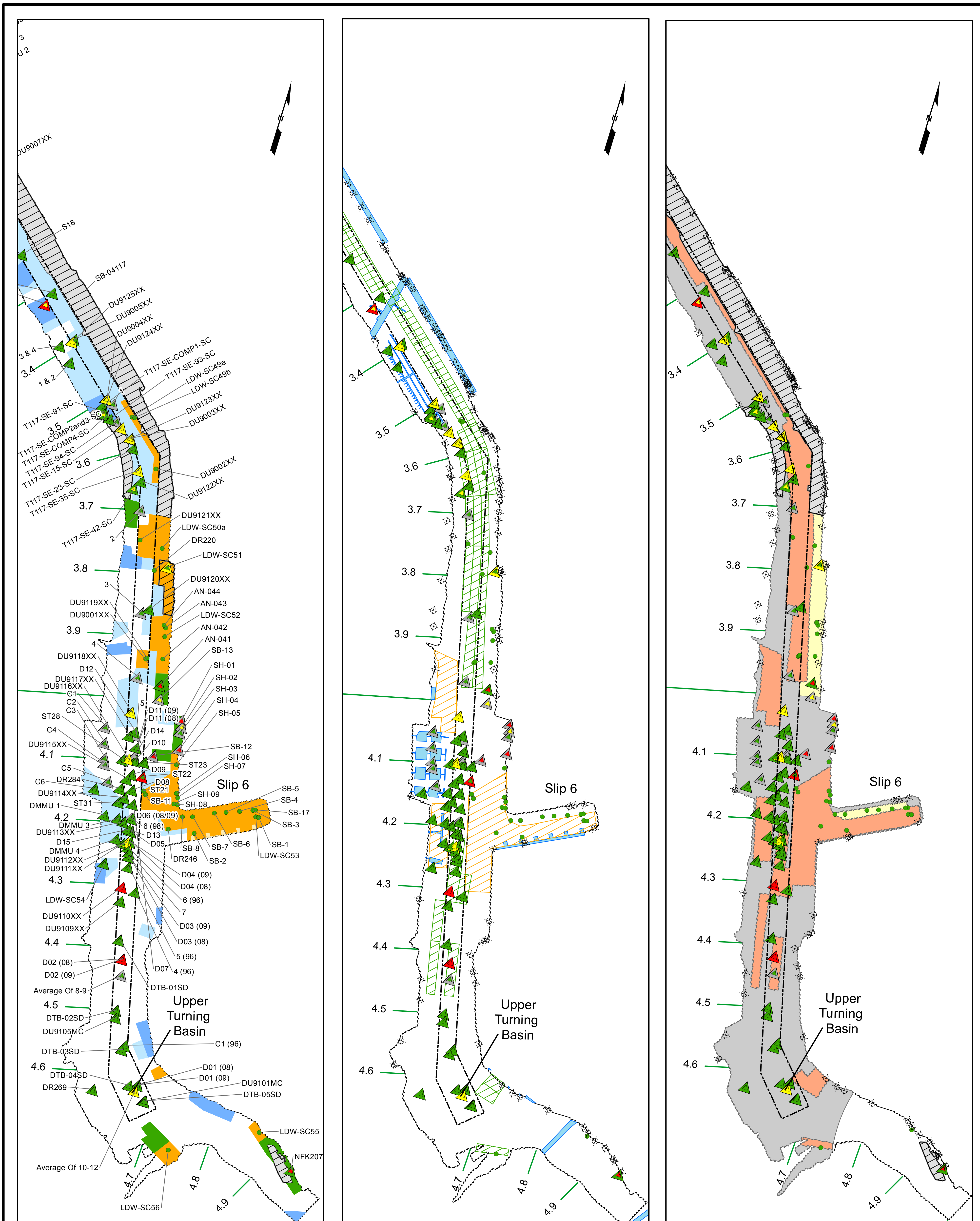
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 5 Combined Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)
DATE: 10/31/12 / DWRN:MVI/sea / Revision: 0	FIGURE G-25b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-25bCoreRecoveryMid5C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet: 0 200 400 800

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- AOPC 2
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

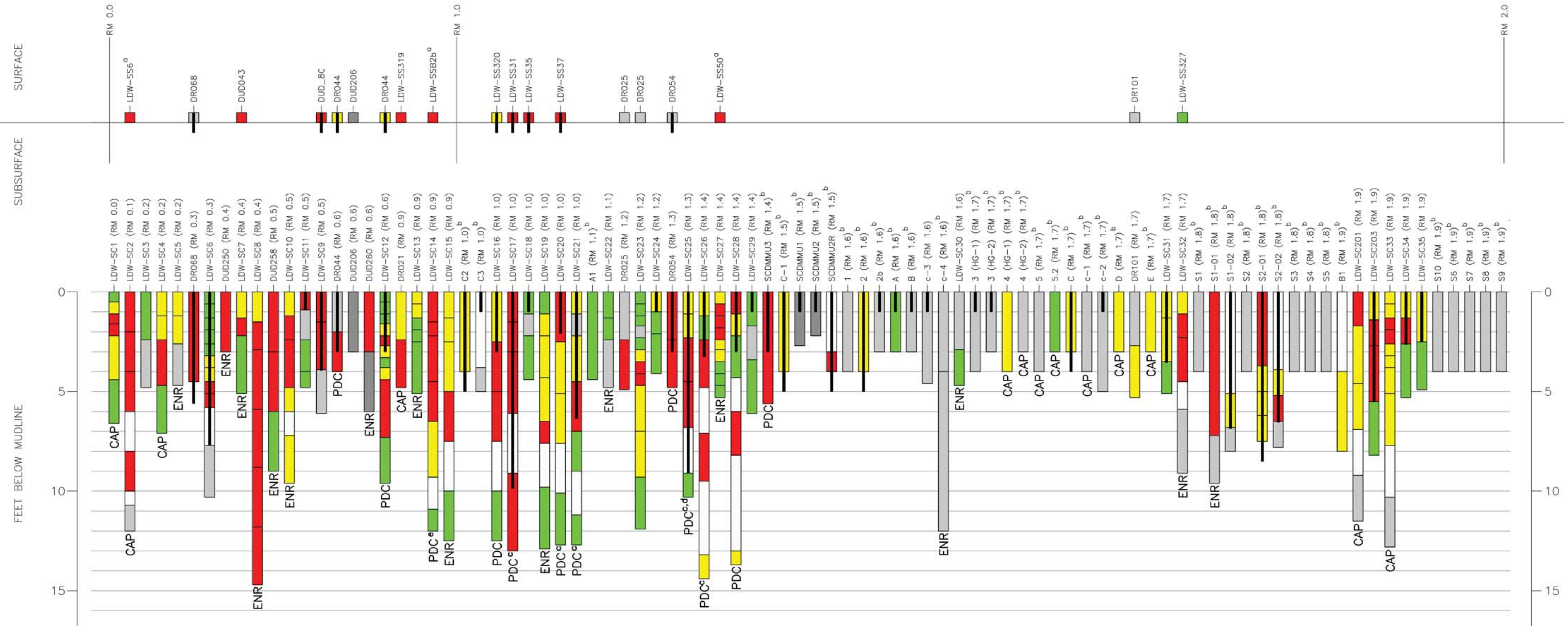
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 5 Combined Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-25c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-25cCoreRecoverySouth5C.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.
e For this remedial alternative, partial dredging and capping was assigned to this location based on continuity with adjacent areas. However, this analysis indicates that dredging would not be warranted in this specific location, and cap would be a more appropriate technology assignment.

AECOM

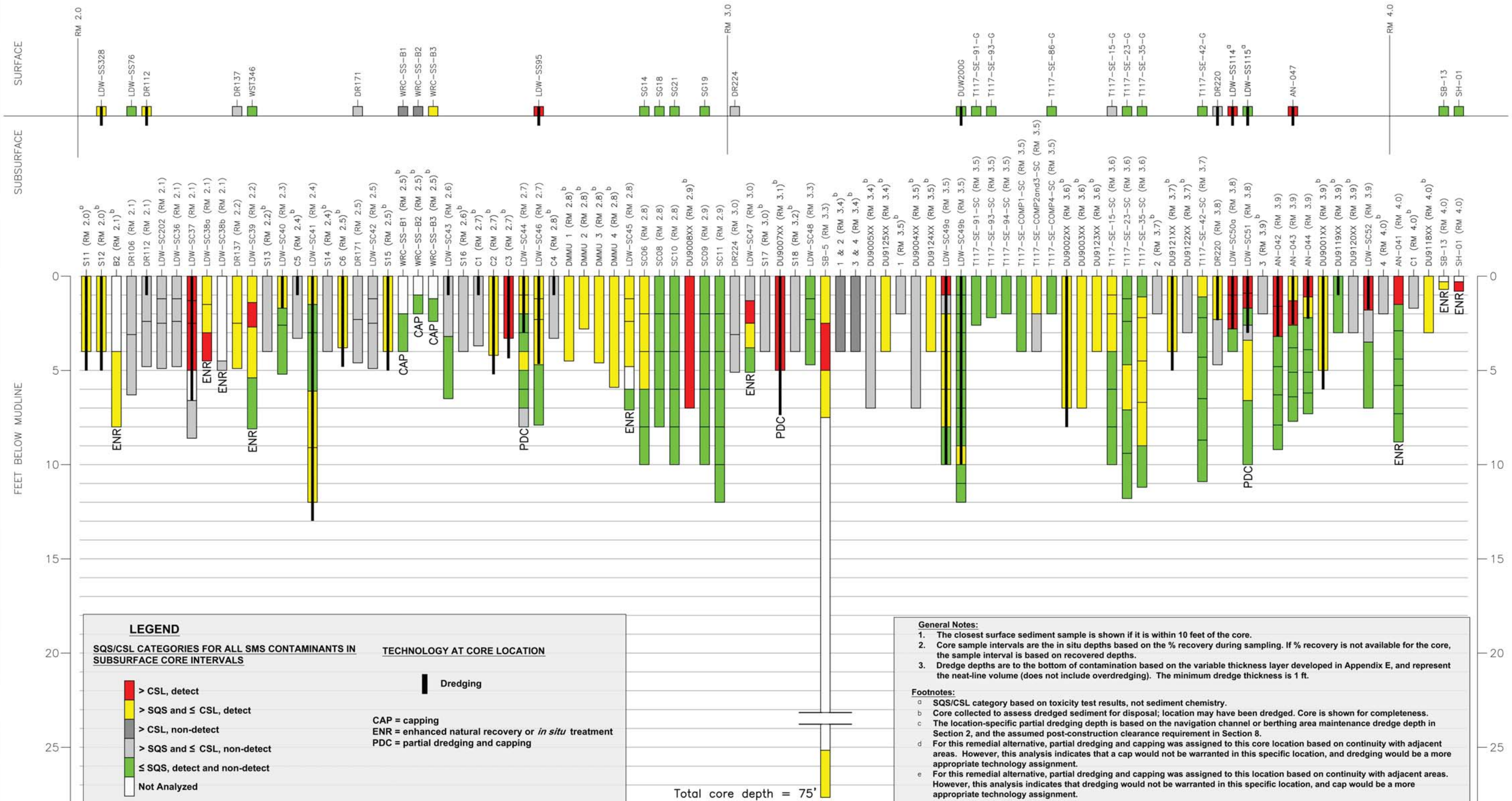
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 5 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-26a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.
e For this remedial alternative, partial dredging and capping was assigned to this location based on continuity with adjacent areas. However, this analysis indicates that dredging would not be warranted in this specific location, and cap would be a more appropriate technology assignment.

AECOM

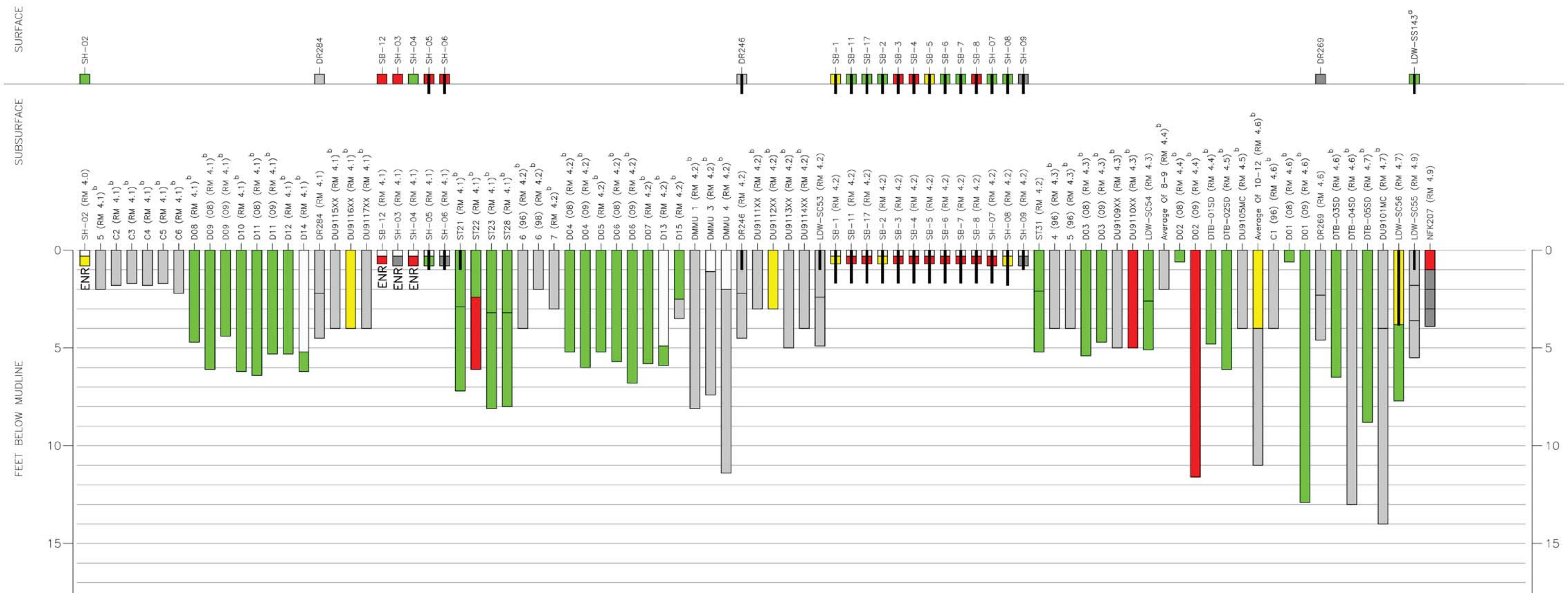
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 5 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-26b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.
e For this remedial alternative, partial dredging and capping was assigned to this location based on continuity with adjacent areas. However, this analysis indicates that dredging would not be warranted in this specific location, and cap would be a more appropriate technology assignment.

AECOM

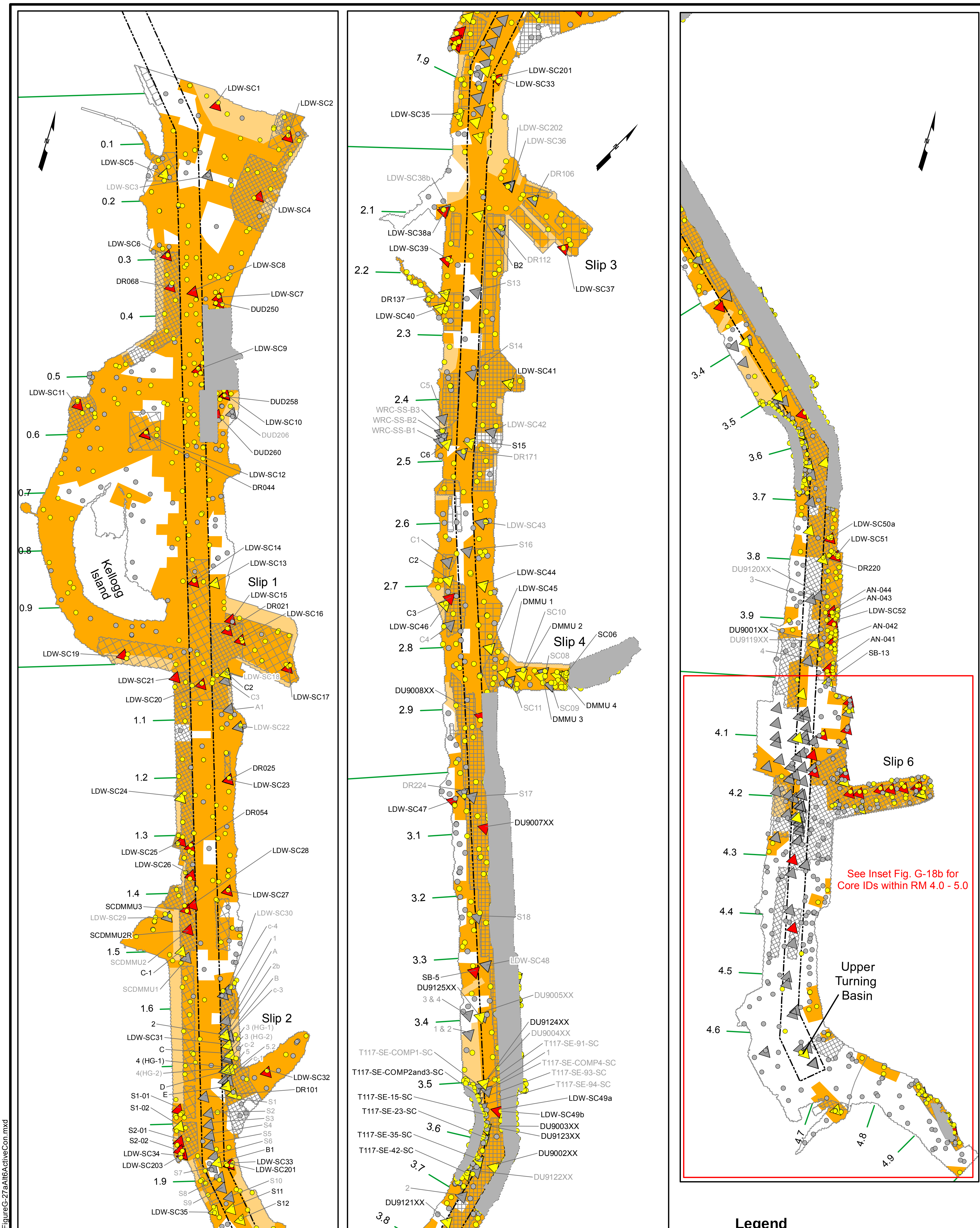
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 5 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-26c



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 6	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Technology Assignment

AOPC 1+2
- Dredge (274 acres)
- Cap or Partial Dredge and Cap (28 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (0 acres)

Early Action Area (29 acres)

Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

0 200 400 800 Feet

Legend

Surface Sediment Exceedance Location
- >Alt 6 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black

Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

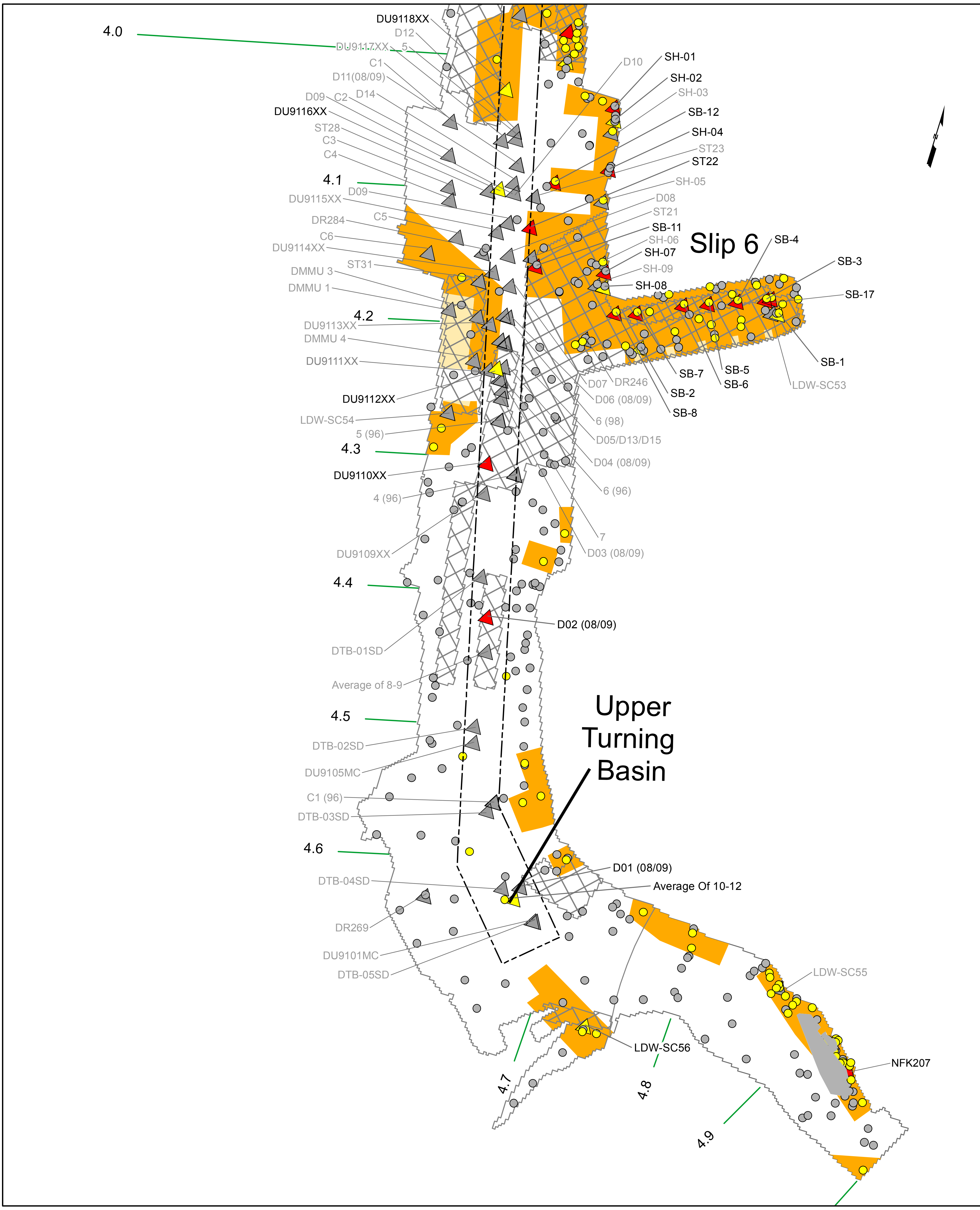
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 6 Removal Technology Assignments and Waterway Conditions

FIGURE G-27a

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-27aAlt6ActiveCon.mxd



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 6	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Technology Assignment

AOPC 1+2
- Dredge (274 acres)
- Cap or Partial Dredge and Cap (28 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (0 acres)
- Verification Monitoring (0 acres)

- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Legend

Surface Sediment Exceedance Location
- >Alt 6 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black

Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

0 200 400 800 Feet

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-27bAlt6ActiveConB.mxd

AECOM

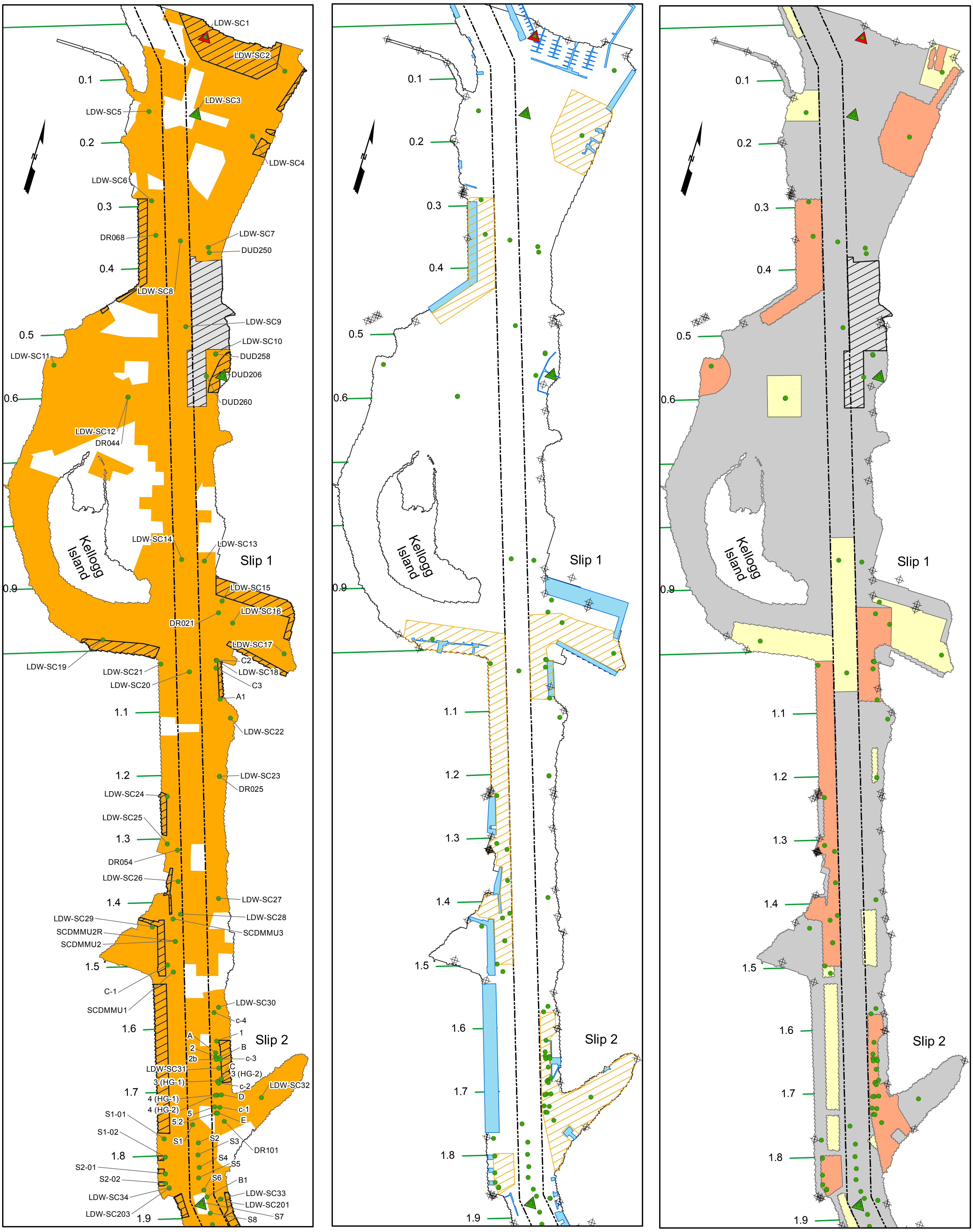
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 6 Removal Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

FIGURE G-27b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

0 200 400 800 Feet

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

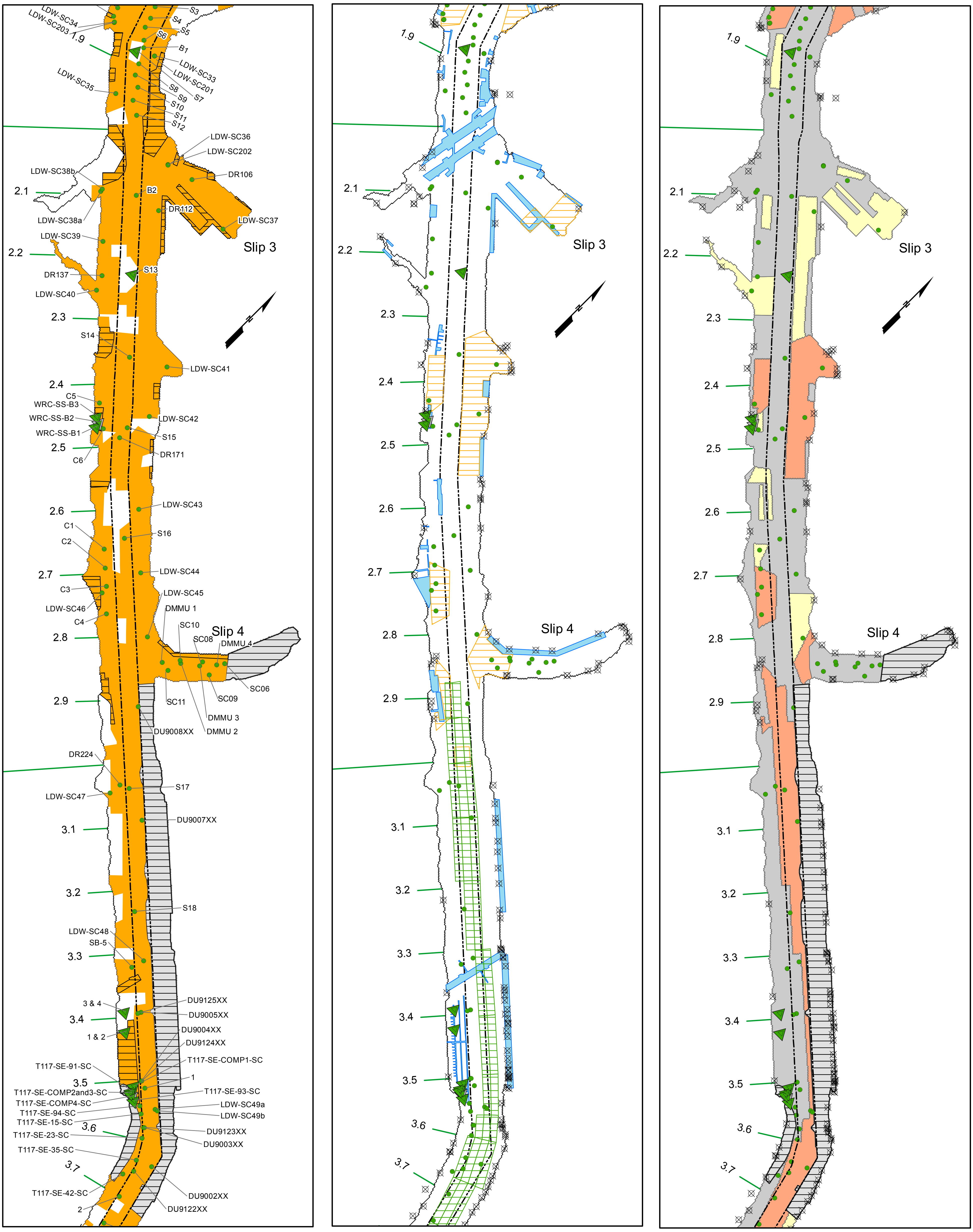
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 6 Removal Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE G-28a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-28aCoreRecoveryNorth6R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

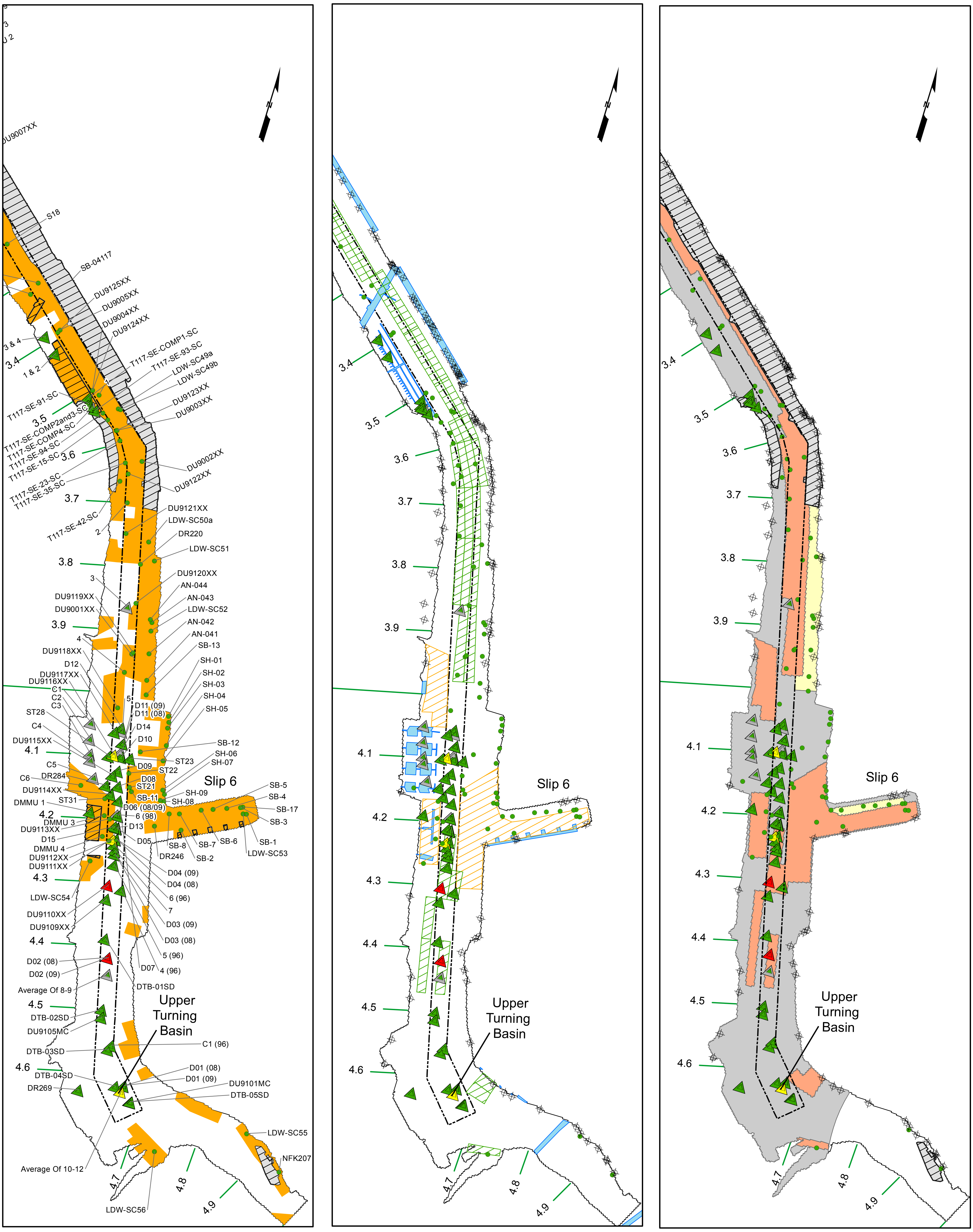
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group — Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 6 Removal Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)
DATE: 10/31/12 · DWRN:MVI/sea · Revision: 0	FIGURE G-28b

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-28bCoreRecoveryMid6R.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

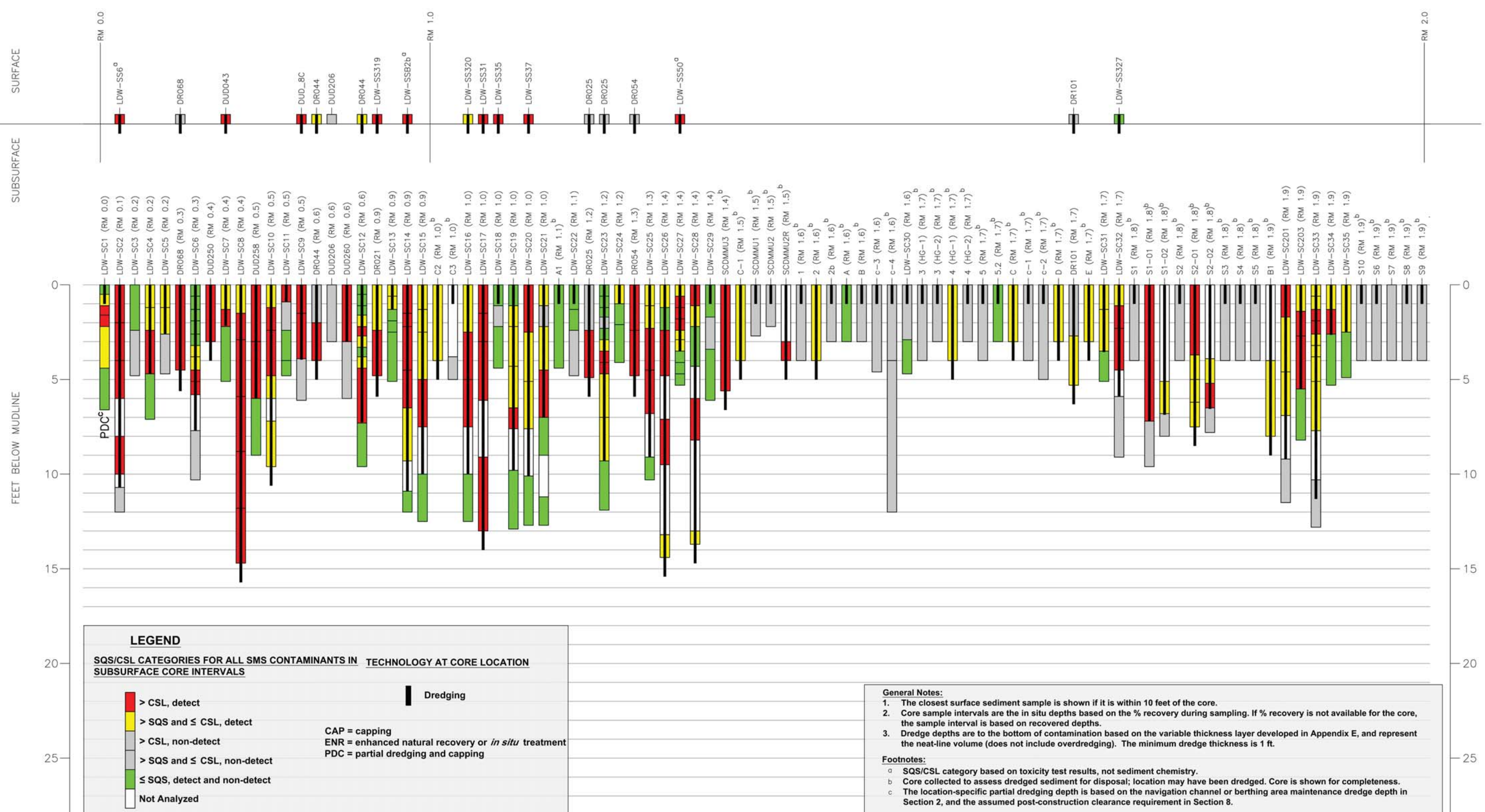
Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	**Alternative 6 Removal Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)**
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	**FIGURE G-28c**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-28cCoreRecoverySouth6R.mxd



General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

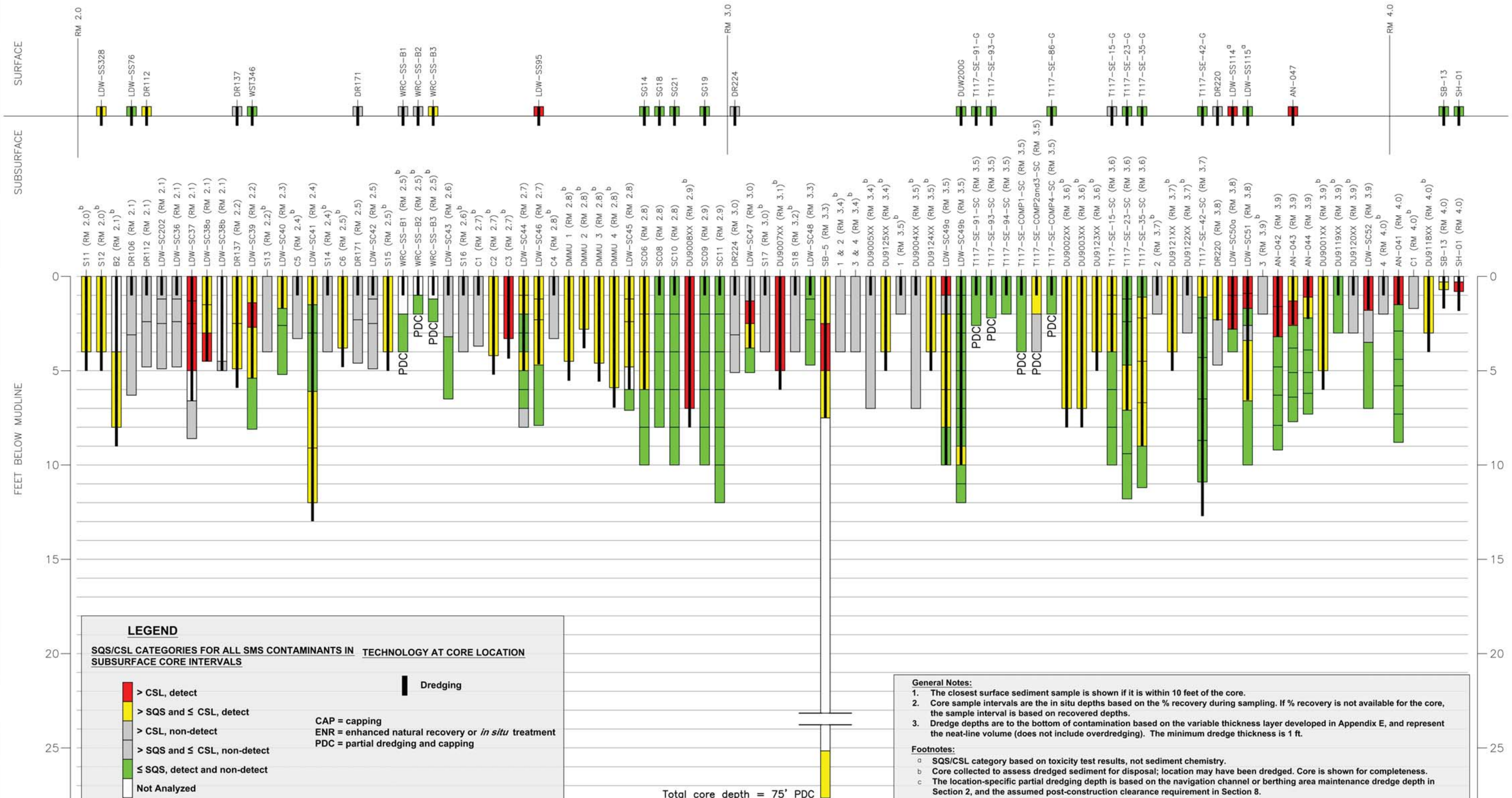
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 | DRWN: MO/SEA

ALTERNATIVE 6 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)

FIGURE G-29a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

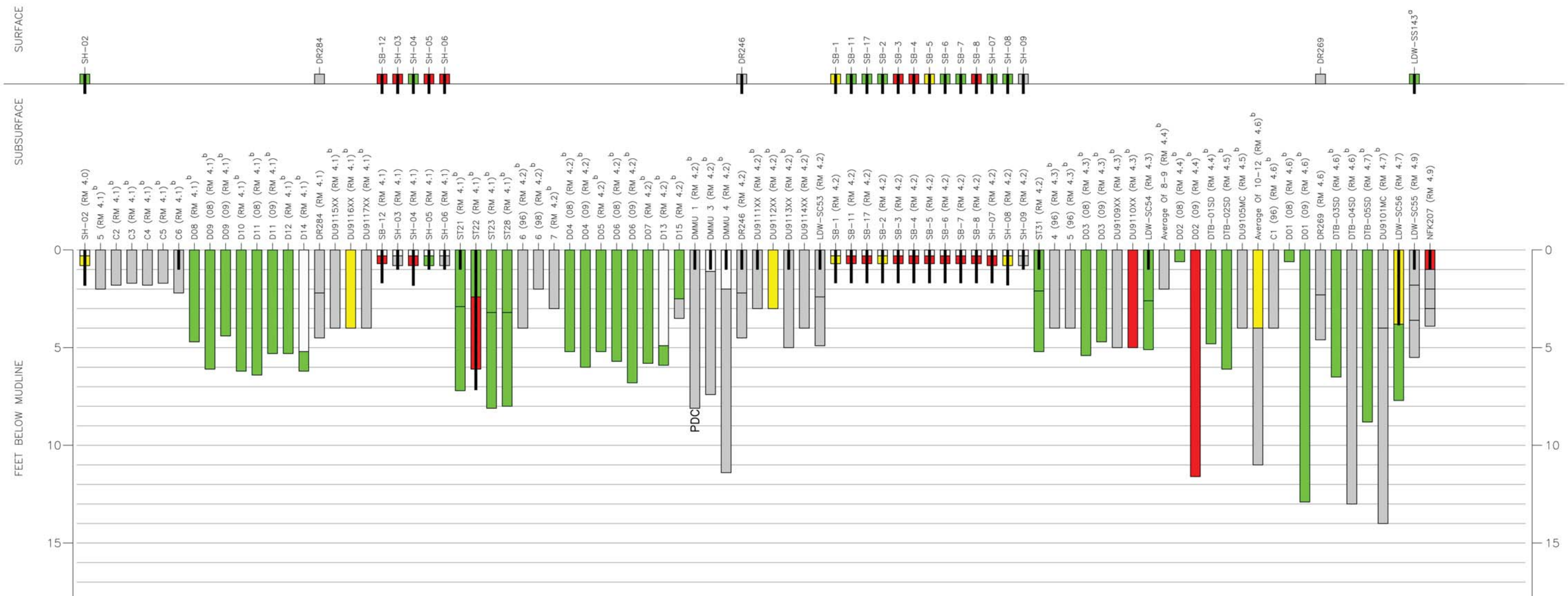
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 6 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-29b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 6 REMOVAL REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-29c

Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 6	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Technology Assignment

AOPC 1+2
- Dredge (108 acres)
- Cap or Partial Dredge and Cap (93 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (101 acres)
- Verification Monitoring (0 acres)

- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Feet
0 200 400 800

Legend

Surface Sediment Exceedance Location
- >Alt 6 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

System ID Labeled in Black
System ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

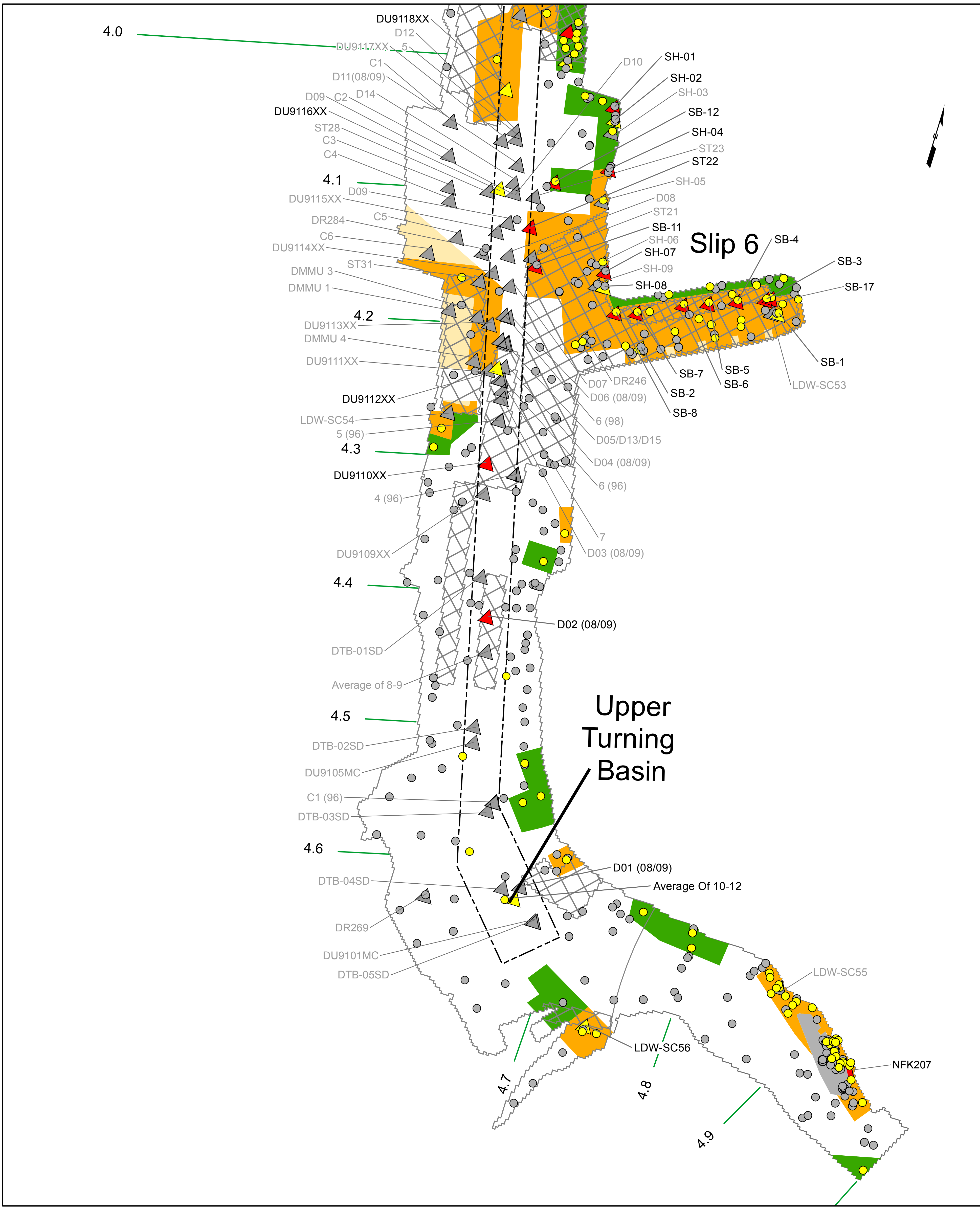
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Alternative 6 Combined Technology Assignments and Waterway Conditions

FIGURE G-30a

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-30aAlt6CombinedCon.mxd



Notes:
1. FS baseline dataset used. Total Study Area: 441 acres.
2. Technology assignments are for the FS and may change based on additional data collected during remedial design.
3. See Section 8 for additional details on technology assignments. Exceptions to the technology assignment criteria in Section 8 are explained in text boxes.
4. See Section 6 for development of recovery categories and RALs.
5. Subsurface exceedances in cores are at any depth and represent the highest level of exceedance for any SMS contaminant.

Remedial Alternative	Remedial Action Levels (RALs)				
	Total PCBs	cPAHs	Dioxins/ Furans	Arsenic	Benthic SMS
	µg/kg dw	µg TEQ/kg dw	ng TEQ/kg dw	mg/kg dw	41 Chemicals
Alt 6	100	1,000 (site-wide), 900 (intertidal)	15	15	SQS

Technology Assignment

AOPC 1+2
- Dredge (108 acres)
- Cap or Partial Dredge and Cap (93 acres)
- Monitored Natural Recovery (0 acres)
- ENR/*in situ* (101 acres)
- Verification Monitoring (0 acres)

- Early Action Area (29 acres)
- Remaining Study Area (Institutional Controls and Site-wide Monitoring) (110 acres)

Feet
0 200 400 800

Legend

Surface Sediment Exceedance Location
- >Alt 6 RALs
- Pass or Non-detect

Subsurface Exceedance Location and ID
- > CSL, detected
- > SQS and ≤ CSL, detected
- Pass or Non-detect

Station ID Labeled in Black
Station ID Labeled in Grey

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Navigation Channel
- River Mile Marker

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-30bAlt6CombinedConB.mxd

AECOM

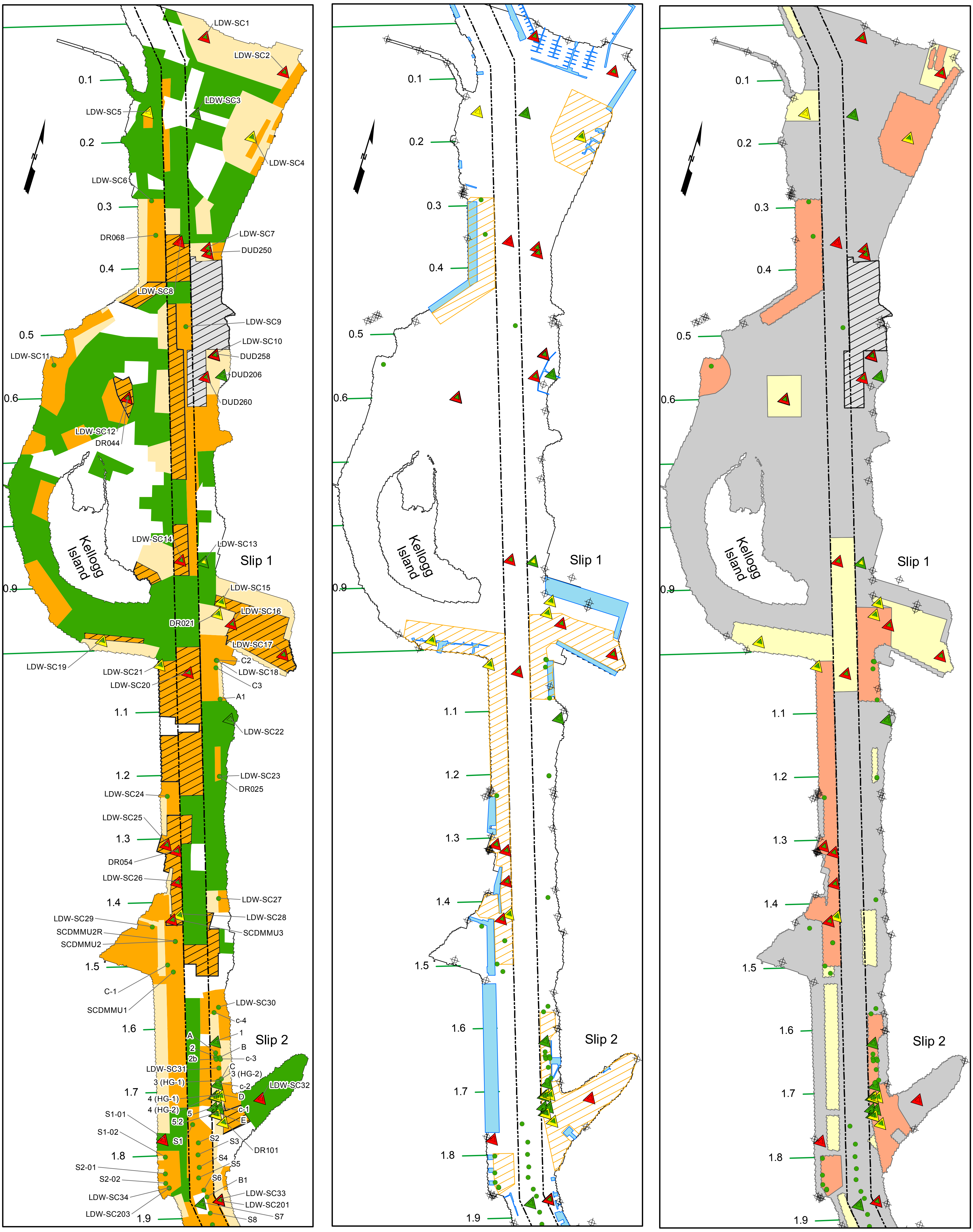
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 6 Combined Technology Assignments and Waterway Conditions (RM 4.0 to 5.0)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-30b



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment
- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core
- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories
- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

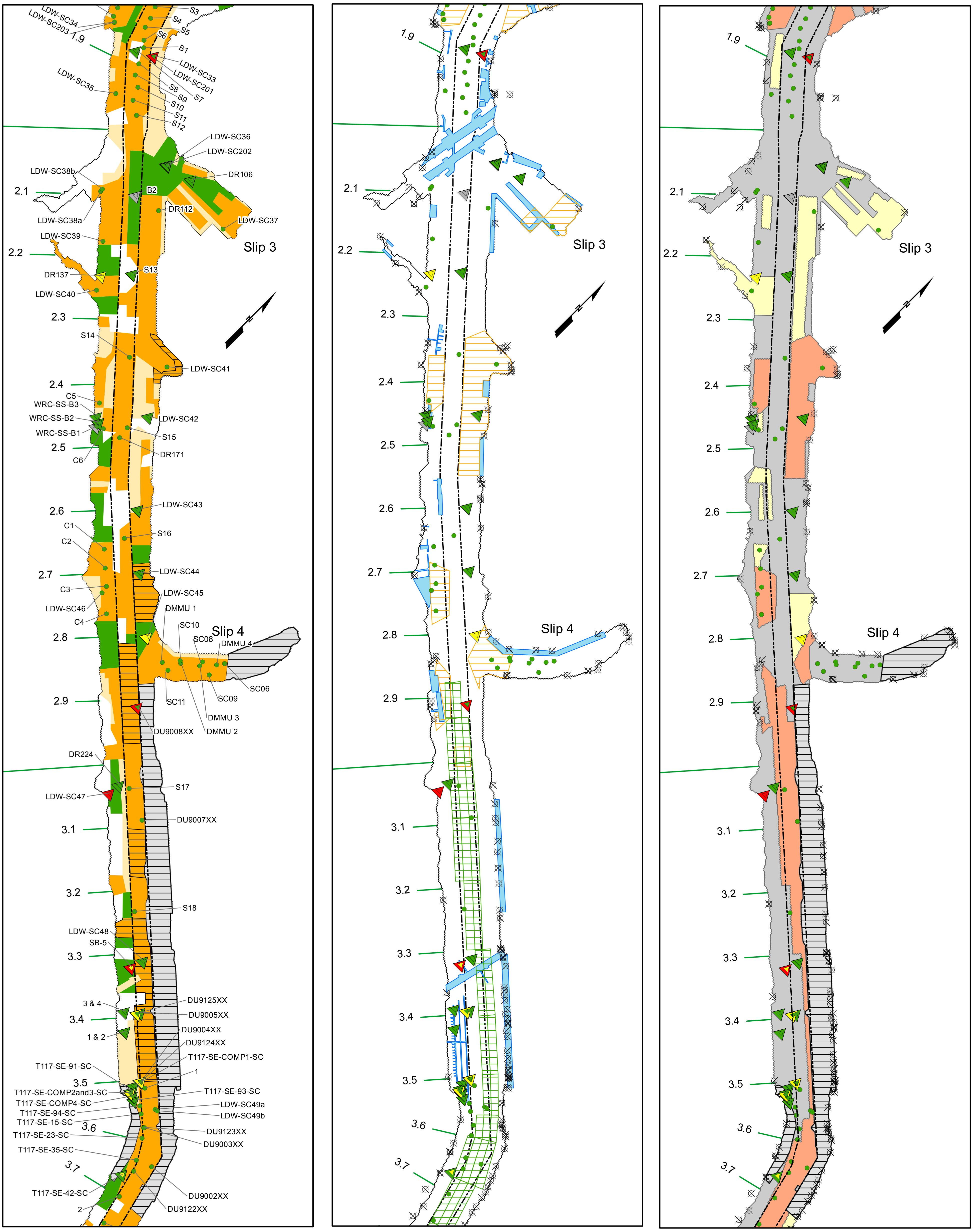
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group — Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 6 Combined Remaining Subsurface Contamination - Plan View (RM 0.0 to 1.9)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-31a

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\G-31aCoreRecoveryNorth6C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core — Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

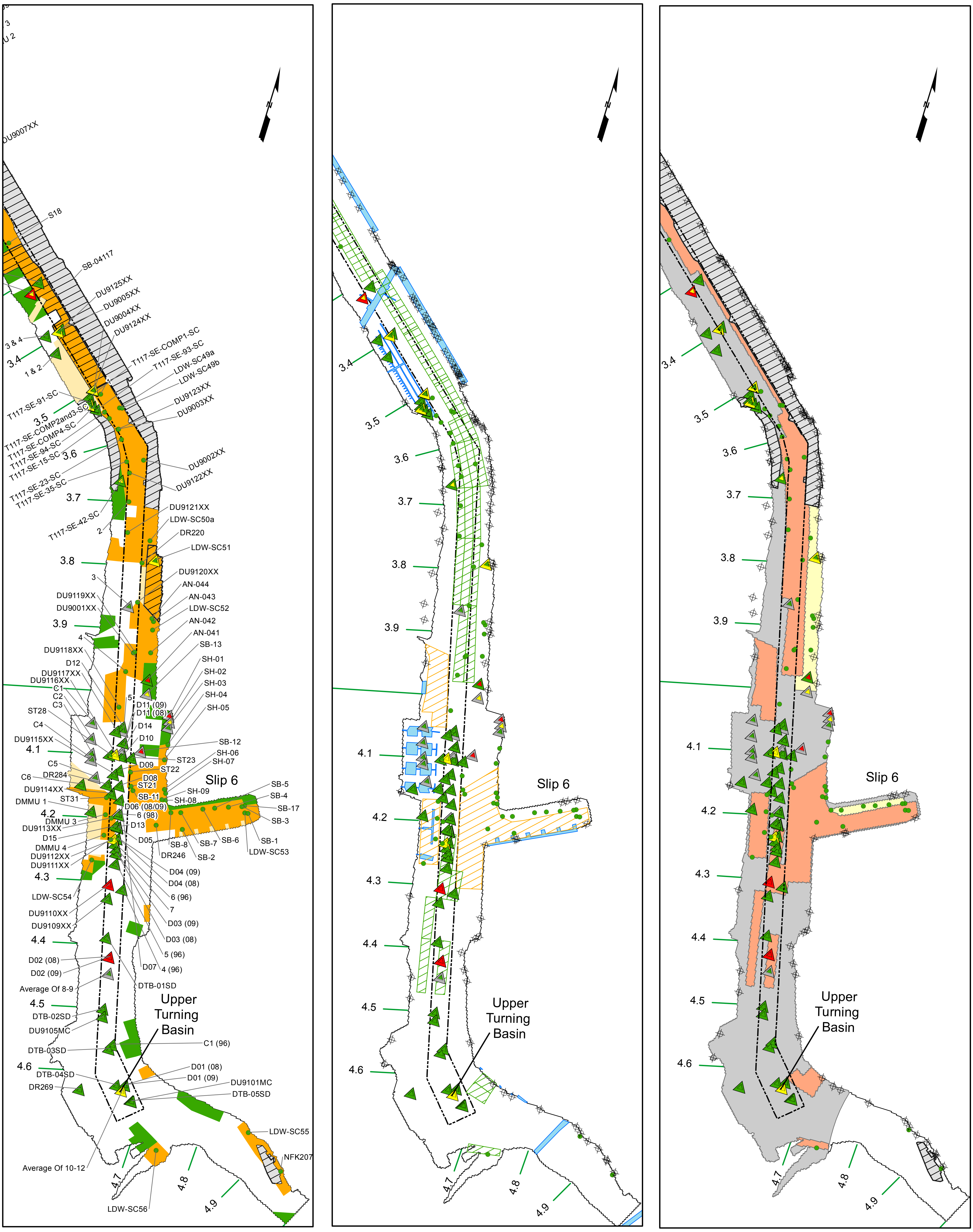
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.46

Alternative 6 Combined Remaining Subsurface Contamination - Plan View (RM 1.9 to 3.6)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE G-31b

L:\Lower Duwamish FS\FS_Final_GIS\GISOct2012\FS_GIS_MXDs_Oct12\Appendix G\G-31bCoreRecoveryMid6C.mxd



Notes:
1. If cores overlap, the core with the highest exceedance status is shown on top.
2. Core intervals are based on *in situ* depths.
3. Any sample interval that overlaps the 0-2 or 2-4 ft interval is included. Samples that overlap both core intervals are mapped in both intervals.
4. For cores in capping areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval displays the 0-2 ft exceedance status.
5. For cores in partial dredge and cap areas, the 0-2 ft interval is set to <SQS. The 2-4 ft interval exceedance status is retained.
6. For cores in ENR areas, both the 0-2 ft and the 2-4 ft interval exceedance statuses are retained.
7. Cores in EAAs are not shown.

Feet
0 200 400 800

Legend

Technology Assignment

- Dredge
- Partial Dredge and Cap
- Cap
- Monitored Natural Recovery
- ENR/*in situ*
- Verification Monitoring
- Remaining Study Area (Institutional Controls and Site-wide Monitoring)

SMS Exceedance Status Following Remediation

Maximum exceedance 0-2 ft in core / Maximum exceedance 2-4 ft in core

- > CSL
- >SQS and ≤ CSL
- ≤ SQS or Non-detect
- Interval Not Analyzed
- Core Location Dredged During Remediation

Physical Lines of Evidence Used in Assigning Recovery Categories

- STM Predicted 100-Year High-flow Scour > 10 cm
- Evidence of Propeller Wash Scour
- Overwater Structure
- Outfall Location

Recovery Category

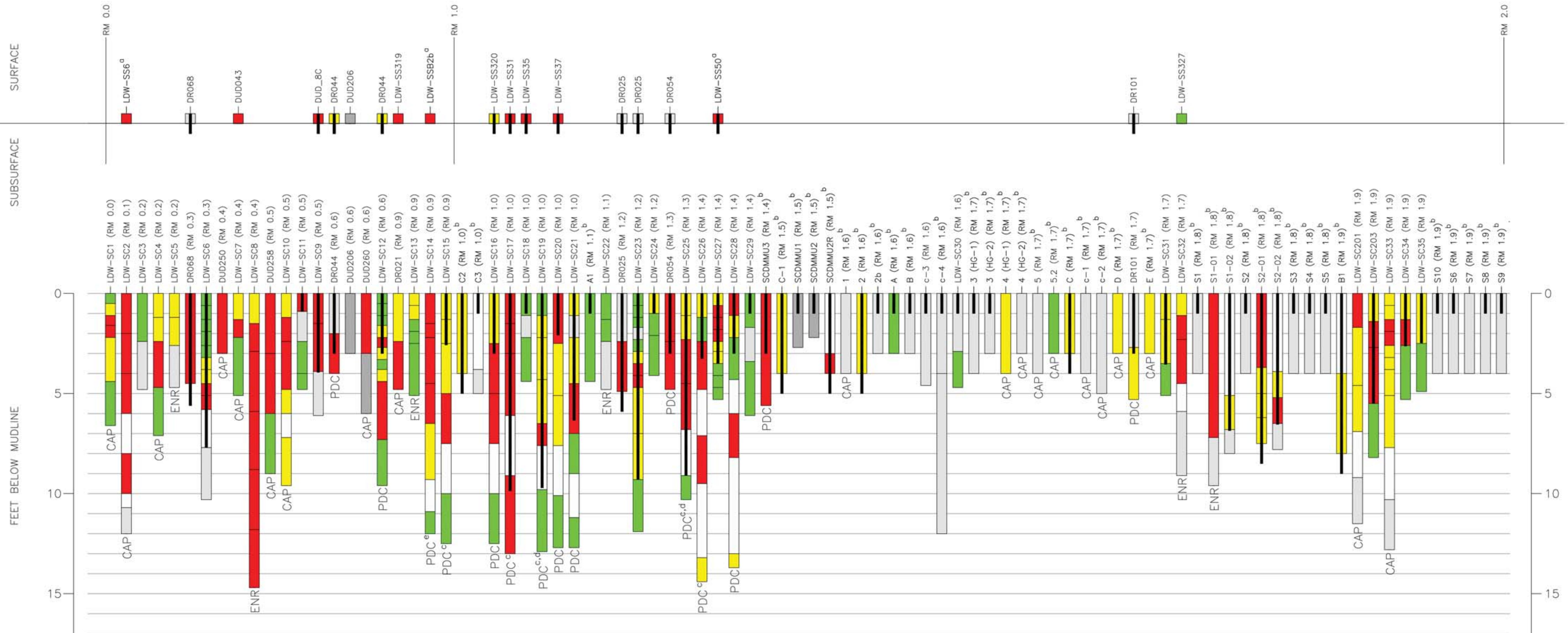
- Category 1: Recovery Presumed to be Limited
- Category 2: Recovery Less Certain
- Category 3: Predicted to Recover
- Early Action Area
- Navigation Channel
- River Mile Marker

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.46	Alternative 6 Combined Remaining Subsurface Contamination - Plan View (RM 3.6 to 5.0)
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE G-31c

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix G\FigureG-31cCoreRecoverySouth6C.mxd



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

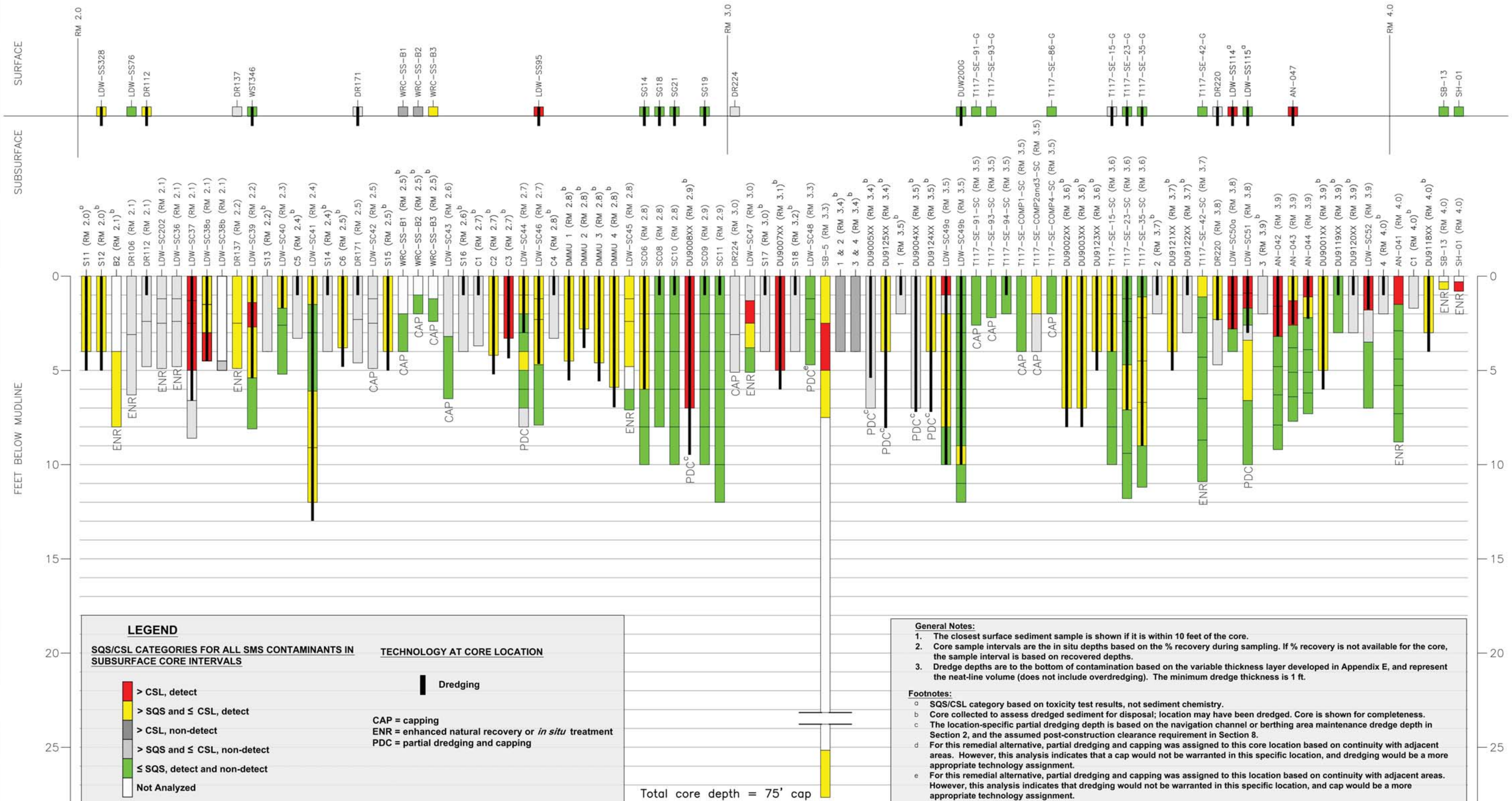
Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.
e For this remedial alternative, partial dredging and capping was assigned to this location based on continuity with adjacent areas. However, this analysis indicates that dredging would not be warranted in this specific location, and cap would be a more appropriate technology assignment.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY FINAL FEASIBILITY STUDY 60150279-14.46	ALTERNATIVE 6 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 0.0 TO 2.0)
DATE: 10/31/12 DRWN: MO/SEA	FIGURE G-32a



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a. SQS/CSL category based on toxicity test results, not sediment chemistry.
b. Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c. The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d. For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.
e. For this remedial alternative, partial dredging and capping was assigned to this location based on continuity with adjacent areas. However, this analysis indicates that dredging would not be warranted in this specific location, and cap would be a more appropriate technology assignment.

AECOM

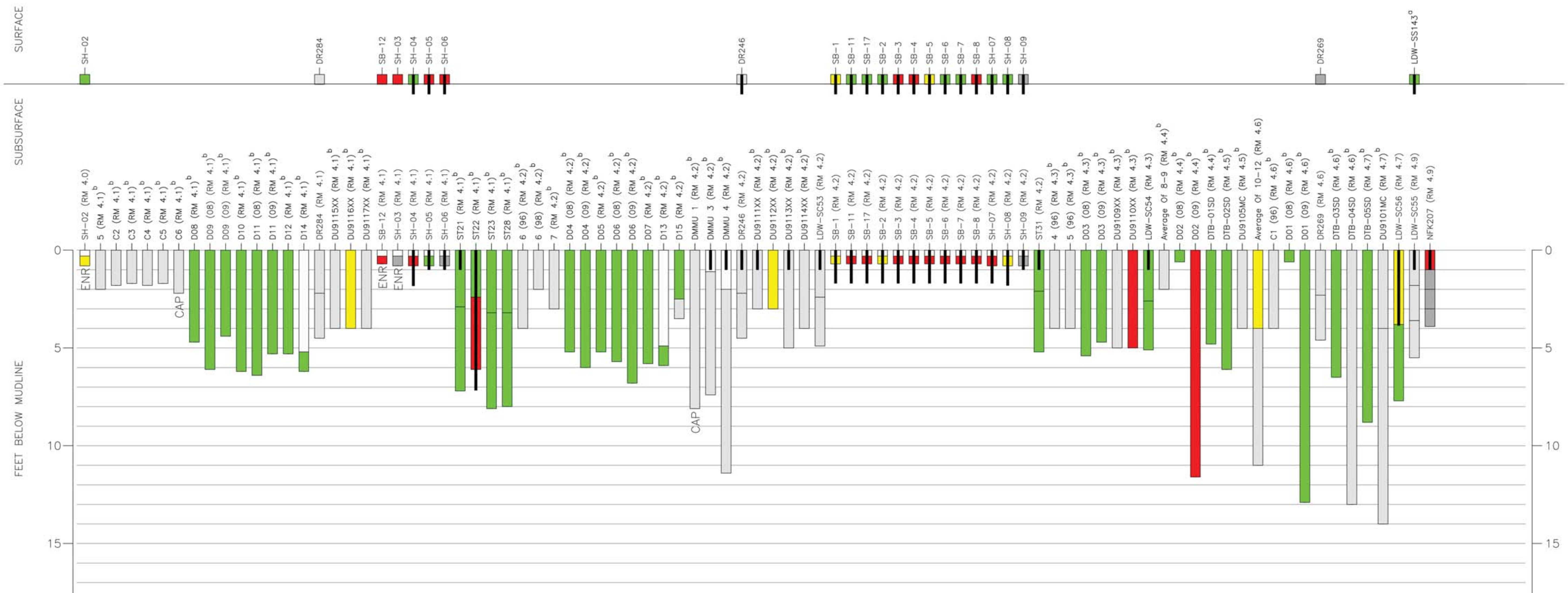
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 6 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 2.0 TO 4.0)

FIGURE G-32b



LEGEND

SQS/CSL CATEGORIES FOR ALL SMS CONTAMINANTS IN SUBSURFACE CORE INTERVALS

- > CSL, detect
- > SQS and ≤ CSL, detect
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detect and non-detect
- Not Analyzed

TECHNOLOGY AT CORE LOCATION

- Dredging

CAP = capping
ENR = enhanced natural recovery or *in situ* treatment
PDC = partial dredging and capping

General Notes:

1. The closest surface sediment sample is shown if it is within 10 feet of the core.
2. Core sample intervals are the in situ depths based on the % recovery during sampling. If % recovery is not available for the core, the sample interval is based on recovered depths.
3. Dredge depths are to the bottom of contamination based on the variable thickness layer developed in Appendix E, and represent the neat-line volume (does not include overdredging). The minimum dredge thickness is 1 ft.

Footnotes:

a SQS/CSL category based on toxicity test results, not sediment chemistry.
b Core collected to assess dredged sediment for disposal; location may have been dredged. Core is shown for completeness.
c The location-specific partial dredging depth is based on the navigation channel or berthing area maintenance dredge depth in Section 2, and the assumed post-construction clearance requirement in Section 8.
d For this remedial alternative, partial dredging and capping was assigned to this core location based on continuity with adjacent areas. However, this analysis indicates that a cap would not be warranted in this specific location, and dredging would be a more appropriate technology assignment.
e For this remedial alternative, partial dredging and capping was assigned to this location based on continuity with adjacent areas. However, this analysis indicates that dredging would not be warranted in this specific location, and cap would be a more appropriate technology assignment.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

LOWER DUWAMISH WATERWAY
FINAL FEASIBILITY STUDY
60150279-14.46

DATE: 10/31/12 DRWN: MO/SEA

ALTERNATIVE 6 COMBINED REMAINING SUBSURFACE CONTAMINATION CORE DIAGRAMS (RM 4.0 TO 5.0)

FIGURE G-32c

Lower Duwamish Waterway Group

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

Appendix H
Coverage Rates for Selected Upper Confidence Limit Methods for Mean of Total PCB in Sediments

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by:
Kern Statistical Services, Inc.
5175 NE River Rd.
Sauk Rapids, MN 56379

COVERAGE RATES FOR SELECTED UPPER CONFIDENCE LIMIT METHODS FOR MEAN OF TOTAL PCB IN SEDIMENTS

LOWER DUWAMISH WATERWAY SEATTLE, WASHINGTON

March 30, 2010

Prepared for:
Assessment and Restoration Division
Office of Response and Restoration,
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE
Seattle, WA

Prepared By:
Kern Statistical Services, Inc.
5175 NE River Rd.
Sauk Rapids, MN 56379

Introduction

Over 1300 locations were sampled along the Lower Duwamish Waterway (LDW) in efforts to characterize contaminant concentrations supporting remedial decision making. The data configuration is based on a biased sampling design with higher sample density within areas now identified as Early Action Areas (EAAs) and lower sampling density within the remainder of the river, referred to here as interstitial spaces. Because the sampling design is biased and the sample inclusion probabilities are unknown, ad-hoc methods have been proposed for estimation of upper confidence limits for the mean of contaminant concentrations within the surface sediments. The effect of the sampling bias is apparently large with the un-weighted mean PCB concentration being 1166 ug/kg and the Thiessen polygon weighted average being just 352 ug/kg—nearly a full order of magnitude lower. Understanding the most appropriate approach is of substantive importance. This study uses the sample data to develop a probability model of total PCB concentrations that is then used to test proposed UCL methods in efforts to develop an approach to UCL method selection for the site.

UCL Methods

Statistical methods are not generally available for biased sampling plans. Methods to correct sampling biases in efforts to approximate upper confidence limits for the mean have been proposed for the LDW, although the performance of proposed methods had not been tested prior to this study. In this study, three bias reduction methods were investigated; 1) IDW Interpolation, 2) Site stratification (2 and 11 strata) and 3) Thiessen polygon weighting. The 11 strata represent three interstitial areas, three navigational channel areas and 5 EAAs (Figure 1). The 2 stratum configuration treated all EAAs as one stratum and the remaining areas as the second stratum.

For the interpolated bias correction approach, Hall's bootstrap and the Bootstrap T were applied to the interpolated surfaces to obtain parameter estimates, while for the stratified approach bootstrap re-sampling followed the "naïve" bootstrap for the and the balanced bootstrap with importance sampling (Davison and Hinkley, 1986). The balanced bootstrap with importance sampling method was also used for the Thiessen polygon weighting method. In all seven approaches were tested. UCL methods were tested on the full LDW study area, as well as for data sets restricted to each of the three reaches identified in the feasibility study.

Synthetic Data

Total PCB data and sampling configuration from LDW were used to develop a probability model of the distribution of PCB contamination in sediment consistent with the stratification of the mean among EAAs and interstitial spaces as well as spatial correlation and nugget effect. Generally speaking the PCB concentration varies among EAAs with elevated PCB concentrations and interstitial spaces containing generally much lower PCB concentrations. Data and maps provided by LDWG further subdivide the site into three river segments which were further subdivided into the navigational channel and the remaining areas.

Synthetic populations were developed with simulated stratum means constrained to the observed stratum means using an analysis of variance model of the form

$$\log(PCB_{ij}) = \mu_i + \epsilon_{ij};\ \ i = 1,2,\ldots 11 \ \textit{and}\ j = 1,2,\ldots.,1248$$

where μ_i represents the log-mean concentration within the ith stratum and ϵ_{ij} is a mean zero and spatially correlated.

The residuals were subjected to a semi-variogram analysis and the sample semi-variogram and fitted model were plotted.

Equally likely synthetic surfaces were generated by simulating a mean-zero variance 1.0 spatially correlated surface which was then multiplied by the appropriate stratum specific standard deviation and added to the appropriate stratum mean. These re-trended values were exponentiated, arriving at synthetic populations with stratum means and variances; and spatial correlation consistent with the observed data. These synthetic values were used to populate the 10 by 10 foot IDW grid cells defined by the LDWG interpolation grid. These synthetic surfaces differ from interpolated surfaces in that they are not smooth, but rather retain the variance and spatial correlation observed in the sample data. One thousand such surfaces were simulated providing synthetic data with known statistical properties to which sample estimates could be compared.

Findings

1. Residuals were found to be approximately normally distributed (Figure 2).
2. Semivariogram was plotted in Figure 3 showing
    a. The range of influence of the log(pcb) residuals was approximately 70 feet.
    b. Small scale heterogeneity (i.e. nugget effect) constituted approximately 7% (0.17/2.45) of the total variance in log-scale.
3. Example synthetic means are plotted against observed sample means in Figure 4 showing that synthetic data reproduced large scale stratification observed in sample data.
4. One of the 1000 synthetic maps is shown in Figure 5, illustrating the large scale variation of mean concentration among strata as well as the smaller scale fluctuations in concentration characteristic of the interstitial spaces.
5. Confidence limits for the LDW were estimated for total PCBs using 2 methods based on re-sampling the IDW interpolated grids, 2 methods for each of 2 stratified sampling approaches --2 stratum and 11 stratum designs.
    a. All methods resulted in UCLs ranging from approximately 550 ug/kg to 700 ug/kg.
    b. The method that most closely reproduced 95% coverage was the 2 stratum approach with a UCL of 665 ug/kg and coverage rate of 95.3%.
    c. The difference between 550 ug/kg and 700 ug/kg is unlikely to substantively impact remedial decision making.
6. Study results for the LDW are conditional on the biased sample configuration, weighting scheme and analysis method selection. Robustness of methods to changes in sample size and subarea

population statistics was tested by repeating the simulations for each of the three reaches separately. Coverage probabilities are summarized in Table 2.

   a. Coverage rates for methods based on the balanced bootstrap (stratified or Thiessen weights) more closely matched the 95% nominal confidence level than did the interpolation based methods.
      i. The two stratum design with balanced bootstrap was no worse than 3% different from the nominal rate in each reach and was exact for the full LDW.
   b. Methods based on resampling from the interpolated grid, consistently understated the population variance and skewness within reaches as well as at the global level.
   c. Coverage rates for the interpolation based methods were either approximately 100% or 90% primarily due to under or over correction of the sample mean relative to the true population mean.

7. The UCL performance results cannot be generalized to UCL estimation for smaller subareas or other sites.
8. The data spacing within the interstitial spaces is typically on the order of 150 feet indicating that
   a. sample data density is adequate to confirm that large hotspots are unlikely to have been missed, but
   b. interpolated surfaces in the interstitial areas may be poorly constrained
   c. edges of EAAs remain areas of high uncertainty, and
   d. that smaller isolated hotspot areas on the order of 50-150 feet in diameter may remain.

UCL Performance Details

This study included analysis of the coverage rate for each UCL method, including investigation of key parameter estimates mean, variance and skewness to improve understanding of underlying root causes controlling method performance. Following is a summary of the findings for each method and the bias associated with individual parameter estimates.

1. Simulated coverage rates and the biases in parameter estimates are summarized in Table 1.
2. The IDW approach understated the population variance and skewness, but overstated the population mean.
   a. Low bias in the variance and skewness were expected based on mathematical relationship between the population variance and the variance of the smoothed IDW surface, as well as from previous simulations (Kern 2009).
   b. The mean was overstated by the IDW methods which was not expected based on any particular statistical theory, but rather was apparently due to the idiosyncrasies of the particular sampling configuration and the distribution of the underlying population.
   c. The high bias in the mean mitigated understatement of the variance and skewness, but this behavior cannot be expected in general as was shown in previous simulations (Kern 2009) in which the mean estimate was relatively unbiased.
3. Reproduction of coverage probabilities varied among methods, sample weighting assumptions and method of stratification

   a. Coverage rates ranged from 78% for the 11 stratum bootstrap T approach to 99.9% for both of the IDW based approaches.
   b. The 2 stratum approach using importance sampling resulted in the most accurate 95.5% coverage rate with an estimated UCL of 665 ug/kg based on the sample data.
   c. Coverage for the same approach applied to the 11 stratum design was 91%, which is moderately less than the target 95% rate. The estimated UCL based on sample data was 589 ug/kg.
4. The Hall's and Bootstrap T approaches based on IDW interpolation require estimates of the mean and variance and additionally, the Hall's method also requires an estimate of the skewness of the underlying population. For the IDW surface,
   a. the population mean was overstated on average by 14%
   b. the population variance was understated on average by 13%
   c. the skewness was understated on average by 45%
5. The importance sampling approach based on stratified sampling provided a more accurate estimate of the mean which is the only estimate required for the method.
   a. For the 2 stratum case the estimated mean was 3% greater than the population mean on average.
   b. For the 11 stratum case, the estimated mean was 6% less than the population mean on average.
6. For estimation of the mean and UCL for the LDW, the large sample size (N> 1300 locations) is probably the most important factor causing estimated UCLs to be similar.

References

Davison, A.C., Hinkley, D.V. and Schechtman, E. (1986) Efficient bootstrap simulation. Biometrika, 73, 555–566.

Kern Statistical Services, Inc. 2009. Review of Appendix-H: Hall's upper confidence limit for IDW-interpolated data, draft feasibility study. Lower Duwamish Waterway, Seattle, WA.

Table 1. Performance summary for IDW interpolation and stratified sampling based UCL estimates

Method				Average Ratio of Estimated to True Parameters		
		Estimated UCL (mg/kg)	Simulated Coverage Rate	Mean	Variance	Skewness
Interpolated				1.14	0.87	0.55
	Halls Bootstrap	702	99.9%			
	Bootstrap T	545	99.9%			
Stratified Design (2 stratum case)				1.03	NA	NA
	Bootstrap T	629	87.4%			
	Balanced Bootstrap With Importance Sampling	665	95.3%			
Stratified Design (11 stratum case)				0.94	NA	NA
	Bootstrap T	544	72.1%			
	Balanced Bootstrap With Importance Sampling	589	90.8%			
Thiessen Polygon Method	Balanced Bootstrap With Importance Sampling	680	99.2%	1.06	1.15	NA

Table 2. Summary of coverage rates for 5 UCL methods for reaches 1, 2 and 3 and the full LDW study area. Stratified approaches were based on the two stratum configuration.

	Halls Interp	Bootstrap T Interpolated	Bootstrap T Stratified	Balanced Bootstrap Thiessen	Balanced Bootstrap Stratified
Reach 1	90%	89%	92%	93%	94%
Reach 2	100%	100%	96%	97%	98%
Reach 3	91%	91%	88%	97%	92%
Full Site	100%	100%	87%	99%	95%

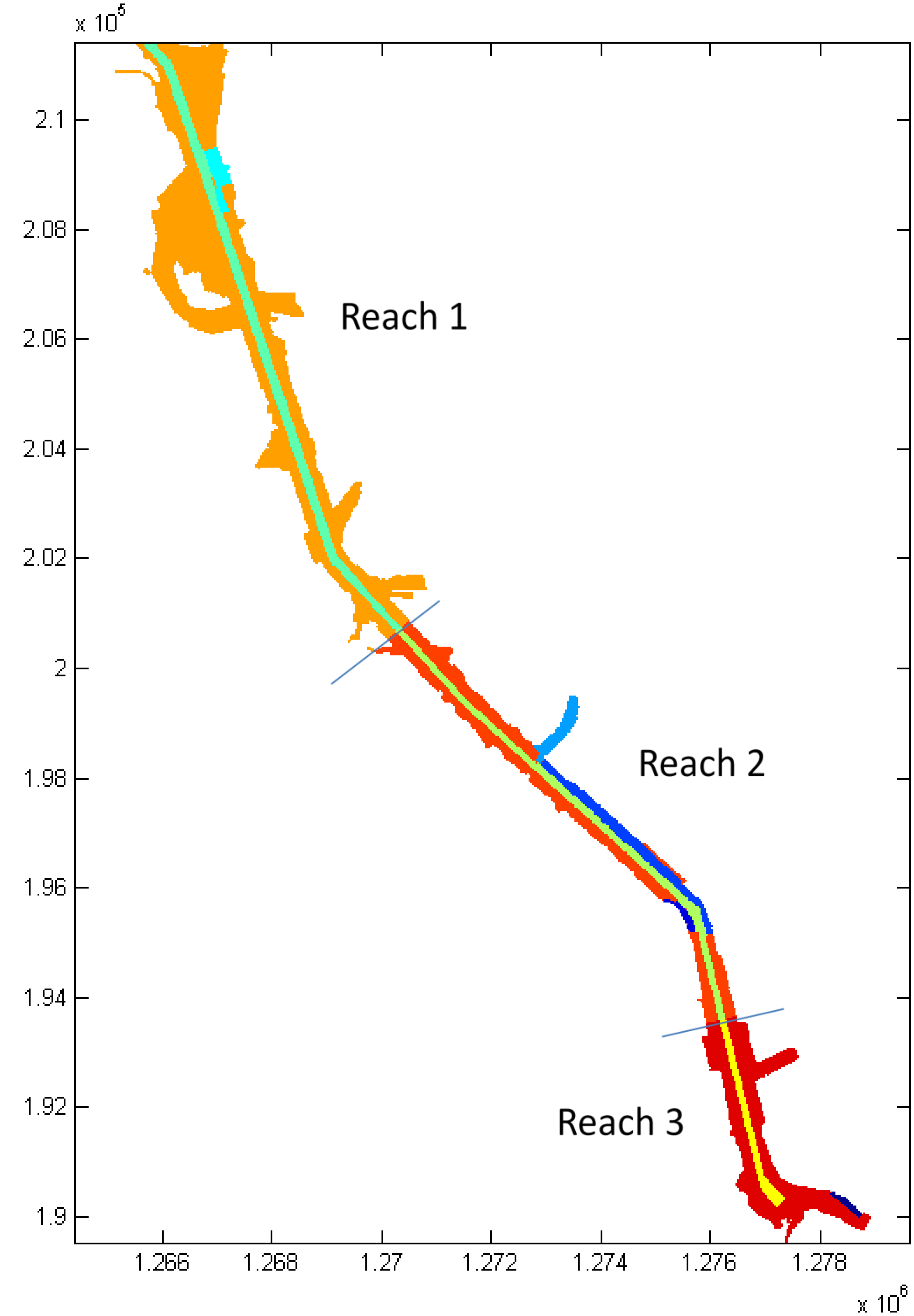


Figure 1. Stratification of study area in the Lower Duwamish Waterway Site.

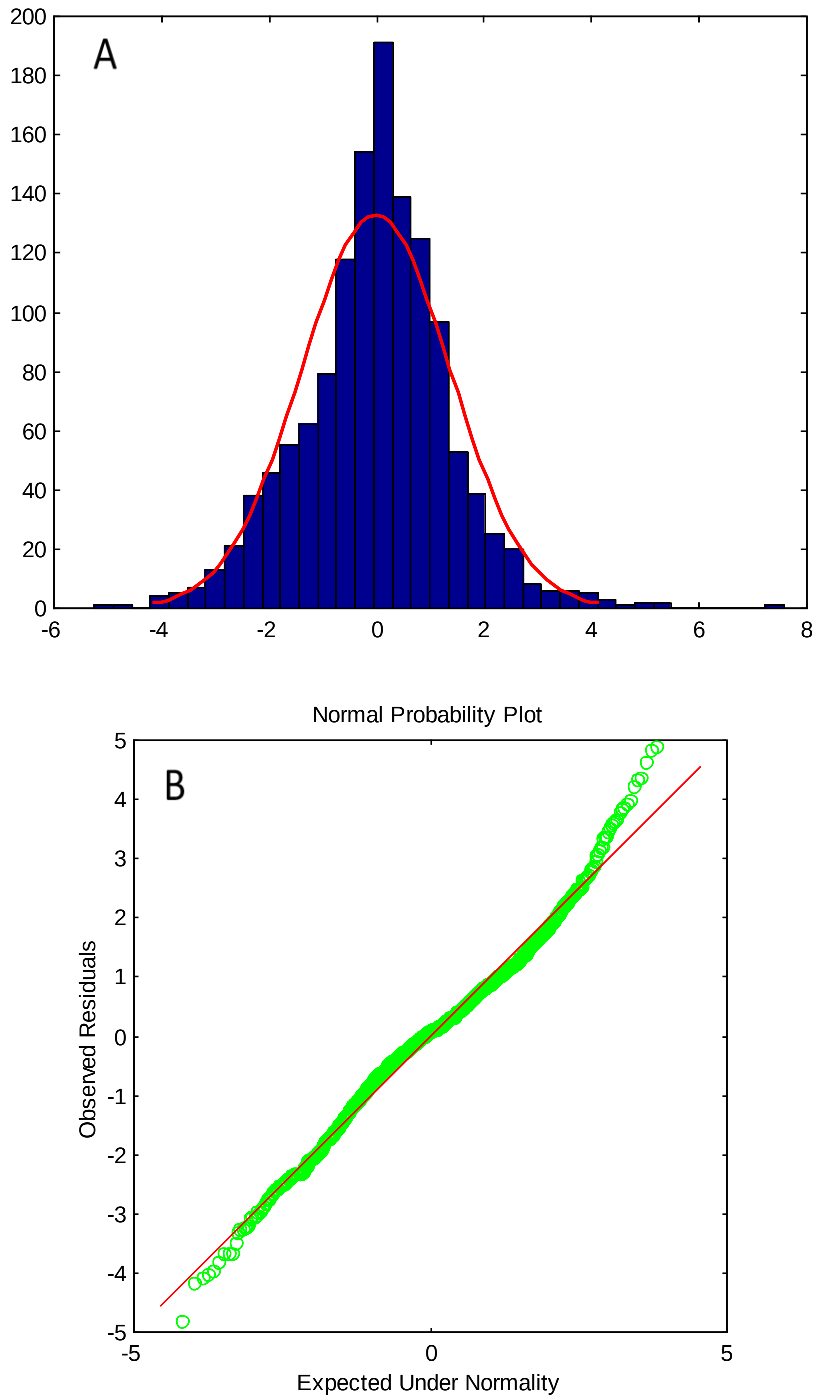


Figure 2. Histogram of residuals of log(PCB) with fitted normal distribution (panel A) and normal probability plot for residuals (panel B). Residuals are similar to a normal distribution (p> 0.10)

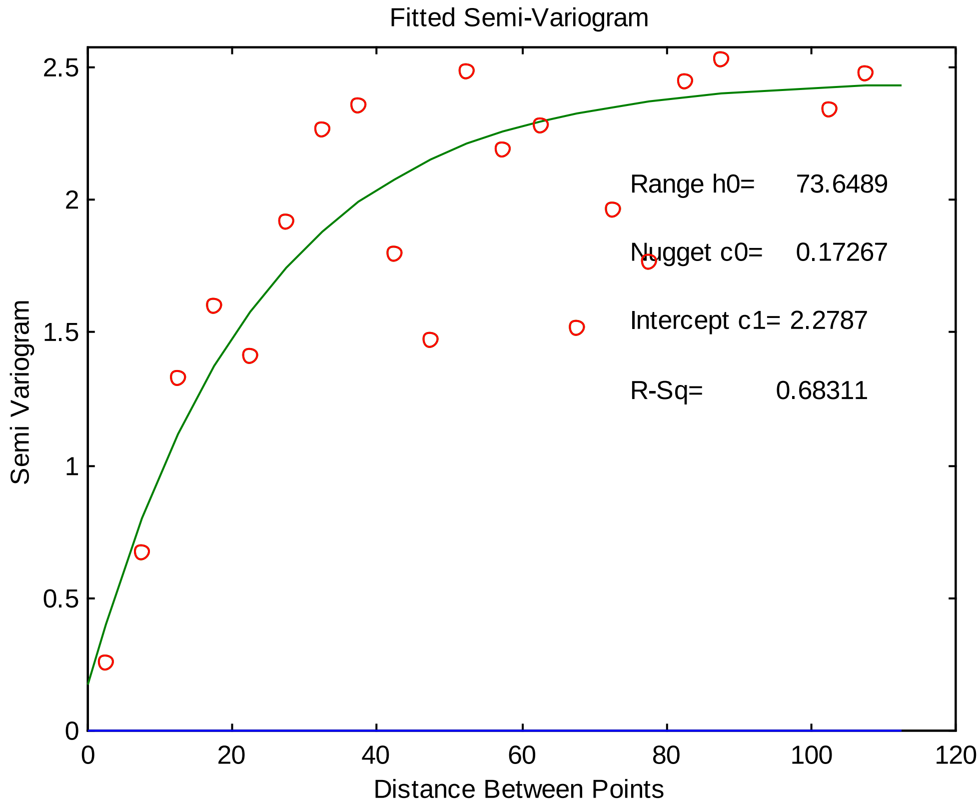


Figure 3. Semivariogram of residual log(PCB) concentration.

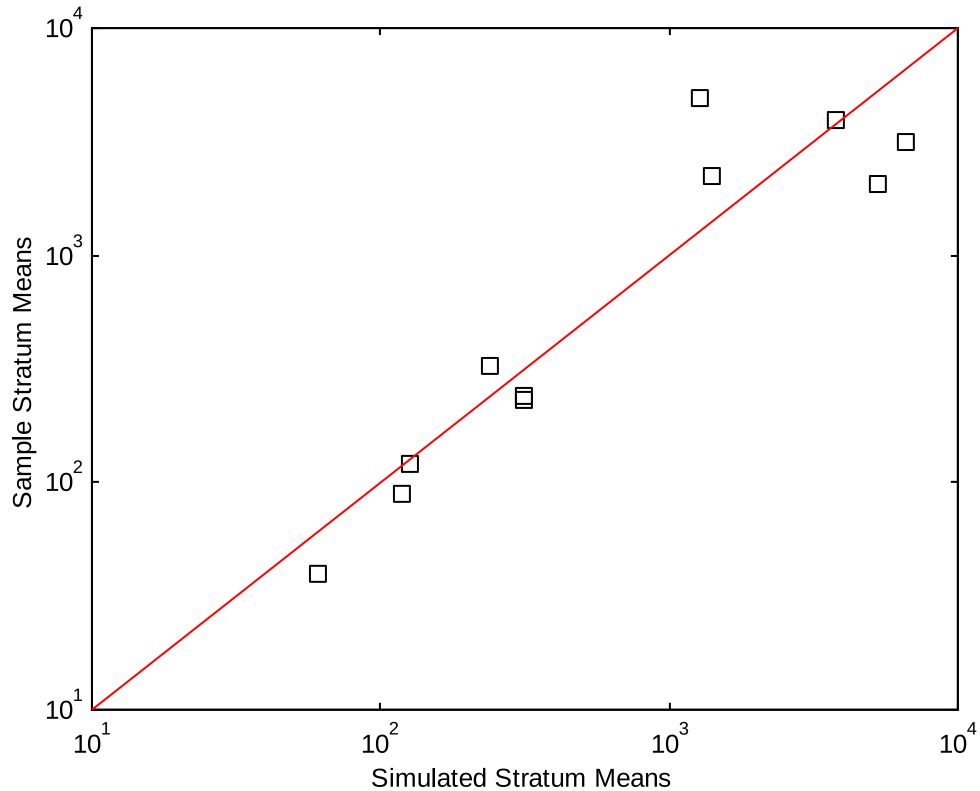


Figure 4. Sample vs. simulated stratum means from one synthetic population.

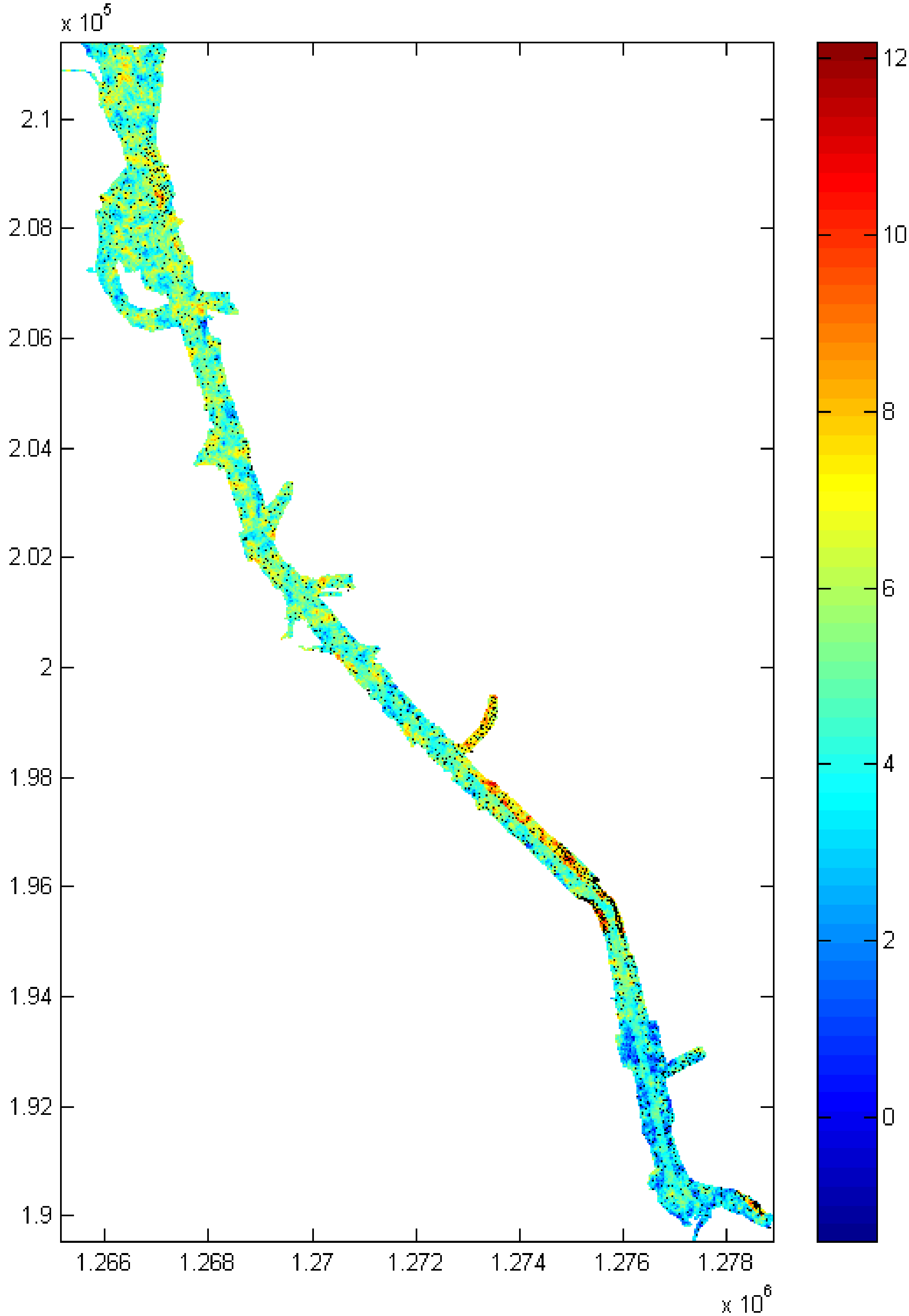


Figure 5. Simulated log(PCB) concentration in surface sediments. One of 1000 realizations generated. Black dots represent sample locations.

Lower Duwamish Waterway Group

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

Appendix I
Detailed Cost Estimates

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ⬩ Seattle, Washington ⬩ 98104

Table of Contents

List of Tables

Attachments

I.1 Introduction

This appendix contains the detailed cost estimates prepared for the remedial alternatives developed in Section 8 of the Lower Duwamish Waterway (LDW) Feasibility Study (FS). The following information is provided in this appendix:

- Primary cost assumptions (Table I-1)
- An explanation of the spreadsheet workbook used to prepare and assemble the detailed cost estimates (Table I-2)
- Cost sensitivity considerations (Tables I-3 and I-4)
- The detailed cost estimates (Attachment 1, Tables I-5 through I-51).

The cost estimates were developed in accordance with the U.S. Environmental Protection Agency's (EPA) guidance document *Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (EPA 2000). An independent review of the FS cost estimate was performed by Mr. Greg Hartman of Hartman Associates. The cost estimates meet EPA requirements for FS cost estimates and are consistent with those prepared for other projects similar to the LDW (Hartman 2011).

I.2 Primary Cost Assumptions

Primary engineering cost assumptions common to all remedial alternatives are provided in Table I-1.

I.3 Guide to Spreadsheet-Based Cost Estimation Workbook

The contents of the cost estimate workbook (Attachment 1) for the FS are summarized in Table I-2. The workbook contains 47 worksheets (Tables I-5 to I-51) that are broadly organized as follows:

- Tables I-5 through I-10 provide the building blocks for estimating the construction costs component of the remedial alternatives (e.g., mobilization/demobilization, transloading facility set-up, dredging and material placement rates, and material procurement costs).
- Tables I-11 through I-21 are cost assumption source files for post-construction performance monitoring, operation and maintenance (O&M) monitoring, and maintenance/repairs. One table is provided for each alternative.
- Table I-22 is a cost assumption source file for long-term monitoring and applies to all alternatives.
- Tables I-23a through I-33 detail the net present value calculations for the recurring monitoring and O&M costs developed in Tables I-11 through I-22. One table is provided for each alternative.

- Tables I-34 and I-35 develop cost assumptions and net present value estimates for institutional controls; these apply to all alternatives.
- Table I-36 consolidates all key area and material volumes associated with each remedial alternative. Areas and volumes form the basis for dredging, disposal, capping, enhanced natural recovery (ENR)/*in situ* treatment, residuals management, and technology-specific monitoring costs.
- Table I-37 is a master reference file of unit costs and other cost and production rate assumptions.
- Tables I-38 through I-49 are the cost summary tables with totals for each remedial alternative. (Note: These summary tables represent the culmination of information contained in all preceding source tables and provide the reader with a complete breakdown of all essential cost factors).
- Tables I-50 and I-51 summarize monitoring and total project costs respectively and allow for quick comparisons among the alternatives.

I.4 Cost Accuracy and Sensitivity

Several factors can influence the accuracy of estimated remedial alternative costs at the FS level. In particular, modest changes in estimated dredge volumes can significantly impact costs. Other factors (e.g., fuel and labor costs) can change depending on future economic conditions. The FS cost estimates are best estimates under current economic conditions. However, the selected remedy is unlikely to be fully underway until several years following the issuance of the Record of Decision (ROD). Future economic conditions are difficult to predict and prices in some markets (e.g., petroleum fuels) are quite volatile. Therefore the relative accuracy of the cost estimates is likely better for alternatives with shorter durations than for those with longer durations.

The sensitivity of remedial alternative cost estimates to some of the key assumptions and predictions are discussed below. Sensitivity analysis is a type of uncertainty analysis that measures the impact on project cost estimates from changing one or more of the input parameters (EPA 2000). The parameters discussed in Sections I.4.1 and I.4.2 were used to illustrate the sensitivity of the cost estimates to:

- Dredge-cut prism and performance contingency volumes
- Treated material disposal from soil washing operations (Alternative 5R-Treatment).

I.4.1 Dredge-Cut Prism and Performance Contingency Volumes

Variation in the scope of each remedial alternative (i.e., area to be remediated and assignment of remedial technologies) is a significant contributing factor to cost uncertainty. In general, changes in the volume of sediment dredged and disposed of have a much greater influence on cost than changes of a proportionately similar magnitude in the area remediated using other technologies (i.e., capping and ENR/*in situ* treatment).

Section 8.2.2.1 and Appendix E provide the rationale for and methodologies by which dredge-cut prism and performance contingency volumes were estimated for each remedial alternative. The dredge-cut prism volume represents an estimate of sediment that would be removed by dredging during construction of each remedial alternative without consideration of any contingency actions. For the best estimate of dredge-cut prism volumes the neat-line volumes were multiplied by a factor of 1.5. The assumed low and high cost-sensitivity conditions for bounding the best estimate were as follows:

- ♦ Low sensitivity dredge-cut prism volume: Neat-line volume based on depth to sediment quality standards (SQS) plus 25%
- ♦ High sensitivity dredge-cut prism volume: Neat-line volume assuming dredging to top of the lower alluvium

The depth to lower alluvium conservatively represents the maximum extent of contaminated sediment for any alternative.

The performance contingency volume is an additional amount of material that would be removed (i.e., in addition to the dredge-cut prism volume), assuming that a fraction of designated verification monitoring, ENR/*in situ* treatment, and monitored natural recovery (MNR) areas require active remediation based on data collected at the remedial design phase or because of inadequate performance identified during post-construction or long-term monitoring. For costing purposes, dredging is the assumed performance contingency action. The base-case remedial alternatives developed in Section 8 assumed 15% of the total area designated for verification monitoring, MNR, or ENR/*in situ* treatment would require active remediation (assumed to be dredging). The removal volume associated with this area is referred to as the performance contingency volume (Section 8.2.2.1). The low and high cost sensitivity conditions assumed for bounding the base case were as follows:

- ♦ **Low Sensitivity:** no contingency actions for verification monitoring, ENR/*in situ* treatment, and MNR areas
- ♦ **High Sensitivity:** contingency actions for 25% of verification monitoring, ENR/*in situ* treatment, and MNR areas.

Performance contingency dredge volumes were approximated by using the site-wide average thickness of sediment exceeding the SQS (i.e., 4 feet below mudline), plus a volume allowance factor of 1.5, the latter being consistent with the assumption used for the base case dredge-cut prism volume. Table I-3 summarizes the effects of these volume sensitivity assumptions on the total dredge volume estimates used to develop the cost estimates.

I.4.2 Re-use of Treated Material

Disposal of treated sand from soil washing operations (Alternative 5R-Treatment) was considered for the cost sensitivity analysis. Treated sand from soil washing operations will have low and detectable levels of contamination. If a beneficial outlet for this material cannot be identified, then landfill disposal costs could conceivably be incurred. The low sensitivity and best estimate assume no costs are incurred for disposal of treated material (cost neutral). Disposal cost for treated sand ($60/ton, the same as for untreated sediment) was included in the high sensitivity estimate for Alternative 5R-Treatment in the event no beneficial use can be identified.

I.4.3 Summary

Table I-4 presents best estimate total costs for the remedial alternatives. EPA guidance notes that the amount and quality of RI data needed to develop and scope remedial alternatives according to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements correspond to an expected accuracy for FS cost estimates of approximately –30 to +50 percent (EPA 2000). The effects of the sensitivity assumptions on the best estimates of remedial alternative costs are also shown in Table I-4. Ranges in the low and high sensitivity costs as percentages of the best estimate are generally higher for the lower numbered alternatives primarily because the contingency volume assumptions have greater influence on alternatives with appreciable verification monitoring, ENR/*in situ*, and MNR areas. Note that with few exceptions, the sensitivity ranges fall within the expected cost accuracy range of –30 to +50 percent.

Total estimated costs of the remedial alternatives are expressed as net present values. Net present value analysis is a standard method used to evaluate expenditures that occur over different time periods. The present value is the amount of money that would need to be set aside at an initial point in time (base year) so that funds for implementing a remedial alternative would be available in the future as needed. The real discount rate, (i.e., interest less inflation), is the predictive parameter that accounts for the time value of money reflecting judgments of future economic conditions. The *Guide to Developing and Documenting Cost Estimates during the Feasibility Study*, (EPA 2000) recommends that a discount rate of 7% be used for estimating the net present value of cleanups conducted by non-federal parties. This is based on recommendations in the Office of Management and Budget (OMB) Circular A-94 for benefit-cost analyses of proposed federal programs, policies, and regulations. The rate of 7% approximates the marginal pretax rate of return on an average investment in the private sector and has been adjusted to eliminate the effect of expected inflation. A discount rate of 2.3% (from Appendix C of OMB Circular A-94 for Year 2011) was used in the FS, and the basis for selection of this rate is detailed in a separate technical memorandum (AECOM 2012). Briefly, three of the four parties to the Administrative Order on Consent (AOC) are public entities and are likely to be involved in the primary consent decree and implementation of the remedy. Like the federal government, these entities have a different cost of capital than the private sector. The current low interest environment, as reflected in the interest rates published in Appendix C of OMB Circular A-94, will affect the financing of the cleanup, and is a consideration for these and private entities as well. Further, it is likely that, during implementation of the remedy, there will be limits on investment of capital based on public entity involvement. Regardless of the ultimate public/private mix of parties responsible for the cleanup, a discount rate derived using Appendix C of the OMB Circular A-94 is equivalent to a low-risk rate of return, one that is consistent with the premise of setting aside money today in a safe, secure investment to pay for future cleanup costs.

While useful for comparing remedial alternatives, discounted costs may not be meaningful projections for the parties contributing money to the cleanup. Certain parties (public, public-private entities) may not be able to set aside sufficient funds for investment (without incurring additional costs of bonding or borrowing) before remediation starts and will therefore not be able to take advantage of the interest accumulation assumption implied by the net present value calculation. For informational purposes, non-discounted costs for the remedial alternatives are provided in Table I-4.

Finally, the duration of the construction and monitoring phases for several remedial alternatives presented herein could span a lengthy period (e.g., more than 10 years and up to 42 years in the case of Alternative 6R). Depending on economic conditions, significant inflationary pressures would result in increased overall construction and monitoring costs. In particular, fuel prices and landfill tipping fees could exceed the average inflation rate embodied in the discount rate. Increases in fuel prices translate into higher construction, transportation, and disposal costs.

I.5 References

BNSF 2009. Letter from BNSF to AECOM. March 23, 2009.

Hartman, G. 2011. Review LDW Cost Estimate Revisions Memorandum. Prepared by Hartman and Associates, LLC. Prepared for AECOM. May 29, 2011.

AECOM 2012. *Technical Memorandum: Backup for Early Action Area (EAA) Costs and Remedial Alternative Cost Estimates Using Range of Present Value Discount Rates*. Submitted to the U.S. Environmental Protection Agency and the Washington State Department of Ecology. Prepared for the Lower Duwamish Waterway

Group, to support the Lower Duwamish Waterway Feasibility Study. August 30, 2012.

Palermo, M. 2009. "*In Situ Volume Creep for Environmental Dredging Remedies*," Fifth International Conference on Remediation of Contaminated Sediments, Jacksonville, FL. February 2 – 5, 2009.

Office of Management and Budget 1992. *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.* Circular No. A-94 Revised. October 29, 1992. available at: http://www.whitehouse.gov/omb/circulars_a094.

Office of Management and Budget 2011. Memorandum for The Heads Of Departments And Agencies. Circular No. A-94. *Appendix C (Revised December 2010) Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses*. available at: http://www.whitehouse.gov/sites/default/files/omb/memoranda/2011/m11-12.pdf.

U.S. Army Corps of Engineers (USACE) 2008. "*Technical Guidelines for Environmental Dredging of Contaminated Sediments*," ERDC/EL TR-08-29. September 2008.

U.S. Environmental Protection Agency (EPA) 2000. *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study*. EPA 540-R-00-002, OSWER 9355.0-75. July 2000.

Table I-1 Main Engineering Assumptions Pertaining to Cost Estimation

Item No.	Topic	Assumption
Work Period		
1	In-water construction season and number of construction operating days	Construction season: October 1 through February 15 (138 calendar days) Construction operating days per season: 88 days (see Table I-5 for calculations)
2	Work shifts	Two work shift scenarios assumed for developing seasonal construction rate estimates: 1) 24 hours per day, 6 days per week (50% of work), and 2) 12 hours per day, 5 days per week (50% of work).
Placement of Imported Aggregate Materials		
3	Equipment	3-cy bucket for water depth less than 10 ft. 5-cy and 8-cy buckets for water depths greater than 10 ft.
4	Material source	Quarry material delivered to the site by barge.
5	Cap and backfill material volume	Capping: 3.5 ft of sand/gravel/rock to achieve a minimum 3-ft cap thickness over application area. Backfill (to preserve grade in removal areas above -10 ft MLLW); equal to dredge-cut prism volume over application area.
6	ENR and thin-layer sand placement for dredge residuals management	Apply 9 inches of sand to achieve the goal of a minimum 6-inch-thick layer in both cases. For management of dredge residuals, apply to equivalent of 100% of dredged area (although placement may also occur outside of the dredge area).
7	*In situ* Treatment	Apply granular activated carbon (4% organic carbon by weight) to a depth equivalent to the assumed ENR thickness of 9 inches. Assumes activated carbon mixed into sand for placement over 50% of combined ENR/*in situ* area.
Mechanical Dredging		
8	Equipment	Derrick barge/clamshell and precision excavators: See Table I-5 for specifics.
9	Average Annual Dredge Production Rate	1,039 cy/operational day averaged over the dredge season and based on a combination of dredge equipment and operating regimes. This equates to 1,559 tons/operational day average dredge production rate over the 88 days of dredging. See Table I-5.
10	Construction Period	Based on dredging as the rate-limiting technology (see Table I-5). The construction time frame is based on the dredge-cut prism volume estimate as opposed to the performance contingency volume estimate.
11	Backfill	Areas shallower than -10 ft MLLW are backfilled to original grade for habitat restoration purposes.
12	Dredge volume estimation	See Section 8.2.2.1 for volume terminology and estimation methodology. Total dredge volumes (sum of dredge-cut prism and performance contingency volumes) are used to estimate costs.

Table I-1 Main Engineering Assumptions Pertaining to Cost Estimation (continued)

Item No.	Topic	Assumption
Mechanical Dredging (continued)		
13	Gravity dewatered dredge material density	Wet bulk density of dewatered sediment for disposal: 1.5 tons/cy
14	Dredging debris sweep	Debris removal and on-barge handling occupies 10% of dredge operations at a lower effective bucket capacity of 40%. The need for debris removal was reviewed as commonly needed for many sediment dredging projects (USACE 2008).
15	Capping and ENR/*in situ* treatment debris sweep	10% of the capping and ENR/*in situ* treatment footprint requires debris removal.
16	CAD overburden	Mechanically dredged, barged to, and disposed of at DMMP Elliott Bay open water disposal site. Assume dredged material complies with DMMP open water disposal criteria.
Transloading, Transport, and Landfilling of Dredged Materials		
17	Barge transport	Three 1,600-cy capacity material barges for receipt of mechanically dredged sediment and transport to transloading facility. Capping materials delivered to the site by barge.
18	Transloading	Gravity dewatered sediment transferred to 20-ft containers fitted with disposable liner and loaded onto truck chassis. Containers transported to local intermodal facility and transferred to railcars. Existing infrastructure assumed adequate for assumed material production rate of ~1,600 tons/day. Stormwater and wastewater generated at transloading facility treated on-site.
19	Railcar transport	Lined 20-ft containers; one container per railcar (75 tons). No material stabilization (e.g., with lime).
20	Landfill	Two regional Subtitle D facilities accept wet dredged materials: Allied Waste Services (Roosevelt, WA), and Waste Management Inc. (Columbia Ridge, OR).

Table I-1 Main Engineering Assumptions Pertaining to Cost Estimation (continued)

Item No.	Topic	Assumption
Sediment Washing		
21	Mobilization/Demobilization	Capital for design, permitting, and construction. Total plant footprint of 4 to 7 acres with capacity of 40 to 45 tons per hour.
22	Operations	50% of dredged sediment processed through treatment unit. Only 50% of dredged material is expected to meet the grain size criterion ideal for soil washing. Recover 50% of processed material as sand. Includes labor, plant operations, maintenance, and filter cake disposal. Assume no credit for beneficial reuse of sand because of the uncertainty in final chemical characteristics and end-use options.
Monitoring and Maintenance		
23	Construction monitoring	Survey boat, labor, and equipment for routine bathymetric surveys and surface water quality testing during construction (for the latter see Appendix K).
24	Other monitoring	Post-construction, baseline and long-term monitoring: see Appendix K.
25	Repair	5% of cap and ENR/*in situ* treatment areas. Fraction of remediation areas assumed to undergo repair by addition of clean import material (approximately 3.5 ft for caps and 9 inches for ENR/*in situ* treatment areas) following construction. ENR/*in situ* repair costs assume approximately 50% of any ENR area requiring repair will include *in situ* treatment, consistent with the rest of the cost estimate.
26	Institutional Controls	Initial cost, annual cost, and periodic cost developed for implementing institutional controls. Assumed institutional controls would begin upon signing of the ROD and annual costs applied from Year 1 to Year 50. Some of the periodic costs (e.g., seafood consumption advisories) may apply to the project in perpetuity.
Discount Rate		
27	Discount rate used for present value calculations	2.3%, consistent with Real 30-year discount rate published in 2011 Office of Management and Budget Circular A-94 (see also separate memorandum, AECOM 2012)

Notes:

CAD = contained aquatic disposal; cy = cubic yards; DMMP = Dredged Material Management Program; ENR = enhanced natural recovery; MLLW = mean lower low water; MNR = monitored natural recovery; ROD = Record of Decision; USACE = U.S. Army Corps of Engineers.

Table I-2 Identification and Brief Description of Cost Estimating Tables in Attachment 1

Table No.	Description
I-5	**Dredge Production Estimate.** Dredge production rate calculations are consistent with estimation methods and efficiency factors set forth in USACE guidance (USACE 2008). The estimates assume two simultaneous dredging operations (one in open water and one in shallow water). Dredging is assumed to be evenly divided between the 24-hour, 6-day/week, and 12-hour, 5-day/week operating regimes throughout the in-water construction window. Both are common operating regimes for projects in the Puget Sound region and are largely a function of project size and location as well as commercial navigation and community concerns (nighttime noise and illumination). For each in-water construction season, the calculations account for 5 days of holidays and 15 days of dredge downtime to accommodate ancillary construction (e.g., piling/dolphin, bulkhead, pier/dock-related work), tribal fishing delays, weather and water quality related delays, and a dredging-free period near the end of the in-water construction window for residuals management. The dredge production rate is used as the basis for the time component of dredge cost calculations for Alternatives 2 through 6 (Tables I-39 through I-49).
I-6	**Material Placement Production Estimate.** Production rate assumptions are developed based on a range of equipment, operating environment (e.g., open water or nearshore), operating hours, cycle time, bucket capacity, and total efficiency. The material placement production rates are used as the basis for the time component of material placement cost calculations for Alternatives 2 through 6 (Tables I-39 through I-49).
I-7	**Material Placement Unit Costs.** Material costs for capping assume purchase of cap material from local or regional quarries. Unit costs for cap material include material cost and transportation cost. For the estimate, distance to the material supplier's loading facility is assumed to be 60 nautical miles per round trip by barge. See Tables I-39 through I-49 for Alternatives 2 through 6 purchased material and placement costs.
I-8	**Transloading, Water Management, and Dredging Daily Rate.** Costs for transloading area setup, dewatering, water handling, and management at a transloading facility located in the Duwamish Valley. Dredging daily labor and material rate assumptions include transportation of sediment from the dredging location to the transloading facility. Sediment handling costs at the transloading facility, including material transfer from barges onto lined 20-ft containers, transfer of loaded containers onto trucks, and truck transport of the containers to an intermodal facility for transfer to rail are part of the unit price for material disposal at the Subtitle D landfill ($60/ton; see Table I-37).
I-9	**Construction Monitoring.** Costs are provided for single beam/multi-beam surveys inclusive of labor and equipment for acquisition, processing, and data delivery. Costs also include water column monitoring during construction.
I-10	**Mobilization, Demobilization, and Contractor Project Management Costs.** These costs include all contractor labor for mobilization of equipment and support facilities, land lease for operations and staging, development of construction quality assurance plans, and barge protection.
I-11 through I-21	**Monitoring, Operation and Maintenance Costs.** These tables provide the cost basis for post-construction performance monitoring, annual operation and maintenance, repair for caps and ENR/*in situ* treatment, and a performance contingency (i.e., additional sediment volume removed in areas originally identified for ENR/*in situ* treatment, MNR, or verification monitoring). One table is provided for each remedial alternative (see Appendix K for more details on monitoring).
I-22	**Baseline and Long-term Monitoring.** Provides the basis for baseline and long-term monitoring annual and periodic costs (see also Appendix K).

Table I-2 Identification and Brief Description of Cost Estimating Tables in Attachment 1 (continued)

Table No.	Description
I-23 through I-33	**Net Present Value Calculation for Agency Oversight, Reporting, O&M, and Long-term Monitoring.** Calculates the net present value of component costs developed in Tables I-11 through I-22 for each remedial alternative. Monitoring frequencies and duration are developed in Appendix K. The duration of long-term monitoring is assumed to be 30 years except for Alternative 6R, which assumes 45 years.
I-34	**Institutional Controls.** Provides the basis for initial, annual, and periodic costs associated with institutional controls.
I-35	**Net Present Value Calculations for Institutional Controls.** Calculates the net present value of component costs developed in Table I-34. Table I-35 assumes institutional controls begin after the ROD is signed, initial costs are incurred in Year 1, and the total duration for which institutional controls apply is 50 years.
I-36	**Technology Application Areas, Sediment Removal, and Material Placement Volumes.** The best estimate dredge volumes assume removal to the maximum depth of SQS exceedance (Alternatives 2 through 5) or to the depth of Alternative 6 RAL exceedance (the “neat-line” volume), plus a volume allowance factor of 50% to account for overdredge, constructible side slopes, layback slopes, refinement of vertical extent, and redredge (USACE 2008). These dredge-cut prism volumes are developed in Appendix E. Performance contingency dredge volumes are assumed to account for 15% of verification monitoring, ENR/*in situ* treatment, and MNR surface areas requiring active remediation (dredging) either during remedial design or based on future monitoring. Estimated volumes of material for capping, backfill, management of dredge residuals, and ENR/*in situ* treatment are also provided.
I-37	**Basis for Cost Estimates**. Master reference file of unit and other cost/production rate assumptions.
I-38 through I-49	**Detailed Estimated Costs for each Remedial Alternative.** Capital costs: preconstruction, project management (contractor), construction materials and labor, construction QA/QC (contractor), and post-construction performance monitoring. Construction contingency, sales tax, owner project management and remedial design, and owner construction management are calculated as a percentage of capital costs. **Recurrent operating costs:** Operation, maintenance, monitoring, institutional controls, agency review and oversight, and reporting.
I-50	**Monitoring Cost Summary:** Provides rolled-up monitoring cost estimates for all remedial alternatives. Contingency actions not included.
I-51	**Total Cost Summary – Best Estimate ($ million).**

Notes:

cy = cubic yards; ENR = enhanced natural recovery; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; RAL = remedial action level; ROD = Record of Decision; SQS = sediment quality standards; USACE = U.S. Army Corps of Engineers

Table I-3 Cost Sensitivity – Areas and Volumes

	Parameter		Remedial Alternative								
			2R/2R-CAD	3C	3R	4C	4R	5C	5R/5R-T[a]	6C	6R
Areas	VM Area (acres)		23	23	23	23	23	23	23	0	0
	MNR (10) Area (acres)		19	0	0	50	50	0	0	0	0
	MNR(20) Area (acres)		106	99	99	0	0	0	0	0	0
	ENR/ *in situ* Area (acres)		0	10	0	16	0	53	0	101	0
	Cap Area (acres)		0	11	0	23	0	24	0	51	0
	Partial Dredge and Cap Area (acres)		3	8	8	18	14	23	14	42	28
	Dredge Area (acres)		29	29	50	50	93	57	143	108	274
	Total Area (acres)		180	180	180	180	180	180	180	302	302
Low Sensitivity	Dredge-cut prism volume (neat volume to SQS or Alternative 6 RALs *1.25; cy)		307,980	249,805	488,354	465,949	871,022	535,041	1,346,640	1,249,040	3,285,978
	Performance contingency dredge volume (cy)		0	0	0	0	0	0	0	0	0
	Total dredge volume (cy)		307,980	249,805	488,354	465,949	871,022	535,041	1,346,640	1,249,040	3,285,978
Best Estimate	Dredge-cut prism volume (neat volume to SQS or Alternative 6 RALs *1.5; cy)		369,577	299,766	586,024	559,139	1,045,226	642,049	1,615,968	1,498,848	3,943,174
	Performance contingency dredge area (ac)	15% of VM, MNR, and ENR/ *in situ*, areas convert to dredging during remedial design or based on future monitoring	22	20	18	13	11	11	4	15	0
	Performance contingency dredge volume (cy)	Assume average depth of contamination = 4 ft. Volume = area*depth *1.5.	214,749	191,473	177,673	130,017	106,223	110,960	34,017	146,820	0
	Total dredge volume (cy)		584,326	491,239	763,698	689,156	1,151,450	753,009	1,649,985	1,645,668	3,943,174

Table I-3 Cost Sensitivity – Areas and Volumes (continued)

	Parameter		Remedial Alternative								
			2R/2R-CAD	3C	3R	4C	4R	5C	5R/5R-T[a]	6C	6R
High Sensitivity	Dredge-cut prism volume - high sensitivity (neat volume to alluvium for all alternatives; cy)		429,328	434,965	771,621	730,943	1,383,159	851,387	2,198,760	1,712,240	4,331,720
High Sensitivity	Performance contingency dredge area (ac)	25% of VM, MNR, and ENR/ *in situ*, areas convert to dredging during remedial design or based on future monitoring	37	33	31	22	18	19	6	25	0
High Sensitivity	Performance contingency dredge volume (cy)	Assume average depth of contamination = 4 ft. Volume = area*depth *1.5.	357,916	319,122	296,122	216,694	177,039	184,933	56,694	244,700	0
High Sensitivity	Total dredge volume (cy)		787,244	754,087	1,067,743	947,637	1,560,198	1,036,320	2,255,454	1,956,940	4,331,720

Notes:

1. Values are carried through the cost estimate unrounded. Apparent discrepancies with the values in the main text of the FS (and Table E-2 of Appendix E) are only a result of rounding.
2. Volume estimate methodology is presented in Appendix E and Section 8.
3. Low and high sensitivity results are presented in Table I-4 only. Best estimate dredge volumes are shown in subsequent tables of this appendix.

a. The high sensitivity for Alternative 5R-Treatment has an additional sensitivity parameter not shown. The treated fraction of dredged sediment (assumed to be 25% of total dredged sediment) is disposed of in subtitle D landfill as opposed to beneficially reused.

ac = acres; C = combined technology; CAD = contained aquatic disposal; cy = cubic yards; ENR = enhanced natural recovery; FS = feasibility study; MNR = monitored natural recovery; O&M = operation and maintenance; R = removal emphasis; RAL = remedial action level; SQS = sediment quality standard; T = treatment; VM = verification monitoring

Table I-4 Summary of Costs ($ Millions)

		Remedial Alternative											
Best Estimate	**Cost Parameter**	**1[a]**	**2R**	**2R-CAD**	**3R**	**3C**	**4R**	**4C**	**5R**	**5R-T**	**5C**	**6R**	**6C**
	Capital	n/a	$169	$148	$224	$156	$324	$221	$430	$473	$250	$771	$478
	Monitoring, O&M, reporting, Agency oversight	$9	$46	$48	$43	$45	$38	$41	$36	$36	$41	$42	$51
	Total (NPV, i = 2.3%)	**$9**	**$220**	**$200**	**$270**	**$200**	**$360**	**$260**	**$470**	**$510**	**$290**	**$810**	**$530**
	Total (not discounted, i = 0%)[b]	$12	$250	$230	$310	$230	$430	$300	$580	$630	$330	$1,300	$650

		Remedial Alternative											
Low Sensitivity	**Cost Parameter**	**1[a]**	**2R**	**2R-CAD**	**3R**	**3C**	**4R**	**4C**	**5R**	**5R-T**	**5C**	**6R**	**6C**
	Capital	n/a	$99	$77	$157	$93	$261	$166	$370	$407	$197	$698	$400
	Monitoring, O&M, reporting, Agency oversight	$9	$46	$48	$43	$45	$38	$41	$36	$36	$41	$42	$51
	Total (NPV, i = 2.3%)	$9	$140	$130	$200	$140	$300	$210	$410	$440	$240	$740	$450
	% difference from best-estimate	0%	-36%	-35%	-26%	-30%	-17%	-19%	-13%	-14%	-17%	-9%	-15%

		Remedial Alternative											
High Sensitivity	**Cost Parameter**	**1[a]**	**2R**	**2R-CAD**	**3R**	**3C**	**4R**	**4C**	**5R**	**5R-T**	**5C**	**6R**	**6C**
	Capital	n/a	$218	$197	$296	$222	$409	$283	$538	$638	$317	$809	$533
	Monitoring, O&M, Reporting, Agency oversight	$9	$46	$48	$43	$45	$38	$41	$36	$36	$41	$42	$51
	Total (NPV, i = 2.3%)	$9	$260	$250	$340	$270	$450	$320	$570	$670	$360	$850	$580
	% difference from best-estimate	0%	18%	25%	26%	35%	25%	23%	21%	31%	24%	5%	9%

Notes:

1. Total costs are rounded to 2 significant digits. Capital costs and indirect construction costs are rounded to 3 significant digits for display purposes. All calculations are performed prior to rounding.
2. Capital costs include construction costs, construction contingency, sales tax, engineering, procurement, and construction management.

a. Alternative 1 costs are estimated to be $9 million for LDW-wide monitoring, agency oversight, and reporting. The cost of completing cleanup actions in the EAAs is estimated at approximately $95 million. Decisions on those cleanups have been made and are not part of the decision process represented in this FS. Substantial additional costs are expected for associated upland cleanup and source control. The EAA costs and the costs of upland cleanup and source control are not incorporated into the cost of any alternative and are not used in comparing the alternatives.

b. Total costs assuming a discount rate of 0%. Non-discounted costs are provided for informational purposes.

C = combined technology; CAD = contained aquatic disposal; i = discount rate (percent); n/a = not applicable; NPV = net present value; O&M = operation and maintenance; R = removal emphasis; T = treatment

Attachment 1

Detailed Cost Estimates

TABLE I-5 DREDGE PRODUCTION ESTIMATE

Open Water Dredge Production Rate Estimate

Parameter	Derrick Barge with Environmental Bucket (deep water)	Precision Excavator (deep water)	Precision Excavator (shallow water)
24-hr Operation			
Cycle Time (min)	3.5	3	2.5
Bucket Capacity (cy)	6	5	3
Bucket Fill Factor (@ 55%; cy)[a]	3.3	2.8	1.7
Bucket Fill Factor (@ 40%; cy) - Debris Sweep	2.4	2	1.2
Operating Day (hrs/day)	24	24	24
Effective Working Time (%)[b]	60%	60%	60%
Daily Dredge Production (cy/day)	815	792	570
Daily Dredge Production (cy/day) - Debris Sweep	592	576	415
Combined Dredge Production (cy/day) (10% debris sweep, 90% without debris sweep)	792	770	555
Combined Dredge Production (tons/day @ 1.5 tons/cy)[c]	1,189	1,156	832
Total Combined Dredge Production with One Open Water Operation (Split Between Environmental Bucket and Excavator) and One Shallow Water Operation (tons/day)	2,004		
12-hr Operation			
Combined Dredge Production (cy/day)[d]	396	385	277
Combined Dredge Production (tons/day)[d]	594	578	416
Total Combined Dredge Production with One Open Water Operation (Split Between Environmental Bucket and Excavator) and One Shallow Water Operation (tons/day)	1,002		

Annual Open Water Dredge Production Rate Estimates

Total In-water Construction Window (October 1 through February 15; days)	138
Days per week of operation (days)	5 and 6
Weekend days without operation (days)	29.6
Holidays (days)	5.0
Lost Time (days)	15.0
Net dredging days per season (days)	88.4
Net dredging days per season @12 hrs/day (assume operation 5 days/week; days)	39.3
Net dredging days per season @24 hrs/day (assume operation 6 days/week; days)	49.1
Annual tonnage (tons/year)	137,856
Annual volume removed (cy/year)	91,904
Average dredge production per operational day (tons/day)	1,559
Average dredge production per operational day (cy/day at 1.5 tons/cy)	1,039

Underpier Dredge Production Rate Estimate

Operating Day (hours)	12
Effective Working Time (%)	65%
Daily Production (cy/day)	240

Notes:

1. Construction window: October 1 through February 15.
2. Construction window is split equally (by number of weeks) between 24 hrs/day and 12 hrs/day operations.
3. Assume simultaneous open-water (split between environmental bucket and excavator) and shallow equipment operations (i.e., 2 equipment sets).

a. USACE 2008. *Technical Guidelines for Environmental Dredging of Contaminated Sediments*. ERDC/EL TR-08-29.

b. ibid. Operating efficiency includes allowance for non-production activities such as equipment maintenance/repair, water quality management, navigation systems, agency inspections, waiting for test results, moving dredges/barges, traffic, standby for navigation and refueling.

c. Assumes sediment bulk density of 1.5 tons/cy.

d. Calculations for 12-hr operations use same root assumptions as shown above for 24-hour operations.

TABLE I-6 MATERIAL PLACEMENT PRODUCTION ESTIMATE

Capping Production Estimate Open Access Below -10 ft - Derrick Barge with environmental bucket		
Cycle Time	2.5	min
Bucket Capacity	8	cy
Bucket Fill Factor (85%)	6.8	cy
Operating Day	12	hrs
Effective Working Time	75%	
Daily Production	1,469	cy/day

ENR Production Estimate - Open Access Below -10 ft - Derrick Barge with environmental bucket		
Cycle Time	2.5	min
Bucket Capacity	8	cy
Bucket Fill Factor (85%)	6.8	cy
Operating Day	12	hrs
Effective Working Time	70%	
Daily Production	1,371	cy/day

Capping Production Estimate - Above -10 ft - Precision Excavator		
Cycle Time	2	min
Bucket Capacity	5	cy
Bucket Fill Factor (85%)	4.25	cy
Operating Day	12	hrs
Effective Working Time	75%	
Daily Production	1,148	cy/day

ENR Production Estimate - Above -10 ft- Precision Excavator		
Cycle Time	2	min
Bucket Capacity	5	cy
Bucket Fill Factor (85%)	4.25	cy
Operating Day	12	hrs
Effective Working Time	70%	
Daily Production	1,071	cy/day

Capping Production Estimate - Underdock - Hydraulic, conveyor		
Operating Day	12	hrs
Daily Production	350	cy/day

ENR Production Estimate - Underdock - Hydraulic, conveyor		
Operating Day	12	hrs
Daily Production	300	cy/day

Notes:

1. These calculation are performed with logic consistent with dredging production rate calculations in Table I-5 and USACE, 2008.

TABLE I-7 MATERIAL PLACEMENT UNIT COST

Sand (8/30 Sieved)

Base cost	$13.00	/ton		
Delivery	$3.70	/ton	$5.99	/ cy
Total	$16.70	/ton	$27.05	/ cy

Granular Activated Carbon (GAC) Amended Sand

Base cost (delivered)	$1.07	/lb		
Base cost (delivered)	$2,140.00	/ton	$1,155.60	/ cy
Mixing percentage (% by volume GAC/sand)	4%			
Total	$102.30	/ton	$161.48	/cy

Assumed Unit Weight

Capping Material	1.62	ton/cy
Granular Activated Carbon	0.54	ton/cy

Tow and Barge Delivery Surcharge Calculation

60	nautical miles RT
5	knots avg
12	hrs sail
400	tons/hr loading
1500	tons capacity
3.75	hrs loading
15.75	total hrs
$300.00	per hr, tug
$50.00	per hr., barge
$350.00	per hr., total
$5,512.50	trip cost
$3.70	add'l per ton

Notes:

1. Sand costs from DuPont RM and Pioneer Aggregates, DuPont, WA.
2. GAC costs from Luthy et al. 2009.

TABLE I-8 TRANSLOADING, WATER MANAGEMENT, AND DREDGING DAILY RATE

Transloading and Water Management	Cost	Unit	Notes
Transloading Area Setup	$1,000,000	LS	Best professional judgment order of magnitude cost for facility set-up
Water Management	$10,000	per day	Water management cost typical for relatively large-scale remediation projects in the Northwest

Dredging Daily Rate Assumptions	Cost	Unit	Notes
Labor	$5,750	12-hr day	Includes superintendent, foreman, 2 operators, 4 deck hands, and boat operator (Hartman 2011).
Dredge	$9,000	12-hr day	Includes one shallow and one deep dredge with tug for each (Hartman 2011).
Haul barge	$3,000	day	Assume one 1,500 cy haul barge and two 1,000 haul barges (Hartman 2011).
Subtotal 12-hr operation	$17,750	12-hr day	
Subtotal 24-hr operation	$32,500	24-hr day	Assume double 12-hr day for labor and dredge no additional cost for haul barge
Average daily rate	$25,963	day	Assume 39 days at 12 hrs and 49 days at 24 hrs

TABLE I-9 CONSTRUCTION MONITORING

Multi-Beam Survey Inclusive of Acquisition, Processing, and Data Delivery

Average of 2 quotes	$	4,928	/ day

Water Quality Sampling during Construction

	# of samples		Cost per sample		Total	
Analytical cost	106	$	1,000	$	106,000	annual cost
Labor, equipment and materials cost	106	$	1,500	$	159,000	annual cost
Subtotal annual cost				$	265,000	annual cost
Subtotal daily cost				$	2,998	/ day

Total Construction Monitoring Daily Rate	$	7,925	/ day

Notes:

1. Multi-beam survey cost includes equipment and labor to collect bathymetric survey data, data processing and delivery, and labor/equipment to collect and document pH/turbidity data. Estimate from John Lally, Lally Consulting, Seattle, WA.

2. Water quality sampling costs assume four monitoring stations: three for the dredging event that occurs in deep water and one for the dredge that operates in shallow water close to the banks; one sampling event for every station every day during the field season, for a total number of field screening samples for general water quality parameters of 352 (88x4=352). The number of samples that will require chemical analysis for PCBs, arsenic and cPAHs is assumed to be 30% of the field screening samples (30% of 352 equals 106).

3. Total construction monitoring includes survey boat, labor and equipment required for routine bathymetric surveys (single beam), data analysis, data delivery, pH/turbidity check, and water quality monitoring. Additional construction oversight is included in the 10% construction management cost described in Table I-37.

4. Construction monitoring is assumed to occur during dredging (88 days/season) and is incorporated in capital costs in Tables I-39 through I-49.

TABLE I-10 MOBILIZATION, DEMOBILIZATION, AND CONTRACTOR PROJECT MANAGEMENT COSTS

Mobilization/Demobilization	Cost	Unit	Notes
Mobilize/Demobilize Equipment and Facilities (project)	$400,000	Lump sum per mob	Start of project and end of project - includes mobilization of construction equipment for both dredging and material placement: 3 excavators (various bucket sizes), one clamshell, 2 derrick barges, 8 haul barges, 2 flat-decked barges, crew boat, survey boat (Hartman 2011).
Mobilize/Demobilize Equipment and Facilities (construction season)	$120,000	per year	Yearly mobilization/demobilization is assumed to be 30% of the project mob/demob cost of $400,000 for all years of project. Includes project management and labor during mobilization and demobilization (Hartman 2011).

Project Management and Operations	Cost	Unit	Notes
Land Lease for Operations and Staging	$250,000	per year	Based on review of lease rates in the Lower Duwamish Valley.
Site Office & Operating Expense	$21,600	per month	Includes housing, trailer, boats, travel.
Contractor Work Plan Submittals	$100,000	per year	Based on project experience.
Barge Protection	$80,000	lump sum	Barge protection is necessary to mitigate wear to barges during dredging operations.
Labor and Supervision	$62,000	per month	Includes project manager, chief surveyor and quality manager, works manager or superintendent, surveyor, accountant, certified industrial hygienist/ health and safety, physicals, HAZWOPER training.

Notes:

1. Cost assumptions for mobilization and demobilization reviewed in Hartman (2011).

TABLE I-11 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 2R

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	29.2	3.4	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	23	5	-
Bathymetry (note 4)	$ 20,241	$ 5,606	$ -
Subtotal analytical cost	$ 264,600	$ 31,136	$ -
Subtotal labor, equipment, bathymetry and materials cost	$ 206,907	$ 49,536	$ -
Data management, analysis and reporting (note 5)	$ 113,507	$ 31,436	$ -
Total monitoring cost for Post-Construction Event	$ 585,015	$ 112,107	$ -

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR (10)	MNR (20)
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4	4
No. of porewater samples per acre	0	1	4	0	0
No. of cores per acre	0	1	0	0	0
No. of samples for physical testing per acre	0	2	4	4	4
Remediation area (acre)	29.2	3.4	0.0	19.0	105.5
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	12	5	-	30	169
Bathymetry (note 4)	$ 20,241	$ 5,606	$ -	$ 15,644	$ 43,777
Subtotal per event analytical cost (note 6)	$ 132,300	$ 54,487	$ -	$ 172,235	$ 957,096
Subtotal per event labor, equipment and materials cost	$ 113,574	$ 46,790	$ -	$ 258,656	$ 1,394,177
Data management, analysis and reporting (note 5)	$ 113,507	$ 31,436	$ -	$ 87,729	$ 245,495
Total monitoring costs per event	$ 359,381	$ 132,713	$ -	$ 518,619	$ 2,596,768

See Table I-23 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: i.e., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core

Repair Costs for Cap and ENR - 5% of total area

	Cap and PDC	ENR
Area	0.2	0.0
Cost/Ac	$300,000	$100,000
Total repair cost per event	$51,481	$0

Notes:

1. See Table I-23b for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-23b for PV analysis as part of O&M and monitoring cost development
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-12 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 2R-CAD

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	29.2	27.4	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	23	44	-
Bathymetry (note 4)	$ 20,241	$ 19,510	$ -
Subtotal analytical cost	$ 264,600	$ 248,864	$ -
Subtotal labor, equipment, bathymetry and materials cost	$ 206,907	$ 370,640	$ -
Data management, analysis and reporting (note 5)	$ 113,507	$ 109,407	$ -
Total monitoring cost for Post-Construction Event	$ 585,015	$ 728,911	$ -

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR (10)	MNR (20)
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4	4
No. of porewater samples per acre	0	2	4	0	0
No. of cores per acre	0	1	0	0	0
No. of samples for physical testing per acre	0	2	4	4	4
Remediation area (acre)	29.2	27.4	0.0	19.0	105.5
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	12	47	-	30	169
Bathymetry (note 4)	$ 20,241	$ 19,510	$ -	$ 15,644	$ 43,777
Subtotal per event analytical cost (note 6)	$ 132,300	$ 497,727	$ -	$ 172,235	$ 957,096
Subtotal per event labor, equipment and materials cost	$ 113,574	$ 392,585	$ -	$ 258,656	$ 1,394,177
Data management, analysis and reporting (note 5)	$ 113,507	$ 109,407	$ -	$ 87,729	$ 245,495
Total monitoring costs per event	$ 359,381	$ 999,720	$ -	$ 518,619	$ 2,596,768

See Table I-24 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.

2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.

3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).

4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6:
e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.

5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.

6. Analytical cost assumes 4 samples per core.

Repair Costs for Cap and ENR - 5% of total area

	Cap and PDC	ENR
Area	1.4	0.0
Cost/Ac	$300,000	$100,000
Total repair cost per event	$411,481	$0

Notes:

1. See Table I-24 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.

2. These repair costs are carried over to Table I-24 for PV analysis as part of O&M and monitoring cost development.

3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/ acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-13   MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 3R

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	50.3	7.5	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	40	12	-
Bathymetry (note 4)	$ 28,065	$ 8,975	$ -
Subtotal analytical cost	$ 456,203	$ 68,227	$ -
Subtotal labor, equipment, bathymetry and materials cost	$ 349,902	$ 105,240	$ -
Data management, analysis and reporting (note 5)	$ 157,385	$ 50,332	$ -
Total monitoring cost for Post-Construction Event	$ 963,490	$ 223,799	$ -

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR (20)
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	50.3	7.5	0.0	99.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	20	13	-	158
Bathymetry (note 4)	$ 28,065	$ 8,975	$ -	$ 42,126
Subtotal per event analytical cost (note 6)	$ 228,102	$ 136,455	$ -	$ 897,682
Subtotal per event labor, equipment and materials cost	$ 188,983	$ 111,256	$ -	$ 1,308,697
Data management, analysis and reporting (note 5)	$ 157,385	$ 50,332	$ -	$ 236,234
Total monitoring costs per event	$ 574,471	$ 298,043	$ -	$ 2,442,613

See Table I-25 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	0.4	0.0
Cost/Ac	$300,000	$100,000
Total repair cost per event	$112,810	$0

Notes:

1. See Table I-25 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-25 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-14 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 3C

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	28.6	19.7	9.5
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	23	31	15
Bathymetry (note 4)	$ 20,015	$ 15,983	$ 10,329
Subtotal analytical cost	$ 259,706	$ 178,503	$ 86,221
Subtotal labor, equipment, bathymetry and materials cost	$ 203,229	$ 267,840	$ 131,981
Data management, analysis and reporting (note 5)	$ 112,243	$ 89,631	$ 57,921
Total monitoring cost for Post-Construction Event	$ 575,178	$ 535,974	$ 276,124

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR (20)
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	28.6	19.7	9.5	99.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	11	33	23	158
Bathymetry (note 4)	$ 20,015	$ 15,983	$ 10,329	$ 42,126
Subtotal per event analytical cost (note 6)	$ 129,853	$ 357,007	$ 172,443	$ 897,682
Subtotal per event labor, equipment and materials cost	$ 111,622	$ 283,581	$ 192,808	$ 1,308,697
Data management, analysis and reporting (note 5)	$ 112,243	$ 89,631	$ 57,921	$ 236,234
Total monitoring costs per event	$ 353,718	$ 730,219	$ 423,172	$ 2,442,613

See Table I-26 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	1.0	0.5
Cost/Ac	$300,000	$100,000
Total repair cost per event	$295,145	$47,521

Notes:

1. See Table I-26 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-26 for PV analysis as part of O&M and monitoring cost developmen
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/acre approximately equals the capital cos for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-15 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 4R

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	93.2	13.8	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	75	22	-
Bathymetry (note 4)	$ 40,648	$ 12,907	$ -
Subtotal analytical cost	$ 845,804	$ 125,000	$ -
Subtotal labor, equipment, bathymetry and materials cost	$ 637,334	$ 189,274	$ -
Data management, analysis and reporting (note 5)	$ 227,946	$ 72,380	$ -
Total monitoring cost for Post-Construction Event	$ 1,711,084	$ 386,654	$ -

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR (10)
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	93.2	13.8	0.0	49.7
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	37	23	-	80
Bathymetry (note 4)	$ 40,648	$ 12,907	$ -	$ 27,883
Subtotal per event analytical cost (note 6)	$ 422,902	$ 250,001	$ -	$ 451,267
Subtotal per event labor, equipment and materials cost	$ 338,991	$ 200,297	$ -	$ 664,591
Data management, analysis and reporting (note 5)	$ 227,946	$ 72,380	$ -	$ 156,362
Total monitoring costs per event	$ 989,838	$ 522,677	$ -	$ 1,272,220

See Table I-27 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	0.7	0.0
Cost/Ac	$300,000	$100,000
Total repair cost per event	$206,680	$0

Notes:

1. See Table I-27 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-27 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/ acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-16 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 4C

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	49.7	41.0	16.4
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	40	66	26
Bathymetry (note 4)	$ 27,853	$ 24,819	$ 14,321
Subtotal analytical cost	$ 450,476	$ 371,690	$ 148,659
Subtotal labor, equipment, bathymetry and materials cost	$ 345,649	$ 549,249	$ 224,070
Data management, analysis and reporting (note 5)	$ 156,197	$ 139,180	$ 80,313
Total monitoring cost for Post-Construction Event	$ 952,322	$ 1,060,118	$ 453,042

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR (10)
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	49.7	41.0	16.4	49.7
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	20	70	39	80
Bathymetry (note 4)	$ 27,853	$ 24,819	$ 14,321	$ 27,883
Subtotal per event analytical cost (note 6)	$ 225,238	$ 743,379	$ 297,318	$ 451,267
Subtotal per event labor, equipment and materials cost	$ 186,751	$ 582,025	$ 328,944	$ 664,591
Data management, analysis and reporting (note 5)	$ 156,197	$ 139,180	$ 80,313	$ 156,362
Total monitoring costs per event	$ 568,186	$ 1,464,585	$ 706,575	$ 1,272,220

See Table I-28 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	2.0	0.8
Cost/Ac	$300,000	$100,000
Total repair cost per event	$614,566	$81,933

Notes:

1. See Table I-28 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-28 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/ acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-17 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 5R

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	143.1	13.6	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	114	22	-
Bathymetry (note 4)	$ 52,565	$ 12,828	$ -
Subtotal analytical cost	$ 1,298,279	$ 123,730	$ -
Subtotal labor, equipment, bathymetry and materials cost	$ 968,458	$ 187,403	$ -
Data management, analysis and reporting (note 5)	$ 294,775	$ 71,937	$ -
Total monitoring cost for Post-Construction Event	$ 2,561,512	$ 383,070	$ -

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	143.1	13.6	0.0	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	57	23	-	-
Bathymetry (note 4)	$ 52,565	$ 12,828	$ -	$ -
Subtotal per event analytical cost (note 6)	$ 649,140	$ 247,460	$ -	$ -
Subtotal per event labor, equipment and materials cost	$ 510,511	$ 198,314	$ -	$ -
Data management, analysis and reporting (note 5)	$ 294,775	$ 71,937	$ -	$ -
Total monitoring costs per event	$ 1,454,426	$ 517,711	$ -	$ -

See Table I-29 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	0.7	0.0
Cost/Ac	$300,000	$100,000
Total repair cost per event	$204,580	$0

Notes:

1. See Table I-29 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-29 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-18 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 5R - TREATMENT

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	143.1	13.6	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	114	22	-
Bathymetry (note 4)	$ 52,565	$ 12,828	$ -
Subtotal analytical cost	$ 1,298,279	$ 123,730	$ -
Subtotal labor, equipment, bathymetry and materials cost	$ 968,458	$ 187,403	$ -
Data management, analysis and reporting (note 5)	$ 294,775	$ 71,937	$ -
Total monitoring cost for Post-Construction Event	$ 2,561,512	$ 383,070	$ -

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	143.1	13.6	0.0	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	57	23	-	-
Bathymetry (note 4)	$ 52,565	$ 12,828	$ -	$ -
Subtotal per event analytical cost (note 6)	$ 649,140	$ 247,460	$ -	$ -
Subtotal per event labor, equipment and materials cost	$ 510,511	$ 198,314	$ -	$ -
Data management, analysis and reporting (note 5)	$ 294,775	$ 71,937	$ -	$ -
Total monitoring costs per event	$ 1,454,426	$ 517,711	$ -	$ -

See Table I-30 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	0.7	0.0
Cost/Ac	$300,000	$100,000
Total repair cost per event	$204,580	$0

Notes:

1. See Table I-30 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-30 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/ acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-19 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 5C

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	56.7	47.1	53.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	45	75	85
Bathymetry (note 4)	$ 30,152	$ 26,981	$ 28,960
Subtotal analytical cost	$ 514,122	$ 427,213	$ 480,695
Subtotal labor, equipment, bathymetry and materials cost	$ 392,848	$ 629,751	$ 707,189
Data management, analysis and reporting (note 5)	$ 169,087	$ 151,306	$ 162,402
Total monitoring cost for Post-Construction Event	$ 1,076,056	$ 1,208,269	$ 1,350,286

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	56.7	47.1	53.0	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	23	80	127	-
Bathymetry (note 4)	$ 30,152	$ 26,981	$ 28,960	$ -
Subtotal per event analytical cost (note 6)	$ 257,061	$ 854,426	$ 961,390	$ -
Subtotal per event labor, equipment and materials cost	$ 211,500	$ 667,424	$ 1,046,304	$ -
Data management, analysis and reporting (note 5)	$ 169,087	$ 151,306	$ 162,402	$ -
Total monitoring costs per event	$ 637,647	$ 1,673,155	$ 2,170,096	$ -

See Table I-31 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	2.4	2.6
Cost/Ac	$300,000	$100,000
Total repair cost per event	$706,371	$264,933

Notes:

1. See Table I-31 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-31 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/ acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-20 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 6R

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	274.5	27.6	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	220	44	-
Bathymetry (note 4)	$ 77,697	$ 19,572	$ -
Subtotal analytical cost	$ 2,490,128	$ 250,188	$ -
Subtotal labor, equipment, bathymetry and materials cost	$ 1,834,402	$ 372,571	$ -
Data management, analysis and reporting (note 5)	$ 435,715	$ 109,756	$ -
Total monitoring cost for Post-Construction Event	$ 4,760,245	$ 732,515	$ -

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	274.5	27.6	0.0	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	110	47	-	-
Bathymetry (note 4)	$ 77,697	$ 19,572	$ -	$ -
Subtotal per event analytical cost (note 6)	$ 1,245,064	$ 500,376	$ -	$ -
Subtotal per event labor, equipment and materials cost	$ 956,049	$ 394,633	$ -	$ -
Data management, analysis and reporting (note 5)	$ 435,715	$ 109,756	$ -	$ -
Total monitoring costs per event	$ 2,636,829	$ 1,004,766	$ -	$ -

See Table I-32 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.
2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.
3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).
4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.
5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.
6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	1.4	0.0
Cost/Ac	$300,000	$100,000
Total repair cost per event	$413,671	$0

Notes:

1. See Table I-32 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-32 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/ acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-21 MONITORING, OPERATION AND MAINTENANCE COSTS - ALTERNATIVE 6C

Post-Construction Performance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268
No. of chemical surface samples per acre	4	4	4
No. of locations for physical testing/inspection per acre	0	4	4
Remediation area (acres)	108.5	92.6	101.1
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	87	148	162
Bathymetry (note 4)	$ 44,532	$ 40,494	$ 42,674
Subtotal analytical cost	$ 984,758	$ 840,493	$ 917,238
Subtotal labor, equipment, bathymetry and materials cost	$ 739,246	$ 1,226,375	$ 1,336,837
Data management, analysis and reporting (note 5)	$ 249,728	$ 227,086	$ 239,309
Total monitoring cost for Post-Construction Event	$ 1,973,732	$ 2,293,953	$ 2,493,384

Operation and Maintenance Monitoring

Cost Parameter	Dredge	Cap and PDC	ENR	MNR
Analytical cost per sample (note 1)	$ 2,268	$ 2,268	$ 2,268	$ 2,268
No. of surface sediment samples per acre	2	2	4	4
No. of porewater samples per acre	0	2	4	0
No. of cores per acre	0	1	0	0
No. of samples for physical testing per acre	0	2	4	4
Remediation area (acre)	108.5	92.6	101.1	0.0
Daily labor, equipment, materials (note 2)	$ 8,000	$ 8,000	$ 8,000	$ 8,000
No. of monitoring days (note 3)	43	157	243	-
Bathymetry (note 4)	$ 44,532	$ 40,494	$ 42,674	$ -
Subtotal per event analytical cost (note 6)	$ 492,379	$ 1,680,986	$ 1,834,477	$ -
Subtotal per event labor, equipment and materials cost	$ 391,889	$ 1,300,492	$ 1,983,919	$ -
Data management, analysis and reporting (note 5)	$ 249,728	$ 227,086	$ 239,309	$ -
Total monitoring costs per event	$ 1,133,996	$ 3,208,564	$ 4,057,705	$ -

See Table I-33 and Appendix K for assumed Post-Construction Monitoring Frequency

Notes:

1. Analytical costs assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions.

2. "Daily labor, equipment, and materials" rate applies to surface sediment, porewater sampling, sediment cores, and physical or diver-assisted inspections based on the number of samples or stations.

3. Post Construction Monitoring days calculated assuming 5 locations per day: (total samples or locations/acre)*(acres) / (5 samples or locations/day). Operation and Maintenance Monitoring days also include 2 core locations per day: (total samples or locations/acre)*(acres)/(2 samples or locations/day).

4. Bathymetric costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = cost(site-wide) * (area A/418 acres)^0.6.

5. Data management, analysis and reporting costs calculated by scaling estimated per acre cost of $15,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = (cost) * (area A)^0.6.

6. Analytical cost assumes 4 samples per core.

Repair Costs - 5% of total area

	Cap and PDC	ENR
Area	4.6	5.1
Cost/Ac	$300,000	$100,000
Total repair cost per event	$1,389,704	$505,533

Notes:

1. See Table I-33 for repair frequency assumption. During implementation, repair frequency and scope would be determined based on monitoring results.
2. These repair costs are carried over to Table I-33 for PV analysis as part of O&M and monitoring cost development.
3. Costs per acre are based on the final costs for capping and ENR for the remedial alternatives (Tables I-38 through I-49). For ENR, $100,000/ acre approximately equals the capital cost for materials and labor. For capping, $300,000/acre is about 60% of the capital costs for materials and labor, using the assumption that cap repair could represent placement of less than 3 ft of material.

TABLE I-22 BASELINE AND LONG-TERM MONITORING

Monitoring Costs per Event

Surface Sediment		
Total Sediment Analytical Cost	$	285,830
Sample collection, data management, analysis, reporting, QC (50% of analytical)	$	142,915
Total cost per event	$	428,745

Tissue		
Total Tissue Analytical Cost	$	143,840
Sample collection, data management, analysis, reporting, QC (50% of analytical)	$	71,920
Total cost per event	$	215,760

Surface Water Quality		
Total Surface Water Analytical Cost	$	48,280
Sample collection, data management, analysis, reporting, QC (50% of analytical)	$	24,140
Total cost per event	$	72,420

Survey Costs per Event

Bathymetric Survey			
Bank-to-bank site-wide multi-beam bathymetric survey		$	100,000
Other Miscellaneous Surveys			
Benthic survey or other (scope to be defined) (cost per event)		$	250,000
	Total cost per event	$	350,000

Upstream Loading Sampling

One multi-media sampling event after site equilibrium is reached in sediment (cost proportional to the site-wide sampling event)	**Total cost per event**	$	600,000

Notes:

1. See Tables I-23 through I-33 for monitoring frequency for each remedial alternative, based on Appendix K.

2. Baseline monitoring to occur before construction in year 0. Long-term monitoring at intervals of 5, 10, and 15 years after the active portion of remedy is completed for alternatives that take 10 years or less to construct (Alternatives 2R, 2R-CAD 3R, 3C, 4C and 5C). Assume one additional sample round for Alternatives 4R, 5R, 5R-T, and 6C. Assume two additional sample rounds for Alternative 6R.

3. The purpose of baseline sampling is to establish surface sediment, tissue, and water quality conditions.

TABLE I-23a NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, AND LONG-TERM MONITORING - Alt 1

Year	Long-term Monitoring[a]					Annual Cost			Present Value Factor (2.3%)	Present Value[d]		
	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Agency Oversight[b]	Reporting[b]	Long-term Monitoring[c]		Agency Oversight	Reporting	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y	$200,000	$0	$1,666,925	1.00	$200,000	$0	$1,666,925
1						$100,000	$0	$0	0.98	$97,752	$0	$0
2						$100,000	$0	$0	0.96	$95,554	$0	$0
3		Y				$100,000	$0	$215,760	0.93	$93,406	$0	$201,532
4						$100,000	$0	$0	0.91	$91,306	$0	$0
5						$200,000	$250,000	$0	0.89	$178,506	$223,132	$0
6	Y	Y	Y		Y	$100,000	$0	$1,066,925	0.87	$87,246	$0	$930,851
7						$100,000	$0	$0	0.85	$85,285	$0	$0
8		Y				$100,000	$0	$215,760	0.83	$83,367	$0	$179,873
9						$100,000	$0	$0	0.81	$81,493	$0	$0
10						$200,000	$250,000	$0	0.80	$159,321	$199,152	$0
11	Y	Y	Y			$100,000	$0	$716,925	0.78	$77,870	$0	$558,267
12						$100,000	$0	$0	0.76	$76,119	$0	$0
13						$100,000	$0	$0	0.74	$74,408	$0	$0
14						$100,000	$0	$0	0.73	$72,735	$0	$0
15						$200,000	$250,000	$0	0.71	$142,199	$177,748	$0
16	Y	Y	Y			$100,000	$0	$716,925	0.70	$69,501	$0	$498,269
17						$100,000	$0	$0	0.68	$67,938	$0	$0
18						$100,000	$0	$0	0.66	$66,411	$0	$0
19						$100,000	$0	$0	0.65	$64,918	$0	$0
20						$200,000	$250,000	$0	0.63	$126,916	$158,645	$0
21	Y	Y	Y			$100,000	$0	$716,925	0.62	$62,031	$0	$444,719
22						$100,000	$0	$0	0.61	$60,637	$0	$0
23						$100,000	$0	$0	0.59	$59,273	$0	$0
24						$100,000	$0	$0	0.58	$57,941	$0	$0
25						$200,000	$250,000	$0	0.57	$113,276	$141,595	$0
26	Y	Y	Y	Y		$100,000	$0	$1,316,925	0.55	$55,365	$0	$729,113
27						$100,000	$0	$0	0.54	$54,120	$0	$0
28						$100,000	$0	$0	0.53	$52,903	$0	$0
29						$100,000	$0	$0	0.52	$51,714	$0	$0
30						$200,000	$250,000	$0	0.51	$101,102	$126,378	$0
Totals						$3,800,000	$1,500,000	$6,633,070		$2,760,610	$1,026,650	$5,209,547

Notes:

a. Monitoring frequencies are based on Appendix K.

b. See I-37 for assumptions.

c. Long-term monitoring costs per event are based on Table I-22.

d. Values equal to the annual cost times the present value factor.

TABLE I-23b NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, LONG-TERM MONITORING - Alt 2R

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$200,000	$250,000	$0	$0	$0	$0	$0	0.89	$178,506	$223,132	$0	$0	$0	$0	$0
6	Y	Y	Y		Y	Y	Y	Y	Y			$200,000	$0	$359,381	$132,713	$0	$3,115,387	$1,066,925	0.87	$174,492	$0	$313,546	$115,787	$0	$2,718,055	$930,851
7									Y			$200,000	$0	$0	$0	$0	$3,115,387	$0	0.85	$170,569	$0	$0	$0	$0	$2,656,945	$0
8		Y										$200,000	$0	$0	$0	$0	$0	$215,760	0.83	$166,734	$0	$0	$0	$0	$0	$179,873
9						Y	Y	Y	Y	Y	Y	$200,000	$0	$359,381	$184,194	$0	$3,115,387	$0	0.81	$162,986	$0	$292,870	$150,105	$0	$2,538,817	$0
10												$200,000	$250,000	$0	$0	$0	$0	$0	0.80	$159,321	$199,152	$0	$0	$0	$0	$0
11	Y	Y	Y						Y			$200,000	$0	$0	$0	$0	$3,115,387	$716,925	0.78	$155,739	$0	$0	$0	$0	$2,425,940	$558,267
12												$200,000	$0	$0	$0	$0	$0	$0	0.76	$152,238	$0	$0	$0	$0	$0	$0
13												$200,000	$0	$0	$0	$0	$0	$0	0.74	$148,815	$0	$0	$0	$0	$0	$0
14							Y	Y	Y	Y	Y	$200,000	$0	$0	$184,194	$0	$3,115,387	$0	0.73	$145,469	$0	$0	$133,973	$0	$2,265,965	$0
15												$200,000	$250,000	$0	$0	$0	$0	$0	0.71	$142,199	$177,748	$0	$0	$0	$0	$0
16	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.70	$139,002	$0	$0	$0	$0	$0	$498,269
17												$200,000	$0	$0	$0	$0	$0	$0	0.68	$135,876	$0	$0	$0	$0	$0	$0
18												$200,000	$0	$0	$0	$0	$0	$0	0.66	$132,822	$0	$0	$0	$0	$0	$0
19									Y			$200,000	$0	$0	$0	$0	$3,115,387	$0	0.65	$129,835	$0	$0	$0	$0	$2,022,437	$0
20												$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.62	$124,063	$0	$0	$0	$0	$0	$444,719
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23												$200,000	$0	$0	$0	$0	$0	$0	0.59	$118,547	$0	$0	$0	$0	$0	$0
24									Y			$200,000	$0	$0	$0	$0	$3,115,387	$0	0.58	$115,882	$0	$0	$0	$0	$1,805,082	$0
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.55	$110,730	$0	$0	$0	$0	$0	$729,113
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28												$200,000	$0	$0	$0	$0	$0	$0	0.53	$105,806	$0	$0	$0	$0	$0	$0
29												$200,000	$0	$0	$0	$0	$0	$0	0.52	$103,428	$0	$0	$0	$0	$0	$0
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$8,700,000	$1,750,000	$718,763	$501,101	$0	$21,807,711	$6,633,070		$6,889,985	$1,265,659	$606,416	$399,864	$0	$16,433,240	$5,209,547

Notes:

a. Costs from the start of construction. Construction years are shaded.
b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.
c. See I-37 for assumptions.
d. O&M monitoring and repair costs per event are based on Table I-11.
e. Long-term monitoring costs per event are based on Table I-22.
f. Values equal to the annual cost times the present value factor.

TABLE I-24 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING- Alt 2R-CAD

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$200,000	$250,000	$0	$0	$0	$0	$0	0.89	$178,506	$223,132	$0	$0	$0	$0	$0
6	Y	Y	Y		Y	Y	Y	Y	Y			$200,000	$0	$359,381	$999,720	$0	$3,115,387	$1,066,925	0.87	$174,492	$0	$313,546	$872,217	$0	$2,718,055	$930,851
7									Y			$200,000	$0	$0	$0	$0	$3,115,387	$0	0.85	$170,569	$0	$0	$0	$0	$2,656,945	$0
8		Y										$200,000	$0	$0	$0	$0	$0	$215,760	0.83	$166,734	$0	$0	$0	$0	$0	$179,873
9						Y	Y	Y	Y	Y	Y	$200,000	$0	$359,381	$1,411,201	$0	$3,115,387	$0	0.81	$162,986	$0	$292,870	$1,150,027	$0	$2,538,817	$0
10												$200,000	$250,000	$0	$0	$0	$0	$0	0.80	$159,321	$199,152	$0	$0	$0	$0	$0
11	Y	Y	Y						Y			$200,000	$0	$0	$0	$0	$3,115,387	$716,925	0.78	$155,739	$0	$0	$0	$0	$2,425,940	$558,267
12												$200,000	$0	$0	$0	$0	$0	$0	0.76	$152,238	$0	$0	$0	$0	$0	$0
13												$200,000	$0	$0	$0	$0	$0	$0	0.74	$148,815	$0	$0	$0	$0	$0	$0
14							Y	Y	Y	Y	Y	$200,000	$0	$0	$1,411,201	$0	$3,115,387	$0	0.73	$145,469	$0	$0	$1,026,431	$0	$2,265,965	$0
15												$200,000	$250,000	$0	$0	$0	$0	$0	0.71	$142,199	$177,748	$0	$0	$0	$0	$0
16	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.70	$139,002	$0	$0	$0	$0	$0	$498,269
17												$200,000	$0	$0	$0	$0	$0	$0	0.68	$135,876	$0	$0	$0	$0	$0	$0
18												$200,000	$0	$0	$0	$0	$0	$0	0.66	$132,822	$0	$0	$0	$0	$0	$0
19									Y			$200,000	$0	$0	$0	$0	$3,115,387	$0	0.65	$129,835	$0	$0	$0	$0	$2,022,437	$0
20												$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.62	$124,063	$0	$0	$0	$0	$0	$444,719
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23												$200,000	$0	$0	$0	$0	$0	$0	0.59	$118,547	$0	$0	$0	$0	$0	$0
24									Y			$200,000	$0	$0	$0	$0	$3,115,387	$0	0.58	$115,882	$0	$0	$0	$0	$1,805,082	$0
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.55	$110,730	$0	$0	$0	$0	$0	$729,113
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28												$200,000	$0	$0	$0	$0	$0	$0	0.53	$105,806	$0	$0	$0	$0	$0	$0
29												$200,000	$0	$0	$0	$0	$0	$0	0.52	$103,428	$0	$0	$0	$0	$0	$0
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$8,700,000	$1,750,000	$718,763	$3,822,121	$0	$21,807,711	$6,633,070		$6,889,985	$1,265,659	$606,416	$3,048,675	$0	$16,433,240	$5,209,547

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-12.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-25 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING- Alt 3R

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$200,000	$0	$0	$0	$0	$0	$0	0.85	$170,569	$0	$0	$0	$0	$0	$0
8	Y	Y	Y		Y	Y	Y	Y	Y			$200,000	$0	$574,471	$298,043	$0	$2,442,613	$1,066,925	0.83	$166,734	$0	$478,920	$248,470	$0	$2,036,337	$889,465
9									Y			$200,000	$0	$0	$0	$0	$2,442,613	$0	0.81	$162,986	$0	$0	$0	$0	$1,990,554	$0
10		Y										$200,000	$250,000	$0	$0	$0	$0	$215,760	0.80	$159,321	$199,152	$0	$0	$0	$0	$171,876
11						Y	Y	Y	Y	Y	Y	$200,000	$0	$574,471	$410,853	$0	$2,442,613	$0	0.78	$155,739	$0	$447,338	$319,930	$0	$1,902,054	$0
12												$200,000	$0	$0	$0	$0	$0	$0	0.76	$152,238	$0	$0	$0	$0	$0	$0
13	Y	Y	Y						Y			$200,000	$0	$0	$0	$0	$2,442,613	$716,925	0.74	$148,815	$0	$0	$0	$0	$1,817,488	$533,446
14												$200,000	$0	$0	$0	$0	$0	$0	0.73	$145,469	$0	$0	$0	$0	$0	$0
15												$200,000	$250,000	$0	$0	$0	$0	$0	0.71	$142,199	$177,748	$0	$0	$0	$0	$0
16							Y	Y	Y	Y	Y	$200,000	$0	$0	$410,853	$0	$2,442,613	$0	0.70	$139,002	$0	$0	$285,546	$0	$1,697,636	$0
17												$200,000	$0	$0	$0	$0	$0	$0	0.68	$135,876	$0	$0	$0	$0	$0	$0
18	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.66	$132,822	$0	$0	$0	$0	$0	$476,115
19												$200,000	$0	$0	$0	$0	$0	$0	0.65	$129,835	$0	$0	$0	$0	$0	$0
20												$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21									Y			$200,000	$0	$0	$0	$0	$2,442,613	$0	0.62	$124,063	$0	$0	$0	$0	$1,515,188	$0
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.59	$118,547	$0	$0	$0	$0	$0	$424,946
24												$200,000	$0	$0	$0	$0	$0	$0	0.58	$115,882	$0	$0	$0	$0	$0	$0
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26									Y			$200,000	$0	$0	$0	$0	$2,442,613	$0	0.55	$110,730	$0	$0	$0	$0	$1,352,347	$0
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.53	$105,806	$0	$0	$0	$0	$0	$696,696
29												$200,000	$0	$0	$0	$0	$0	$0	0.52	$103,428	$0	$0	$0	$0	$0	$0
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$9,700,000	$1,850,000	$1,148,941	$1,119,750	$0	$17,098,294	$6,633,070		$7,772,480	$1,353,908	$926,258	$853,946	$0	$12,311,604	$5,061,002

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-13.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-26 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING- Alt 3C

2.3%

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost								Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$200,000	$0	$0	$0	$0	$0	$0	0.91	$182,611	$0	$0	$0	$0	$0	$0
5	Y	Y	Y		Y	Y	Y	Y	Y			$200,000	$250,000	$353,718	$730,219	$423,172	$2,442,613	$1,066,925	0.89	$178,506	$223,132	$315,703	$651,741	$377,693	$2,180,101	$952,260
6									Y			$200,000	$0	$0	$0	$0	$2,442,613	$0	0.87	$174,492	$0	$0	$0	$0	$2,131,086	$0
7		Y										$200,000	$0	$0	$0	$0	$0	$215,760	0.85	$170,569	$0	$0	$0	$0	$0	$184,010
8						Y	Y	Y	Y	Y	Y	$200,000	$0	$353,718	$1,025,363	$470,693	$2,442,613	$0	0.83	$166,734	$0	$294,885	$854,816	$392,403	$2,036,337	$0
9												$200,000	$0	$0	$0	$0	$0	$0	0.81	$162,986	$0	$0	$0	$0	$0	$0
10	Y	Y	Y						Y			$200,000	$250,000	$0	$0	$0	$2,442,613	$716,925	0.80	$159,321	$199,152	$0	$0	$0	$1,945,801	$571,107
11												$200,000	$0	$0	$0	$0	$0	$0	0.78	$155,739	$0	$0	$0	$0	$0	$0
12												$200,000	$0	$0	$0	$0	$0	$0	0.76	$152,238	$0	$0	$0	$0	$0	$0
13							Y	Y	Y	Y	Y	$200,000	$0	$0	$1,025,363	$470,693	$2,442,613	$0	0.74	$148,815	$0	$0	$762,947	$350,231	$1,817,488	$0
14												$200,000	$0	$0	$0	$0	$0	$0	0.73	$145,469	$0	$0	$0	$0	$0	$0
15	Y	Y	Y									$200,000	$250,000	$0	$0	$0	$0	$716,925	0.71	$142,199	$177,748	$0	$0	$0	$0	$509,729
16												$200,000	$0	$0	$0	$0	$0	$0	0.70	$139,002	$0	$0	$0	$0	$0	$0
17												$200,000	$0	$0	$0	$0	$0	$0	0.68	$135,876	$0	$0	$0	$0	$0	$0
18									Y			$200,000	$0	$0	$0	$0	$2,442,613	$0	0.66	$132,822	$0	$0	$0	$0	$1,622,159	$0
19												$200,000	$0	$0	$0	$0	$0	$0	0.65	$129,835	$0	$0	$0	$0	$0	$0
20	Y	Y	Y									$200,000	$250,000	$0	$0	$0	$0	$716,925	0.63	$126,916	$158,645	$0	$0	$0	$0	$454,947
21												$200,000	$0	$0	$0	$0	$0	$0	0.62	$124,063	$0	$0	$0	$0	$0	$0
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23									Y			$200,000	$0	$0	$0	$0	$2,442,613	$0	0.59	$118,547	$0	$0	$0	$0	$1,447,822	$0
24												$200,000	$0	$0	$0	$0	$0	$0	0.58	$115,882	$0	$0	$0	$0	$0	$0
25	Y	Y	Y	Y								$200,000	$250,000	$0	$0	$0	$0	$1,316,925	0.57	$113,276	$141,595	$0	$0	$0	$0	$745,882
26												$200,000	$0	$0	$0	$0	$0	$0	0.55	$110,730	$0	$0	$0	$0	$0	$0
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28												$200,000	$0	$0	$0	$0	$0	$0	0.53	$105,806	$0	$0	$0	$0	$0	$0
29												$200,000	$0	$0	$0	$0	$0	$0	0.52	$103,428	$0	$0	$0	$0	$0	$0
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$8,200,000	$1,700,000	$707,436	$2,780,945	$1,364,558	$17,098,294	$6,633,070		$6,433,457	$1,220,006	$610,588	$2,269,504	$1,120,327	$13,180,793	$5,286,393

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-14.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-27 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING - Alt 4R

2.3%

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost								Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$700,000	$50,000	$0	$0	$0	$0	$0	0.85	$596,992	$42,642	$0	$0	$0	$0	$0
8	Y	Y	Y		Y							$700,000	$50,000	$0	$0	$0	$0	$1,066,925	0.83	$583,570	$41,684	$0	$0	$0	$0	$889,465
9												$700,000	$50,000	$0	$0	$0	$0	$0	0.81	$570,450	$40,746	$0	$0	$0	$0	$0
10												$700,000	$300,000	$0	$0	$0	$0	$0	0.80	$557,624	$238,982	$0	$0	$0	$0	$0
11												$700,000	$50,000	$0	$0	$0	$0	$0	0.78	$545,087	$38,935	$0	$0	$0	$0	$0
12												$200,000	$0	$0	$0	$0	$0	$0	0.76	$152,238	$0	$0	$0	$0	$0	$0
13	Y	Y	Y			Y	Y	Y	Y			$200,000	$0	$989,838	$522,677	$0	$1,272,220	$716,925	0.74	$148,815	$0	$736,514	$388,911	$0	$946,628	$533,446
14									Y			$200,000	$0	$0	$0	$0	$1,272,220	$0	0.73	$145,469	$0	$0	$0	$0	$925,345	$0
15		Y										$200,000	$250,000	$0	$0	$0	$0	$215,760	0.71	$142,199	$177,748	$0	$0	$0	$0	$153,404
16						Y	Y	Y	Y	Y	Y	$200,000	$0	$989,838	$729,358	$0	$1,272,220	$0	0.70	$139,002	$0	$687,946	$506,910	$0	$884,203	$0
17												$200,000	$0	$0	$0	$0	$0	$0	0.68	$135,876	$0	$0	$0	$0	$0	$0
18	Y	Y	Y						Y			$200,000	$0	$0	$0	$0	$1,272,220	$716,925	0.66	$132,822	$0	$0	$0	$0	$844,892	$476,115
19												$200,000	$0	$0	$0	$0	$0	$0	0.65	$129,835	$0	$0	$0	$0	$0	$0
20												$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21							Y	Y	Y	Y	Y	$200,000	$0	$0	$729,358	$0	$1,272,220	$0	0.62	$124,063	$0	$0	$452,431	$0	$789,176	$0
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.59	$118,547	$0	$0	$0	$0	$0	$424,946
24												$200,000	$0	$0	$0	$0	$0	$0	0.58	$115,882	$0	$0	$0	$0	$0	$0
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26												$200,000	$0	$0	$0	$0	$0	$0	0.55	$110,730	$0	$0	$0	$0	$0	$0
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.53	$105,806	$0	$0	$0	$0	$0	$696,696
29												$200,000	$0	$0	$0	$0	$0	$0	0.52	$103,428	$0	$0	$0	$0	$0	$0
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$12,200,000	$2,100,000	$1,979,677	$1,981,393	$0	$6,361,102	$6,633,070		$9,810,854	$1,557,746	$1,424,460	$1,348,252	$0	$4,390,243	$5,042,530

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-15.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-28 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING - Alt 4C

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$200,000	$0	$0	$0	$0	$0	$0	0.85	$170,569	$0	$0	$0	$0	$0	$0
8	Y	Y	Y		Y	Y	Y	Y	Y			$200,000	$0	$568,186	$1,464,585	$706,575	$1,272,220	$1,066,925	0.83	$166,734	$0	$473,681	$1,220,983	$589,052	$1,060,614	$889,465
9									Y			$200,000	$0	$0	$0	$0	$1,272,220	$0	0.81	$162,986	$0	$0	$0	$0	$1,036,768	$0
10		Y										$200,000	$250,000	$0	$0	$0	$0	$215,760	0.80	$159,321	$199,152	$0	$0	$0	$0	$171,876
11						Y	Y	Y	Y	Y	Y	$200,000	$0	$568,186	$2,079,151	$788,508	$1,272,220	$0	0.78	$155,739	$0	$442,444	$1,619,027	$614,008	$990,673	$0
12												$200,000	$0	$0	$0	$0	$0	$0	0.76	$152,238	$0	$0	$0	$0	$0	$0
13	Y	Y	Y						Y			$200,000	$0	$0	$0	$0	$1,272,220	$716,925	0.74	$148,815	$0	$0	$0	$0	$946,628	$533,446
14												$200,000	$0	$0	$0	$0	$0	$0	0.73	$145,469	$0	$0	$0	$0	$0	$0
15												$200,000	$250,000	$0	$0	$0	$0	$0	0.71	$142,199	$177,748	$0	$0	$0	$0	$0
16							Y	Y	Y	Y	Y	$200,000	$0	$0	$2,079,151	$788,508	$1,272,220	$0	0.70	$139,002	$0	$0	$1,445,027	$548,020	$884,203	$0
17												$200,000	$0	$0	$0	$0	$0	$0	0.68	$135,876	$0	$0	$0	$0	$0	$0
18	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.66	$132,822	$0	$0	$0	$0	$0	$476,115
19												$200,000	$0	$0	$0	$0	$0	$0	0.65	$129,835	$0	$0	$0	$0	$0	$0
20												$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21												$200,000	$0	$0	$0	$0	$0	$0	0.62	$124,063	$0	$0	$0	$0	$0	$0
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.59	$118,547	$0	$0	$0	$0	$0	$424,946
24												$200,000	$0	$0	$0	$0	$0	$0	0.58	$115,882	$0	$0	$0	$0	$0	$0
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26												$200,000	$0	$0	$0	$0	$0	$0	0.55	$110,730	$0	$0	$0	$0	$0	$0
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.53	$105,806	$0	$0	$0	$0	$0	$696,696
29												$200,000	$0	$0	$0	$0	$0	$0	0.52	$103,428	$0	$0	$0	$0	$0	$0
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$9,700,000	$1,850,000	$1,136,372	$5,622,887	$2,283,591	$6,361,102	$6,633,070		$7,772,480	$1,353,908	$916,125	$4,285,036	$1,751,079	$4,918,886	$5,061,002

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-16.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-29 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING - Alt 5R

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$700,000	$50,000	$0	$0	$0	$0	$0	0.85	$596,992	$42,642	$0	$0	$0	$0	$0
8	Y	Y	Y		Y							$700,000	$50,000	$0	$0	$0	$0	$1,066,925	0.83	$583,570	$41,684	$0	$0	$0	$0	$889,465
9												$700,000	$50,000	$0	$0	$0	$0	$0	0.81	$570,450	$40,746	$0	$0	$0	$0	$0
10												$700,000	$300,000	$0	$0	$0	$0	$0	0.80	$557,624	$238,982	$0	$0	$0	$0	$0
11												$700,000	$50,000	$0	$0	$0	$0	$0	0.78	$545,087	$38,935	$0	$0	$0	$0	$0
12												$700,000	$50,000	$0	$0	$0	$0	$0	0.76	$532,832	$38,059	$0	$0	$0	$0	$0
13	Y	Y	Y									$700,000	$50,000	$0	$0	$0	$0	$716,925	0.74	$520,853	$37,204	$0	$0	$0	$0	$533,446
14												$700,000	$50,000	$0	$0	$0	$0	$0	0.73	$509,142	$36,367	$0	$0	$0	$0	$0
15												$700,000	$300,000	$0	$0	$0	$0	$0	0.71	$497,695	$213,298	$0	$0	$0	$0	$0
16												$700,000	$50,000	$0	$0	$0	$0	$0	0.70	$486,506	$34,750	$0	$0	$0	$0	$0
17												$700,000	$50,000	$0	$0	$0	$0	$0	0.68	$475,568	$33,969	$0	$0	$0	$0	$0
18												$200,000	$0	$0	$0	$0	$0	$0	0.66	$132,822	$0	$0	$0	$0	$0	$0
19	Y	Y	Y			Y	Y	Y	Y			$200,000	$0	$1,454,426	$517,711	$0	$0	$716,925	0.65	$129,835	$0	$944,179	$336,086	$0	$0	$465,411
20									Y			$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21		Y										$200,000	$0	$0	$0	$0	$0	$215,760	0.62	$124,063	$0	$0	$0	$0	$0	$133,839
22						Y	Y	Y	Y	Y	Y	$200,000	$0	$1,454,426	$722,291	$0	$0	$0	0.61	$121,274	$0	$881,917	$437,974	$0	$0	$0
23												$200,000	$0	$0	$0	$0	$0	$0	0.59	$118,547	$0	$0	$0	$0	$0	$0
24	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.58	$115,882	$0	$0	$0	$0	$0	$415,392
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26												$200,000	$0	$0	$0	$0	$0	$0	0.55	$110,730	$0	$0	$0	$0	$0	$0
27										Y	Y	$200,000	$0	$0	$204,580	$0	$0	$0	0.54	$108,240	$0	$0	$110,719	$0	$0	$0
28												$200,000	$0	$0	$0	$0	$0	$0	0.53	$105,806	$0	$0	$0	$0	$0	$0
29	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.52	$103,428	$0	$0	$0	$0	$0	$681,032
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$15,200,000	$2,400,000	$2,908,851	$1,444,582	$0	$0	$6,633,070		$11,969,851	$1,773,645	$1,826,096	$884,778	$0	$0	$4,987,043

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-17.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-30 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING - Alt 5R-Treatment

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$700,000	$50,000	$0	$0	$0	$0	$0	0.85	$596,992	$42,642	$0	$0	$0	$0	$0
8	Y	Y	Y		Y							$700,000	$50,000	$0	$0	$0	$0	$1,066,925	0.83	$583,570	$41,684	$0	$0	$0	$0	$889,465
9												$700,000	$50,000	$0	$0	$0	$0	$0	0.81	$570,450	$40,746	$0	$0	$0	$0	$0
10												$700,000	$300,000	$0	$0	$0	$0	$0	0.80	$557,624	$238,982	$0	$0	$0	$0	$0
11												$700,000	$50,000	$0	$0	$0	$0	$0	0.78	$545,087	$38,935	$0	$0	$0	$0	$0
12												$700,000	$50,000	$0	$0	$0	$0	$0	0.76	$532,832	$38,059	$0	$0	$0	$0	$0
13	Y	Y	Y									$700,000	$50,000	$0	$0	$0	$0	$716,925	0.74	$520,853	$37,204	$0	$0	$0	$0	$533,446
14												$700,000	$50,000	$0	$0	$0	$0	$0	0.73	$509,142	$36,367	$0	$0	$0	$0	$0
15												$700,000	$300,000	$0	$0	$0	$0	$0	0.71	$497,695	$213,298	$0	$0	$0	$0	$0
16												$700,000	$50,000	$0	$0	$0	$0	$0	0.70	$486,506	$34,750	$0	$0	$0	$0	$0
17												$700,000	$50,000	$0	$0	$0	$0	$0	0.68	$475,568	$33,969	$0	$0	$0	$0	$0
18												$200,000	$0	$0	$0	$0	$0	$0	0.66	$132,822	$0	$0	$0	$0	$0	$0
19	Y	Y	Y			Y	Y	Y	Y			$200,000	$0	$1,454,426	$517,711	$0	$0	$716,925	0.65	$129,835	$0	$944,179	$336,086	$0	$0	$465,411
20									Y			$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21		Y										$200,000	$0	$0	$0	$0	$0	$215,760	0.62	$124,063	$0	$0	$0	$0	$0	$133,839
22						Y	Y	Y	Y	Y	Y	$200,000	$0	$1,454,426	$722,291	$0	$0	$0	0.61	$121,274	$0	$881,917	$437,974	$0	$0	$0
23												$200,000	$0	$0	$0	$0	$0	$0	0.59	$118,547	$0	$0	$0	$0	$0	$0
24	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.58	$115,882	$0	$0	$0	$0	$0	$415,392
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26												$200,000	$0	$0	$0	$0	$0	$0	0.55	$110,730	$0	$0	$0	$0	$0	$0
27										Y	Y	$200,000	$0	$0	$204,580	$0	$0	$0	0.54	$108,240	$0	$0	$110,719	$0	$0	$0
28												$200,000	$0	$0	$0	$0	$0	$0	0.53	$105,806	$0	$0	$0	$0	$0	$0
29	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.52	$103,428	$0	$0	$0	$0	$0	$681,032
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$15,200,000	$2,400,000	$2,908,851	$1,444,582	$0	$0	$6,633,070		$11,969,851	$1,773,645	$1,826,096	$884,778	$0	$0	$4,987,043

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-18.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-31 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING - Alt 5C

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$700,000	$50,000	$0	$0	$0	$0	$0	0.85	$596,992	$42,642	$0	$0	$0	$0	$0
8												$200,000	$0	$0	$0	$0	$0	$0	0.83	$166,734	$0	$0	$0	$0	$0	$0
9	Y	Y	Y		Y	Y	Y	Y	Y			$200,000	$0	$637,647	$1,673,155	$2,170,096	$0	$1,066,925	0.81	$162,986	$0	$519,637	$1,363,501	$1,768,473	$0	$869,467
10									Y			$200,000	$250,000	$0	$0	$0	$0	$0	0.80	$159,321	$199,152	$0	$0	$0	$0	$0
11		Y										$200,000	$0	$0	$0	$0	$0	$215,760	0.78	$155,739	$0	$0	$0	$0	$0	$168,011
12						Y	Y	Y	Y	Y	Y	$200,000	$0	$637,647	$2,379,526	$2,435,030	$0	$0	0.76	$152,238	$0	$485,370	$1,811,269	$1,853,517	$0	$0
13												$200,000	$0	$0	$0	$0	$0	$0	0.74	$148,815	$0	$0	$0	$0	$0	$0
14	Y	Y	Y						Y			$200,000	$0	$0	$0	$0	$0	$716,925	0.73	$145,469	$0	$0	$0	$0	$0	$521,453
15												$200,000	$250,000	$0	$0	$0	$0	$0	0.71	$142,199	$177,748	$0	$0	$0	$0	$0
16												$200,000	$0	$0	$0	$0	$0	$0	0.70	$139,002	$0	$0	$0	$0	$0	$0
17							Y	Y	Y	Y	Y	$200,000	$0	$0	$2,379,526	$2,435,030	$0	$0	0.68	$135,876	$0	$0	$1,616,608	$1,654,316	$0	$0
18												$200,000	$0	$0	$0	$0	$0	$0	0.66	$132,822	$0	$0	$0	$0	$0	$0
19	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.65	$129,835	$0	$0	$0	$0	$0	$465,411
20												$200,000	$250,000	$0	$0	$0	$0	$0	0.63	$126,916	$158,645	$0	$0	$0	$0	$0
21												$200,000	$0	$0	$0	$0	$0	$0	0.62	$124,063	$0	$0	$0	$0	$0	$0
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23												$200,000	$0	$0	$0	$0	$0	$0	0.59	$118,547	$0	$0	$0	$0	$0	$0
24	Y	Y	Y									$200,000	$0	$0	$0	$0	$0	$716,925	0.58	$115,882	$0	$0	$0	$0	$0	$415,392
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26												$200,000	$0	$0	$0	$0	$0	$0	0.55	$110,730	$0	$0	$0	$0	$0	$0
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28												$200,000	$0	$0	$0	$0	$0	$0	0.53	$105,806	$0	$0	$0	$0	$0	$0
29	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.52	$103,428	$0	$0	$0	$0	$0	$681,032
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$10,200,000	$1,900,000	$1,275,294	$6,432,207	$7,040,156	$0	$6,633,070		$8,198,903	$1,396,551	$1,005,006	$4,791,378	$5,276,306	$0	$4,989,224

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-19.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-32 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M,AND LONG-TERM MONITORING - Alt 6R

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$700,000	$50,000	$0	$0	$0	$0	$0	0.85	$596,992	$42,642	$0	$0	$0	$0	$0
8	Y	Y	Y		Y							$700,000	$50,000	$0	$0	$0	$0	$1,066,925	0.83	$583,570	$41,684	$0	$0	$0	$0	$889,465
9												$700,000	$50,000	$0	$0	$0	$0	$0	0.81	$570,450	$40,746	$0	$0	$0	$0	$0
10												$700,000	$300,000	$0	$0	$0	$0	$0	0.80	$557,624	$238,982	$0	$0	$0	$0	$0
11												$700,000	$50,000	$0	$0	$0	$0	$0	0.78	$545,087	$38,935	$0	$0	$0	$0	$0
12												$700,000	$50,000	$0	$0	$0	$0	$0	0.76	$532,832	$38,059	$0	$0	$0	$0	$0
13	Y	Y	Y									$700,000	$50,000	$0	$0	$0	$0	$716,925	0.74	$520,853	$37,204	$0	$0	$0	$0	$533,446
14												$700,000	$50,000	$0	$0	$0	$0	$0	0.73	$509,142	$36,367	$0	$0	$0	$0	$0
15												$700,000	$300,000	$0	$0	$0	$0	$0	0.71	$497,695	$213,298	$0	$0	$0	$0	$0
16												$700,000	$50,000	$0	$0	$0	$0	$0	0.70	$486,506	$34,750	$0	$0	$0	$0	$0
17												$700,000	$50,000	$0	$0	$0	$0	$0	0.68	$475,568	$33,969	$0	$0	$0	$0	$0
18	Y	Y	Y									$700,000	$50,000	$0	$0	$0	$0	$716,925	0.66	$464,875	$33,205	$0	$0	$0	$0	$476,115
19												$700,000	$50,000	$0	$0	$0	$0	$0	0.65	$454,424	$32,459	$0	$0	$0	$0	$0
20												$700,000	$300,000	$0	$0	$0	$0	$0	0.63	$444,207	$190,374	$0	$0	$0	$0	$0
21												$700,000	$50,000	$0	$0	$0	$0	$0	0.62	$434,220	$31,016	$0	$0	$0	$0	$0
22												$700,000	$50,000	$0	$0	$0	$0	$0	0.61	$424,457	$30,318	$0	$0	$0	$0	$0
23												$700,000	$50,000	$0	$0	$0	$0	$0	0.59	$414,914	$29,637	$0	$0	$0	$0	$0
24												$700,000	$50,000	$0	$0	$0	$0	$0	0.58	$405,586	$28,970	$0	$0	$0	$0	$0
25												$700,000	$300,000	$0	$0	$0	$0	$0	0.57	$396,467	$169,914	$0	$0	$0	$0	$0
26												$700,000	$50,000	$0	$0	$0	$0	$0	0.55	$387,553	$27,682	$0	$0	$0	$0	$0
27												$700,000	$50,000	$0	$0	$0	$0	$0	0.54	$378,840	$27,060	$0	$0	$0	$0	$0
28	Y	Y	Y									$700,000	$50,000	$0	$0	$0	$0	$716,925	0.53	$370,323	$26,452	$0	$0	$0	$0	$379,277
29												$700,000	$50,000	$0	$0	$0	$0	$0	0.52	$361,997	$25,857	$0	$0	$0	$0	$0
30												$700,000	$300,000	$0	$0	$0	$0	$0	0.51	$353,858	$151,653	$0	$0	$0	$0	$0

TABLE I-32 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M,AND LONG-TERM MONITORING - Alt 6R

2.3%

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost								Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
31												$700,000	$50,000	$0	$0	$0	$0	$0	0.49	$345,902	$24,707	$0	$0	$0	$0	$0
32												$700,000	$50,000	$0	$0	$0	$0	$0	0.48	$338,125	$24,152	$0	$0	$0	$0	$0
33												$700,000	$50,000	$0	$0	$0	$0	$0	0.47	$330,523	$23,609	$0	$0	$0	$0	$0
34												$700,000	$50,000	$0	$0	$0	$0	$0	0.46	$323,092	$23,078	$0	$0	$0	$0	$0
35												$700,000	$300,000	$0	$0	$0	$0	$0	0.45	$315,828	$135,355	$0	$0	$0	$0	$0
36												$700,000	$50,000	$0	$0	$0	$0	$0	0.44	$308,727	$22,052	$0	$0	$0	$0	$0
37												$700,000	$50,000	$0	$0	$0	$0	$0	0.43	$301,786	$21,556	$0	$0	$0	$0	$0
38	Y	Y	Y									$700,000	$50,000	$0	$0	$0	$0	$716,925	0.42	$295,001	$21,072	$0	$0	$0	$0	$302,134
39												$700,000	$50,000	$0	$0	$0	$0	$0	0.41	$288,369	$20,598	$0	$0	$0	$0	$0
40												$700,000	$300,000	$0	$0	$0	$0	$0	0.40	$281,885	$120,808	$0	$0	$0	$0	$0
41												$700,000	$50,000	$0	$0	$0	$0	$0	0.39	$275,548	$19,682	$0	$0	$0	$0	$0
42												$700,000	$50,000	$0	$0	$0	$0	$0	0.38	$269,353	$19,239	$0	$0	$0	$0	$0
43												$200,000	$0	$0	$0	$0	$0	$0	0.38	$75,228	$0	$0	$0	$0	$0	$0
44	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.37	$73,536	$0	$0	$0	$0	$0	$484,209
45												$200,000	$250,000	$0	$0	$0	$0	$0	0.36	$71,883	$89,854	$0	$0	$0	$0	$0
46												$0	$0	$0	$0	$0	$0	$0	0.35	$0	$0	$0	$0	$0	$0	$0
47												$0	$0	$0	$0	$0	$0	$0	0.34	$0	$0	$0	$0	$0	$0	$0
48												$0	$0	$0	$0	$0	$0	$0	0.34	$0	$0	$0	$0	$0	$0	$0
49												$0	$0	$0	$0	$0	$0	$0	0.33	$0	$0	$0	$0	$0	$0	$0
50												$0	$0	$0	$0	$0	$0	$0	0.32	$0	$0	$0	$0	$0	$0	$0
Totals												$30,700,000	$4,400,000	$0	$0	$0	$0	$7,134,235		$19,644,440	$2,717,387	$0	$0	$0	$0	$4,933,103

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging), and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-20.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-33 NET PRESENT VALUE CALCULATION FOR AGENCY OVERSIGHT, REPORTING, O&M, AND LONG-TERM MONITORING - Alt 6C

	Long-term Monitoring[b]					O&M Monitoring[b]				O&M Repair[b]		Annual Cost							2.3%	Present Value[f]						
Year[a]	Surface Sediment	Tissue	Surface Water	Upstream	Bathymetry and Other Surveys	Dredge	Cap & PDC	ENR	MNR	Cap & PDC	ENR	Agency Oversight[c]	Reporting[c]	O&M Dredging[d]	O&M Cap & PDC[d]	O&M ENR[d]	O&M MNR[d]	Long-term Monitoring[e]	Present Value Factor	Agency Oversight	Reporting	O&M Dredging	O&M Cap	O&M ENR	O&M MNR	Long-Term Monitoring
0 (baseline)	Y	Y	Y	Y	Y							$700,000	$50,000	$0	$0	$0	$0	$1,666,925	1.00	$700,000	$50,000	$0	$0	$0	$0	$1,666,925
1												$700,000	$50,000	$0	$0	$0	$0	$0	0.98	$684,262	$48,876	$0	$0	$0	$0	$0
2												$700,000	$50,000	$0	$0	$0	$0	$0	0.96	$668,878	$47,777	$0	$0	$0	$0	$0
3		Y										$700,000	$50,000	$0	$0	$0	$0	$215,760	0.93	$653,839	$46,703	$0	$0	$0	$0	$201,532
4												$700,000	$50,000	$0	$0	$0	$0	$0	0.91	$639,139	$45,653	$0	$0	$0	$0	$0
5												$700,000	$300,000	$0	$0	$0	$0	$0	0.89	$624,770	$267,758	$0	$0	$0	$0	$0
6												$700,000	$50,000	$0	$0	$0	$0	$0	0.87	$610,723	$43,623	$0	$0	$0	$0	$0
7												$700,000	$50,000	$0	$0	$0	$0	$0	0.85	$596,992	$42,642	$0	$0	$0	$0	$0
8	Y	Y	Y		Y							$700,000	$50,000	$0	$0	$0	$0	$1,066,925	0.83	$583,570	$41,684	$0	$0	$0	$0	$889,465
9												$700,000	$50,000	$0	$0	$0	$0	$0	0.81	$570,450	$40,746	$0	$0	$0	$0	$0
10												$700,000	$300,000	$0	$0	$0	$0	$0	0.80	$557,624	$238,982	$0	$0	$0	$0	$0
11												$700,000	$50,000	$0	$0	$0	$0	$0	0.78	$545,087	$38,935	$0	$0	$0	$0	$0
12												$700,000	$50,000	$0	$0	$0	$0	$0	0.76	$532,832	$38,059	$0	$0	$0	$0	$0
13	Y	Y	Y									$700,000	$50,000	$0	$0	$0	$0	$716,925	0.74	$520,853	$37,204	$0	$0	$0	$0	$533,446
14												$700,000	$50,000	$0	$0	$0	$0	$0	0.73	$509,142	$36,367	$0	$0	$0	$0	$0
15												$700,000	$300,000	$0	$0	$0	$0	$0	0.71	$497,695	$213,298	$0	$0	$0	$0	$0
16												$700,000	$50,000	$0	$0	$0	$0	$0	0.70	$486,506	$34,750	$0	$0	$0	$0	$0
17												$700,000	$50,000	$0	$0	$0	$0	$0	0.68	$475,568	$33,969	$0	$0	$0	$0	$0
18	Y	Y	Y			Y	Y	Y	Y			$700,000	$50,000	$1,133,996	$3,208,564	$4,057,705	$0	$716,925	0.66	$464,875	$33,205	$753,095	$2,130,832	$2,694,753	$0	$476,115
19									Y			$200,000	$0	$0	$0	$0	$0	$0	0.65	$129,835	$0	$0	$0	$0	$0	$0
20		Y										$200,000	$250,000	$0	$0	$0	$0	$215,760	0.63	$126,916	$158,645	$0	$0	$0	$0	$136,917
21						Y	Y	Y	Y	Y	Y	$200,000	$0	$1,133,996	$4,598,268	$4,563,237	$0	$0	0.62	$124,063	$0	$703,434	$2,852,371	$2,830,641	$0	$0
22												$200,000	$0	$0	$0	$0	$0	$0	0.61	$121,274	$0	$0	$0	$0	$0	$0
23	Y	Y	Y						Y			$200,000	$0	$0	$0	$0	$0	$716,925	0.59	$118,547	$0	$0	$0	$0	$0	$424,946
24												$200,000	$0	$0	$0	$0	$0	$0	0.58	$115,882	$0	$0	$0	$0	$0	$0
25												$200,000	$250,000	$0	$0	$0	$0	$0	0.57	$113,276	$141,595	$0	$0	$0	$0	$0
26							Y	Y	Y	Y	Y	$200,000	$0	$0	$4,598,268	$4,563,237	$0	$0	0.55	$110,730	$0	$0	$2,545,820	$2,526,426	$0	$0
27												$200,000	$0	$0	$0	$0	$0	$0	0.54	$108,240	$0	$0	$0	$0	$0	$0
28	Y	Y	Y	Y								$200,000	$0	$0	$0	$0	$0	$1,316,925	0.53	$105,806	$0	$0	$0	$0	$0	$696,696
29												$200,000	$0	$0	$0	$0	$0	$0	0.52	$103,428	$0	$0	$0	$0	$0	$0
30												$200,000	$250,000	$0	$0	$0	$0	$0	0.51	$101,102	$126,378	$0	$0	$0	$0	$0
Totals												$15,700,000	$2,450,000	$2,267,991	$12,405,099	$13,184,179	$0	$6,633,070		$12,301,904	$1,806,851	$1,456,529	$7,529,023	$8,051,820	$0	$5,026,043

Notes:

a. Costs from the start of construction. Construction years are shaded.

b. Monitoring frequencies are based on Appendix K. Construction monitoring (e.g., water quality monitoring during dredging) and post-construction performance monitoring are not included in this table; these are incorporated into capital costs for remedial alternatives.

c. See I-37 for assumptions.

d. O&M monitoring and repair costs per event are based on Table I-21.

e. Long-term monitoring costs per event are based on Table I-22.

f. Values equal to the annual cost times the present value factor.

TABLE I-34 INSTITUTIONAL CONTROLS

	Initial Cost	Annual Cost	Periodic Cost	Cost Basis	Source
Informational Devices					
Monitoring and Notification of Waterway Users					
Initial Costs	$100,000			0.5 FTE @ $100/hr	Professional judgment
Surveillance Monitoring	$75,000	$25,000		0.36 FTE for initial cost and 0.12 FTE for annual cost @ $100/hr	
Cleanup Hotline	$75,000	$50,000		0.36 FTE for initial cost and 0.25 FTE for annual cost @$100/hr	
Construction Permit Review	$50,000	$25,000		0.25 FTE for initial cost and 0.12 FTE for annual cost @$100/hr	
Reporting to EPA and Ecology		$25,000		0.12 FTE @ $100/hr	
Seafood Consumption Advisories, Public Outreach and Education					
Baseline behavior research	$150,000			0.72 FTE @ $100/hr	Enviro Issues, Seattle, WA
Incentives and messages development and delivery	$75,000	$50,000		0.36 FTE for initial cost and 0.24 FTE for annual cost @ $100/hr	
Culturally-appropriate outreach	$50,000	$200,000		0.24 FTE for initial cost and 0.96 FTE for annual cost @$100/hr	
Monitoring behavior change and revising approach	$50,000	$75,000	$150,000	0.24 FTE for initial cost and 0.36 FTE for annual cost @$100/hr	
Direct costs	$25,000	$10,000			
Site Registry					
Deed Notice Filing	$10,000				Professional judgment
	$660,000	$460,000	$150,000		
Proprietary Controls					
Restrictive Covenants	$10,000			$100 per parcel. Total number of parcels to be addressed range from 27	Tom Newlon, Attorney
Easements				to 60 for the alternatives.	Seattle, WA
Total Cost	$10,000	$0	$0		
Enforcement Tools					
Agency Order	$50,000			0.25 FTE @ $100/hr	Professional judgment
Agency 5-year Review		$25,000		0.12 FTE @ $100/hr	
Total Cost	$50,000	$25,000	$0		

Notes:

1. Initial cost includes activities used to establish or setup institutional controls. This is a one-time cost and is not recurring.
2. Annual costs include activities performed on a regular basis (annual) to monitor and maintain the institutional controls.
3. Periodic costs include activities needed in response to specific events during institutional controls monitoring and maintenance (e.g., address potential institutional controls failure during monitoring).
4. Assumes institutional controls would begin after Record Of Decision is signed and annual costs would begin in Year 2. Annual costs applied to Year 50.
5. Periodic costs applied at Year 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50. See I-35 for cost frequency.

FTE = full time equivalent

TABLE I-35 NET PRESENT VALUE CALCULATION FOR INSTITUTIONAL CONTROLS

Year, n	Annual Cost: Informational Devices	Annual Cost: Proprietary Controls	Annual Cost: Enforcement Tools	Annual Cost: Sum of Year "n" Costs	2.3% Present Value Factor [1]	Present Value: Informational Devices	Present Value: Proprietary Controls	Present Value: Enforcement Tools	Present Value: Sum of Year "n" Costs
0				$0	1.00	$0	$0	$0	$0
1	$660,000	$10,000	$50,000	$710,000	0.98	$645,161	$9,775	$48,876	$694,037
2	$460,000	$0	$0	$460,000	0.96	$439,548	$0	$0	$439,548
3	$460,000	$0	$0	$460,000	0.93	$429,666	$0	$0	$429,666
4	$460,000	$0	$0	$460,000	0.91	$420,006	$0	$0	$420,006
5	$610,000	$0	$25,000	$635,000	0.89	$544,442	$0	$22,313	$566,755
6	$460,000	$0	$0	$460,000	0.87	$401,332	$0	$0	$401,332
7	$460,000	$0	$0	$460,000	0.85	$392,309	$0	$0	$392,309
8	$460,000	$0	$0	$460,000	0.83	$383,489	$0	$0	$383,489
9	$460,000	$0	$0	$460,000	0.81	$374,867	$0	$0	$374,867
10	$610,000	$0	$25,000	$635,000	0.80	$485,930	$0	$19,915	$505,845
11	$460,000	$0	$0	$460,000	0.78	$358,200	$0	$0	$358,200
12	$460,000	$0	$0	$460,000	0.76	$350,147	$0	$0	$350,147
13	$460,000	$0	$0	$460,000	0.74	$342,275	$0	$0	$342,275
14	$460,000	$0	$0	$460,000	0.73	$334,579	$0	$0	$334,579
15	$610,000	$0	$25,000	$635,000	0.71	$433,706	$0	$17,775	$451,481
16	$460,000	$0	$0	$460,000	0.70	$319,704	$0	$0	$319,704
17	$460,000	$0	$0	$460,000	0.68	$312,516	$0	$0	$312,516
18	$460,000	$0	$0	$460,000	0.66	$305,490	$0	$0	$305,490
19	$460,000	$0	$0	$460,000	0.65	$298,621	$0	$0	$298,621
20	$610,000	$0	$25,000	$635,000	0.63	$387,095	$0	$15,865	$402,959
21	$460,000	$0	$0	$460,000	0.62	$285,345	$0	$0	$285,345
22	$460,000	$0	$0	$460,000	0.61	$278,929	$0	$0	$278,929
23	$460,000	$0	$0	$460,000	0.59	$272,658	$0	$0	$272,658
24	$460,000	$0	$0	$460,000	0.58	$266,528	$0	$0	$266,528
25	$610,000	$0	$25,000	$635,000	0.57	$345,493	$0	$14,160	$359,652
26	$460,000	$0	$0	$460,000	0.55	$254,678	$0	$0	$254,678
27	$460,000	$0	$0	$460,000	0.54	$248,952	$0	$0	$248,952
28	$460,000	$0	$0	$460,000	0.53	$243,355	$0	$0	$243,355
29	$460,000	$0	$0	$460,000	0.52	$237,884	$0	$0	$237,884
30	$610,000	$0	$25,000	$635,000	0.51	$308,362	$0	$12,638	$321,000
31	$460,000	$0	$0	$460,000	0.49	$227,307	$0	$0	$227,307
32	$460,000	$0	$0	$460,000	0.48	$222,197	$0	$0	$222,197
33	$460,000	$0	$0	$460,000	0.47	$217,201	$0	$0	$217,201
34	$460,000	$0	$0	$460,000	0.46	$212,318	$0	$0	$212,318
35	$610,000	$0	$25,000	$635,000	0.45	$275,222	$0	$11,280	$286,501
36	$460,000	$0	$0	$460,000	0.44	$202,878	$0	$0	$202,878
37	$460,000	$0	$0	$460,000	0.43	$198,317	$0	$0	$198,317
38	$460,000	$0	$0	$460,000	0.42	$193,858	$0	$0	$193,858
39	$460,000	$0	$0	$460,000	0.41	$189,500	$0	$0	$189,500
40	$610,000	$0	$25,000	$635,000	0.40	$245,643	$0	$10,067	$255,710
41	$460,000	$0	$0	$460,000	0.39	$181,074	$0	$0	$181,074
42	$460,000	$0	$0	$460,000	0.38	$177,003	$0	$0	$177,003
43	$460,000	$0	$0	$460,000	0.38	$173,024	$0	$0	$173,024
44	$460,000	$0	$0	$460,000	0.37	$169,134	$0	$0	$169,134
45	$610,000	$0	$25,000	$635,000	0.36	$219,243	$0	$8,985	$228,229
46	$460,000	$0	$0	$460,000	0.35	$161,614	$0	$0	$161,614
47	$460,000	$0	$0	$460,000	0.34	$157,980	$0	$0	$157,980
48	$460,000	$0	$0	$460,000	0.34	$154,428	$0	$0	$154,428
49	$460,000	$0	$0	$460,000	0.33	$150,956	$0	$0	$150,956
50	$610,000	$0	$25,000	$635,000	0.32	$195,681	$0	$8,020	$203,700
Totals	$24,700,000	$10,000	$300,000	$25,000,000		$14,625,843	$9,775	$189,893	$14,815,736

Notes:

1. Annual costs based on Table I-34.

TABLE I-36 TECHNOLOGY APPLICATION AREAS, SEDIMENT REMOVAL, AND MATERIAL PLACEMENT VOLUMES

Remedy Type/ Engineering Constraint	Alt 2R										Alt 2R-CAD											
	Dredge		Cap/PDC		Residuals Management		ENR/*in situ*		MNR		Dredge		CADs		Cap/PDC		Residuals Management		ENR/*in situ*		MNR	
	cy	days	acres	days	acres	days	acres	days	acres	area	cy	days	cy	days	acres	days	acres	days	acres	days	acres	area
Under Pier	11,268	47	3.4	55.4	0.0	0.0	0.0	0.0	0.0		11,268	47.0	0	0.0	3.4	55.4	0.0	0.0	0.0	0.0	0.0	
Above -10 ft MLLW	69,536	67	0.0	0.0	11.2	11.8	0.0	0.0	105.5	MNR(20)	69,536	66.9	0	0.0	0.0	0.0	11.2	11.8	0.0	0.0	105.5	MNR(20)
Below -10 ft MLLW	288,772	278	0.0	0.0	17.9	14.8	0.0	0.0	19.0	MNR(10)	288,772	277.9	371,000	247.3	0.0	0.0	17.9	14.8	0.0	0.0	19.0	MNR(10)
Dredge-cut Prism Volume	369,577										369,577											
Performance Contingency Volume	214,749	207									214,749	207										
Totals	584,326	598	3.4	55.4	29.2	26.6	0.0	0.0	124.5		584,326	598	371,000	247	3.4	55.4	29.2	26.6	0.0	0.0	124.5	
Import Material Volume (cy)	69,536		19,380		35,292						69,536		74,000		19,380		35,292					
											CAD area		24	acres								
											CAD capacity		310,000	cy								

Remedy Type/ Engineering Constraint	Alt 3R										Alt 3C									
	Dredge		Cap/PDC		Residuals Management		ENR/*in situ*		MNR		Dredge		Cap/PDC		Residuals Management		ENR/*in situ*		MNR	
	cy	days	acres	days	acres	days	acres	days	acres	area	cy	days	acres	days	acres	days	acres	days	acres	area
Under Pier	26,086	109	7.5	121.3	0.0	0.0	0.0	0.0	0.0		0	0	7.5	121.3	0.0	0.0	0.0	0.0	0.0	
Above -10 ft MLLW	160,376	154	0.0	0.0	24.3	25.6	0.0	0.0	99.0	MNR(20)	112,282	108	4.3	21.0	16.2	17.1	4.4	4.6	99.0	MNR(20)
Below -10 ft MLLW	399,563	384	0.0	0.0	26.0	21.4	0.0	0.0	0.0	MNR(10)	187,484	180	7.9	30.3	12.4	10.2	5.1	4.2	0.0	MNR(10)
Dredge-cut Prism Volume	586,024										299,766									
Performance Contingency Volume	177,673	171									191,473	184								
Totals	763,698	818	7.5	121.3	50.3	47.0	0.0	0.0	99.0		491,239	473	19.7	172.7	28.6	27.3	9.5	8.8	99.0	
Import Material Volume (cy)	160,376		42,467		60,847						112,282		111,106		34,639		11,500			

Remedy Type/ Engineering Constraint	Alt 4R										Alt 4C									
	Dredge		Cap/PDC		Residuals Management		ENR/*in situ*		MNR		Dredge		Cap/PDC		Residuals Management		ENR/*in situ*		MNR	
	cy	days	acres	days	acres	days	acres	days	acres	area	cy	days	acres	days	acres	days	acres	days	acres	area
Under Pier	41,265	172	13.8	222.3	0.0	0.0	0.0	0.0	0.0		0	0	13.8	222.3	0.0	0.0	0.0	0.0	0.0	
Above -10 ft MLLW	242,715	234	0.0	0.0	36.0	38.0	0.0	0.0	0.0	MNR(20)	160,877	155	7.2	35.4	21.7	22.9	9.3	9.8	0.0	MNR(20)
Below -10 ft MLLW	761,247	732	0.0	0.0	57.2	47.1	0.0	0.0	49.7	MNR(10)	398,262	383	20.0	76.9	28.0	23.0	7.1	5.9	49.7	MNR(10)
Dredge-cut Prism Volume	1,045,226										559,139									
Performance Contingency Volume	106,223	102									130,017	125								
Totals	1,151,450	1240	13.8	222.3	93.2	85.1	0.0	0.0	49.7		689,156	663	41.0	334.6	49.7	45.9	16.4	15.6	49.7	
Import Material Volume (cy)	242,715		77,804		112,811						160,877		231,350		60,083		19,828			

TABLE I-36 TECHNOLOGY APPLICATION AREAS, SEDIMENT REMOVAL, AND MATERIAL PLACEMENT VOLUMES

Remedy Type/ Engineering Constraint	Alt 5R Dredge		Alt 5R Cap/PDC		Alt 5R Residuals Management		Alt 5R ENR/*in situ*		Alt 5R MNR		Alt 5C Dredge		Alt 5C Cap/PDC		Alt 5C Residuals Management		Alt 5C ENR/*in situ*		Alt 5C MNR	
	cy	days	acres	days	acres	days	acres	days	acres	area	cy	days	acres	days	acres	days	acres	days	acres	area
Under Pier	45,457	189	13.6	220.0	0.0	0.0	0.0	0.0	0.0		0	0	13.6	220.0	0.0	0.0	0.0	0.0	0.0	
Above -10 ft MLLW	337,381	325	0.0	0.0	53.6	56.5	0.0	0.0	0.0	MNR(20)	184,251	177	8.5	42.0	25.3	26.7	21.8	22.9	0.0	MNR(20)
Below -10 ft MLLW	1,233,130	1186	0.0	0.0	89.5	73.7	0.0	0.0	0.0	MNR(10)	457,798	440	24.9	95.8	31.4	25.9	31.2	25.7	0.0	MNR(10)
Dredge-cut Prism Volume	1,615,968										642,049									
Performance Contingency Volume	34,017	33									110,960	107								
Totals	1,649,985	1733	13.6	220.0	143.1	130.3	0.0	0.0	0.0		753,009	725	47.1	357.8	56.7	52.5	53.0	48.7	0.0	
Import Material Volume (cy)	337,381		77,013		173,161						184,251		265,909		68,572		64,114			

Remedy Type/ Engineering Constraint	Alt 5R - Treatment Dredge		Cap/PDC		Residuals Management		ENR/*in situ*		MNR	
	cy	days	acres	days	acres	days	acres	days	acres	area
Under Pier	45,457	189	13.6	220.0	0.0	0.0	0.0	0.0	0.0	
Above -10 ft MLLW	337,381	325	0.0	0.0	53.6	56.5	0.0	0.0	0.0	MNR(20)
Below -10 ft MLLW	1,233,130	1186	0.0	0.0	89.5	73.7	0.0	0.0	0.0	MNR(10)
Dredge-cut Prism Volume	1,615,968									
Performance Contingency Volume	34,017	33								
Totals	1,649,985	1733	13.6	220.0	143.1	130.3	0.0	0.0	0.0	
Import Material Volume (cy)	337,381		77,013		173,161					

Remedy Type/ Engineering Constraint	Alt 6R Dredge		Alt 6R Cap/PDC		Alt 6R Residuals Management		Alt 6R ENR/*in situ*		Alt 6R MNR		Alt 6C Dredge		Alt 6C Cap/PDC		Alt 6C Residuals Management		Alt 6C ENR/*in situ*		Alt 6C MNR	
	cy	days	acres	days	acres	days	acres	days	acres		cy	days	acres	days	acres	days	acres	days	acres	
Under Pier	101,677	424	27.6	444.9	0.0	0.0	0.0	0.0	0.0		0	0	27.6	444.9	0.0	0.0	0.0	0.0	0.0	
Above -10 ft MLLW	702,652	676	0.0	0.0	85.5	90.2	0.0	0.0	0.0	MNR(20)	360,717	347	15.5	76.2	39.1	41.2	38.2	40.2	0.0	MNR(20)
Below -10 ft MLLW	3,138,845	3020	0.0	0.0	189.0	155.7	0.0	0.0	0.0	MNR(10)	1,138,130	1095	49.6	190.6	69.4	57.2	62.9	51.9	0.0	MNR(10)
Dredge-cut Prism Volume	3,943,174										1,498,848									
Performance Contingency Volume	0	0									146,820	141								
Totals	3,943,174	4120	27.6	444.9	274.5	245.8	0.0	0.0	0.0		1,645,668	1583	92.6	711.7	108.5	98.4	101.1	92.1	0.0	
Import Material Volume (cy)	702,652		155,724		332,127						360,717		523,146		131,344		122,339			

Notes:

1. Areas and volumes are based on Table I-3 best estimate. See Section 8 for development of technology areas. See Appendix E and Table I-3 for development of dredging volumes.
2. For residuals management within the dredge footprint, import material volume based on 9 inches of thin-layer sand placement.
3. Dredging volume for areas with partial dredging and capping are included in the total dredge volume presented in the table.
4. Backfill of dredging in habitat areas (above -10 ft MLLW) are included in import material volume.
5. R = removal emphasis, C = combined technology

TABLE I-37 BASIS FOR COST ESTIMATES

Project Phase	Quantity	Units	Source	Notes
Cost Estimating Parameters & Methodology:				
Discount Rate	2.3%		OMB Circular A-94, 2011	30 year real discount rate.
Project Management and Remedial Design	30.0%		EPA, July 2000	Includes 10% toward project management and 20% toward remedial design. Selected percentages are the high end specified in the EPA cost guidance document due to the complex nature of the sediments project. Remedial design includes pre-design sampling and analysis, engineering survey, design plans and specifications, cost estimate, and schedule.
Construction Management	10.0%		EPA, July 2000	The selected percentage (10%) is in the mid to high range as specified in the EPA cost guidance document. A higher percentage was selected due to the complex nature of the project. Construction monitoring is included as a separate line-item below.
Sales Tax	9.5%			Washington State.
Contingency	35.0%		EPA, July 2000	Total contingency includes 20% toward scope contingency and 15% toward bid contingency. Scope contingency is toward the high end specified in the EPA cost guidance document, because project scope for a sediments project of this magnitude will likely change considerably between FS and final design. Bid contingency of 15% is mid-range of the values specified in the EPA cost guidance document.
Agency Review and Oversight (construction)	$700,000	per year during construction	LDW project experience	Based on project experience during RI/FS.
Agency Review and Oversight (monitoring)	$200,000	per year during monitoring	Based on LDW project experience	Costs are expected to be higher or lower based on monitoring and review cycles, however, $200,000 per year is a reasonable average value. For Alternative 1, assume lower annual cost of $200,000 for each 5-year reporting year, otherwise $100,000.
Mobilization, Demobilization and Site Restoration (Dredging and Capping)				
Mobilize/Demobilize Equipment and Facilities (project)	$800,000	LS	Provided by Hartman, 2011	$400,000 for mobilization plus $400,000 for demobilization. Includes project management and labor during mobilization and demobilization. See Table I-10.
Mobilize/Demobilize Equipment and Facilities (construction season)	$120,000	per year	Provided by Hartman, 2011	Yearly mobilization/demobilization is assumed to be 15% of the total project mob/demob cost of $800,000 for all years of project. Includes project management and labor during mobilization and demobilization. See Table I-10.
Land Lease for Operations and Staging	$250,000	per year	BPJ	Based on Table I-10. Professional judgment based on review of lease rates in the Lower Duwamish Valley.
Contractor Work Plan Submittals	$100,000	per year	BPJ	Based on Table I-10. Professional judgment based on local dredging contractor.
Barge Protection	$80,000	LS	BPJ	Based on Table I-10. Professional judgment based on local dredging contractor.
Project Management (Contractor)				
Labor and Supervision	$62,000	per month	BPJ	Based on Table I-10. Includes superintendant, chief surveyor and quality control management, accountant, certified industrial hygienist, travel, and housing.
Construction Office and Operating Expense	$21,600	per month	BPJ	Based on Table I-10. Includes rental office trailers, operating expense, vehicle rental, support staff.
Contained Aquatic Disposal				
Impacted Material/Clean Cap Material Placement Rate (Derrick Crane - 8 cy bucket)	1,469	cy per day (12-hr)	Project experience	Based on Table I-6, assumptions for open-water placement.
Overburden Removal Rate from CAD Cell (Derrick Crane - 6 cy bucket)	1,500	cy *in situ* per day (12-hr)	Reviewed by Hartman, 2011	
Transport and Disposal of Material at Elliott Bay Open Water Site	$12	cy	Reviewed by Hartman, 2011	Includes barge transport and disposal at the DMMP Elliott Bay open water disposal site.
Dredging				
Shift Rate	$25,963	per day	Provided by Hartman, 2011	Based on Table I-8. Assume 2 dredging operations, one deep access and one shallow access, split between 24-hr and 12-hr dredging days as outlined in Table I-5. Includes 3 barges and 4 tugs.
Dredge Rate (open-water)	1,039	cy *in situ* per day	Project experience; USACE, 2008	Based on Table I-5.
Dredge Rate (underpier)	240	cy *in situ* per day	Reviewed by Hartman, 2011	Based on Table I-5.
Gravity Dewatering (on the barge)	$10	per cy	Reviewed by Hartman, 2011	

TABLE I-37 BASIS FOR COST ESTIMATES

Project Phase	Quantity	Units	Source	Notes
Sediment Handling and Disposal Costs				
Transload, Railcar transport to and tipping at Subtitle D Landfill	$60	per ton	Joe Casalini, Allied Waste Services, Seattle, WA	Cost includes material transfer from barge onto offloading area, load dewatered sediment onto truck with containers, truck transport to rail facility. Offloading of sediments from barges at an offloading facility (infrastructure to be built in the future) in the vicinity of site to transloading area. Trucks with 20-ft containers on chassis and fitted with liner.
Transloading Area Setup	$1,000,000	LS	BPJ	Based on Table I-8. Value based on discussions with waste management engineers.
Water Management	$10,000	per day	Project experience	Based on Table I-8. Value based on discussions with contractors with local experience and reviewed by Hartman, 2011.
Capping/ENR				
Debris Sweep	$30,000	per acre	Reviewed by Hartman 2011	Assume 10% of capping/ENR area requires debris sweep. Assume cost includes labor, equipment and survey.
Shift Rate	$12,500	per day	Provided by Hartman 2011	Assuming 1 operation split between deep access and shallow access, at 12-hr (5-day weeks).
Cap Placement Rate (deep water)	1,469	cy per day (12-hr)	Project experience	Based on Table I-6 (Derrick barge with environmental bucket: 8-cy bucket).
Cap Placement Rate (shallow water)	1,148	cy per day (12-hr)	Project experience	Based on Table I-6 for assumptions (Excavator: 5-cy bucket).
Cap Placement Rate (underdock)	350	cy per day (12-hr)	Project experience	Based on Table I-6 for assumptions (Hydraulic conveyor).
ENR Placement Rate (deep water)	1,371	cy per day (12-hr)	Project experience	Based on Table I-6 for assumptions (Derrick barge with environmental bucket: 8-cy bucket).
ENR Placement Rate (shallow water)	1,071	cy per day (12-hr)	Project experience	Based on Table I-6 for assumptions (Excavator: 5-cy bucket).
ENR Placement Rate (underdock)	300	cy per day (12-hr)	Project experience	Based on Table I-6 for assumptions (Hydraulic conveyor).
Cap/ ENR/ backfill/ dredge residuals material procurement and delivery (Sand)	$27	per cy	Glacier Northwest, Seattle, WA	Based on Table I-7. Cost includes delivery to the site by barge, additional cap material (10% of total cap volume) included to account for capping material required in steep slope areas to address slope stability.
Carbon amended material procurement and delivery (Sand+4% GAC)	$161	per cy	Luthy et al. 2009	Based on Table I-7. Assumes $1/lb of carbon at 4% by volume of carbon/(sand+carbon).
Treatment by Soil Washing, Mechanical Dewatering & Water Trmt				
Mob/Demob, Site Layout, Land Leasing Costs	$4,000,000	LS	ART Engineering, LLC., Tampa FL.	Includes capital cost from conception to production, total plant footprint of approximately 4 acres to 7 acres with 40 to 45 tons per hour capacity.
Soil Washing, Mech Dewatering, Water Trmt, disposal of fine fraction	$120	per cy	ART Engineering, LLC., Tampa FL.	Assume 50% sand treated sand and 50% remaining fines. Cost includes labor, plant operations, maintenance fine fraction, disposal of remaining fine fraction at Subtitle D landfill, and no credit for beneficial reuse of sand.
Treated Sand Disposal	$0	per cy	BPJ	Assume no credit for beneficial reuse of sand. Treated sand may have a disposal cost.
Construction QA/QC				
Construction Monitoring	$7,925	per day	Vendor quote and BPJ	Based on Table I-9. Construction monitoring includes survey boat, labor and equipment required for routine bathymetric surveys (single beam), data analysis, data delivery, pH/turbidity check, and water quality monitoring. Additional construction oversight is included in the 10% construction management cost described in Table I-37.
Analytical cost	$2,268	per sample	Project experience	Assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions. Assumption incorporated in Tables I-11 through I-21.
Sampling rate	5	samples/day	Project experience	Assumption incorporated in Tables I-11 through I-21.
Post-construction performance monitoring surface sediment sampling density (dredging, PDC, capping, ENR)	4	samples/acre	Project experience	See Appendix K for sampling description. Assumption incorporated in Tables I-11 through I-21.
Post-construction performance monitoring physical sampling density (PDC, capping, ENR)	4	samples/acre	Project experience	See Appendix K for sampling description. Assumption incorporated in Tables I-11 through I-21.
Post-construction performance monitoring daily cost	$8,000	per day	Project experience	Daily labor, equipment and material costs during performance monitoring. Assumption incorporated in Tables I-11 through I-21.
Data Management Analysis and Reporting	$15,000	per acre	Project experience	Assume $15,000 for first acre and scale up using power of 0.6. Assumption incorporated in Tables I-11 through I-21.
Project Completion Report (incl. as-built drawings)	$50,000	per work year	Project experience	Assumption incorporated in Tables I-11 through I-21.
Remedial Action 5 year Review Cycle	$250,000	LS	Project experience	Assumption incorporated in Tables I-11 through I-21.

TABLE I-37 BASIS FOR COST ESTIMATES

Project Phase	Quantity	Units	Source	Notes
Operations, Maintenance and Monitoring Costs				
Analytical cost	$2,268	per sample	Project experience	Assume 75% Group A parameters and 25% Group B parameters. See Appendix K for parameter assumptions. Assumption incorporated in Tables I-11 through I-21.
Sampling rate	5	samples/day	Project experience	Assumption incorporated in Tables I-11 through I-21.
O&M monitoring surface sediment sampling density (dredging, PDC, capping, ENR)	2	samples/acre	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
O&M monitoring surface sediment sampling density (dredging, PDC, capping, ENR)	4	samples/acre	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
O&M monitoring physical sampling density (PDC, capping)	4	samples/acre	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
O&M monitoring physical sampling density (ENR, MNR)	4	samples/acre	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
O&M monitoring coring sampling density (PDC and capping)	1	samples/acre	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
O&M monitoring porewater sampling density (PDC and capping)	1	samples/acre	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
O&M monitoring porewater sampling density (ENR)	4	samples/acre	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
OM&M Sampling Daily Cost	$8,000	per day	Project experience	Assumption incorporated in Tables I-11 through I-21. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
Data Management Analysis and Reporting	$15,000	per acre	Project experience	Assume $15,000 for first acre and scale up using power of 0.6. Monitoring frequency based on Appendix K and shown in Tables I-23 through I-33.
Cap Repair	$300,000	per acre	Project experience	Assumed for 5% of the cap area implemented at Year 5 and 10. Based on approximately 60% of unit costs for materials and labor for capping. Assumption incorporated in Tables I-11 through I-21.
ENR Repair	$100,000	per acre	Project experience	Assumed for 5% of the ENR area implemented at Year 5 and 10. Based on approximate unit costs for materials and labor for ENR. Assumption incorporated in Tables I-11 through I-21.
OM&M Bathymetric survey	$100,000	site-wide per event	Vendor quote for LDW	Vendor quote - Bathymetry costs calculated by scaling estimated site-wide cost of $100,000 (supported by vendor quote) using a power scaling function and power of 0.6: e.g., cost(area A) = Cost(site-wide) * (Area A/418 acres)^0.6. Assumption incorporated in Tables I-11 through I-21.
Long-term Monitoring				
Surface Sediment	$428,745	per event	Project experience	Based on Table I-22, incorporated into Tables I-23 through I-33.
Tissue	$215,760	per event	Project experience	Based on Table I-22, incorporated into Tables I-23 through I-33.
Surface water Quality	$72,420	per event	Project experience	Based on Table I-22, incorporated into Tables I-23 through I-33.
Survey Cost	$350,000	per event	Project experience	Based on Table I-22, incorporated into Tables I-23 through I-33.
Stormwater Sampling	$500,000	per event	Project experience	Based on Table I-22, incorporated into Tables I-23 through I-33.
Institutional Controls				
Institutional Controls	$14,815,736	present value for 50 years	EnviroIssues, Tom Newlon, and BPJ	Based on Tables I-34 and I-35.

TABLE I-38 ALTERNATIVE 1 NO FURTHER ACTION

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
AGENCY OVERSIGHT, REPORTING, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$2,760,610	$2,760,610	I-23a
Reporting	1	PROJECT	$1,026,650	$1,026,650	I-23a
Long-term Monitoring	1	PROJECT	$5,209,547	$5,209,547	I-23a
TOTAL COST				$8,996,808	

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Net present value calculation applied to Agency oversight, reporting, and monitoring costs.

TABLE I-39 ALTERNATIVE 2 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	6.8	YEAR	$120,000	$812,222	I-36/I-37
Land Lease for Operations and Staging	6.8	YEAR	$250,000	$1,692,129	I-36/I-10
Contractor Work Plan Submittals	6.8	YEAR	$100,000	$676,852	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$3,261,203	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	30.7	MONTH	$62,000	$1,902,405	I-36/I-10
Construction Office and Operating Expense	30.7	MONTH	$21,600	$662,773	I-36/I-10
Subtotal:				$2,565,178	
DREDGING					
Shift Rate	598	DAY	$25,963	$15,534,663	I-36/I-8
Gravity Dewatering (on the barge)	584,326	CY	$10	$5,843,258	I-36/I-37
Subtotal:				$21,377,921	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	598	DAY	$10,000	$5,983,369	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	876,489	TON	$60	$52,589,325	I-36/I-37
Subtotal:				$59,572,694	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	143	DAY	$12,500	$1,782,305	I-36/I-37
Cap material procurement and delivery (sand)	124,208	CY	$27	$3,360,313	I-36/I-7
Subtotal:				$5,142,618	
ENHANCED NATURAL RECOVERY					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	0	DAY	$12,500	$0	I-36/I-37
Material procurement and delivery (sand)	0	CY	$27	$0	I-36/I-7
Material procurement and delivery (carbon amended sand)	0	CY	$161	$0	I-36/I-7
Subtotal:				$0	
CONSTRUCTION QA/QC					
Construction Monitoring	598	DAY	$7,925	$4,741,962	I-36/I-9
Subtotal:				$4,741,962	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$585,015	$585,015	NA/I-11
Compliance Testing (Capping)	1	PROJECT	$728,911	$728,911	NA/I-11
Compliance Testing (ENR)	1	PROJECT	$0	$0	NA/I-11
Subtotal:				$1,313,925	
CAPITAL COST (BASE)				$97,975,502	
CAPITAL COST (present value)				$91,844,434	Assume capital costs distributed over construction years

TABLE I-39 ALTERNATIVE 2 REMOVAL

Construction Contingency				$32,145,552	NA/I-37
Sales Tax				$8,725,221	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$27,553,330	NA/I-37
Construction Management				$9,184,443	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$169,452,981	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$6,889,985	$6,889,985	NA/I-23
Reporting	1	PROJECT	$1,265,659	$1,265,659	NA/I-23
Operation and Maintenance (Dredging)	1	PROJECT	$606,416	$606,416	NA/I-23
Operation and Maintenance (Capping)	1	PROJECT	$399,864	$399,864	NA/I-23
Operation and Maintenance (ENR)	1	PROJECT	$0	$0	NA/I-23
Operation and Maintenance (MNR)	1	PROJECT	$16,433,240	$16,433,240	NA/I-23
Long-term Monitoring	1	PROJECT	$5,209,547	$5,209,547	NA/I-23
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$45,630,223	
TOTAL COST				$215,083,200	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operation & Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).
4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.
5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-40 ALTERNATIVE 2 REMOVAL WITH CAD

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRE-CONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	6.8	YEAR	$120,000	$812,222	I-36/I-37
Land Lease for Operations and Staging	6.8	YEAR	$250,000	$1,692,129	I-36/I-10
Contractor Work Plan Submittals	6.8	YEAR	$100,000	$676,852	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$3,261,203	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	30.7	MONTH	$62,000	$1,902,405	I-36/I-10
Construction Office and Operating Expense	30.7	MONTH	$21,600	$662,773	I-36/I-10
Subtotal:				$2,565,178	
DREDGING					
Shift Rate	598	DAY	$25,963	$15,534,663	I-36/I-8
Gravity Dewatering (on the barge)	584,326	CY	$10	$5,843,258	I-36/I-37
Subtotal:				$21,377,921	
CONFINED AQUATIC DISPOSAL					
Overburden Removal (Shift Rate - 12 hours)	247	DAY	$25,963	$6,421,532	I-36/I-8
Impacted Material Placement (Shift Rate - 12-hours)	170	DAY	$12,500	$2,119,077	I-36/I-37
Cap Material procurement and delivery (Sand)	74,000	CY	$27	$2,001,996	I-36/I-7
Cap Placement (Shift Rate - 12 hours)	50	DAY	$12,500	$629,766	I-36/I-37
Overburden Transport and Disposal at Elliott Bay Open Water Site	371,000	CY	$12	$4,452,000	I-36/I-37
Subtotal:				$15,624,371	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	598	DAY	$10,000	$5,983,369	I-36/I-8
CAD capacity (for calculating remainder upland disposal)	310,000	CY			I-36/NA
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	411,489	TON	$60	$24,689,325	I-36/I-37
Subtotal:				$31,672,694	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	143	DAY	$12,500	$1,782,305	I-36/I-37
Cap material procurement and delivery (Sand)	124,208	CY	$27	$3,360,313	I-36/I-7
Subtotal:				$5,142,618	
ENHANCED NATURAL RECOVERY					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	0	DAY	$12,500	$0	I-36/I-37
Material procurement and delivery (Sand)	0	CY	$27	$0	I-36/I-7
Material procurement and delivery (carbon amended sand)	0	CY	$161	$0	I-36/I-7
Subtotal:				$0	
CONSTRUCTION QA/QC					
Construction Monitoring	598	DAY	$7,925	$4,741,962	I-36/I-9
Subtotal:				$4,741,962	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$585,015	$585,015	NA/I-12
Compliance Testing (Capping)	1	PROJECT	$728,911	$728,911	NA/I-12
Compliance Testing (ENR)	0	PROJECT	$0	$0	NA/I-12
Subtotal:				$1,313,925	
CAPITAL COST (BASE)				$85,699,873	
CAPITAL COST (present value)				$80,336,984	Assume capital costs distributed over construction years

TABLE I-40 ALTERNATIVE 2 REMOVAL WITH CAD

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$28,117,944	NA/I-37
Sales Tax				$7,632,013	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$24,101,095	NA/I-37
Construction Management				$8,033,698	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$148,221,735	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$6,889,985	$6,889,985	NA/I-24
Reporting	1	PROJECT	$1,265,659	$1,265,659	NA/I-24
Operation and Maintenance (Dredging)	1	PROJECT	$606,416	$606,416	NA/I-24
Operation and Maintenance (Capping)	1	PROJECT	$3,048,675	$3,048,675	NA/I-24
Operation and Maintenance (ENR)	0	PROJECT	$0	$0	NA/I-24
Operation and Maintenance (MNR)	1	PROJECT	$16,433,240	$16,433,240	NA/I-24
Long-term Monitoring	1	PROJECT	$5,209,547	$5,209,547	NA/I-24
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$48,279,034	
TOTAL COST				$196,500,800	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operation & Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).
4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.
5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-41 ALTERNATIVE 3 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	9.3	YEAR	$120,000	$1,110,961	I-36/I-37
Land Lease for Operations and Staging	9.3	YEAR	$250,000	$2,314,502	I-36/I-10
Contractor Work Plan Submittals	9.3	YEAR	$100,000	$925,801	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$4,431,264	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	42.0	MONTH	$62,000	$2,602,118	I-36/I-10
Construction Office and Operating Expense	42.0	MONTH	$21,600	$906,544	I-36/I-10
Subtotal:				$3,508,662	
DREDGING					
Shift Rate	818	DAY	$25,963	$21,248,381	I-36/I-8
Gravity Dewatering (on the barge)	763,698	CY	$10	$7,636,978	I-36/I-37
Subtotal:				$28,885,359	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	818	DAY	$10,000	$8,184,079	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	1,145,547	TON	$60	$68,732,799	I-36/I-37
Subtotal:				$77,916,878	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	308	DAY	$12,500	$3,851,574	I-36/I-37
Cap material procurement and delivery (Sand)	263,690	CY	$27	$7,133,860	I-36/I-7
Subtotal:				$10,985,434	
ENHANCED NATURAL RECOVERY					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	0	DAY	$12,500	$0	I-36/I-37
Material procurement and delivery (Sand)	0	CY	$27	$0	I-36/I-7
Material procurement and delivery (carbon amended sand)	0	CY	$161	$0	I-36/I-7
Subtotal:				$0	
CONSTRUCTION QA/QC					
Construction Monitoring	818	DAY	$7,925	$6,486,077	I-36/I-9
Subtotal:				$6,486,077	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$963,490	$963,490	NA/I-13
Compliance Testing (Capping)	1	PROJECT	$223,799	$223,799	NA/I-13
Compliance Testing (ENR)	0	PROJECT	$0	$0	NA/I-13
Subtotal:				$1,187,290	
CAPITAL COST (BASE)				$133,400,964	
CAPITAL COST (present value)				$121,667,553	Assume capital costs distributed over construction years

TABLE I-41 ALTERNATIVE 3 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$42,583,644	NA/I-37
Sales Tax				$11,558,418	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$36,500,266	NA/I-37
Construction Management				$12,166,755	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$224,476,635	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$7,772,480	$7,772,480	NA/I-25
Reporting	1	PROJECT	$1,353,908	$1,353,908	NA/I-25
Operation and Maintenance (Dredging)	1	PROJECT	$926,258	$926,258	NA/I-25
Operation and Maintenance (Capping)	1	PROJECT	$853,946	$853,946	NA/I-25
Operation and Maintenance (ENR)	0	PROJECT	$0	$0	NA/I-25
Operation and Maintenance (MNR)	1	PROJECT	$12,311,604	$12,311,604	NA/I-25
Long-term Monitoring	1	PROJECT	$5,061,002	$5,061,002	NA/I-25
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$43,104,708	
TOTAL COST				$267,581,300	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).
4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.
5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-42 ALTERNATIVE 3 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	5.3	YEAR	$120,000	$641,622	I-36/I-37
Land Lease for Operations and Staging	5.3	YEAR	$250,000	$1,336,713	I-36/I-10
Contractor Work Plan Submittals	5.3	YEAR	$100,000	$534,685	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$2,593,021	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	24.2	MONTH	$62,000	$1,502,822	I-36/I-10
Construction Office and Operating Expense	24.2	MONTH	$21,600	$523,564	I-36/I-10
Subtotal:				$2,026,386	
DREDGING					
Shift Rate	473	DAY	$25,963	$12,271,751	I-36/I-8
Gravity Dewatering (on the barge)	491,239	CY	$10	$4,912,393	I-36/I-37
Subtotal:				$17,184,144	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	473	DAY	$10,000	$4,726,618	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	736,859	TON	$60	$44,211,536	I-36/I-37
Subtotal:				$49,938,154	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	1.1	ACRE	$30,000	$33,829	I-36/I-37
Shift Rate (12 hours)	298	DAY	$12,500	$3,722,950	I-36/I-37
Cap material procurement and delivery (Sand)	258027	CY	$27	$6,980,660	I-36/I-7
Subtotal:				$10,737,438	
ENHANCED NATURAL RECOVERY					
Debris Sweep	1.0	ACRE	$30,000	$28,512	I-36/I-37
Shift Rate (12 hours)	8.8	DAY	$12,500	$110,439	I-36/I-37
Material procurement and delivery (Sand)	5,750	CY	$27	$155,561	I-36/I-7
Material procurement and delivery (carbon amended sand)	5,750	CY	$161	$928,491	I-36/I-7
Subtotal:				$1,223,002	
CONSTRUCTION QA/QC					
Construction Monitoring	473	DAY	$7,925	$3,745,957	I-36/I-9
Subtotal:				$3,745,957	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$575,178	$575,178	NA/I-14
Compliance Testing (Capping)	1	PROJECT	$535,974	$535,974	NA/I-14
Compliance Testing (ENR)	1	PROJECT	$276,124	$276,124	NA/I-14
Subtotal:				$1,387,276	
CAPITAL COST (BASE)				$88,835,380	
CAPITAL COST (present value)				$84,601,899	Assume capital costs distributed over construction years

TABLE I-42 ALTERNATIVE 3 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$29,610,665	NA/I-37
Sales Tax				$8,037,180	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$25,380,570	NA/I-37
Construction Management				$8,460,190	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$156,090,504	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$6,433,457	$6,433,457	NA/I-26
Reporting	1	PROJECT	$1,220,006	$1,220,006	NA/I-26
Operation and Maintenance (Dredging)	1	PROJECT	$610,588	$610,588	NA/I-26
Operation and Maintenance (Capping)	1	PROJECT	$2,269,504	$2,269,504	NA/I-26
Operation and Maintenance (ENR)	1	PROJECT	$1,120,327	$1,120,327	NA/I-26
Operation and Maintenance (MNR)	1	PROJECT	$13,180,793	$13,180,793	NA/I-26
Long-term Monitoring	1	PROJECT	$5,286,393	$5,286,393	NA/I-26
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$44,946,578	
TOTAL COST				$201,037,100	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.

2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.

3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).

4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.

5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-43 ALTERNATIVE 4 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	14.0	YEAR	$120,000	$1,683,445	I-36/I-37
Land Lease for Operations and Staging	14.0	YEAR	$250,000	$3,507,177	I-36/I-10
Contractor Work Plan Submittals	14.0	YEAR	$100,000	$1,402,871	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$6,673,493	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	63.6	MONTH	$62,000	$3,943,002	I-36/I-10
Construction Office and Operating Expense	63.6	MONTH	$21,600	$1,373,691	I-36/I-10
Subtotal:				$5,316,693	
DREDGING					
Shift Rate	1,240	DAY	$25,963	$32,197,782	I-36/I-8
Gravity Dewatering (on the barge)	1,151,450	CY	$10	$11,514,496	I-36/I-37
Subtotal:				$43,712,278	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	1,240	DAY	$10,000	$12,401,378	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	1,727,174	TON	$60	$103,630,464	I-36/I-37
Subtotal:				$117,031,842	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	519	DAY	$12,500	$6,486,558	I-36/I-37
Cap material procurement and delivery (Sand)	433,330	CY	$27	$11,723,297	I-36/I-7
Subtotal:				$18,209,854	
ENHANCED NATURAL RECOVERY					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	0	DAY	$12,500	$0	I-36/I-37
Material procurement and delivery (Sand)	0	CY	$27	$0	I-36/I-7
Material procurement and delivery (carbon amended sand)	0	CY	$161	$0	I-36/I-7
Subtotal:				$0	
CONSTRUCTION QA/QC					
Construction Monitoring	1,240	DAY	$7,925	$9,828,387	I-36/I-9
Subtotal:				$9,828,387	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$1,711,084	$1,711,084	NA/I-15
Compliance Testing (Capping)	1	PROJECT	$386,654	$386,654	NA/I-15
Compliance Testing (ENR)	0	PROJECT	$0	$0	NA/I-15
Subtotal:				$2,097,738	
CAPITAL COST (BASE)				$202,870,285	
CAPITAL COST (present value)				$175,677,297	Assume capital costs distributed over construction years

TABLE I-43   ALTERNATIVE 4 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$61,487,054	NA/I-37
Sales Tax				$16,689,343	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$52,703,189	NA/I-37
Construction Management				$17,567,730	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$324,124,613	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$9,810,854	$9,810,854	NA/I-27
Reporting	1	PROJECT	$1,557,746	$1,557,746	NA/I-27
Operation and Maintenance (Dredging)	1	PROJECT	$1,424,460	$1,424,460	NA/I-27
Operation and Maintenance (Capping)	1	PROJECT	$1,348,252	$1,348,252	NA/I-27
Operation and Maintenance (ENR)	0	PROJECT	$0	$0	NA/I-27
Operation and Maintenance (MNR)	1	PROJECT	$4,390,243	$4,390,243	NA/I-27
Long-term Monitoring	1	PROJECT	$5,042,530	$5,042,530	NA/I-27
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$38,399,595	
TOTAL COST				$362,524,200	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.

2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.

3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).

4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.

5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-44 ALTERNATIVE 4 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	7.5	YEAR	$120,000	$900,127	I-36/I-37
Land Lease for Operations and Staging	7.5	YEAR	$250,000	$1,875,264	I-36/I-10
Contractor Work Plan Submittals	7.5	YEAR	$100,000	$750,106	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$3,605,497	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	34.0	MONTH	$62,000	$2,108,297	I-36/I-10
Construction Office and Operating Expense	34.0	MONTH	$21,600	$734,504	I-36/I-10
Subtotal:				$2,842,801	
DREDGING					
Shift Rate	663	DAY	$25,963	$17,215,942	I-36/I-8
Gravity Dewatering (on the barge)	689,156	CY	$10	$6,891,557	I-36/I-37
Subtotal:				$24,107,499	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	663	DAY	$10,000	$6,630,935	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	1,033,734	TON	$60	$62,024,011	I-36/I-37
Subtotal:				$69,654,946	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	2.3	ACRE	$30,000	$68,913	I-36/I-37
Shift Rate (12 hours)	521	DAY	$12,500	$6,508,620	I-36/I-37
Cap material procurement and delivery (Sand)	452,310	CY	$27	$12,236,800	I-36/I-7
Subtotal:				$18,814,333	
ENHANCED NATURAL RECOVERY					
Debris Sweep	1.6	ACRE	$30,000	$49,160	I-36/I-37
Shift Rate (12 hours)	16	DAY	$12,500	$195,430	I-36/I-37
Material procurement and delivery (Sand)	9,914	CY	$27	$268,210	I-36/I-7
Material procurement and delivery (carbon amended sand)	9,914	CY	$161	$1,600,861	I-36/I-7
Subtotal:				$2,113,661	
CONSTRUCTION QA/QC					
Construction Monitoring	663	DAY	$7,925	$5,255,174	I-36/I-9
Subtotal:				$5,255,174	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$952,322	$952,322	NA/I-16
Compliance Testing (Capping)	1	PROJECT	$1,060,118	$1,060,118	NA/I-16
Compliance Testing (ENR)	1	PROJECT	$453,042	$453,042	NA/I-16
Subtotal:				$2,465,482	
CAPITAL COST (BASE)				$128,859,394	
CAPITAL COST (present value)				$119,820,753	Assume capital costs distributed over construction years

TABLE I-44   ALTERNATIVE 4 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$41,937,263	NA/I-37
Sales Tax				$11,382,971	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$35,946,226	NA/I-37
Construction Management				$11,982,075	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$221,069,289	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$7,772,480	$7,772,480	NA/I-28
Reporting	1	PROJECT	$1,353,908	$1,353,908	NA/I-28
Operation and Maintenance (Dredging)	1	PROJECT	$916,125	$916,125	NA/I-28
Operation and Maintenance (Capping)	1	PROJECT	$4,285,036	$4,285,036	NA/I-28
Operation and Maintenance (ENR)	1	PROJECT	$1,751,079	$1,751,079	NA/I-28
Operation and Maintenance (MNR)	1	PROJECT	$4,918,886	$4,918,886	NA/I-28
Long-term Monitoring	1	PROJECT	$5,061,002	$5,061,002	NA/I-28
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$40,884,027	
TOTAL COST				$261,953,300	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).
4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.
5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-45 ALTERNATIVE 5 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	19.6	YEAR	$120,000	$2,352,832	I-36/I-37
Land Lease for Operations and Staging	19.6	YEAR	$250,000	$4,901,733	I-36/I-10
Contractor Work Plan Submittals	19.6	YEAR	$100,000	$1,960,693	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$9,295,258	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	88.9	MONTH	$62,000	$5,510,855	I-36/I-10
Construction Office and Operating Expense	88.9	MONTH	$21,600	$1,919,911	I-36/I-10
Subtotal:				$7,430,766	
DREDGING					
Shift Rate	1733	DAY	$25,963	$45,000,562	I-36/I-8
Gravity Dewatering (on the barge)	1,649,985	CY	$10	$16,499,846	I-36/I-37
Subtotal:				$61,500,408	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	1733	DAY	$10,000	$17,332,529	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	2,474,977	TON	$60	$148,498,611	I-36/I-37
Subtotal:				$166,831,139	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	644	DAY	$12,500	$8,053,849	I-36/I-37
Cap material procurement and delivery (Sand)	587,555	CY	$27	$15,895,714	I-36/I-7
Subtotal:				$23,949,563	
ENHANCED NATURAL RECOVERY					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	0	DAY	$12,500	$0	I-36/I-37
Material procurement and delivery (Sand)	0	CY	$27	$0	I-36/I-7
Material procurement and delivery (carbon amended sand)	0	CY	$161	$0	I-36/I-7
Subtotal:				$0	
CONSTRUCTION QA/QC					
Construction Monitoring	1733	DAY	$7,925	$13,736,441	I-36/I-9
Subtotal:				$13,736,441	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$2,561,512	$2,561,512	NA/I-17
Compliance Testing (Capping)	1	PROJECT	$383,070	$383,070	NA/I-17
Compliance Testing (ENR)	0	PROJECT	$0	$0	NA/I-17
Subtotal:				$2,944,582	
CAPITAL COST (BASE)				$285,688,157	
CAPITAL COST (present value)				$233,129,066	Assume capital costs distributed over construction years

TABLE I-45 ALTERNATIVE 5 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$81,595,173	NA/I-37
Sales Tax				$22,147,261	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$69,938,720	NA/I-37
Construction Management				$23,312,907	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$430,123,127	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$11,969,851	$11,969,851	NA/I-29
Reporting	1	PROJECT	$1,773,645	$1,773,645	NA/I-29
Operation and Maintenance (Dredging)	1	PROJECT	$1,826,096	$1,826,096	NA/I-29
Operation and Maintenance (Capping)	1	PROJECT	$884,778	$884,778	NA/I-29
Operation and Maintenance (ENR)	0	PROJECT	$0	$0	NA/I-29
Operation and Maintenance (MNR)	0	PROJECT	$0	$0	NA/I-29
Long-term Monitoring	1	PROJECT	$4,987,043	$4,987,043	NA/I-29
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$36,266,924	
TOTAL COST				$466,390,100	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.

2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.

3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).

4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.

5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-46 ALTERNATIVE 5 REMOVAL WITH TREATMENT

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	19.6	YEAR	$120,000	$2,352,832	I-36/I-37
Land Lease for Operations and Staging	19.6	YEAR	$250,000	$4,901,733	I-36/I-10
Contractor Work Plan Submittals	19.6	YEAR	$100,000	$1,960,693	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$9,295,258	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	88.9	MONTH	$62,000	$5,510,855	I-36/I-10
Construction Office and Operating Expense	88.9	MONTH	$21,600	$1,919,911	I-36/I-10
Subtotal:				$7,430,766	
DREDGING					
Shift Rate	1,733	DAY	$25,963	$45,000,562	I-36/I-8
Gravity Dewatering (on the barge)	1,649,985	CY	$10	$16,499,846	I-36/I-37
Subtotal:				$61,500,408	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	1,733	DAY	$10,000	$17,332,529	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill (assume 50% of dredged sediment is sent straight to the landfill)	1,237,488	TON	$60	$74,249,305	I-36/I-37
Subtotal:				$92,581,834	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	644	DAY	$12,500	$8,053,849	I-36/I-37
Cap material procurement and delivery (Sand)	587,555	CY	$27	$15,895,714	I-36/I-7
Subtotal:				$23,949,563	
ENHANCED NATURAL RECOVERY					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	0	DAY	$12,500	$0	I-36/I-37
Material procurement and delivery (Sand)	0	CY	$27	$0	I-36/I-7
Material procurement and delivery (carbon amended sand)	0	CY	$161	$0	I-36/I-7
Subtotal:				$0	
TREATMENT BY SOIL WASHING					
Mobilization/Demobilization and Site Layout	1	LS	$4,000,000	$4,000,000	NA/I-37
Soil Washing, Mechanical Dewatering, Water Treatment, Disposal of Fine Fraction (assume 50% of dredged material is treated, and 50% of the treated sediment [fine fraction] is disposed of in a land fill)	824,992	CY	$120	$98,999,074	I-36/I-37
Treated Sand Disposal (assume 50% of treated sediment [coarse fraction] is reusable)	412,496	CY	$0	$0	I-36/I-37
Subtotal:				$102,999,074	
CONSTRUCTION QA/QC					
Construction Monitoring	1,733	DAY	$7,925	$13,736,441	I-36/I-9
Subtotal:				$13,736,441	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$2,561,512	$2,561,512	NA/I-18
Compliance Testing (Capping)	1	PROJECT	$383,070	$383,070	NA/I-18
Compliance Testing (ENR)	0	PROJECT	$0	$0	NA/I-18
Subtotal:				$2,944,582	
CAPITAL COST (BASE)				$314,437,925	
CAPITAL COST (present value)				$256,589,635	Assume capital costs distributed over construction years

TABLE I-46 ALTERNATIVE 5 REMOVAL WITH TREATMENT

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$89,806,372	NA/I-37
Sales Tax				$24,376,015	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$76,976,890	NA/I-37
Construction Management				$25,658,963	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$473,407,877	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$11,969,851	$11,969,851	NA/I-30
Reporting	1	PROJECT	$1,773,645	$1,773,645	NA/I-30
Operation and Maintenance (Dredging)	1	PROJECT	$1,826,096	$1,826,096	NA/I-30
Operation and Maintenance (Capping)	1	PROJECT	$884,778	$884,778	NA/I-30
Operation and Maintenance (ENR)	0	PROJECT	$0	$0	NA/I-30
Operation and Maintenance (MNR)	0	PROJECT	$0	$0	NA/I-30
Long-term Monitoring	1	PROJECT	$4,987,043	$4,987,043	NA/I-30
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$36,266,924	
TOTAL COST				$509,674,800	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.

2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.

3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).

4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.

5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-47 ALTERNATIVE 5 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	8.2	YEAR	$120,000	$983,527	I-36/I-37
Land Lease for Operations and Staging	8.2	YEAR	$250,000	$2,049,015	I-36/I-10
Contractor Work Plan Submittals	8.2	YEAR	$100,000	$819,606	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$3,932,149	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	37.2	MONTH	$62,000	$2,303,640	I-36/I-10
Construction Office and Operating Expense	37.2	MONTH	$21,600	$802,558	I-36/I-10
Subtotal:				$3,106,198	
DREDGING					
Shift Rate	725	DAY	$25,963	$18,811,068	I-36/I-8
Gravity Dewatering (on the barge)	753,009	CY	$10	$7,530,087	I-36/I-37
Subtotal:				$26,341,156	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	725	DAY	$10,000	$7,245,318	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	1,129,513	TON	$60	$67,770,786	I-36/I-37
Subtotal:				$76,016,104	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	2.4	ACRE	$30,000	$73,174	I-36/I-37
Shift Rate (12 hours)	571	DAY	$12,500	$7,136,416	I-36/I-37
Cap material procurement and delivery (Sand)	518,732	CY	$27	$14,033,787	I-36/I-7
Subtotal:				$21,243,378	
ENHANCED NATURAL RECOVERY					
Debris Sweep	5.3	ACRE	$30,000	$158,960	I-36/I-37
Shift Rate (12 hours)	49	DAY	$12,500	$608,375	I-36/I-37
Material procurement and delivery (Sand)	32,057	CY	$27	$867,269	I-36/I-7
Material procurement and delivery (carbon amended sand)	32,057	CY	$161	$5,176,447	I-36/I-7
Subtotal:				$6,811,050	
CONSTRUCTION QA/QC					
Construction Monitoring	725	DAY	$7,925	$5,742,087	I-36/I-9
Subtotal:				$5,742,087	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$1,076,056	$1,076,056	NA/I-19
Compliance Testing (Capping)	1	PROJECT	$1,208,269	$1,208,269	NA/I-19
Compliance Testing (ENR)	1	PROJECT	$1,350,286	$1,350,286	NA/I-19
Subtotal:				$3,634,612	
CAPITAL COST (BASE)				$146,826,732	
CAPITAL COST (present value)				$135,485,032	Assume capital costs distributed over construction years

TABLE I-47 ALTERNATIVE 5 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$47,419,761	NA/I-37
Sales Tax				$12,871,078	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$40,645,510	NA/I-37
Construction Management				$13,548,503	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$249,969,885	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$8,198,903	$8,198,903	NA/I-31
Reporting	1	PROJECT	$1,396,551	$1,396,551	NA/I-31
Operation and Maintenance (Dredging)	1	PROJECT	$1,005,006	$1,005,006	NA/I-31
Operation and Maintenance (Capping)	1	PROJECT	$4,791,378	$4,791,378	NA/I-31
Operation and Maintenance (ENR)	1	PROJECT	$5,276,306	$5,276,306	NA/I-31
Operation and Maintenance (MNR)	0	PROJECT	$0	$0	NA/I-31
Long-term Monitoring	1	PROJECT	$4,989,224	$4,989,224	NA/I-31
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$40,482,879	
TOTAL COST				$290,452,800	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).
4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.
5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-48 ALTERNATIVE 6 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	46.6	YEAR	$120,000	$5,592,589	I-36/I-37
Land Lease for Operations and Staging	46.6	YEAR	$250,000	$11,651,227	I-36/I-10
Contractor Work Plan Submittals	46.6	YEAR	$100,000	$4,660,491	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$21,984,307	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	211	MONTH	$62,000	$13,099,086	I-36/I-10
Construction Office and Operating Expense	211	MONTH	$21,600	$4,563,553	I-36/I-10
Subtotal:				$17,662,639	
DREDGING					
Shift Rate	4,120	DAY	$25,963	$106,964,566	I-36/I-8
Gravity Dewatering (on the barge)	3,943,174	CY	$10	$39,431,736	I-36/I-37
Subtotal:				$146,396,302	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	4,120	DAY	$10,000	$41,198,739	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	5,914,760	TON	$60	$354,885,627	I-36/I-37
Subtotal:				$397,084,365	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	1303	DAY	$12,500	$16,288,793	I-36/I-37
Cap material procurement and delivery (Sand)	1,190,503	CY	$27	$32,207,878	I-36/I-7
Subtotal:				$48,496,671	
ENHANCED NATURAL RECOVERY					
Debris Sweep	0	ACRE	$30,000	$0	I-36/I-37
Shift Rate (12 hours)	0	DAY	$12,500	$0	I-36/I-37
Material procurement and delivery (Sand)	0	CY	$27	$0	I-36/I-7
Material procurement and delivery (carbon amended sand)	0	CY	$161	$0	I-36/I-7
Subtotal:				$0	
CONSTRUCTION QA/QC					
Construction Monitoring	4,120	DAY	$7,925	$32,650,979	I-36/I-9
Subtotal:				$32,650,979	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$4,760,245	$4,760,245	NA/I-20
Compliance Testing (Capping)	1	PROJECT	$732,515	$732,515	NA/I-20
Compliance Testing (ENR)	0	PROJECT	$0	$0	NA/I-20
Subtotal:				$5,492,760	
CAPITAL COST (BASE)				$669,768,023	
CAPITAL COST (present value)				$417,698,523	Assume capital costs distributed over construction years

TABLE I-48 ALTERNATIVE 6 REMOVAL

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$146,194,483	NA/I-37
Sales Tax				$39,681,360	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$125,309,557	NA/I-37
Construction Management				$41,769,852	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$770,653,775	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$19,644,440	$19,644,440	NA/I-32
Reporting	1	PROJECT	$2,717,387	$2,717,387	NA/I-32
Operation and Maintenance (Dredging)	1	PROJECT	$0	$0	NA/I-32
Operation and Maintenance (Capping)	1	PROJECT	$0	$0	NA/I-32
Operation and Maintenance (ENR)	0	PROJECT	$0	$0	NA/I-32
Operation and Maintenance (MNR)	0	PROJECT	$0	$0	NA/I-32
Long-term Monitoring	1	PROJECT	$4,933,103	$4,933,103	NA/I-32
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$42,120,442	
TOTAL COST				$812,774,200	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).
4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.
5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-49 ALTERNATIVE 6 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
PRECONSTRUCTION					
Mobilization, Demobilization and Site Restoration (project)	1	LS	$800,000	$800,000	NA/I-37
Mobilization, Demobilization and Site Restoration (seasonal)	17.9	YEAR	$120,000	$2,149,456	I-36/I-37
Land Lease for Operations and Staging	17.9	YEAR	$250,000	$4,478,033	I-36/I-10
Contractor Work Plan Submittals	17.9	YEAR	$100,000	$1,791,213	I-36/I-10
Barge Protection	1	LS	$80,000	$80,000	NA/I-10
Subtotal:				$8,498,703	
PROJECT MANAGEMENT (CONTRACTOR)					
Labor and Supervision	81.6	MONTH	$62,000	$5,060,455	I-36/I-10
Construction Office and Operating Expense	81.6	MONTH	$21,600	$1,762,997	I-36/I-10
Subtotal:				$6,823,452	
DREDGING					
Shift Rate	1,583	DAY	$25,963	$41,110,768	I-36/I-8
Gravity Dewatering (on the barge)	1,645,668	CY	$10	$16,456,677	I-36/I-37
Subtotal:				$57,567,445	
SEDIMENT HANDLING AND DISPOSAL					
Transloading Area Setup	1	LS	$1,000,000	$1,000,000	NA/I-8
Water Management	1,583	DAY	$10,000	$15,834,326	I-36/I-8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	2,468,502	TON	$60	$148,110,091	I-36/I-37
Subtotal:				$164,944,417	
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL					
Debris Sweep	5.1	ACRE	$30,000	$152,841	I-36/I-37
Shift Rate (12 hours)	1,125	DAY	$12,500	$14,056,689	I-36/I-37
Cap material procurement and delivery (Sand)	1,015,208	CY	$27	$27,465,435	I-36/I-7
Subtotal:				$41,674,965	
ENHANCED NATURAL RECOVERY					
Debris Sweep	10.1	ACRE	$30,000	$303,320	I-36/I-37
Shift Rate (12 hours)	92	DAY	$12,500	$1,151,170	I-36/I-37
Material procurement and delivery (Sand)	61,169	CY	$27	$1,654,878	I-36/I-7
Material procurement and delivery (carbon amended sand)	61,169	CY	$161	$9,877,435	I-36/I-7
Subtotal:				$12,986,803	
CONSTRUCTION QA/QC					
Construction Monitoring	1,583	DAY	$7,925	$12,549,079	I-36/I-9
Subtotal:				$12,549,079	
POST-CONSTRUCTION PERFORMANCE MONITORING					
Compliance Testing (Dredging)	1	PROJECT	$1,973,732	$1,973,732	NA/I-21
Compliance Testing (Capping)	1	PROJECT	$2,293,953	$2,293,953	NA/I-21
Compliance Testing (ENR)	1	PROJECT	$2,493,384	$2,493,384	NA/I-21
Subtotal:				$6,761,070	
CAPITAL COST (BASE)				$311,805,933	
CAPITAL COST (present value)				$259,038,304	Assume capital costs distributed over construction years

TABLE I-49 ALTERNATIVE 6 COMBINED TECHNOLOGY

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST	SOURCE TABLE QUANTITY/UNIT COST
Construction Contingency				$90,663,406	NA/I-37
Sales Tax				$24,608,639	NA/I-37
Project Management, Remedial Design and Baseline Monitoring				$77,711,491	NA/I-37
Construction Management				$25,903,830	NA/I-37
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)				$477,925,671	
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (net present value)					
Agency Review and Oversight	1	PROJECT	$12,301,904	$12,301,904	NA/I-33
Reporting	1	PROJECT	$1,806,851	$1,806,851	NA/I-33
Operation and Maintenance (Dredging)	1	PROJECT	$1,456,529	$1,456,529	NA/I-33
Operation and Maintenance (Capping)	1	PROJECT	$7,529,023	$7,529,023	NA/I-33
Operation and Maintenance (ENR)	1	PROJECT	$8,051,820	$8,051,820	NA/I-33
Operation and Maintenance (MNR)	0	PROJECT	$0	$0	NA/I-33
Long-term Monitoring	1	PROJECT	$5,026,043	$5,026,043	NA/I-33
Institutional Controls	1	PROJECT	$14,825,511	$14,825,511	NA/I-35
Subtotal:				$50,997,682	
TOTAL COST				$528,923,400	

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.

2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.

3. Operation and Maintenance and Monitoring Costs include O&M, monitoring, and repair (for capping and ENR).

4. Net present value calculation applied to both capital costs and O&M and agency oversight, reporting, and monitoring costs.

5. Areas, volumes and durations from Table I-36.

NA = not applicable

TABLE I-50 MONITORING COST SUMMARY BY ALTERNATIVE

Remedial Alternative	Baseline and Long-term Monitoring	Construction Monitoring	Post-construction Performance Monitoring	Operation and Maintenance Monitoring [a]	Total Monitoring Costs
Alt 1	$5,200,000	-	-	-	$5,200,000
2R	$5,200,000	$4,700,000	$1,300,000	$17,000,000	$28,200,000
2R-CAD	$5,200,000	$4,700,000	$1,300,000	$20,000,000	$31,200,000
3R	$5,100,000	$6,500,000	$1,200,000	$14,000,000	$26,800,000
3C	$5,300,000	$3,700,000	$1,400,000	$17,000,000	$27,400,000
4R	$5,000,000	$9,800,000	$2,100,000	$7,000,000	$23,900,000
4C	$5,100,000	$5,300,000	$2,500,000	$12,000,000	$24,900,000
5R	$5,000,000	$13,700,000	$2,900,000	$3,000,000	$24,600,000
5R-T	$5,000,000	$13,700,000	$2,900,000	$3,000,000	$24,600,000
5C	$5,000,000	$5,700,000	$3,600,000	$11,000,000	$25,300,000
6R	$4,900,000	$32,700,000	$5,500,000	$0	$43,100,000
6C	$5,000,000	$12,500,000	$6,800,000	$17,000,000	$41,300,000

Footnotes:

a. Includes agency oversight, reporting, and monitoring costs only and does not include maintenance costs (i.e., repair costs) associated with Operation and Maintenance.

General Notes:

1. Monitoring costs are a summary of costs presented in Tables I-21 through I-31 and I-38 through I-49.

TABLE I-51 SUMMARY OF COSTS – BEST ESTIMATE ($ million)

Cost parameter	Remedial Alternative											
	1[a]	2R	2R - CAD	3R	3C	4R	4C	5R	5R-T	5C	6R	6C
Capital	n/a	$169	$148	$224	$156	$324	$221	$430	$473	$250	$771	$478
Monitoring, O&M, Reporting, Agency oversight	$9	$45.6	$48.3	$43.1	$44.9	$38.4	$40.9	$36.3	$36.3	$40.5	$42.1	$51.0
Total (NPV, i = 2.3%)	$9	$220	$200	$270	$200	$360	$260	$470	$510	$290	$810	$530
Total -30%	n/a	$150	$140	$190	$140	$250	$180	$330	$360	$200	$570	$370
Total +50%	n/a	$320	$290	$400	$300	$540	$390	$700	$760	$440	$1,200	$790
Total (not discounted)[b]	$12	$250	$230	$310	$230	$430	$300	$580	$630	$330	$1,300	$650

Notes:

1. Total costs are rounded to 2 significant digits. Capital costs and indirect construction costs are rounded to 3 significant digits for display purposes. All calculations are performed prior to rounding.
2. Capital cost includes construction costs, construction contingency, sales tax, engineering, procurement, and construction management.

a. Alternative 1 costs are $9 million for LDW-wide monitoring, agency oversight, and reporting as shown in Table I-38. The cost of completing the cleanup actions in the EAAs is estimated at approximately $95 million. Decisions on those cleanups have been made and are not part of the decision process represented in this FS. Substantial additional costs are expected for upland cleanup and source control. The EAA costs and the costs of upland cleanup and source control are not incorporated into the cost of any alternative and are not used in comparing the alternatives.

b. Non-discounted costs are provided for informational purposes.

C = combined technology; CAD = contained aquatic disposal; EAA = early action area; FS = feasibility study; NPV = net present value; O&M = Operation and Maintenance; R = removal emphasis; T = treatment

Lower Duwamish Waterway Group

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

Appendix J
Recontamination Potential and Regional Site Data

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

List of Tables

List of Figures

J.1 Introduction

The Lower Duwamish Waterway (LDW) is an estuarine tidal water body located in an urban environment. It has multiple uses, including as a working commercial/industrial waterway. Consequently, multiple external sources of contaminant inputs to the LDW exist. They reflect regional and local sources and are the primary factors influencing the surface sediment contaminant concentrations that will prevail in the long term following any cleanup. In other words, surface sediment within the LDW will have detectable contaminant concentrations following any cleanup actions. The purpose of this appendix is two-fold:

- Evaluate regional data and literature to provide confidence in the long-term model-predicted range of future concentrations (on a site-wide spatially-weighted average concentration [SWAC] basis), which are largely influenced by upstream inflows from the Green/Duwamish River watershed and to a lesser extent by the lateral inflows from the LDW drainage basin. These levels represent a return to urban background and long-term "equilibrium" (i.e., inputs from diffuse sources).
- Assess the potential for recontamination at smaller scales, based on urban inputs. This appendix evaluates LDW post-maintenance dredging data to reveal the nature of sediments being deposited within the site, as lines of evidence for these levels. This appendix also presents published studies and modeling as additional lines of evidence for small-scale recontamination.

For simplicity, this appendix defines "recontamination" as contaminant concentrations in surface sediments that return to unacceptable levels after a cleanup (e.g., concentrations of Washington State Sediment Management Standards [SMS] contaminants above the sediment quality standards [SQS]). While this appendix considers only exceedances of the SQS, other thresholds described in the feasibility study (FS) are also applicable for defining recontamination. Recontamination can be caused by the diffuse, urban sources external to the LDW and by localized resuspension and redeposition of sources internal to the LDW. Source control actions, including those upstream of the site, will affect long-term contaminant concentrations in LDW sediments. The level of surface sediment recontamination will reflect the aggregate inputs of both internal and external sources.

J.1.1 Sources and Pathways of Recontamination

The general external pathways (to both the LDW and to the upstream Green/Duwamish River watershed, which aggregates contaminants from various pathways into the upstream inflow to the LDW) include (see Figure J-1):

- Direct discharge into the LDW (e.g., combined sewer overflows [CSOs] and storm drains)

- Surface water runoff or sheet flow
- Spills and/or leaks to the ground, surface water, or directly into the LDW
- Groundwater migration/discharge
- Bank erosion/leaching
- Atmospheric deposition.

Several national studies have shown that atmospheric fluxes and in-water concentrations of contaminants, polychlorinated biphenyls (PCBs) in particular, correlate strongly with the degree of urbanization surrounding the water body being studied (Gingrich et al. 2001; Jamshidi et al. 2007; Offenberg and Baker 1997; Simcik et al. 1997; Totten et al. 2006; Van Metre and Mahler 2005; Wethington and Hornbuckle 2005).

Internal sources (transport of resuspended contaminated sediments) also influence surface sediment contaminant concentrations, both under existing conditions and in the short term following any cleanup actions. These internal mechanisms include:

- Scour of subsurface sediments
- Bed movement and deposition of surface sediments onto remediated areas
- Deposition of dredging residuals during cleanup actions or maintenance dredging actions.

These internal sources of recontamination are discussed within the body of the FS in terms of model predictions (Section 5) and technology performance (Sections 7 and 8).

In this appendix, multiple lines of evidence are used to provide context for the range of contaminant concentrations that surface sediments in the LDW are predicted to achieve, or equilibrate to, over the long term following remedial actions and source control. The empirical data used in this evaluation reflect the combined effect of the sources listed above, as it is recorded in the sediment bed. LDW sediment data presented in this appendix were collected following focused remedial actions and dredging for maintenance purposes. While it is understood that empirical trends are not necessarily indicative of future source control efforts and long-term trends, they do provide context for shorter-term recontamination potential (on the time span of 0 to 10 years after remedial actions have been completed).

In Section 9 of the FS, the long-term model-predicted surface sediment contaminant concentrations reflect the “best estimate” of what a combination of remedial actions, source control, and natural recovery can achieve in the LDW on a site-wide basis. The model considers ongoing contributions from nonpoint sources. The bed composition model (BCM) was also used to evaluate localized recontamination potential in the LDW, as presented in this appendix. However, the assessment of ongoing inputs to the

LDW is subject to several limitations. The dataset used for lateral loads is limited and considered only inputs from municipal storm drain solids and CSOs, excluding other potential sources such as groundwater, bank erosion, and most private stormwater discharges. Also, the BCM assigns uniform contaminant concentrations to input points that represent major outfalls and aggregations of smaller outfalls, whereas varying contaminant concentrations are expected, based on empirical data. Similarly, estimates of upstream inputs are based on a limited dataset.

To support this evaluation of an urban signature and long-term model-predicted concentrations, this appendix examines several lines of evidence relative to recontamination potential in the LDW:

- Regional and Puget Sound trends (Section J.2)
- LDW-specific temporal trends and model predictions (Section J.3)
- Atmospheric deposition of contaminants as a pathway to the LDW from external sources (Section J.4).

J.1.2 Land Use and Urban Inputs

The degree of urbanization in the Green/Duwamish River watershed generally decreases with distance upstream. This relative pattern of urban development is not expected to change significantly. Therefore, sources discharging directly to the LDW are expected to have higher contaminant concentrations than those contributing to the upstream Green/Duwamish River watershed into the foreseeable future. This is tied to the observation that atmospheric deposition (either to the surface water itself or to the watershed surrounding the water body) is an important and sometimes dominant pathway for nonpoint source loading to water bodies. These external sources are discussed at length in the remedial investigation (RI; Windward 2010) and summarized in Section 2:

- The Green/Duwamish River watershed is 470 square miles and is divided into four subwatersheds. These are listed upstream to downstream and shown on Figure J-2 (King County 2005):
  - Upper Green River: 142,000 acres from headwaters downstream to the Howard Hanson Dam, contains 45% of the entire watershed's land area and river mileage; primary land use is forest (99%).
  - Middle Green River: 113,000 acres from the Howard Hanson Dam downstream to the confluence with Soos Creek at river mile (RM) 32; major land uses are residential (50%), forest (27%), and agriculture (12%). It contains the cities of Enumclaw, Black Diamond, Covington, and Maple Valley, but most of the area is in unincorporated King County.

- Lower Green River: 41,000 acres from RM 32 downstream to RM 11; historically the White and Cedar/Black rivers joined the Green River in this stretch; major land uses are residential (50%) and commercial/industrial (27%).
- Duwamish estuary: 17,000 acres from RM 11 to 0 (at Harbor Island), including the East and West Waterways; the mouth of the subwatershed is at Elliott Bay. This subwatershed includes the LDW and Duwamish River (King County 2005). This subwatershed contains 36% residential, 18% industrial, and 11% commercial land uses. Eighteen percent of the subwatershed is used for right-of-way areas (including roads and highways); while 17% is open/undeveloped land and parks (Schmoyer, personal communication, 2011).

An assessment of planned development was conducted in a study area comprised of the Upper Green, Middle Green, and a portion of the Lower Green subwatersheds. The assessment showed that the lower portion of the study area is already heavily urbanized, with Soos, Jenkins, and Mill creeks (Auburn) drainage basins having more than 30% impervious cover. A land use change analysis found 18.5 square miles of urban density development planned for forested or bare ground areas, with one half of that development planned in Soos, Jenkins, and Covington creeks (King County 2005).

J.2 Regional and Puget Sound Trends

Urban-influenced nonpoint sources of contaminants to the LDW will influence the extent to which recontamination of any cleanup will occur at either the site-wide or location-specific scale. Following targeted source control efforts to identify and control pathways of elevated levels of contaminants to the LDW, the more diffuse, widespread nonpoint sources will still reach the LDW.

Data are available in the region to determine how such general urban sources contribute to recontamination in sediments of urban and near-urban water bodies. The regional data were collected from four sources for evaluation:

- Total PCB, arsenic, and carcinogenic polycyclic aromatic hydrocarbon (cPAH) sediment data collected from five urban water bodies in the Puget Sound region (Table J-1)
- Dioxin/furan sediment data collected immediately offshore of outfalls in the greater Seattle area (Table J-2)
- Dioxin/furan sediment data collected in Elliott Bay as part of the Puget Sound Assessment and Monitoring Program (PSAMP; formerly the Puget

Sound Ambient Monitoring Program) and in and around five open water dredged sediment disposal sites in Puget Sound (Table J-3)[1]

- A literature review of studies and associated data from the Puget Sound region (Table J-4).

J.2.1 Total PCB, Arsenic, and cPAH Sediment Data from Five Puget Sound Region Urban Water Bodies

Surface sediment data from five Puget Sound region urban water bodies (i.e., Elliott Bay, Bellingham Bay, Commencement Bay, Lake Washington, and Lake Sammamish) were queried from the Washington State Department of Ecology's (Ecology) Environmental Information Management (EIM) System in January 2007 (PCBs and arsenic) and in January 2008 (polycyclic aromatic hydrocarbons [PAHs]) by AECOM (known as RETEC/ENSR prior to 2008). The data queried were from samples collected between 1990 and 2004. In these queries, individual PCB Aroclor and PAH data were retrieved and used to calculate total PCBs and cPAH toxic equivalents (TEQs).

J.2.2 Data Treatment

These data were screened to exclude:

- Samples collected as part of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Model Toxics Control Act (MTCA) cleanup study prior to any sediment remediation (because the goal was to examine how urban sources influence a site after remedial actions have occurred, not before). Data available from post-remediation monitoring events were retained.

- Samples collected as part of routine monitoring of the open water dredged material disposal sites. Data from those sites are representative of regional sediment quality, but were excluded because the sediment characteristics of the disposed material may be biased toward the original locations from where the sediments were dredged.[2] Therefore, the conclusion was that they may not represent the urban water body being investigated.

Elliott Bay data were then reduced and divided in the following manner (Table J-1):

- Data were divided into inner and outer Elliott Bay datasets (Figure J-3).[3] Three locations near the middle and east of the dividing line were included

[1] The five open water disposal sites are not in the same five urban water bodies noted in the first bullet.

[2] Open water disposal site samples were excluded in the analysis of total PCB, arsenic, and cPAH data, but were used for the dioxin/furan evaluation discussed in Section J.2.2.

[3] The demarcation between inner and outer Elliott Bay was delineated by drawing a north-south line from the Duwamish Head in West Seattle to Pier 91/92 north of downtown Seattle.

in the outer Elliott Bay dataset following a 150-meter mean lower low water (MLLW) bathymetric contour.

- Data collected within 250 feet (ft) of the shoreline were excluded (to minimize the possible influence of point sources).
- Data collected from the Denny Way CSO and Pier 51/52 caps (downtown Seattle) were excluded from the inner Elliott Bay dataset. Although they are post-remedy data, the receiving sediments may be influenced by localized outfall discharges.
- Both the inner and outer Elliott Bay datasets exclude data collected before 1991.

For the other urban water bodies, geographical divisions were not used to separate or differentiate among data.

Summary statistics for each urban water body were generated for total PCBs, arsenic, and cPAHs (Table J-1). It is noted that the available data for each water body may not represent the overall conditions in that water body; some of the studies conducted to gather these data were not designed to characterize the entire water body, but rather were designed to focus on particular areas of concern. Aside from the minimal screening discussed above, these data were not thoroughly screened to ensure that all data that might be associated with other potential point sources of contamination (i.e., adjacent to upland contaminated sites) were removed; however, for the purpose of this appendix, which is to evaluate summaries of these data for informational purposes, these datasets are considered adequate.

J.2.2.1 Summary of Data

A reasonable degree of consistency in contaminant concentrations is expected for sediments from the same region (i.e., from the Puget Sound region). This is because the chemical composition of stormwater runoff and atmospherically deposited material may be similar within broad urbanized geographic regions, including the LDW watershed. It is difficult to completely resolve point sources from other source contributions measured in surface sediments. Thus, it is appropriate to compare concentrations observed in the urban water bodies (Table J-1) to the long-term model-predicted concentrations for the LDW (equilibrium) and to areas with localized recontamination potential. Both are influenced by urban sources. The results of these comparisons are discussed for three of the four human health risk drivers:

- The mean total PCB concentrations from these water bodies, excluding inner Elliott Bay, are in the range of 40 to 90 micrograms per kilogram dry weight (µg/kg dw). This is consistent with the best-estimate long-term model-predicted concentrations of 40 to 50 µg/kg dw and the full sensitivity range of long-term model-predicted concentrations of 10 to 100 µg/kg dw[4] (Figure J-4a). These data also suggest surface sediment concentrations in small areas (90th percentile of data) of up to about 200 µg/kg dw (Table J-1, excluding inner Elliott Bay).

- For arsenic, the mean concentrations from these water bodies, excluding Lake Sammamish, are in the range of 5 to 10 milligrams (mg)/kg dw. The Lake Sammamish mean concentration is 15 mg/kg dw. This data range is fairly tight. The urban water bodies yield statistics very similar to the full sensitivity range of long-term model-predicted concentrations of 7 to 10 mg/kg dw (Figure J-4b). These data also suggest concentrations in small areas (90th percentile) of up to about 17 mg/kg dw (Table J-1).

- The cPAH data from Commencement Bay, Lake Sammamish, and Lake Washington have the highest mean values (more than 200 µg TEQ/kg dw). Data from outer Elliott Bay and Bellingham Bay have cPAH means around 100 µg TEQ/kg dw. This is consistent with the best-estimate long-term model-predicted concentrations of 100 to 120 µg TEQ/kg dw (full sensitivity range from 50 to 320 µg TEQ/kg dw) (Figure J-4c). The mean cPAH concentration for inner Elliott Bay exceeds 580 µg/kg dw (Table J-1), which suggests concentrations in small areas around 300 to 500 µg TEQ/kg dw. This range also includes the 90th percentile of the outer Elliott Bay dataset.

J.2.3 Greater Seattle Dioxin/Furan Sediment Sampling Immediately Offshore of Outfalls

Surface sediment sampling for dioxins/furans in the greater Seattle metropolitan area was conducted as part of the RI sampling event in 2005. This Seattle-area study was designed to collect sediment samples near storm drains and other areas receiving runoff associated with typical urban sources. The total number of samples was relatively small (n= 11; Windward 2010), but these data were combined with other lines of evidence for assessing recontamination potential in this appendix.

The criteria used to select sampling areas representative of urban influences were as follows: 1) the area must receive drainage from basins with land uses similar to the LDW; 2) the area must not be located near known industrial point sources of dioxins/furans; 3) the area must represent a range of receiving water environments; and 4) the area must represent a range of stormwater discharge frequencies, volumes, and types similar to those in the LDW.

The mean of these data, excluding samples from the Ship Canal and Union Bay, which exceeded 50 nanograms (ng) TEQ/kg dw, was 14.9 ng TEQ/kg dw. The 90th percentile

[4] The full range of BCM predictions are presented in Sections 9 and 10 of the FS, and are the result of low to high sensitivity runs of the BCM input parameter values 30 years after remediation of Alternative 6.

was 16.3 ng TEQ/kg dw (Table J-2; Windward 2010). These data are higher than the full range of long-term model-predicted concentrations (2 to 8 µg/TEQ/kg dw), but they are indicative of sediment concentrations immediately offshore of outfalls in the Greater Seattle area.

J.2.4 Dioxin/Furan Data from Regional Open Water Disposal Sites

Because the dioxin/furan data are limited compared to data for the other human health risk drivers, urban water body data for this risk driver were obtained from studies of Puget Sound open water disposal sites (Table J-3) and included in the analysis.

Dioxins/furans were analyzed from Dredged Material Management Program (DMMP) samples collected near and within five nondispersive open water dredged material disposal sites from 2005 to 2008. These data were compiled in an effort to revise guidelines related to open water disposal of dioxin/furan-containing dredged material. Data were provided as a part of a series of public meetings led by the DMMP related to these guidelines in 2009 (DMMP 2009).

Sample locations were divided into on-site and off-site samples (the latter at least one-eighth of a mile from the sites; Table J-3). The mean concentrations at the Elliott Bay disposal site (2005 and 2007) were 6 and 8 ng TEQ/kg dw for on-site and off-site samples, respectively. Dioxin/furan data were also collected in Elliott Bay in 2008 for the PSAMP to assess ambient conditions. These samples were not collected in close proximity to the Elliott Bay disposal site. The PSAMP surface (0 to 10 centimeter [cm]) samples had a slightly lower mean of 5 ng TEQ/kg dw (range 1 to 14 ng TEQ/kg dw)[5] compared to the 2005/2007 DMMP samples. For the other urban bays, the mean values of the DMMP on-site samples ranged from 2 to 6 ng TEQ/kg dw. The mean values of the off-site samples ranged from 2 to 8 ng TEQ/kg dw; more samples were collected off-site, which could account for the larger range (DMMP 2009, Wakeman and Hoffman 2006).

Some regional differences may exist, but these dioxin/furan data generally support the full range of long-term model-predicted concentrations of 2 to 8 ng TEQ/kg dw (Figure J-4d).

J.2.5 Published Studies on Regional Trends

Coring studies and temporal surface sediment sampling of water bodies within the Puget Sound region provide valuable information regarding regional sources, trends, and current concentrations on a large scale. The PSAMP (Partridge et al. 2005) shows that in urban watersheds, and in Puget Sound in particular, concentrations of industrial contaminants are decreasing in sediments, while concentrations of contaminants related

[5] Samples within 250 ft of the shoreline were excluded to eliminate samples that could be significantly influenced by potential nearshore sources. Two outliers at 87 and 97 ng TEQ/kg dw were also excluded.

to urbanization (e.g., bis(2-ethylhexyl)phthalate [BEHP] and PAHs) are increasing. The temporal trends from 10 long-term PSAMP monitoring stations sampled from 1989 to 2000 documented decreases in metal concentrations and increases in PAH concentrations over time. The decreases in industrial-sourced contaminants, such as metals, are linked to the use of best management practices (BMPs) and controls on industrial activities and waste disposal. The increases in PAH concentrations can be linked to general urbanization. Using population growth as a surrogate for urbanization, the City of Seattle has grown by about 47,000 people, or by 9%, from 1990 to 2000. This rate is twice as fast as the city's growth from 1980 to 1990 and close to the national increase of 10% growth in a 10-year period (City of Seattle 2008).

Empirical data from previous sediment cleanups in the Puget Sound region suggest that some recontamination may occur in localized areas near large outfalls. Recent trends in Puget Sound have shown increasing concentrations of persistent, non-point source contaminants typically found in urbanized areas and often associated with street dirt, car exhaust, and asphalt paving.

Table J-4 summarizes the regional and national studies evaluated to describe regional trends. Figures J-4a through J-4d graphically present the range of regional concentrations relative to long-term model-predicted concentrations. Empirical data trends observed from regional and national studies help provide context for the long-term model-predicted concentrations and for recontamination potential in the LDW. These findings are described below.

J.2.5.1 Total PCBs

The National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends (NST) Program (McCain et al. 2000) reports much lower total PCB surface sediment concentrations in less-urbanized water bodies. In the Nisqually Reach (Puget Sound), an area with no urban or industrial development, total PCB sediment concentrations were around 10 µg/kg dw while samples collected in Elliott Bay were significantly higher, up to 1,000 µg/kg dw (McCain et al. 2000). This program also evaluated six sediment cores collected in the main basin of Puget Sound, which had maximum concentrations of 35 µg/kg dw in subsurface sediment and an average concentration of 8 µg/kg dw in the surface-interval samples (Lefkovitz et al. 1997).

Sediment cores collected from two remote lakes on the Olympic Peninsula (Lake Ozette and Beaver Lake, WA) revealed maximum total PCB concentrations at depth (i.e., they were buried by less contaminated sediment) at 60 and 175 µg/kg dw in intervals dated in the mid-1960s. By the mid-1970s, concentrations had fallen to 40 and 100 µg/kg dw, respectively (Cleverly et al. 1996 as cited in Yake 2001). These core trends demonstrate the historical trends in total PCB contamination away from urban influences. Figure J-4a displays only the more recent data, which are relevant to the long-term model-predicted concentrations.

Lake Ballinger (Snohomish County, light urban) and Lake Washington (urban) sediment cores contained total PCB concentration peaks of 220 and 265 µg/kg dw at depth, respectively, in sediment dated in the 1960s. Concentrations in these cores fell to 40 and 75 µg/kg dw, respectively, in intervals dated in the 1980s (shallower intervals; USGS 2000 as cited in Yake 2001). This demonstrates the land use gradients (i.e., higher concentrations in more urbanized areas) and historical trends of buried peaks and decreasing total PCB concentrations with decreasing depth.

In another study, Van Metre and Mahler (2005) analyzed sediment core data from 38 urban and reference (non-urban, undeveloped) lakes distributed across the United States. Higher total PCB concentrations were found in dense urban lakes with a historical (1965 to 1975) median of 275 µg/kg dw, dropping to 108 µg/kg dw in shallower core intervals (post-1990). Light urban lakes had total PCB concentrations ranging from 51 (1970s) to 15 µg/kg dw (post-1990).[6]

The total PCB concentrations reported in these studies (Table J-4) were coincident with the degree of urban land use surrounding the water bodies. This suggests, in the case of the LDW, the need to consider inputs to the LDW from its immediate drainage basin as opposed to focusing exclusively on solids entering the site from the Green/Duwamish River (i.e., from upstream inflows where nonpoint sources originate from a less-urbanized watershed than the LDW drainage basin).

These studies (concentrations reported in Table J-4) support the best-estimate of long-term model-predicted total PCB concentrations range of 40 to 50 µg/kg dw, and the full sensitivity range of long-term model-predicted concentrations of 10 to 100 µg/kg dw. Localized areas can potentially recontaminate above 100 µg/kg dw (Figure J-4a; based on the dense-urban data median in Cleverly et al. 1996 as cited in Yake 2001, and Van Metre and Mahler 2005).

J.2.5.2 Arsenic

Sediment data collected during three regional studies have shown (Table J-4; Figure J-4b):

- Arsenic concentrations from 10 to 25 mg/kg dw in Lake Washington and Lake Ballinger (Snohomish County) subsurface sediment dated between 1960 and 2000 (USGS 2000 as cited in Yake 2001).
- Arsenic concentrations in the range of 10 to 20 mg/kg dw in Puget Sound subsurface sediment dated after 1970 from three cores far removed from river discharges or outfalls, with buried peak concentrations of 28 mg/kg dw and pre-industrial concentrations in the range of 5 to 10 mg/kg dw (Lefkovitz et al. 1997).

[6] For this study, land use in the watersheds was categorized as "dense urban" (>52% urban land use; 14 lakes), "light urban" (5-42% urban; 17 lakes), or "reference" (<1.5% urban; 7 lakes), as determined from the 1992 USGS National Land Cover Data.

- Temporal trends in surface sediments from Puget Sound nonurban and urban areas reported by PSAMP (Partridge et al. 2005). This study revealed minimal changes in arsenic concentrations over recent time. The study showed a median arsenic concentration of 10 mg/kg dw within a 1989 to 1996 dataset, with a decrease in all concentrations to below 10 mg/kg dw for a sampling event conducted in 2000.

The EIM database, maintained by Ecology, was also queried for post-2000 arsenic data from surface soil samples in the vicinity of the LDW and within the LDW watershed. The majority of the 765 samples were collected in conjunction with the *Tacoma Smelter Plume King County Child Use Study* and the *Tacoma Smelter Plume Phase II Mainland Footprint Study*. The mean arsenic soil concentration of this dataset was 10 mg/kg dw, and the 90th percentile was 20 mg/kg dw.

NOAA's NST Program cited mean arsenic concentrations of up to 13 mg/kg dw along the Pacific Coast, with the reference station (Dana Point, California) at 9.3 mg/kg dw (Meador et al. 1994).

Rice (1999) summarized concentrations of trace elements, including arsenic which is an element naturally present in soil, in streambed surface sediments throughout the United States, and reported a median arsenic concentration of 6.3 mg/kg dw. This study also documented median arsenic concentrations in nonurban indicator site soils ranging from 4.8 to 21 mg/kg dw.

Arsenic data from these studies provide evidence of the regional concentrations (Table J-4; Figure J-4b) and support the full sensitivity range of long-term model-predicted concentrations of 7 to 10 mg/kg dw, with localized areas containing sediment concentrations in the range of 10 to 20 mg/kg dw from general urban inputs.

J.2.5.3 cPAHs

Lefkovitz et al. (1997) evaluated sediment cores from three locations in Puget Sound that were geographically remote from river discharges and outfalls. The data show increasing benzo(a)pyrene, or B(a)P, concentrations beginning around 1900, peaking in the 1950s, and leveling off in the 1980s to a concentration of approximately 100 µg/kg dw. B(a)P is used as a surrogate for cPAHs because this individual PAH was commonly analyzed and reported in these studies, although other individual PAHs required for the calculation were not.[7]

In the 2000 PSAMP monitoring event, the B(a)P mean (of all samples) ranged from 143 µg TEQ/kg dw (in the 1989 to 1996 dataset) to 100 µg/kg dw (in the 2000 dataset). However, some individual PAHs, total PAHs, and high molecular weight PAHs

[7] cPAHs are also called B(a)P equivalents because the calculation of the TEQ adjusts the concentrations of seven PAH compounds based on their toxicity to mammals relative to that for B(a)P.

increased over time (1989 to 1996 dataset compared to 2000 dataset) in most areas of Puget Sound from which samples were collected (Partridge et al. 2005).

Van Metre et al. (2000 as cited in Yake 2001) observed that B(a)P from Lake Washington sediment cores showed little temporal (depth) variation in concentrations that remain at or below approximately 100 µg/kg dw. Conversely to PCB trends, Lake Ballinger sediment data exhibited a steep increase in B(a)P to concentrations in the 1,000 to 3,000 µg/kg dw range by the 1990s. This increase was likely associated with increased urbanization and population growth. These PAH temporal trends differ from those discussed earlier in this appendix for PCBs for at least three reasons:

- PCBs are recalcitrant and are very slow to degrade, relative to PAHs. Therefore, a lack of buried peak concentrations of PAHs in the core profiles could, in part, be due to degradation.
- PCBs are man-made chemicals, such that they are only produced by industrial processes, whereas PAHs are derived from both natural and urban sources.
- PCBs were intentionally produced. They were specifically manufactured prior to 1979 by particular industrial processes. In contrast, certain PAHs are unintentionally produced and are released to the atmosphere by combustion.

The body of literature on urban sediments suggests that PAH concentrations vary in proportion to the level of urbanization within a watershed. Van Metre and Mahler (2005) observed upward trends in PAH concentrations over time and strong correlations with urban land use. Increases occurred almost exclusively in lakes surrounded by urban watersheds. The Van Metre and Mahler (2005) data show median B(a)P concentrations in cores collected from dense urban lakes rising from 580 µg/kg dw during the period 1965 to 1975 up to 1,500 µg/kg dw in the post-1990 period (a 2.6-fold increase). The data for light urban lakes show median B(a)P concentrations during the same time periods rising from 50 to 120 µg/kg dw.

Similarly, Mauro et al. (2006) found that soils sampled in urban areas had average B(a)P concentrations of 495 µg/kg dw, with a median concentration of 130 µg/kg dw.

In summary, the Puget Sound (Lefkovitz et al. 1997) and light urban lakes data (Van Metre and Mahler 2005) support the best estimate of long-term model-predicted cPAH concentrations of about 100 to 120 µg TEQ/kg dw (full sensitivity range from 50 to 320 µg TEQ/kg dw). These regional studies, supported by national trends, document that localized inputs can result in contaminant concentrations above the upstream BCM input parameters (40 to 270 µg TEQ/kg dw), and localized recontamination potential up to about 500 µg TEQ/kg dw (dense urban median) is possible given the LDW drainage basin's urban land uses (Figure J-4c).

J.2.5.4 Dioxins/Furans

In one regional study, Ecology analyzed surface soils throughout Washington State for dioxins/furans (as cited in Rogowski et al. 1999 and Yake et al. 2000). Concentrations ranged from 0.0078 to 19 ng TEQ/kg dw. All samples had detectable concentrations, including those from remote wilderness areas. Dioxin/furan concentrations were generally higher in urban areas (0.13 to 19 ng TEQ/kg dw) than in forested, open, and agricultural areas (0.0078 to 5.2 ng TEQ/kg dw). Three of the highest detected values were from urban areas, which is consistent with combustion processes being the primary source of dioxins/furans in the environment. The study concluded that dioxin/furan concentrations detected in Washington State soils were comparable to those reported in studies conducted in other parts of the world.

Cleverly et al. (1996 as cited in Yake 2001) found peak dioxin/furan concentrations (2 ng TEQ/kg dw) in sediment cores collected in remote Olympic Peninsula lakes (Lake Ozette and Beaver Lake, WA) associated with buried sediment dated in the mid-1950s. Surface intervals from these cores had dioxin/furan concentrations of approximately 1 ng TEQ/kg dw. Contrasting these data to the urban water body data reveals the influence of urban sources (urban-rural gradient). However, the identification of detectable levels of dioxins/furans in these remote lakes infers atmospheric transport of this chemical class.

The U.S. Environmental Protection Agency (EPA) analyzed dioxins/furans in surface sediment samples from 11 lakes and reservoirs removed from known sources. The range reported was 0.12 to 16.3 ng TEQ/kg dw, with a mean of 5.3 ng TEQ/kg dw (EPA 2000 as cited in Windward 2010).

In another study, analysis of 10 samples collected from catch basins and manholes in the storm drain system in the LDW drainage basin revealed dioxins/furans ranging from 6 to 26 ng TEQ/kg dw (Integral 2008). One street dirt sample from the same study had a dioxin/furan concentration of 91 ng TEQ/kg dw.

The Washington State studies support the full sensitivity range of long-term model predictions for dioxins/furans of 2 to 8 ng TEQ/kg dw (Table J-4 and Figure J-4d). Localized dioxin/furan concentrations could be expected in the range of 10 to 20 ng TEQ/kg dw (rounded from 19), based on data from Rogowski et al. (1999), Yake et al. (2000), and EPA (2000 as cited in Yake 2001).

J.2.5.5 Phthalates

Empirical data from sediment cleanups in Puget Sound suggest that some recontamination may occur in localized areas near large outfalls. Monitoring results from the Thea Foss and Wheeler-Osgood Waterways in Commencement Bay have shown elevated concentrations of phthalates (BEHP) and PAHs in designated “recovery” areas (City of Tacoma and Floyd|Snider 2007a and 2007b). These concentrations may be attributable to the influence of localized effects from sources that are not controllable (e.g., BEHP and PAHs in urban stormwater).

Recent trends in Puget Sound have shown increasing concentrations of persistent, nonpoint source contaminants typically found in urbanized areas and often associated with street dirt, car exhaust, and asphalt paving. The Sediment Phthalate Work Group[8] recently concluded that phthalates are among several pervasive urban contaminants that follow the air-water-sediment pathway and are likely to pose greater problems as population and urban development increase (City of Tacoma et al. 2007).

Phthalates are not discussed as extensively in this appendix, because they were not identified as human health risk drivers for the LDW. Brief reviews of data from urban water bodies and of published literature were conducted for this appendix. Two phthalates were identified as having a high potential to cause recontamination on a model grid-cell basis, as discussed in Section J.3.2.1. Phthalate empirical data are also presented in Appendix F in the context of natural recovery potential.

J.3 LDW Evaluation

The types of probable contaminant pathways to the LDW that are cataloged in the RI (Windward 2010) and Ecology's Source Control Strategy (Ecology 2004) include: direct discharge into the LDW; surface water runoff or sheet flow; spills and/or leaks to the ground, surface water, or directly into the LDW; groundwater migration/discharge; bank erosion/leaching; and atmospheric deposition (see Figure J-1). In addition, contaminant pathways within the LDW include the resuspension and transport of contaminated sediments. In this FS, it is assumed that source control efforts and the remediation of sediment containing higher contaminant concentrations will sufficiently reduce point and nonpoint sources of contamination. This section describes the nature of sediment entering and depositing in the LDW receiving sediment to demonstrate long-term model-predicted contaminant concentrations that would occur following source control and remediation. This section also describes the areas with higher potential to recontaminate (as predicted by the BCM). Additionally, passive sampling of atmospheric deposition is presented to demonstrate that urban-source contaminants (PCBs, PAHs, and phthalates) are depositing within the LDW drainage basin. This section focuses on impacts to receiving sediments, as opposed to data collected from source media (e.g., groundwater, riverbank soils) because conditions in the receiving sediments reflect the influence of all internal and external contaminant sources to the LDW.

[8] The Sediment Phthalate Work Group includes representatives from the following agencies: City of Tacoma, City of Seattle, King County, Washington State Department of Ecology, and the U.S. Environmental Protection Agency.

J.3.1 Recent Surface Sediment Chemistry in Dredged and/or Capped Areas

Changes in surface sediment contaminant concentrations in maintenance dredged or capped areas after actions have been taken provide indications of potential recontamination. Analysis of contaminant concentrations in dredged areas, on sand caps, or on enhanced natural recovery (ENR) areas reveals the nature of recent sediments settling after the surface sediment has been removed or covered. The analysis allows legacy (historical) contamination to be separated from impacts associated with new sediment depositing on the remediated area; and provides an understanding of the chemical quality of material being deposited within the LDW, which is responsible for recontamination.

It is noted, however, that contamination may also exist in areas adjacent to the remediated areas, and this may be a component of the "new" sediment depositing in the remediated area. In addition, upland source control work in these areas is ongoing and was not complete at the time of sediment remediation. Sediments affecting actively remediated areas can originate from lateral sources, suspended material transported downstream from the Green/Duwamish River, or from LDW bed sediment that is resuspended and redeposited onto these areas. These data provide empirical evidence supporting the chemical nature of material depositing after sediment removal, capping, and/or thin-layer placement in the short term. The results discussed below may not be indicative of future trends at other outfalls. In addition, future trends may show further declines due to continued source control efforts.

J.3.1.1 Duwamish/Diagonal

The Duwamish/Diagonal Early Action Area (EAA, RM 0.5E) cleanup involved a combination of dredging and capping in 2003 to 2004 and thin-layer sand placement (ENR) in 2005. These actions were conducted by King County for the Elliott Bay/ Duwamish Restoration Program (EB/DRP), which was established in 1991 to implement a Natural Resource Damage Consent Decree. Surface sediment chemistry is being monitored on and adjacent to the actively remediated areas of the EAA; four years of post-ENR data (2006 through 2009) and five years of post-dredge/cap data (2005 through 2009) are available (Tables J-5a and J-5b, Figures J-5a and J-5b). Preliminary 2010 data have been collected by King County, but data were not available in time to be included in the database for this FS.

ENR Area

Following placement of the thin layer of sand (ENR) in February 2005 southwest of the Duwamish/Diagonal EAA, concentrations of contaminants of concern (COCs) reported for this ENR area are trending toward the range of concentrations predicted by the BCM. The ENR area is farther from the Duwamish/Diagonal CSO/storm drain (SD) outfalls than the dredged and capped areas. The initial sampling event in 2005 occurred approximately one month after ENR placement. Monitoring data in the four-year period following placement of the ENR sands show low concentrations of COCs were present immediately following sand placement, indicating the clean nature of the sand material placed. Over time, concentrations have been increasing slightly, indicating they have been equilibrating to a mixture of upstream inputs, lateral inputs, and the surrounding area. Specifically:

- Total PCB concentrations in surface sediment in the ENR area have remained below the SQS, with the highest concentration measured in 2009 being 144 µg/kg dw (8.3 mg/kg organic carbon [oc]). Average total PCB concentrations in 2007 through 2009 were in the 60 to 70 µg/kg dw range, above the best-estimate long-term model-predicted concentrations of 40 to 50 µg/kg dw, but within the full sensitivity range of long-term model-predicted concentrations (Table J-5a; Figure J-5a).

- At all seven of the ENR monitoring locations, the arsenic concentrations were at or below 11 mg/kg dw in 2009, with average concentrations in 2007 through 2009 in the 7 to 8 mg/kg dw range, within the range of long-term model-predicted concentrations (Table J-5a; Figure J-5a).

- For cPAHs, the maximum concentration measured in 2009 was 150 µg TEQ/kg dw. The average concentrations in 2008 and 2009 were in the 60 to 110 µg TEQ/kg dw range, similar to the range of best-estimate long-term model-predicted concentrations of 100 to 120 µg TEQ/kg dw (Table J-5a; Figure J-5a).

- Six of the seven BEHP samples collected in 2009 were undetectable (U qualified), but the qualification was added because of blank contamination, not because of concentrations below the reporting limit. The one detected sample exceeded the SQS of 47 mg/kg oc. Average concentrations in 2007 and 2008 were in the 130 to 150 µg/kg dw range (Table J-5a; Figure J-5a). For reference, the upstream BCM input parameter is 120 µg/kg dw, and the lateral BCM input parameter is 15,475 µg/kg dw (Table 5-3 of the FS).

- A 2009 composite sample from the ENR area had a dioxin/furan concentration of 3.3 ng TEQ/kg dw, similar to the best-estimate long-term model-predicted concentration of 4 ng TEQ/kg dw (full sensitivity range of 2 to 8 ng TEQ/kg dw; Figures J-4d and J-5a).

Cap Data

Two sand caps were placed in adjacent areas of the Duwamish/Diagonal EAA in 2004, following dredging activities (Table J-5b; Figure J-5b). Monitoring of the sediment accumulating on top of these caps has been conducted annually since 2004. The initial sampling event occurred approximately 5 months after cap placement, and showed average total PCB concentrations of 22 and 77 µg/kg dw on Caps A and B, respectively. In 2005 and 2006, sediment concentrations on Cap A, which is located closer to shore, showed increases in total PCB concentrations. These increases are believed to be the result of contamination from outfall discharges. Since 2006, total PCB concentrations have decreased on this cap, with an average of 62 µg/kg dw in 2009. Sediment concentrations on Cap B have shown similar averages over most years, and in 2009 had an average of 41 µg/kg dw. Both caps appear to be equilibrating to a level around 50 µg/kg dw, close to the best-estimate long-term model-predicted concentration range of 40 to 50 µg/kg dw.

Sediment concentrations of cPAH and BEHP on the caps follow similar trends, with the peak cPAH concentration measured on Cap A in 2006 (average of 375 µg TEQ/kg dw). Later cPAH concentrations on average trend toward the 110 to 230 µg TEQ/kg dw range for the caps, with Cap B having the lowest average concentrations. The highest BEHP average concentrations were measured on Cap A in 2005 and 2006 (averages of 1,933 and 1,485 µg/kg dw, respectively). Later BEHP concentrations on average trend toward the 300 to 750 µg/kg dw range for the caps, with Cap B having the lowest average concentrations.

Arsenic data for Cap B does not follow this trend. Concentrations on Cap B have been slightly higher than those on Cap A for 2007 through 2009. Arsenic concentrations started low (in 2004; cap material) and increased such that they equilibrated with upstream and lateral source inputs and surrounding areas.[9] At the eight cap monitoring locations, all arsenic samples were at or below 14 mg/kg dw in 2009. Arsenic data for both caps appear to be equilibrating to a concentration around 10 mg/kg dw.

Composite samples collected in 2009 on Caps A and B had dioxin/furan concentrations of 7.0 and 5.1 ng TEQ/kg dw, respectively, consistent with the full sensitivity range of long-term model-predicted concentrations of 2 to 8 ng TEQ/kg dw (Figure J-5b).

In summary, the ENR area and cap demonstrate that recontamination can occur at a very localized scale after cleanup (Tables J-5a and J-5b). However, with the exception of discharges from outfalls in the 2005/2006 wet season that resulted in higher concentrations of organic contaminants, contaminant concentrations are relatively low. The concentrations can be highly variable on a year-to-year basis. These data support the long-term model-predicted range of concentrations.

J.3.1.2 Norfolk Area

The Norfolk Area, located on the east bank at RM 4.9–5.0, encompasses two sediment removal actions. In 1999, King County conducted sediment removal and backfilling offshore of the Norfolk CSO/SD for the EB/DRP. At an adjacent, smaller area near the Boeing Developmental Center south storm drain, The Boeing Company conducted sediment removal and capping in 2003.

[9] For the BCM input parameters, a smaller range of concentrations was assigned for arsenic, which is consistent (appears to be reflected) in the cap data.

Norfolk CSO/SD Cleanup Area

Post-cleanup surface sediment samples from four general locations in the Norfolk CSO/SD cleanup area were collected annually from 1999 through 2004 by King County; the same four locations were resampled in 2006 as part of the RI. Three of the four locations were also sampled in 2008 by Ecology.

In 2001 (prior to the adjacent Boeing Developmental Center south storm drain cleanup), post-cleanup surface sediment samples in the Norfolk CSO/SD cleanup area[10] had total PCB concentrations ranging from 31 µg/kg dw to 1,330 µg/kg dw in the upper 10 cm of sediment and reached up to 1,900 µg/kg dw in the 0- to 2-cm samples. Following the adjacent south storm drain sediment removal and cap placement in 2003, total PCB concentrations at three of the four stations (NFK 501, 503, and 504) initially increased, but the concentrations at all four locations have subsequently decreased (Table J-6 and Figure J-6). The total PCB concentrations in the four samples collected on the cleanup area by Ecology in 2008 ranged from 2.2 to 7 µg/kg dw. In general, the total PCB concentrations remain low (in very sandy material), well below the long-term model-predicted range of 10 to 100 µg/kg dw.

The increase observed in Norfolk CSO/SD post-cleanup total PCB concentrations (prior to dredging and capping of the adjacent area offshore of the Boeing Developmental Center south storm drain in 2003) identifies the need to also look at adjacent sediment when evaluating recontamination potential. Recontamination is not only attributable to external sources (e.g., storm drains, upstream inflow) but can also be from internal sources (e.g., movement and redeposition of adjacent bed sediment, scour of subsurface sediment).

Arsenic concentrations in samples collected in April 1999 were all below 4 mg/kg dw. In 2004, all four of the 0 to 10 cm Norfolk samples were nondetect for arsenic. The arsenic concentrations from three samples collected on the cleanup area by Ecology in 2008 ranged from 6 to 15 mg/kg dw. These concentrations are within and close to the long-term model-predicted concentration range of 7 to 10 mg/kg dw.

In April 1999, cPAHs were not detected in any samples, but cPAH concentrations rose up to 286 µg TEQ/kg dw in 2004. In 2006, two samples were nondetect, and the other two had concentrations of 95 and 220 µg TEQ/kg dw. In 2006, the range for the three samples collected by Ecology was 23 to 230 µg TEQ/kg dw. One of these three samples had an SQS exceedance (for butyl benzyl phthalate). These data are within the long-term model-predicted concentration range of 50 to 320 µg TEQ/kg dw.

Visual observations of the Norfolk CSO/SD cleanup area by the King County Department of Natural Resources and Parks Department staff reveal that the nearshore and upstream portions of the EAA appear to be relatively stable, although two drainage

[10] This removal area was backfilled to grade so the backfilled area is sand placed to bring the area back to grade and not an engineered cap.

channels were observed to have been cut through the backfill by outflow from the Boeing Developmental Center south storm drain and the Norfolk CSO/SD outfall. The depths of these cuts were not measured, but samples collected in/near these channels in 2006 and 2008 were below 70 µg/kg dw for total PCBs (Table J-6). Because most of the contaminated sediment was removed during the 1999 dredging, with the exception of some material remaining deeper than 9 ft below mudline, the channels are not expected to expose contaminated sediment. The backfill was placed for two purposes: to isolate this deep (>9 ft) contamination left behind; and to return the dredged area back to the original grade. Because the backfill is 9 ft thick, there is minimal potential for exposure of buried contamination.

It was noted that once these channels were established (following backfill placement), they have not moved, indicating a relatively stable environment. Because the pedestrian bridge downstream of the Norfolk CSO/SD cleanup area limits access, large vessels are prevented from transiting this area (Mickelson, personal communication, 2009), thereby reducing scour potential from vessels in this area, although high-flow river scour would still occur. This area is upstream of the sediment transport model domain, so high-flow scour depths and net sedimentation rates could not be estimated in this area. However, evidence suggests that following cleanup of the adjacent Boeing Developmental Center south storm drain area, internal sources are not recontaminating the Norfolk CSO/SD cleanup area.

Boeing Developmental Center South Storm Drain Cap

In 2003, Boeing removed 60 cubic yards of sediment from a 0.04-acre area offshore of the Boeing Developmental Center south storm drain at RM 4.9E and backfilled the area with clean sand; this area is inshore of the Norfolk CSO/SD cleanup area. Surface sediment samples have been collected from three stations within the backfilled area on six occasions beginning in 2004 and analyzed for PCBs and total organic carbon (TOC; Table J-6; Figure J-6; CALIBRE 2009).

The results of these sampling events show that PCBs have never been detected at two of the stations (S02 and S03). The third station (S01) is located within a drainage channel that appears to originate at the terminus of the south storm drain outfall. Total PCB concentrations at that station have varied widely, from nondetect in February 2009 to 1,075 µg/kg dw (average of the two station samples; 1,310 and 840 µg/kg dw) in September 2009. The TOC in the sample with the total PCB concentration of 840 µg/kg dw was 14.2%, which is much higher than the LDW-wide average and higher than the TOC concentrations in the other samples (Table J-6; Figure J-6). This elevated TOC concentration may indicate that some disturbance or input affected this sample. The oc-normalized total PCB concentrations from Station S01, excluding September 2009 data, have varied between nondetect and 23 mg/kg oc over time (as compared to the SQS for total PCBs of 12 mg/kg oc).

Beginning in 2000, Boeing has conducted intensive investigations of PCBs within the south storm drain, with the intent of identifying potential sources and reducing the discharge of PCBs in stormwater to the river. Accumulated solids within the storm drain line have been cleaned out on multiple occasions, and a Vortechnics sediment trap was installed in the storm drain line in 2003. Stormwater solids have been collected annually from a manhole upstream of the sediment trap and analyzed for PCBs; total PCB concentrations have been highly variable (1,440 to 61,500 µg/kg dw). Solids samples retained in the sediment trap have had more consistent total PCB concentrations, ranging from 10,600 to 32,000 µg/kg dw. Stormwater solids have also been collected annually from a manhole downstream of the sediment trap and analyzed for PCBs; total PCB concentrations there (1,670 to 16,200 µg/kg dw) have been lower than in the upstream manhole or in the sediment trap. The results of this sampling suggest that the sediment trap has been effective at reducing the discharge of PCBs to the river from this outfall, although some PCBs, likely associated with very fine particulate matter not retained by the sediment trap, are still being discharged. Nevertheless, the mass loading of PCBs from this outfall has been estimated to be very small (average of only 0.25 g/yr) over the six years of data collection. Although such small mass loading may in part contribute to sediment concentrations that exceed the SQS in the immediate vicinity of the outfall, it is apparent that the effect is extremely localized, with sediment PCB concentrations less than 20 ft away being below detection limits. This points out the difficulty in reducing the discharge of contaminants like PCBs to such a degree that no recontamination will occur above very low target concentrations.

Summary

Both portions of the Norfolk cleanup area demonstrate that recontamination can occur at a very localized scale after cleanup. However, with the exception of one sample (and replicate) collected on the Boeing Developmental Center south storm drain cap in 2009, contaminant concentrations are relatively low, although they can be highly variable on a year-to-year basis. These data support the long-term model-predicted range of total PCB concentrations of 10 to 100 µg/kg dw.

J.3.1.3 Sediment Characterization in Maintenance Dredged Areas

Dredging occurs in the LDW for two purposes: to maintain depths necessary for berthing and navigation, and to remove contaminated sediments. The opportunity to evaluate changes in sediment chemistry from dredged areas is most evident in the frequently dredged area of the authorized navigation channel located at the upstream end of the LDW, from RM 4.0 to 4.75. A portion of this area from RM 4.3 to 4.75 and its associated data are discussed in detail as a line of evidence for upstream inputs in

Appendix C. The navigation channel is regularly dredged to an elevation of -17 ft MLLW.[11]

The navigation channel in the upstream reach of the LDW is dredged approximately every two to four years to maintain depths for navigation. The U.S. Army Corps of Engineers (USACE) Seattle District collects subsurface core samples prior to dredging and characterizes the material to evaluate disposal options. Because this area is frequently dredged, it is believed to represent material continually deposited into the LDW from upstream. Subsurface sediment data from 1991 to 2009 were provided by the USACE from their Dredged Analysis Information System and from the data report for the 2008 and 2009 data sampling events (USACE 2009a, 2009b).

Data from the USACE were evaluated by three sections of the navigation channel because spatial heterogeneity, grain size, and organic carbon, which vary among these areas, can have an effect on contaminant concentrations in the LDW (Figure J-7):

- **RM 4.0 to 4.3**: Total PCB concentrations (N = 51) averaged 74 µg/kg dw. Ten of the samples had concentrations greater than 100 µg/kg dw. These data were not used as lines of evidence for the BCM upstream input parameters because they may be impacted by inputs of sources to Hamm Creek and Slip 6.
- **RM 4.3 to 4.5**: Total PCB concentrations (N = 11) averaged 44 µg/kg dw. These data were used as a line of evidence for the BCM upstream input parameters.
- **RM 4.5 to 4.75**: Total PCB concentrations (N = 9) were consistently low, around 20 to 30 µg/kg dw. This area is dominated by coarse-grained sand, bed load material with low organic carbon content that settles primarily in the Upper Turning Basin above RM 4.5. These data were used as a line of evidence for the BCM upstream input parameters.

These trends demonstrate that the continual inflow of sediments that deposit from the Green/Duwamish River contain concentrations of PCBs below the SQS and in the 20 to 44 µg/kg dw range. It is less clear to what extent the lateral inputs or "fining" of deposited material are contributing to the concentration increases observed downstream of the Upper Turning Basin ("fining" or grading from coarse- to fine-grained size with increasing distance downstream from the Upper Turning Basin; see Section 5).

Farther downstream, surface sediment data collected following maintenance dredging events at private berthing areas were used to characterize the sediments resettling in the

[11] Sediment from cores is composited vertically and horizontally, with the depth of the sample collection targeting an elevation of -17 ft MLLW. This is the authorized maintenance depth of -15 ft MLLW, plus 2 ft for overdredging. Therefore, the depth below mudline of the bottom of the cores is dynamic such that they reach to a -17-ft MLLW elevation. Because of this sampling scheme, the data characterize sediment that deposited above the previous dredge cut (i.e., sediment sourced from upstream).

area and to evaluate recontamination potential.[12] In areas previously dredged to maintain vessel berthing depths,[13] surface sediment total PCB concentrations were at or below 240 µg/kg dw in 30 of 32 samples collected more than 5 years after dredging had occurred (Table J-7). The average total PCB concentration in these samples was 137 µg/kg dw total PCBs, with average concentrations increasing from 88 to 196 µg/kg dw as the time elapsed between dredging and sampling increased from 5 to more than 10 years (Table J-7). This demonstrates that surface sediment concentrations are relatively low following dredging but increase over time. This pattern is also observed with arsenic. However, some of these areas are near EAAs or are assigned as active remediation areas in this FS. Surface sediment concentrations observed in these areas may trend lower after active remediation is conducted in the LDW and as source control activities progress.

Among samples in the post-dredge dataset, average cPAH concentrations were about 255 µg TEQ/kg dw within 5 years of dredging, then increased to 703 µg TEQ/kg dw from 6 to 10 years. However, because the subsets of data averaged in Table J-7 are not from the same areas of the LDW, these trends may be more indicative of spatial heterogeneity than of years elapsed after dredging (i.e., they may not be dependent on the temporal changes in concentration from accumulation of upstream materials). The average cPAH concentration among all samples was 469 µg TEQ/kg dw. Only two of the locations had dioxin/furan data, with an average of 10 ng TEQ/kg dw.

Figure J-8 shows all total PCB samples regardless of the number of years that elapsed between dredging and sample collection (N = 80; including samples in the navigation channel; the average is 208 µg/kg dw total PCBs). Based on these data, the short-term localized concentrations could be in the range of 100 to 200 µg TEQ/kg dw for total PCBs, 11 to 18 mg/kg dw for arsenic, and 250 to 700 µg/kg dw for cPAHs.

J.3.2 Sediment Recontamination Potential Using the BCM

For this FS, the potential impacts that source control and ongoing lateral inputs have on recontamination potential for remedial alternatives was evaluated. For these evaluations, the BCM was used in two ways:

- To estimate the model grid cells where recontamination above the SQS is more likely to occur within 10 years following a simulated remedy (Section J.3.2.1).

[12] The USACE does not regularly dredge the navigation channel farther downstream; therefore, private maintenance dredging events were used.

[13] This analysis used locations within and located 10 ft from the dredging footprints; the dredging mapping layer is not precise. It was mostly generated by hand-entering approximate locations from maps in dredging plans. These are the planned dredge prisms, not the “as-built” areas; hand-drawing these areas—usually without the aid of coordinates—makes these geographic information system (GIS) layers approximate.

- To evaluate the range of potential effects of lateral input values on the post-remedy surface sediment conditions; the range of lateral input parameters was used to predict total PCB and cPAH concentrations 30 years following a simulated remediation scenario. Alternative 5 was used for the purpose of this analysis because it actively remediates all areas above the SQS (Section J.3.2.2).

As discussed in Section J.1.1, the datasets used for estimating lateral and upstream inputs to the BCM are limited, and as such, the results presented below should be used with caution.

J.3.2.1 Recontamination of Model Grid Cells above the SQS

Model grid cells predicted to exceed the SQS 10 years following a simulated remedy across the entire LDW were identified by first setting the concentration of risk drivers in the surface sediment to zero[14] (Figures J-9a and J-9b). The BCM was then run for the 10-year condition, and areas predicted to exceed the SQS based only on the influence of lateral and upstream contributions were identified.

The BCM parameters used in this analysis were the recommended input parameters for representative SMS contaminants and the high lateral load and mid upstream input parameters for total PCBs and arsenic (see Section 5). cPAHs were also included in the analysis, though this calculated total does not have an SQS criterion. These values represent an approximate estimate of overall average lateral loading in the next 5 to 10 years based on lateral data compiled by the City of Seattle. It is recognized that some outfalls or tributaries may have higher or lower overall average lateral loads. Table J-8 identifies the specific SMS contaminants evaluated in this exercise and those having the potential to exceed the SQS within 10 years.

The SMS contaminants with the greatest potential for recontamination from lateral sources include BEHP, butylbenzyl phthalate, and to some extent total PCBs and zinc. The areas having the greatest number of SMS contaminants predicted to exceed the SQS are in the EAAs and the areas identified for active remediation in Alternative 2 (Figures J-9a and J-9b).

Although recontamination is modeled for some SMS contaminants, they do not always exceed the SQS in the FS baseline dataset, nor do they exceed the SQS in the Duwamish/Diagonal EAA post-cleanup data. Figures J-9a and J-9b show the locations exceeding the SQS in the FS baseline dataset and where recontamination potential is predicted by the BCM. Because the BCM uses the same lateral input parameter for every outfall, it does not account for geographic subbasin-specific differences in land uses, upland sources, and outfall discharges. The disparity in these instances between

[14] When evaluating remedial alternatives with the BCM (Section 9), sediment concentrations in actively remediated areas are set to the post-remedy bed sediment replacement value. In this exercise, the bed sediment concentrations were set to zero. This change isolates the effects of lateral sources, as predicted by the BCM.

model predictions (where exceedances are predicted) and baseline data (that do not demonstrate SQS exceedances for the SMS contaminants predicted to exceed the SQS) is a source of uncertainty that will likely need confirmation during remedial design.

J.3.2.2 Effects of Lateral Input Parameters on Recontamination Potential

The effects of the lateral input parameters on predicted total PCB and cPAH concentrations were evaluated in a series of 30-year BCM runs where the lateral input parameters were varied and the upstream and post-remedy bed sediment replacement values were held constant at the mid (recommended) values. For the human health risk drivers, a range of values was established for each BCM input parameter (upstream, lateral, and post-remedy bed sediment replacement value). The range of lateral input parameters represents various levels of potential, future source control activities (Appendix C, Part 3):

- **High –** conservative representation of current conditions assuming modest continued levels of source control and management of high priority sources already identified by the Source Control Work Group.
- **Input (Mid, Recommended) –** pragmatic assessment of what might be achieved in the future with anticipated continued levels of source control. This value is based on mean/median concentrations observed in the lateral dataset after control of medium priority sources.
- **Low –** best that might be achievable in 30 to 40 years with increased coverage and continued aggressive source control.

Recontamination potential was evaluated by first setting all of the area actively remediated in Alternative 5 to the mid post-remedy bed sediment replacement value (total PCBs = 60 µg/kg dw; cPAHs = 140 µg TEQ/kg dw). Six BCM runs were then completed for the two risk drivers using three lateral values. The site-wide SWACs and the predicted concentrations in each grid cell are shown in Figures J-10a through J-10c and J-11a through J-11c for total PCBs and cPAHs, respectively.

For total PCBs, the site-wide SWAC increases by 36% from that predicted with the mid lateral input parameter to that with the high (44 versus 60 µg TEQ/kg dw), but only decreases about 9% for the low lateral parameter. Even with the low lateral input parameter, a few localized areas of sediment are predicted to exceed 100 or 240 µg/kg dw total PCBs after remediation of the Alternative 5 footprint. Additionally, when the high lateral input parameter is used, the Reach 2 SWAC is predicted to be two times greater than when the low lateral input parameter is used (44 versus 89 µg/kg dw).

For cPAHs, the site-wide SWAC increase using the high BCM lateral input parameter is 42% (107 vs. 152 µg TEQ/kg dw). The SWAC increase for cPAHs is slightly greater than that for total PCBs because the range of lateral input parameters is wider for cPAHs (500 to 3,400 µg TEQ/kg dw) than for total PCBs (100 to 1,000 µg/kg dw). The cPAH

SWAC decreases about 20% using the low lateral parameter. A few localized areas are predicted to exceed about 380 µg TEQ/kg dw cPAHs, even when the low lateral input parameter is used, after remediation of the Alternative 5 footprint.

The areas identified as having the greatest recontamination potential for SQS exceedances (Section J.3.2.1) are similar to the areas identified using the high lateral input parameters. These areas are predicted to be affected the most by future source control efforts, which are represented by changes in the lateral input parameters. These areas are generally located near modeled outfalls, but surface sediment concentrations in portions of the navigation channel are also predicted to have a potential for recontamination (Figures J-10a through J-10c and J-11a through J-11c).

J.4 Discussion of Atmospheric Deposition

Atmospheric deposition can be an important pathway from ongoing sources both by way of particles depositing directly onto the surface water of the LDW and by way of particles depositing in the watershed and subsequently being delivered to the LDW through stormwater runoff. Data collected from regional and national atmospheric studies are discussed below.

J.4.1 King County Passive Atmospheric Sampling

King County conducted passive sampling of atmospheric deposition at stations within the LDW watershed and on Beacon Hill, a neighborhood located east of the LDW watershed. Two phases of sampling were conducted: one from January through May 2005 and the second from October 2005 through April 2007. Concentrations of PCBs, PAHs, and phthalates were quantified as daily fluxes collected by passive air particulate samplers. PCB concentrations (based on Aroclor® methods) were near method detection limits. When detected, PCB flux rates in the industrialized areas were on the order of 0.01 to 0.06 micrograms per square meter per day (µg/m^2/day; King County 2008; Table J-9).

The study found that BEHP fluxes were fairly similar at all stations, generally on the order of 2 µg/m^2/day. The highest values were found at several river valley stations, and the lowest values were at a station on Beacon Hill. Most of the stations had similar ranges and median values for benzo(a)pyrene, a PAH with median values on the order of 0.06 µg/m^2/day.

This indicates that urban-sourced contaminants, such as PCBs, PAHs, and phthalates, are continually introduced to the LDW sediments from the atmosphere (King County 2008). Most of this atmospheric deposition is already accounted for by the BCM input parameters, which were derived from separated stormwater basin and combined sewer basin source data influenced by atmospheric deposition.

J.4.2 National Studies of Atmospheric Deposition

Other studies (Table J-9) suggest that total PCB concentrations can vary geographically over small scales and that proximity to densely populated urban areas influences loading from non-point sources. This is tied to the observation that atmospheric deposition is an important and sometimes dominant source of PCBs to coastal waters and upland watersheds. Atmospheric PCB concentrations are generally greater in urban areas than in rural or suburban areas (Gingrich et al. 2001; Jamshidi et al. 2007; Offenberg and Baker 1997; Simcik et al. 1997; Totten et al. 2006; Wethington and Hornbuckle 2005). In studies conducted near Lake Michigan, PCB wet fluxes and concentrations determined for urban, overwater, and rural locations support the hypothesis that urban atmospheric PCBs are a major source to coastal Lake Michigan near Chicago, IL and Milwaukee, WI (Offenberg and Baker 1997; Simcik et al. 1997; Wethington and Hornbuckle 2005). The authors noted that urban and overwater total PCB wet deposition rates are highly variable, suggesting meteorology plays a significant role in controlling the magnitude of the urban wet deposition. This can result in small-scale depositional patterns driven largely by source location, season, precipitation, and prevailing wind patterns, a potentially important factor in the distribution of PCB sources to the LDW. Table J-9 summarizes atmospheric flux data from these studies.

J.5 Summary

This appendix examines potential long-term trends in surface sediment concentrations that may be expected following cleanup of the LDW sediments and associated source control, at both large and small spatial scales.

The range of LDW-wide concentrations predicted by the BCM is supported by data collected over the past 15 years from Puget Sound urban water bodies and the LDW. Published studies add additional context and support the empirical trends. Collectively, the multiple lines of evidence presented in this appendix compare favorably with the range of long-term model-predicted concentrations (site-wide SWACs) for LDW sediments listed below. The multiple lines of evidence also suggest the potential for concentrations up to those noted in parentheses near some sources.

- Total PCBs: 10 to 100 µg/kg dw (up to 200 µg/kg dw in smaller areas)
- Arsenic: 7 to 10 mg/kg dw (up to 20 mg/kg dw in smaller areas)
- cPAHs: 50 to 320 µg TEQ/kg dw (up to 500 µg TEQ/kg dw in smaller areas)
- Dioxins/furans: 2 to 8 ng TEQ/kg dw (up to 20 ng TEQ/kg dw in smaller areas).

As noted in Section 9.3.5, the range of these long-term predictions is most heavily influenced by uncertainties in the contaminant concentrations on incoming sediment loads and the amount of sediment deposited in the LDW.

This appendix also considers potential recontamination at local scales, through examination of empirical data at remediated LDW sites and through BCM predictions. In general, the BCM appears to be a useful tool for identifying those areas most likely to recontaminate above the SQS as a result of lateral inputs, and to bound the overall scale of the recontamination potential. Overall, relatively small areas of the LDW (roughly 5 to 10 acres in total) that are located near large lateral inputs have greater potential for recontamination above the SQS. The potential is greatest for phthalates and lesser for PCBs. Empirical data suggest that the BCM could be overpredicting the recontamination potential, both in spatial extent and number of SMS contaminants because of the simplifying assumptions used in the model.

As noted in Section J.1.1, the BCM uses lateral input parameters reflecting actual LDW-wide source tracing datasets from municipal storm drain solids and CSOs. It is important to note that these values may not be representative of all current lateral inputs. For example, a currently uncharacterized outfall that discharges stormwater with unusually high concentrations (and has not yet been addressed by source control actions) may pose a far higher recontamination potential than predicted by the BCM. In some cases, the BCM may overestimate a specific lateral source input or underestimate another. In addition, other sources such as contaminated groundwater or erosion of contaminated bank soils are not considered in the BCM. In concept, the BCM is intended to reflect future average conditions after source control is in place.[15]

The long-term concentrations in LDW sediments (at large and small scales) will depend upon active remediation of hot-spot areas (and sediments historically contaminated by point sources) and source control efforts in the drainage basin and regionally. Uncertainty analyses in this appendix and in Section 9.3.5 (for the sequencing analysis) demonstrate that success of both these efforts has a measurable effect on the site-wide long-term model-predicted concentrations, and could affect the ability to achieve concentrations within the lower end of the range of best estimate SWAC predictions.

The construction period and eventual effectiveness of source control work requires that the timing of in-water sediment remediation activities be considered. For example, if active remediation is undertaken in areas influenced by outfall discharges prior to completion of source control, there would be a greater potential for sediment recontamination. Conversely, active remediation may proceed in other areas regardless of source control status without significant risk of recontamination. In these areas, internal sources of recontamination (e.g., other surface sediments slated for remediation but not yet cleaned up) should be considered before an active remedy is commenced (sequencing).

[15] The BCM applies the same lateral concentration to each outfall. Section 5 discusses uncertainty associated with this model assumption. Actual inputs can differ for outfalls from different drainage basins.

The development of the remedial alternatives for the FS assumes that source control work will be sufficiently completed before construction begins. However, the progress of source control work could impact the timing and sequencing of sediment remediation. Location-specific remedial design should be coordinated with the source control action plans covering that area. It is expected that this coordination will include detailed analyses of source control actions implemented (and to be implemented) and assessments of location-specific data. Ultimately, the recontamination risk will need to be considered during remedial design and managed during remedy implementation and long-term maintenance.

J.6 References

CALIBRE 2009. *2009 Annual Sampling Report. South Storm Drain System.* Boeing Developmental Center. Prepared for The Boeing Company. December 2009.

City of Seattle 2008. *Seattle's Population & Demographics. Population Trends: Size & Growth.* http://www.seattle.gov/DPD/Research/Population_Demographics/Prior_Censuses/1900-2000_Population_Housing_Trends/DPDS_007028.asp. Accessed January 9, 2009.

City of Tacoma and Floyd|Snider 2007a. *Thea Foss and Wheeler–Osgood Waterways Remediation Project. Year 0 Baseline Monitoring, Supplemental Baseline Natural Recovery Monitoring, Preliminary Findings Memorandum*. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, WA. February 1, 2007.

City of Tacoma and Floyd|Snider 2007b. *Thea Foss and Wheeler – Osgood Waterways Remediation Project. Year 0 Baseline Monitoring, Annual Operations, Maintenance, And Monitoring Report*. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle WA. February 28, 2007.

City of Tacoma, City of Seattle, King County, Washington State Department of Ecology, and the U.S. Environmental Protection Agency 2007. *Sediment Phthalates Work Group. Summary of Findings and Recommendations.* Prepared with assistance from Floyd|Snider. September 2007.

Dredged Material Management Program (DMMP) 2009. *Summary of Final Dioxin TEQ Data. All Sites. 2005-2008 Site Monitoring Spreadsheets*. Available at: http://www.nws.usace.army.mil/PublicMenu/Doc_List.cfm?sitename=DMMO&pagename=Dioxin_Statistics. 2009.

Ecology 2004. *Lower Duwamish Waterway Source Control Strategy.* Prepared by Richard Huey, Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program, Bellevue, WA. Publication No. 04-09-043. January 2004.

Gingrich, S.E., M.L. Diamond, G.A. Stern, and B.E. McCarry 2001. Atmospherically Derived Organic Surface Films along an Urban-Rural Gradient. In: *Environmental Science &Technology*, Vol. 35, No. 20, pp. 4031-4037. September 11, 2001.

Herrera. 2004. *Summary Report, Lower Duwamish Waterway Outfall Survey*. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc. Seattle, WA. January 2004.

Integral 2008. *Toxic Equivalent Concentrations of TCDD in Source Sediments and Street Dirt.* Prepared for Seattle Public Utilities. Prepared by Integral Consulting, Inc. Mercer Island, Washington. May 27, 2008.

Jamshidi, A., S. Hunter, S. Hazrati, and S. Harrad 2007. Concentrations and Chiral Signatures of Polychlorinated Biphenyls in Outdoor and Indoor Air and Soil in a Major U.K. Conurbation. In: *Environmental Science &Technology*, Vol. 41, No. 7, pp. 2153-2158. February 21, 2007.

King County 2005. *Water Resource Inventory Area (WRIA) 9 Strategic Assessment Report. Scientific Foundation for Salmonid Habitat Conservation*. Prepared for the Green/Duwamish and Central Puget Sound Watershed WRIA 9 Steering Committee. Prepared by the King County Land and Water Resource Division Natural Resources and Parks Department. November 2005.

King County 2008. *Passive Atmospheric Deposition Sampling. Lower Duwamish Waterway. Monitoring Report – October 2005 to April 2007.* Prepared for the King County Department of Natural Resources and Parks, Sediment Management Program. Prepared by the King County Department of Natural Resources and Parks, Industrial Waste Program. March 2008.

Lefkovitz, L.F., V.I. Cullinan, and E.A. Crecelius 1997. *Historical Trends in the Accumulation of Chemicals in Puget Sound.* National Oceanic and Atmospheric Association. Battelle/Marine Science Laboratory, Sequim, WA. NOAA Technical Memorandum NOS ORCA 111. December 1997.

Mauro, D.M., P.J. DeClercq, R. Siegener, and A. Coleman 2006. *Survey of the Distribution and Sources of PAHs in Urban Surface Soils*. Proceedings of the International Symposium and Exhibition on the Redevelopment of Manufactured Gas Plant Sites. 4 – 6 April 2006, Reading, UK. In: *Land Contamination & Reclamation*, 14 (2). 2006.

McCain, B.B., D.W. Brown, S.L. Chan, J.T. Landahl, W.D. MacLeod, Jr., M.M. Krahn, C.A. Sloan, K.L. Tilbury, S.M. Pierce, D.G. Burrows, and U. Varanasi 2000. *Organic Chemical Contaminants, Cycles I to VII (1984-90).* NOAA Technical Memorandum NMFS-NWFSC-40. National Oceanic and Atmospheric Administration, National Benthic Surveillance Project, Pacific Coast Benthic Surveillance. March 2000.

Meador, J.P., R.C. Clark, Jr., P.A. Robisch, D.W. Ernest, J.T. Landahl, U. Varanasi, S. Chan, and B.B. McCain 1994. *Analyses of Elements in Sediment and Tissue Cycles I to V (1984-88)*. NOAA Technical Memorandum NMFS-NWFSC-16. National

Oceanic and Atmospheric Administration, National Benthic Surveillance Project, Pacific Coast Benthic Surveillance. August 1994.

Mickelson, S. 2009. Personal communication via telephone between S. Mickelson of King County Department of Natural Resources and Parks and Nicole Ott, AECOM, regarding visual observations at the Norfolk CSO EAA. February 3, 2009.

Offenberg, J.H., and J.E. Baker 1997. Polychlorinated Biphenyls in Chicago Precipitation: Enhanced Wet Deposition to Near-Shore Lake Michigan. In: *Environmental Science &Technology*, Vol. 31, No. 5, pp. 1534-1538. 1997.

Partridge, V., K. Welch, S. Aasen, and M. Dutch 2005. *Temporal Monitoring of Puget Sound Sediments: Results of the Puget Sound Ambient Monitoring Program, 1989-2000.* Washington State Department of Ecology, Environmental Assessment Program. Publication No. 05-03-016. July 2005.

Rice, K. 1999. Trace-Element Concentrations in Streambed Sediment across the Conterminous United States. U.S. Geological Survey. In: *Environmental Science &Technology,* Vol. 33, No. 15, pp. 2499-2504. June 11, 1999.

Rogowski, D., S. Golding, D. Bowhay, and S. Singleton 1999. *Final Report: Screening Survey for Metals and Dioxins in Fertilizer Products and Soils in Washington State.* Washington State Department of Ecology. Publication No. 99-300. April 1999.

Schmoyer, B. 2011. Personal communication via email between Beth Schmoyer, City of Seattle, and Nicole Ott, AECOM, regarding the size of the LDW separated and combined drainage basins and the land uses within each basin. Seattle Public Utilities, Seattle, WA. April 12, 2011.

Simcik, M.F., H. Zhang, S.J. Eisenreich, and T.P. Franz 1997. Urban Contamination of the Chicago/Coastal Lake Michigan Atmosphere by PCBs and PAHs during AEOLOS. In: *Environmental Science &Technology*, Vol. 31, No. 7, pp. 2141-2147. 1997.

Totten, L.A., G. Stenchikov, C.L. Gigliotti, N. Lahoti, and S.J. Eisenreich 2006. Measurement and modeling of urban atmospheric PCB concentrations on a small (8 km) spatial scale. In: *Atmospheric Environment,* Vol. 40, pp. 7940-7952. July 7, 2006.

USACE 2009a. *Duwamish River Federal Navigation Channel Dredged Material Characterization (Seattle, WA), Data Report Final*. U.S. Army Corps of Engineers, Seattle District, Seattle, WA. October 7, 2009.

USACE 2009b. *Duwamish River Federal Navigation Channel Dredged Material Characterization (Seattle, WA), Data Report Addendum Final*. U.S. Army Corps of Engineers, Seattle District, Seattle, WA. November 20, 2009.

Van Metre, P.C., and B.J. Mahler 2005. Trends in hydrophobic organic contaminants in urban and reference lake sediments across the United States, 1970-2001. U.S. Geological Survey. In: *ES&T,* vol. 39, 5567 – 5574. 2005.

Wakeman, J., and E. Hoffman 2006. *Analysis to Support Suitability Determination of Dredged Material with Polychlorinated Dibenzo-p-dioxins and Furans for Disposal at the Anderson-Ketron Dredged Material Disposal Site*. Puget Sound Dredged Material Management Program. July 12, 2006.

Wethington, D.M. III, and K.C. Hornbuckle 2005. Milwaukee, WI as a Source of Atmospheric PCBs to Lake Michigan. In: *ES&T*, Vol. 39, No. 1, pp. 57-63. 2005.

Windward Environmental, LLC 2004. *Lower Duwamish Waterway Remedial Investigation. Data Report: Survey and Sampling of Lower Duwamish Waterway Seeps.* Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. November 18, 2004.

Yake, B., D. Rogowski, L. Goldstein, and G. Pelletier 2000. Dioxins in Washington State Soils. *Dioxin 2000: 20th International Symposium on Halogenated Environmental Organic Pollutants & POPS*, Monterey, CA, August 13-17, 2000. Volume 46, pp. 342-345. August 2000.

Yake, B. 2001. T*he Use of Sediment Cores to Track Persistent Pollutants in Washington State: A Review*. Washington State Department of Ecology. Publication No. 01-03-001. January 2001.

Table J-1 Summary of Puget Sound Area Urban Water Body Total PCB, Arsenic, and cPAH Data

Parameter and Urban Water Body Name	Number of Observations (number of detections)	Range of Concentrations					
		Minimum Detect	Maximum Detect	50th Percentile	Mean	90th Percentile	UCL95[a]
Total PCBs (µg/kg dw)							
Outer Elliott Bay	28 (7)	8.1	138	17	38	82	53
Inner Elliott Bay	37 (28)	33	800	99	190	576	255
Bellingham Bay	61 (6)	8.0	425	25	76	114	164
Commencement Bay	71 (49)	4.0	1,104	21	61	64	127
Lake Washington	17 (1)	26	26	47	87	217	137
Lake Sammamish	25 (25)	16	88	34	40	73	49
Arsenic (mg/kg dw)							
Outer Elliott Bay	31 (19)	2.4	14	4.1	5.1	9.8	6.4
Inner Elliott Bay	34 (25)	4.7	27	7.4	8.6	16	10.4
Bellingham Bay	162 (160)	1.5	19	9.2	9.2	13	9.6
Commencement Bay	133 (131)	1.4	45	8.7	9.6	17	12
Lake Washington	29 (25)	2.0	27	6.3	7.2	13	8.9
Lake Sammamish	29 (29)	1.8	72	8.7	15	38	59
cPAHs (µg TEQ/kg dw)							
Outer Elliott Bay	21 (15)	22	327	79	116	292	152
Inner Elliott Bay	66 (64)	14	4,780	269	583	1,410	1,080
Bellingham Bay	64 (53)	5.8	593	32	76	185	108
Commencement Bay	45 (45)	8.8	1,700	115	223	527	345
Lake Washington	33 (30)	43	5,290	216	374	904	635
Lake Sammamish	20 (11)	57	1,870	92	234	574	407

Notes:
1. Excludes data from listed CERCLA or MTCA sites and from disposal sites. Elliott Bay data are post-1991 and exclude data on the Pier 51/52 and Denny Way caps.
2. Urban bay data queried from EIM in January 2007 (PCBs and arsenic) and January 2008 (cPAHs) are from 1990 to 2004.
3. One-half of RLs used for nondetect values in summary statistics calculated with ProUCL v.4.0.
4. Total PCB, arsenic, and cPAH data reported in Tables 7-15 to 7-17 of the Final RI (Windward 2010).

a. Reported value is the UCL95 recommended by ProUCL 4.00.04.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; cPAH = carcinogenic polycyclic aromatic hydrocarbon; dw = dry weight; EIM = Environmental Information Management system; kg = kilogram; µg = micrograms; µg/kg dw = micrograms per kilogram dry weight; mg = milligram; MTCA = Model Toxics Control Act; PCB = polychlorinated biphenyl; RL = reporting limit; TEQ = toxic equivalent; UCL95 = 95% upper confidence limit on the mean

Table J-2 Dioxin/Furan Concentrations in Surface Sediment Collected from Areas Immediately Offshore of Storm Drains and from Other Areas Receiving Runoff in the Greater Seattle Metropolitan Area

General Location in Greater Seattle Area	Sample Location Name	Dioxin/Furan Concentration (ng TEQ/kg dw)		Concentrations included in Calculation of Statistics in RI (ng TEQ/kg dw)
Elliott Bay (Terminal 91)[a]	EB-SS2a	13.7 J		16.3
	EB-SS2b	18.9 J		
Lake Union (Interstate 5 bridge)[a]	LU-SS9a	5.46 J		15.8
	LU-SS9b	26.1 J		
Lake Washington (Bothell)	LW-SS3	13.2 J[b]		13.2
Lake Washington (Bellevue)	LW-SS4	14.7 J		14.7
Lake Washington (Renton)[a]	LW-SS5a	14.1 J		14.3
	LW-SS5b	14.5 J		
Ship Canal (Salmon Bay)[a]	SC-SS1a	187 J		Samples excluded from calculations
	SC-SS1b	63.1 J		
Union Bay (Laurelhurst)	UB-SS8	53.4 J		
Statistics for Greater Seattle Locations	*Count*	*11*	*10*[c]	*5*
	Mean	*38.6*	*23.7*[c]	*14.9*
	90th Percentile	*63.1*	*54.4*[c]	*16.3*
	95% Upper Confidence Limit on the Mean	*91.2*	*37.7*[c]	*16.0*

Notes:

1. Data reported in Table 7-18 of Final Remedial Investigation (Windward 2010); statistics with full dataset and n=10 dataset generated by AECOM using ProUCL 4.00.05.

a. Two samples were collected: one approximately 30 to 50 ft from the outfall and the other approximately 100 to 120 ft from the outfall.
b. Reported concentration is the average of two replicate field samples.
c. Sample at 187 ng TEQ/kg dw was excluded, as indicated by gray shading.

ft = feet; J = estimated concentration; ng TEQ / kg dw = nanograms toxic equivalent per kilogram dry weight; RI = remedial investigation

Table J-3 Open Water Disposal Site and Elliott Bay Puget Sound Assessment and Monitoring Program Sediment Data for Dioxins/Furans

Urban Water Body Name	Number of Observations		Range of Concentrations (ng TEQ/kg dw)					
			Minimum Detect		Maximum Detect		Mean	
	on site	*off site*	*on site*	*off site*	*on site*	*off site*	*on site*	*off site*
Elliott Bay 2005 and 2007 Disposal Site [a]	6	11	4	1	12	17	6	8
Port Gardner 2006 Disposal Site [a]	3	9	1	3	3	5	2	4
Bellingham Bay 2007 Disposal Site [a]	1	10	6	4	6	22	6	8
Commencement Bay 2007 Disposal Site [a]	3	10	1	1	14	5	5	2
Anderson-Ketron 2005 Disposal Site [a]	8	0	2	—	7	—	—	—
Anderson-Ketron 2006 and 2008 Disposal Site [a]	19		1		7		3	
Elliott Bay 2008 PSAMP [b]	13		1		14		5	

Notes:

a. Data collected 2005 to 2008 provided by Dredged Material Management Program in 2009 in a series of public meetings discussing guidelines for open water disposal of dioxin/furan-containing dredged material. Dredged material site monitoring reports are available by request from the Dredged Material Management Office (DMMO), Seattle District.

b. Data provided by Tom Gries, Washington State Department of Ecology. Statistics are reported for 0- to 10-cm samples collected >250 ft from shore only; values of 87 and 97.6 ng TEQ/kg dw are outliers and are therefore excluded from the summary statistics.

dw = dry weight; kg = kilogram; ng = nanogram; PSAMP = Puget Sound Assessment and Monitoring Program (formerly the Puget Sound Ambient Monitoring Program); TEQ = toxic equivalent

Table J-4 Contaminant Concentrations Cited in Regional and National Trend Studies

Source	Study Title	Media	Concentrations Cited [page, figure, or table where cited]	Regional/ National
Total PCBs (µg/kg dw)				
Cleverly et al. 1996 as summarized in Yake 2001 (Ecology)	A time-trends study of the occurrences and levels of CDDs, CDFs, and dioxin-like PCBs in sediment cores from 11 geographically distributed lakes in the United States In: *The Use of Sediment Cores to Track Persistent Pollutants in Washington State: A Review*	subsurface sediment	Concentrations in two Olympic Peninsula lakes (Ozette and Beaver) peaked at 60 and 175 in the mid-1960s. By the mid-1970s, concentrations had fallen to 40 and 100 [p. 13]	R
Lefkovitz et al. 1997 (NOAA Battelle/Marine Sciences Laboratory)	*Historical Trends in the Accumulation of Chemicals in Puget Sound, NOAA Technical Memorandum NOS ORCA 111*	subsurface sediment	Six cores; range from nondetect (pre-industrial) to maximum of 35 in the mid-1970s; average of 8 in surface intervals [p. 52, Fig 3.23]	R
McCain et al. 2000 (NOAA)	*National Benthic Surveillance Project Pacific Coast. Organic chemical contaminants, Cycles I to VII (1984-90). NOAA Technical Memorandum NMFS-NWFSC-40*	surface sediment	Elliott Bay ~1,000; Nisqually ~10 [Fig. 5]	R
USGS 2000 as summarized in Yake 2001 (Ecology)	Reconstructed Trends National Synthesis Study In: *The Use of Sediment Cores to Track Persistent Pollutants in Washington State: A Review*	subsurface sediment	Concentrations in Lake Ballinger (non-urban lake) and Lake Washington peaked at 220 and 265 in the late 1960s. Concentrations fell to 40 and 75 by 1980 [p. 30, Fig. 12]	R
Van Metre and Mahler 2005 (USGS)	Trends in Hydrophobic Organic Contaminants in Urban and Reference Lake Sediments across the United States, 1970-2001 (In:*ES&T, vol. 39, 5567 - 5574)*	subsurface sediment	1965 to 1975 median of 65 in all lakes; 275 in dense urban; and 51 in light urban; nondetect in reference areas [Table 1]	N
			post-1990 median of 43 in all lakes; 108 in dense urban; and 15 in light urban; nondetect in reference areas [Table 1]	N
Arsenic (mg/kg dw)				
Lefkovitz et al. 1997 (NOAA Battelle/Marine Sciences Laboratory)	*Historical Trends in the Accumulation of Chemicals in Puget Sound, NOAA Technical Memorandum NOS ORCA 111*	subsurface sediment	Cores dated from 1970 to 1997: 10 to 20; buried maximum concentration of 28; pre-industrial 5 to 10 [p. 33, Fig. 3.11]	R
Meador et al. 1994 (NOAA)	*National Benthic Surveillance Project. Analyses of Elements in Sediment and Tissue Cycles I to V (1984-88). NOAA Technical Memorandum NMFS-NWFSC-16*	surface sediment	Most Pacific coast site means range 0.63 to 13; reference location (Dana Point, CA) = 9.3 [Fig. 13]	R
Partridge et al. 2005 (Ecology)	*Temporal Monitoring of Puget Sound Sediments: Results of the Puget Sound Ambient Monitoring Program 1989 - 2000*	surface sediment	Median of data collected from 1989 to 1996 was around 10; all samples below 10 during 2000 sampling event [p.100, Fig. 11]	R

Table J-4 Contaminant Concentrations Cited in Regional and National Trend Studies (continued)

Source	Study Title	Media	Concentrations Cited [page, figure, or table where cited]	Regional/ National
Rice 1999 (USGS)	Trace-Element Concentrations in Streambed Sediment Across the Conterminous United States (In: *ES&T, vol. 33, 2499-2504)*	streambed sediment	Median of 6.3 and range 1 to 200, all samples detected [Table 1]	N
		soil	Median values of nonurban soil datasets evaluated: 4.8-21 [Table 2]	N
USGS 2000 as summarized in Yake 2001 (Ecology)	Reconstructed Trends National Synthesis Study In: *The Use of Sediment Cores to Track Persistent Pollutants in Washington State: A Review*	subsurface sediment	Lake Washington rose from 10 and peaked at 36 in late 1930s; Lake Washington and Lake Ballinger at 10 to 25 from post-1950s to 2000 [p. 31, Fig. 17]	R
2007 query of soil data by AECOM from EIMS	*Tacoma Smelter Plume (TSP) King County Child Use Study, TSP Tracer Study, TSP King County Extended Footprint, TSP Phase II Mainland Footprint Study*	soil	Mean is 10, and 90th percentile is 20	R
Benzo(a)pyrene (µg/kg dw)				
Lefkovitz et al. 1997 (NOAA Battelle/Marine Sciences Laboratory)	*Historical Trends in the Accumulation of Chemicals in Puget Sound, NOAA Technical Memorandum NOS ORCA 111*	subsurface sediment	Puget Sound cores pre-industrial (1900) first detections; peaking in 1950s; leveling off to 100 (1980s)	R
Mauro et al. 2006	*Survey of the Distribution and Sources of PAHs in Urban Surface Soils*	soil	average 495; median 130 [p. 516, Table 1]	N
Partridge et al. 2005 (Ecology)	*Temporal Monitoring of Puget Sound Sediments: Results of the Puget Sound Ambient Monitoring Program 1989 - 2000*	surface sediment	Median of data collected from 1989 to 1996 was around 33 and mean was 143; during the 2000 sampling event median was 38 and mean was 100 [p.195, Table 9]. Abstract discusses increases in individual PAHs, total PAHs, and HPAHs over time in most water bodies sampled [p. xv]	R
Van Metre et al. 2000 as summarized in Yake 2001 (Ecology)	Urban Sprawl Leaves its PAH Signature In: *The Use of Sediment Cores to Track Persistent Pollutants in Washington State: A Review*	subsurface sediment	Lake Washington peak at 104 in 1973; Lake Ballinger increasing over time and 1,000-3,000 in upper depths [pp. 29 and 31, Fig. 15]	R
Van Metre and Mahler 2005 (USGS)	Trends in hydrophobic organic contaminants in urban and reference lake sediments across the United States, 1970-2001 *(In:ES&T, vol. 39: 5567-5574)*	subsurface sediment	1965 to 1975 median of 81 in all lakes, 580 in dense urban, and 50 in light urban; nondetect in reference areas [Table 1]	N
			post-1990 median of 350 in all lakes, 1,500 in dense urban, and 120 in light urban; nondetect in reference areas [Table 1]	N

Table J-4 Contaminant Concentrations Cited in Regional and National Trend Studies (continued)

Source	Study Title	Media	Concentrations Cited [page, figure, or table where cited]	Regional/ National
Dioxins / Furans (ng TEQ / kg dw)				
Cleverly et al. 1996 as summarized in Yake 2001 (Ecology)	A time-trends study of the occurrences and levels of CDDs, CDFs, and dioxin-like PCBs in sediment cores from 11 geographically distributed lakes in the United States In: *The Use of Sediment Cores to Track Persistent Pollutants in Washington State: A Review*	subsurface sediment	Concentrations in two Olympic Peninsula lakes (Ozette and Beaver) peaked around 2 (in mid 1950s); mid-1970s concentrations around 1 [p. 12]	R
EPA 2000 as reported in Windward 2010	*Exposure and Human Health Reassessment of 2,3,7,8-tertachlorodibenzo-p-dioxin (TCDD) and Related Compounds*	surface sediment	Eleven lakes and reservoirs removed from known sources; range was 0.12 to 16.3; mean was 5.3 [p. 523]	N
Integral 2008	*Toxic Equivalent Concentrations of TCDD in Source Sediments and Street Dirt*	street & catch basin dirt in LDW basin	Ten catch basin and manhole samples range from 6.2 to 26.3; mean of 16.8; one street dirt sample at 90.5; all samples collected in the LDW drainage basin [Table 2]	R
Rogowski et al. 1999 (Ecology)	*Final Report: Screening Survey for Metals and Dioxins in Fertilizer Products and Soils in Washington State*	soil	Concentrations range from 0.033 to 19; geometric mean ranged from 0.23 to 14 [Tables 3 and 4]	R
Yake et al. 2000 (Ecology)	Dioxins in Washington State Soils (In: *Dioxin 2000: 20th International Symposium on Halogenated Environmental Organic Pollutants & POPs, Monterey, CA. August 13-17, 2000. Volume 46, pp. 342-345)*	soil	In 14 urban samples, concentrations ranged from 0.13 to 19; in 70 samples from other land uses (forest, open, and agricultural) the range was 0.0078 to 5.2 [Table 2].	R

Notes:

CDD = chlorinated dibenzodioxin; CDF = chlorinated dibenzo-p-dioxin; Ecology = Washington State Department of Ecology; ES&T = Journal of Engineering, Science and Technology; HPAH = high molecular weight polycyclic aromatic hydrocarbon; µg/kg dw = micrograms per kilogram dry weight; mg/kg dw = milligrams per kilogram dry weight; NMFS = National Marine Fisheries Service; ng TEQ/kg dw = nanograms toxic equivalent per kilogram dry weight; N = national; NOAA = National Oceanic and Atmospheric Administration; NOS = National Ocean Service; ORCA = Office of Ocean Resources Conservation and Assessment; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyls; POPs = persistent organic pollutants; R = regional; TCDD= 2,3,7,8-tetrachlorodibenzo-p-dioxin; TPAH = total polycyclic aromatic hydrocarbon; TSP = Tacoma Smelter Plume; TSS = total suspended solids; USGS = U.S. Geological Survey

Table J-5a Duwamish/Diagonal Post-remedy ENR Data – Total PCBs, Arsenic, cPAHs, and BEHP

Station ID	Total PCBs (µg/kg dw)					Total PCBs (mg/kg oc)				
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
DUD_3C	1.5	29	80	141	109	n/a	n/a	6.5	11	6.8
DUD_4C	2.7	23	41	35	49	n/a	n/a	4.9	n/a	7.9
DUD_5C	3	26	39	39	34	n/a	4.4	5.2	7.5	2.8
DUD_6C	2	35	33	14	29	n/a	n/a	4.7	n/a	5.2
DUD_7C	2.9 U	6.4	78	57	47	n/a	n/a	5.7	4.9	2.8
DUD_14C	32	26	121	128	144	n/a	n/a	12	9.8	8.3
DUD_15C	1.4	12	43	70	31	n/a	n/a	2.8	6.5	1.9
Average by Year	*6.3*	*23*	*62*	*69*	*63*	*n/a*	*4.4*	*6.0*	*7.9*	*5.1*

Station ID	Arsenic (mg/kg dw)				
	2005	2006	2007	2008	2009
DUD_3C	1.5	2.9	9.4	9.0	10
DUD_4C	1.45	7.4	6	4.6	4
DUD_5C	1.35	3.5	5.5	4.7	7
DUD_6C	1.4	3.3	5.1	3.1	4.4
DUD_7C	1.45	7.05	10	8.4	11
DUD_14C	1.45	3.5	7.3	9.1	11
DUD_15C	1.45	3	9.6	9.1	10
Average by Year	*1.4*	*4.4*	*7.6*	*6.9*	*8*

Table J-5a Duwamish/Diagonal Post-remedy ENR Data – Total PCBs, Arsenic, cPAHs, and BEHP (continued)

Station ID	cPAHs (µg TEQ/kg dw)				
	2005	2006	2007	2008	2009
DUD_3C	4.6	58	108	150	62
DUD_4C	8.0	47	60	62	46
DUD_5C	9.0	47	70	84	45
DUD_6C	7.3	56	54	29	39
DUD_7C	4.5	16	106	69	38
DUD_14C	39	51	142	210	150
DUD_15C	2.1	26	81	160	44
Average by Year	*11*	*43*	*89*	*109*	*61*

Station ID	BEHP (µg/kg dw)					BEHP (mg/kg oc)				
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
DUD_3C	9.1	82	200	204	264 U	n/a	n/a	16	16	16.5 U
DUD_4C	13	64	91	121	519	n/a	n/a	11	n/a	83
DUD_5C	15	105	83	130	381 U	n/a	18	11	25	30.7 U
DUD_6C	12	93	74	66	151 U	n/a	n/a	11	n/a	27 U
DUD_7C	9.0	29	155	104	219 U	n/a	n/a	11	9.0	13 U
DUD_14C	70	82	165	222	274 U	n/a	n/a	16	17	15.7 U
DUD_15C	8.7	52	141	237	588 U	n/a	n/a	9.2	22	36.3 U
Average by Year	*20*	*72*	*130*	*155*	*208*	*n/a*	*18*	*12*	*18*	*22*

Notes:

1. The ENR sands were placed in February 2005 after capping of adjacent areas in 2004. Baseline ENR data were collected in March 2005, one month after placement.

n/a = not applicable because total organic carbon was not within appropriate range for normalizing concentrations or because location not sampled.

BEHP = bis(2-ethylhexyl)phthalate; cPAH = carcinogenic polycyclic aromatic hydrocarbons; ENR = enhanced natural recovery; µg/kg dw = micrograms per kilogram dry weight; mg/kg dw = milligram per kilogram dry weight; mg/kg oc = milligram per kilogram organic carbon; PCB = polychlorinated biphenyl; U = undetected value, one-half of this value was used in the percent change calculation

Table J-5b Duwamish/Diagonal Post-remedy Cap Data – Total PCBs, Arsenic, cPAHs, and BEHP

		Total PCBs (µg/kg dw)						Total PCBs (mg/kg oc)					
	Station ID	2004	2005	2006	2007	2008	2009	2004	2005	2006	2007	2008	2009
Cap A	DUD_1A	18.5	294	422	148	28	57	n/a	n/a	19	11	n/a	3.5
	DUD_2A	47	231	306	143	139	103	8.2	7.8	10	4.9	3.9	3.6
	DUD_3A	n/a	273	191	82	94	85	n/a	12	10	4.0	4.3	4.4
	DUD_4A	20	41	93	51	77	53	n/a	n/a	12	3.9	5.3	3.4
	DUD_5A	1.6	12	5.0	17	8.5	10	n/a	n/a	n/a	n/a	n/a	n/a
	Average by Year	*22*	*170*	*203*	*88*	*69*	*62*	*8*	*10*	*13*	*6*	*4*	*4*
Cap B	DUD_1B	120	94	118	99	166	58	n/a	14	6.7	7.0	11	3.2
	DUD_2B	80	74	70	67	115	45	n/a	5.7	4.6	3.4	5.4	2.5
	DUD_3B	31	n/a	49	62	130	22	n/a	n/a	2.7	3.0	5.7	1.2
	Average by Year	*77*	*84*	*79*	*76*	*137*	*41*	*n/a*	*10*	*5*	*4*	*7*	*2*
All	*Average by Year*	*45*	*146*	*157*	*84*	*95*	*54*	*8*	*9.9*	*9.3*	*5.3*	*6.0*	*3.1*

Table J-5b Duwamish/Diagonal Cap Post-remedy Data – Total PCBs, Arsenic, cPAHs, and BEHP (continued)

	Station ID	Arsenic (mg/kg dw)					
		2004	2005	2006	2007	2008	2009
Cap A	DUD_1A	1.5	5.7	5.5	4.8	3.4	6.6
Cap A	DUD_2A	1.5	11	15	14	16	14
Cap A	DUD_3A	n/a	9.9	14	12	14	12
Cap A	DUD_4A	1.5	1.7	5.2	6.0	7.4	7.6
Cap A	DUD_5A	1.5	1.5	7.3	5.2	2.4	3.1
Cap A	*Average by Year*	*1.5*	*5.9*	*9.4*	*8.4*	*8.7*	*8.7*
Cap B	DUD_1B	3.5	4.7	12	9	9.2	11
Cap B	DUD_2B	5.9	6.8	7.2	13	13	12
Cap B	DUD_3B	1.3	n/a	7.3	13	13	12
Cap B	*Average by Year*	*3.6*	*5.8*	*8.8*	*11.7*	*11.7*	*11.7*
All	*Average by Year*	*2.4*	*5.9*	*9.2*	*9.6*	*9.8*	*9.8*

	Station ID	cPAH (µg TEQ/kg dw)					
		2004	2005	2006	2007	2008	2009
Cap A	DUD_1A	65	668	931	247	66	410
Cap A	DUD_2A	86	471	463	292	410	220
Cap A	DUD_3A	n/a	562	312	120	290	250
Cap A	DUD_4A	57	93	158	165	440	210
Cap A	DUD_5A	20	14	13	31	29	62
Cap A	*Average by Year*	*57*	*362*	*375*	*171*	*247*	*230*
Cap B	DUD_1B	87	190	271	136	230	120
Cap B	DUD_2B	82	n/a	197	153	260	130
Cap B	DUD_3B	43	n/a	129	129	300	77
Cap B	*Average by Year*	*71*	*190*	*199*	*139*	*263*	*109*
All	*Average by Year*	*63*	*333*	*309*	*159*	*253*	*185*

Table J-5b Duwamish/Diagonal Post-remedy Cap Data – Total PCBs, Arsenic, cPAHs, and BEHP (continued)

		BEHP (µg/kg dw)						BEHP (mg/kg oc)					
	Station ID	2004	2005	2006	2007	2008	2009	2004	2005	2006	2007	2008	2009
Cap A	DUD_1A	442	5490	3660	1210	722	876	n/a	n/a	161	87	n/a	54
Cap A	DUD_2A	374	2360	2210	1990	1870	974	65.3	80	74	68	52	34
Cap A	DUD_3A	n/a	1520	835	426	1100	527	n/a	65	45	21	51	27
Cap A	DUD_4A	140	272	709	851	1110	620	n/a	n/a	92	65	77	40
Cap A	DUD_5A	17	24	8.8	74	76	52 U	n/a	n/a	n/a	n/a	n/a	n/a
Cap A	*Average by Year*	*243*	*1,933*	*1,485*	*910*	*976*	*749*	*65*	*73*	*93*	*60*	*60*	*39*
Cap B	DUD_1B	158	255	567	229	417	269	n/a	38	32	16	28	15
Cap B	DUD_2B	168	181	498	436	707	301	n/a	14	33	22	33	17
Cap B	DUD_3B	89	n/a	460	502	991	303	n/a	n/a	25	25	44	17
Cap B	*Average by Year*	*138*	*218*	*508*	*389*	*705*	*291*	n/a	*26*	*30*	*21*	*35*	*16*
All	*Average by Year*	*198*	*1,443*	*1,118*	*715*	*874*	*553*	*65*	*49*	*66*	*43*	*47*	*29*

Notes:

1. Dredging and capping occurred in 2003 and 2004. ENR sands were placed in February 2005. Baseline data were collected in June 2004, approximately four months after cap placement.
2. Underlined values exceed the Sediment Quality Standard (12 mg/kg oc for total PCBs; 47 mg/kg oc for BEHP). All arsenic post-cap monitoring data were below the SQS.

n/a = not applicable because total organic carbon was not within appropriate range for normalizing concentrations or because location was not sampled.

BEHP = bis(2-ethylhexyl)phthalate; cPAH = carcinogenic polycyclic aromatic hydrocarbons; µg/kg dw = micrograms per kilogram dry weight; ng TEQ / kg dw = nanograms toxic equivalent per kilogram dry weight; mg/kg oc = milligram per kilogram organic carbon; PCB = polychlorinated biphenyl; U = undetected value, one-half of this value was used in the percent change calculation

Table J-6 Post-Remedy Total PCBs and Total Organic Carbon in the Norfolk Area

Norfolk CSO/SD

Month-Year	Total PCBs (µg/kg dw)					Total Organic Carbon (%)			
	NFK501	NFK502	NFK503	NFK504	Average by Year	NFK501	NFK502	NFK503	NFK504
Oct-99	21	71	190	5.7	72	0.3	0.4	0.3	0.2
Apr-00	508	10	180	13	178	0.2	0.1	0.2	0.3
Apr-01	36	94	1330	31	373	0.9	0.5	0.4	0.9
Apr-02	174	4.9	777	52	252	2.1	0.1	2.6	1.3
Apr-03	90	21	193	4.7	77	2.2	0.3	2.4	0.1
Apr-04	470	5	470	5.3	238	0.3	0.2	2.6	0.3
Oct-06	67	13.5	50	9.0	35	2.7	1.7	2.1	1.4
May-08	7.0	3.6	—	2.2	4.3	5.4	0.7	—	1.9

Boeing Developmental Center South Storm Drain

Month-Year	Total PCBs (µg/kg dw)						Total Organic Carbon (%)				
	S01	S01 duplicate	S02	S02 duplicate	S03	Average by Year[a]	S01	S01 duplicate	S02	S02 duplicate	S03
Sep-04	27	—	19 U	19 U	20 U	16	0.2	—	0.3	0.1	0.2
Nov-05	353	32 U	31 U	—	31 U	72	1.6	1.5	1.3	—	0.5
Jun-07	280	163	19 U	—	20 U	80	1.7	2.2	1.3	—	1.2
Sep-07	138	204	20 U	—	19 U	64	1.0	1.2	0.8	—	1.6
Feb-09	33 U	32 U	32 U	—	32 U	32 U	1.7	2.6	1.4	—	1.7
Sep-09	1,310	840[b]	32 U	—	33 U	370	3.9	14.2	1.6	—	3.1

Notes:

1. Only PCBs were analyzed on the Boeing Developmental Center south storm drain cap.
2. Norfolk dredging and backfilling occurred in 1999; Boeing Developmental Center dredging and capping occurred in 2003.

a. Average calculated by first calculating location-specific averages (average of parent and duplicate), then by averaging resulting data with other location data. One-half of the reporting limit was used for undetected data.

b. Although this dry weight value is an exceedance of the SQS, when this value is oc-normalized, the resulting value, 6 mg/kg oc, is not an exceedance of the SQS.

U = not detected at reporting limit listed.

— = not sampled or not analyzed.

CSO/SD = combined sewer overflow/ storm drain; µg/kg dw = micrograms per kilogram dry weight; mg/kg oc = milligrams per kilogram organic carbon; PCB = polychlorinated biphenyl

Table J-7 Surface Sediment Human Health Risk-Driver Data Collected More than Five Years after Dredging in Berthing Areas

Location	River Mile	Sampling Event	Year Sampled	Total PCBs (µg/kg dw)	Total PCBs (mg/kg oc)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxins/ Furans (ng TEQ/kg dw)	Dredge Year	Years Elapsed
LDW-SS307	0.2	LDWRI Round 3	2006	231	11	14	960	n/a	1980	26
DR003	0.2	EPA SI	1998	267	13	12	600	n/a	1980	18
DR004	0.3			168	6.6	11	440	n/a		
EST232	0.3	NOAA Site Characterization	1997	140	8.4	n/a	n/a	n/a	1980	17
TRI-056T	1.4	Ecology SPI	2006	170	6.2	15	360	n/a	1993	13
SPI-125	1.8			240	8.8	18	380	n/a		
LDW-SS55	1.4	LDWRI Round 1	2005	24	1.6	17	190	n/a	1993	12
LDW-SS53	1.4	LDWRI Round 2	2005	220	8.3	40	670	n/a	1993	12
SG22	2.9	Slip 4 – Early Action	2004	145	5.2	n/a	n/a	n/a	1992	12
LDW-SS63	1.7	LDWRI Round 1	2005	95	4.0	10	190	n/a	1994	11
Average of data with more than 10 years elapsed				*196*	*8*	*18*	*457*	*n/a*		
DR-181	2.9	Ecology SPI	2006	460	14	20	320	n/a	1996	10
TRI-095T	2.7			97	4.1	13	220	n/a	1998	8
LDW-SS336	2.7	LDWRI Round 3	2006	190	9.1	14	300	n/a	1998	8
SG14	2.8	Slip 4 – Early Action	2004	200	7.2	n/a	n/a	n/a	1996	8
SG16				126	15	n/a	n/a	n/a		
SG18				130	4.1	n/a	n/a	n/a		
SG20				179	5.8	n/a	n/a	n/a		
SG21				158	5.3	n/a	n/a	n/a		
SG24				99	3.4	n/a	n/a	n/a		
SG25				116	4.6	n/a	n/a	n/a		
SG27				77	2.5	n/a	n/a	n/a		

Table J-7 Surface Sediment Human Health Risk-Driver Data Collected More than Five Years after Dredging in Berthing Areas (continued)

Location	River Mile	Sampling Event	Year Sampled	Total PCBs (µg/kg dw)	Total PCBs (mg/kg oc)	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxins/ Furans (ng TEQ/kg dw)	Dredge Year	Years Elapsed
LDW-SS95	2.7	LDWRI Round 2	2005	198	7.5	17	3,100	n/a	1998	7
WRC-SS-B1	2.5	Boyer Towing	2004	10	1.2	7 U	110	n/a	1998	6
WRC-SS-B2				23	1.6	10 U	410	n/a		
WRC-SS-B3				18	n/a	6 U	77	n/a		
Average of data with 6 - 10 years elapsed				*116*	*6*	*15*	*703*	*n/a*		
DR121	1.4	EPA SI	1998	98	4.1	6	160	8.1	1993	5
DR126	1.5			181	5.9	18	350	n/a		
DR092	1.6			64	9.1	13	630	n/a		
DR154	1.8			101	4.3	11	230	12		
DR205	3.4			35	1.6	10	78	n/a		
DR227				25	1.3	8	82	n/a		
WST325	3.0	NOAA Site Characterization	1997	110	5.9	n/a	n/a	n/a	1992	5
Average of data with 5 years elapsed				*88*	*5*	*11*	*255*	*10*		
Average of all data (n = 32)				*137*	*6.1*	*15*	*469*	*10*		

Notes:

1. All total PCBs, cPAHs, and dioxin/furan data were detected. The three arsenic data with "U" qualifiers were not detected and are listed at the reporting limit.

Ecology = Washington State Department of Ecology; EPA = Environmental Protection Agency; LDWRI = Lower Duwamish Waterway Remedial Investigation; µg TEQ/kg dw = micrograms per kilogram toxic equivalent dry weight; mg/kg oc = milligrams per kilogram organic carbon; n/a = risk driver not analyzed in sample; ng TEQ /kg dw = nanograms toxic equivalent per kilogram dry weight; NOAA = National Oceanic and Atmospheric Administration; PCBs = polychlorinated biphenyls; SI = site investigation; SPI = sediment profile imaging

Table J-8 Model-predicted Minimum Lateral Percentage of Lateral Source Sediment Required to Result in Year 10 Concentrations >SQS

Risk Driver	Unit (dw)	BCM Input Parameters		SQS[a] (dw)	SQS (mg/kg oc)	Year 10 Lateral Percentage Needed in the Sediment Bed to Exceed SQS in 10 Years[b]
		Upstream	Lateral			
SMS Contaminants						
Acenaphthene	µg/kg	8	209	320	16	N/P
Bis(2-ethylhexyl)phthalate	µg/kg	120	15,475	940	47	5.4
Butyl benzyl phthalate	µg/kg	11	972	98	4.9	9.1
Chrysene	µg/kg	49	1,807	2,200	110	N/P
Fluoranthene	µg/kg	190	3,989	3,200	160	79.5
Indeno(1,2,3-cd)pyrene	µg/kg	31	675	680	34	N/P
Phenanthrene	µg/kg	53	2,010	2,000	100	99.7
Phenol	µg/kg	10	237	420	n/a	N/P
Total PCBs (recommended BCM input)	µg/kg	35	300	240	12	98.2
Total PCBs (high lateral BCM input)	µg/kg	35	1,000	240	12	21.5
Arsenic (recommended BCM input)	mg/kg	9	13	57	n/a	N/P
Arsenic (high lateral BCM input)	mg/kg	9	30	57	n/a	N/P
Mercury	mg/kg	0.10	0.14	0.41	n/a	N/P
Zinc	mg/kg	64	626	410	n/a	62.2
Other						
cPAH (mid BCM inputs)	µg TEQ/kg dw	70	1,400	1,000[c]	n/a	70.2
cPAH (mid upstream BCM input and high lateral BCM input)	µg TEQ/kg dw	70	3,400	1,000[c]	n/a	28.1

Notes:

a. Concentration in dry weight (dw) units or dw equivalent for oc-normalized SQS using 2% TOC conversion from SQS oc-normalized values.

b. In receiving sediment STM grid cell

c. AOPC 1 cPAH site-wide RAL used, but grid cells predicted to exceed for cPAH not shown on Figures J-9a and J-9b.

$(Bed_c{*}Bed_f)+(Lat_c{*}Lat_f)+(Up_c{*}Up_f)$ = SQS (Year 10 Concentration)

Assume upstream percentage plus lateral percentage = 94 (because average Year 10 bed percentage is 6).

Assume bed concentration is zero. Solve for lateral fraction (Lat_f).

$(SQS - 0.94Up_c) / (Lat_c - Up_c) = Lat_f$

Orange shading = likelihood of recontamination based on lateral percentage below 30.

AOPC = area of potential concern; BCM = bed composition model; cPAH = carcinogenic polycyclic aromatic hydrocarbons; mg/kg oc = milligrams per kilogram organic carbon; N/P= not possible to exceed SQS because BCM lateral input parameter <SQS; RAL = remedial action level SQS = sediment quality standards; TOC = total organic carbon

Table J-9 Contaminant Concentrations Cited in Atmospheric Studies

Source	Study Title	Media	Concentrations Cited	Study Location
Gingrich et al. 2001	Atmospherically Derived Organic Surface Films along an Urban-Rural Gradient (In: *ES&T*, vol. 35, 4031-4037)	organic surface films	Surface films (concentrations from rural to urban) PCBs 1.8 to 95 ng/m^2 TPAHs 210 to 6,100 ng/m^2	Toronto, Ontario, Canada
Jamshidi et al. 2007	Concentrations and Chiral Signatures of Polychlorinated Biphenyls in Outdoor and Indoor Air and Soil in a Major U.K. Conurbation (In: *ES&T*, vol. 41, 2153-2158)	air, soil	PCBs in surface soils range 0.36 to 13.3 µg/kg dw at city center; up to 0.4 mg/kg oc. In air, PCBs average concentrations range from <100 in rural areas to 600 pg/m^3 at the city center.	West Midlands, U.K.
King County 2008	*Passive Atmospheric Deposition Sampling. Lower Duwamish Waterway. Monitoring Report* – October 2005 to April 2007	wet and dry deposition	PCBs were detected in the industrialized areas at flux rates on the order of 0.01 to 0.06 µg/m^2/day; BEHP on the order of 2 µg/m^2/day; B(a)P on the order of 0.06 µg/m^2/day (median).	Duwamish Valley and Beacon Hill, King County, WA
Offenberg and Baker 1997	Polychlorinated Biphenyls in Chicago Precipitation: Enhanced Wet Deposition to Near-Shore Lake Michigan (In: *ES&T*, vol. 31, 1534-1538)	rain water	PCBs in Chicago precipitation: 4.1 ng/L to 189 ng/L. Precipitation falling over Lake Michigan: 2 to 360 times greater than the regional background concentrations measured at South Haven, MI (0.17 and 0.02 ng/L, July 20 and 21, 1994). PCBs in rainwater from the rural site were lower than the volume-weighted mean PCB concentration measured by the IADN network at Sleeping Bear Dunes, MI (1.05+/-0.23 ng/L), suggesting that the regional background signal was sampled at South Haven. Volume-weighted mean at 3 locations (Chicago, IL; Lake Michigan; South Haven, MI) were 29.3, 5.8, and 0.1 ng/L, respectively.	Chicago, IL
Simcik et al. 1997	Urban Contamination of the Chicago/Coastal Lake Michigan Atmosphere by PCBs and PAHs during AEOLOS (In: *ES&T*, vol. 31, 2141-2147)	air	TPAHs and PCBs in Chicago were approximately 4 times the concentration measured over Lake Michigan. The gas phase PAHs are dominated by phenanthrene and fluorene, while the particulate phase is dominated by benzofluoranthenes, chrysene, fluoranthene, and pyrene. Total PCBs in Chicago (urban) range from 270 to 14,200 pg/m^3 and are highest during July.	Chicago, IL

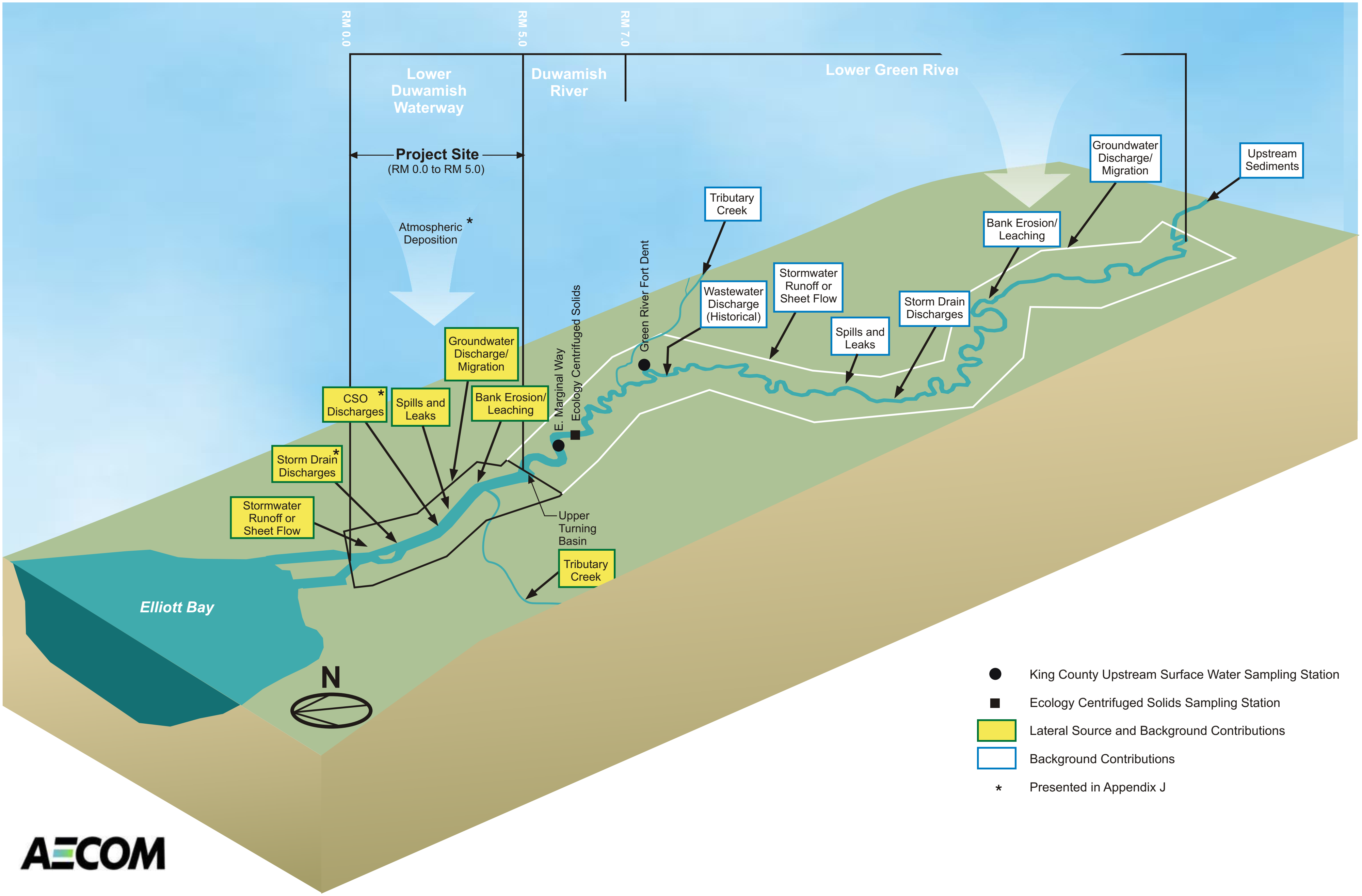
Table J-9 Contaminant Concentrations Cited in Atmospheric Studies (continued)

Source	Study Title	Media	Concentrations Cited	Study Location
Totten et al. 2006	Measurement and modeling of urban atmospheric PCB concentrations on a small (8 km) spatial scale (In: *Atmospheric Environment*, vol. 40, 7940-7952)	air	During a year of simultaneous sampling, average gas-phase total PCB concentrations were 1,600 pg/m^3 at Bayonne and 930 pg/m^3 at Jersey City. These concentrations are typical of those measured over a longer time period (Oct. 1998 to Jan. 2001) for Jersey City: average 1,260 pg/m^3. Concentrations of gas-phase total PCB measured at more remote regions of New Jersey average 150 to 220 pg/m^3.	NJ
Wethington III and Hornbuckle 2005	Milwaukee, WI as a Source of Atmospheric PCBs to Lake Michigan (In: *ES&T*, vol. 39, 57-63)	air	The average PCB gas-phase concentration in Milwaukee was 1,900 pg/m^3, similar to other urban areas and higher than background levels. IADN reports gas-phase concentrations of 620, 2,700, and 1,600 pg/m^3 for 3 samples collected in Chicago. 1996, Baltimore, 20 to 3,400 pg/m^3. 1997 to 1999, suburban New Jersey, 86 to 2,300 pg/m^3. Gas-phase PCB concentrations measured during the Milwaukee study are about 8 times higher than atmospheric concentrations in air collected over Lake Michigan.	Milwaukee, WI

Notes:

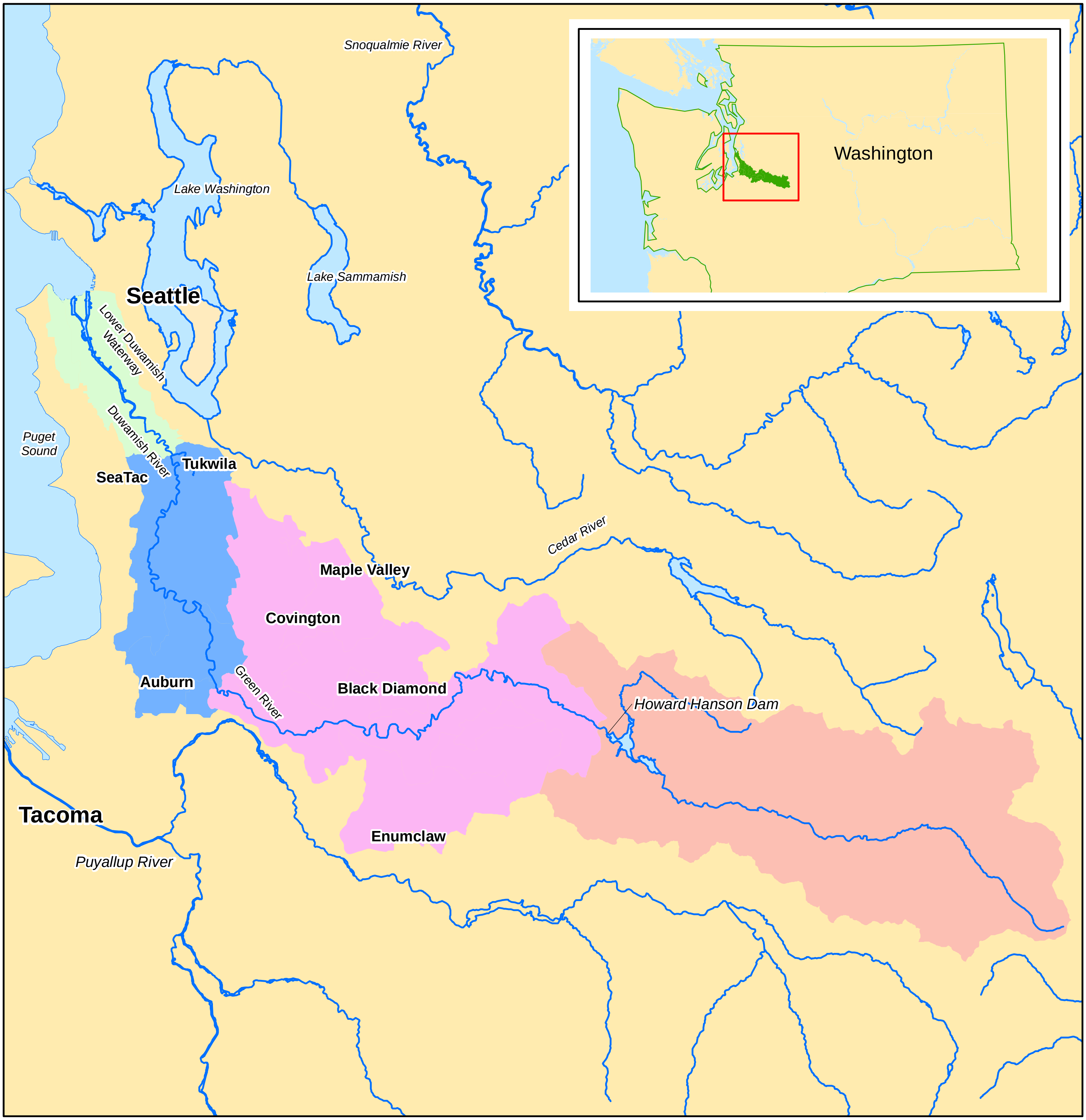
AEOLOS = Atmospheric Exchange Over Lakes and Oceans Study; B(a)P = benzo(a)pyrene; BEHP = bis(2-ethylhexyl)phthalate; ES&T = Journal of Engineering, Science and Technology; IADN = Integrated Atmospheric Deposition Network; µg/kg dw = micrograms per kilogram dry weight; mg/kg oc = milligrams per kilogram organic carbon; ng/L = nanograms per liter; ng/m^3 = nanograms per cubic meter; ng/m^2 = nanogram per square meter; oc = organic carbon normalized; PCBs = polychlorinated biphenyls; pg = picograms; TPAH = total polycyclic aromatic hydrocarbon

Figure J-1 Conceptual Model of External Sources of Recontamination



AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company



Notes:
1. Subwatersheds derived from the major hydrological basin boundaries as defined by King County Dept of Natural Resources and Parks, Water and Lands Resource Division (King County 2005).

Legend

Duwamish/Green River Subwatershed
- Upper Green River
- Middle Green River
- Lower Green River
- Duwamish Estuary
- River/Stream
- Water Body

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix J\FigureJ-2Watershed.mxd

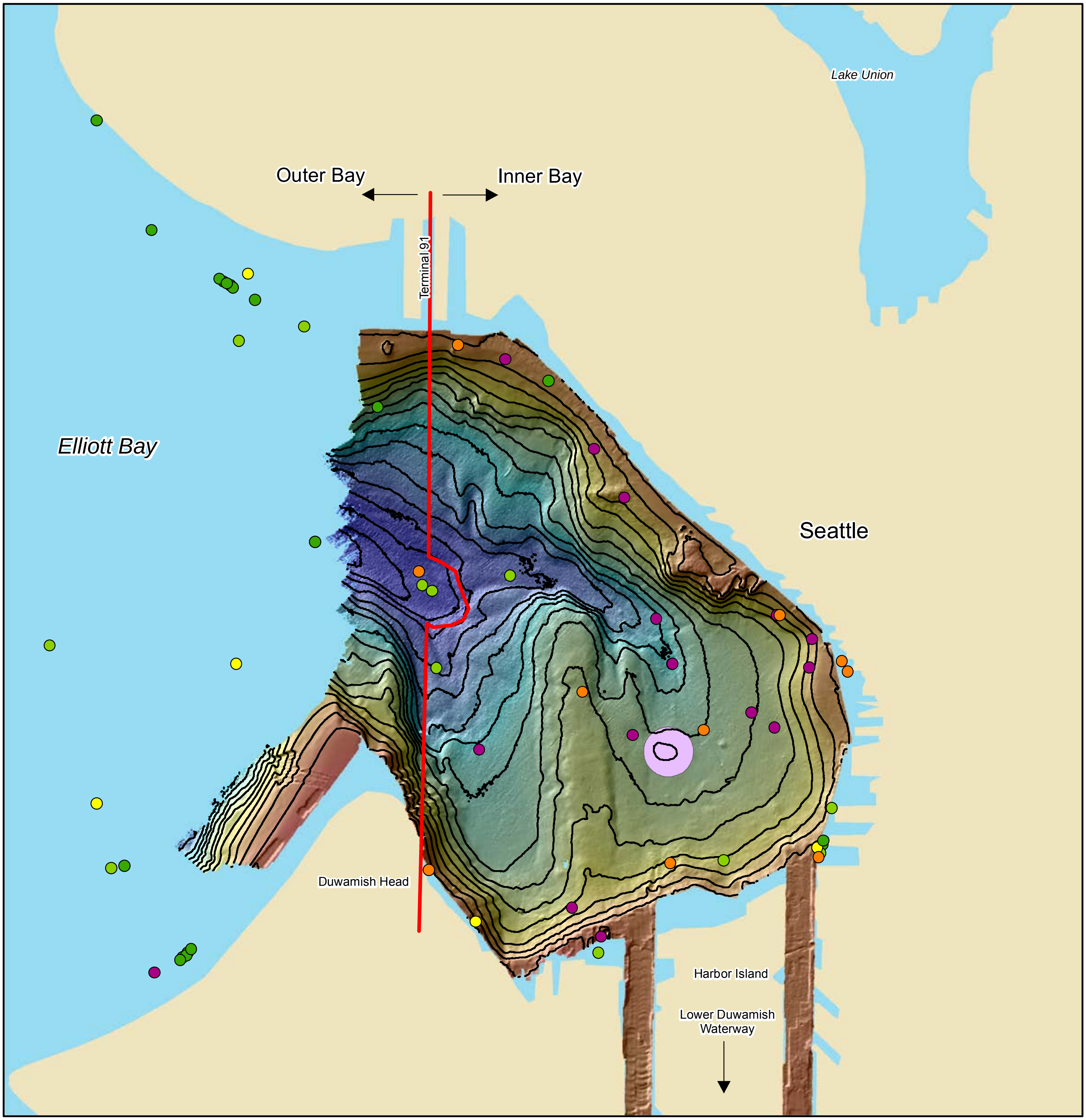
AECOM

Lower Duwamish Waterway Group

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Subwatersheds of the Green/Duwamish River Watershed

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE J-2**



Notes:
1. Bathymetric survey from 2001 NOAA Multibeam Mapping of the Major Deltas of the Southern Puget Sound, Washington.
2. Inner Elliott Bay defined as stations east of line from Duwamish Head to Terminal 91, with the exception of three stations at elevations below -150 m, MLLW.
3. Stations within 250 ft of the shoreline, on the open-water disposal site, and associated with listed MTCA or CERCLA sites are excluded.
4. The Open Water Dredged Material Disposal Site Target Area was generated using the location (Long: 122° 21.45, Lat: 47° 35.91 NAD83) and extent (1,200-ft radius circle) in Figure 11-2 of the 2008 Dredged Material Evaluation and Disposal Procedures manual (USACE 2008).

Legend

Total PCBs in Surface Sediment (µg/kg dw)
- ≤ 10
- > 10 - 50
- > 50 - 100
- > 100 - 200
- > 200

Mudline Elevation (meters, MLLW)
Value
High : -1.74992
Low : -179.795

Mudline Elevation (meters, MLLW)

Open Water Dredged Material Disposal Site Target Area

Miles
0 0.1 0.2 0.4

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix JJ-3EBPCB.mxd

AECOM

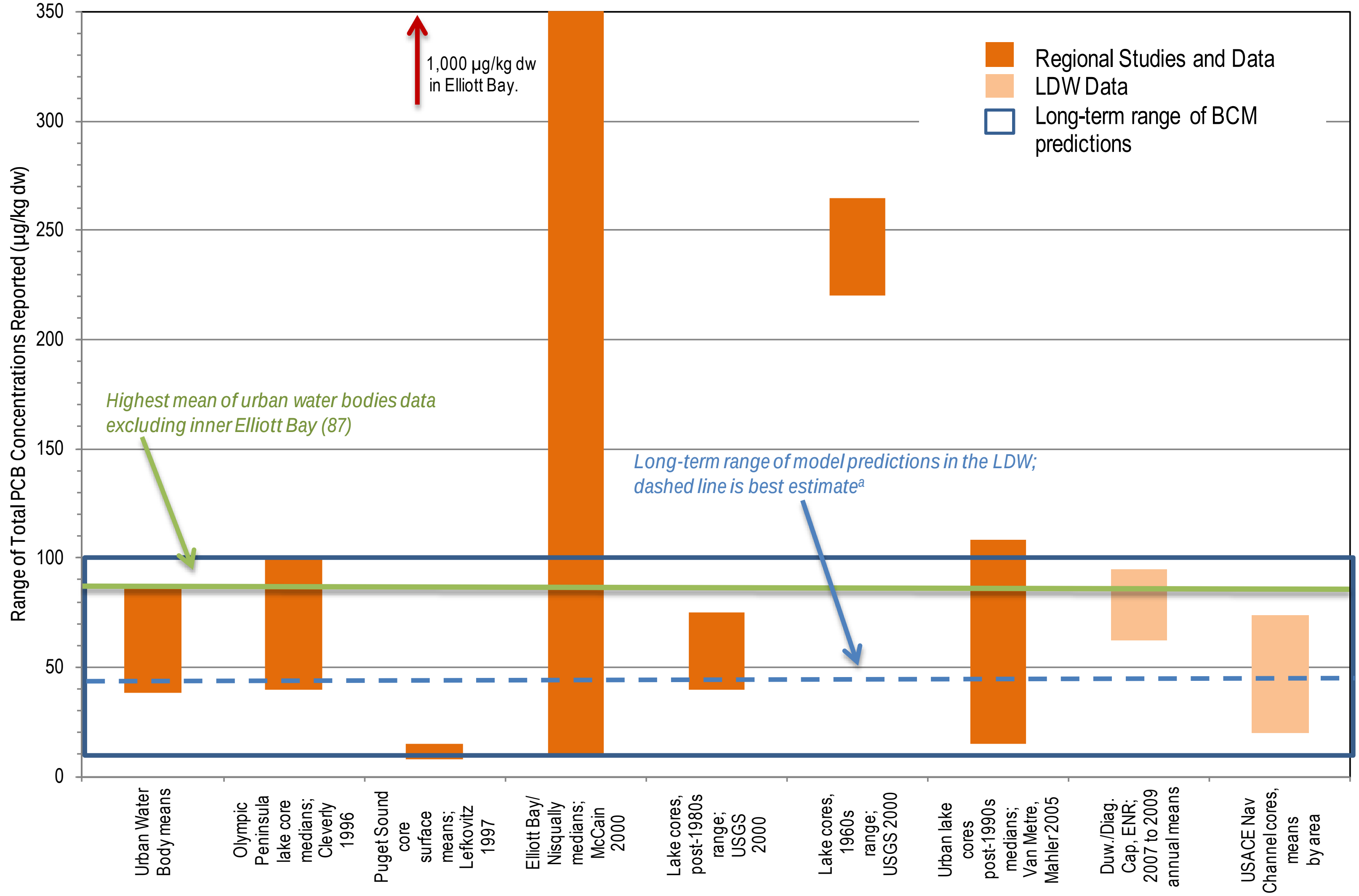
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

Inner and Outer Elliott Bay Total PCB Stations

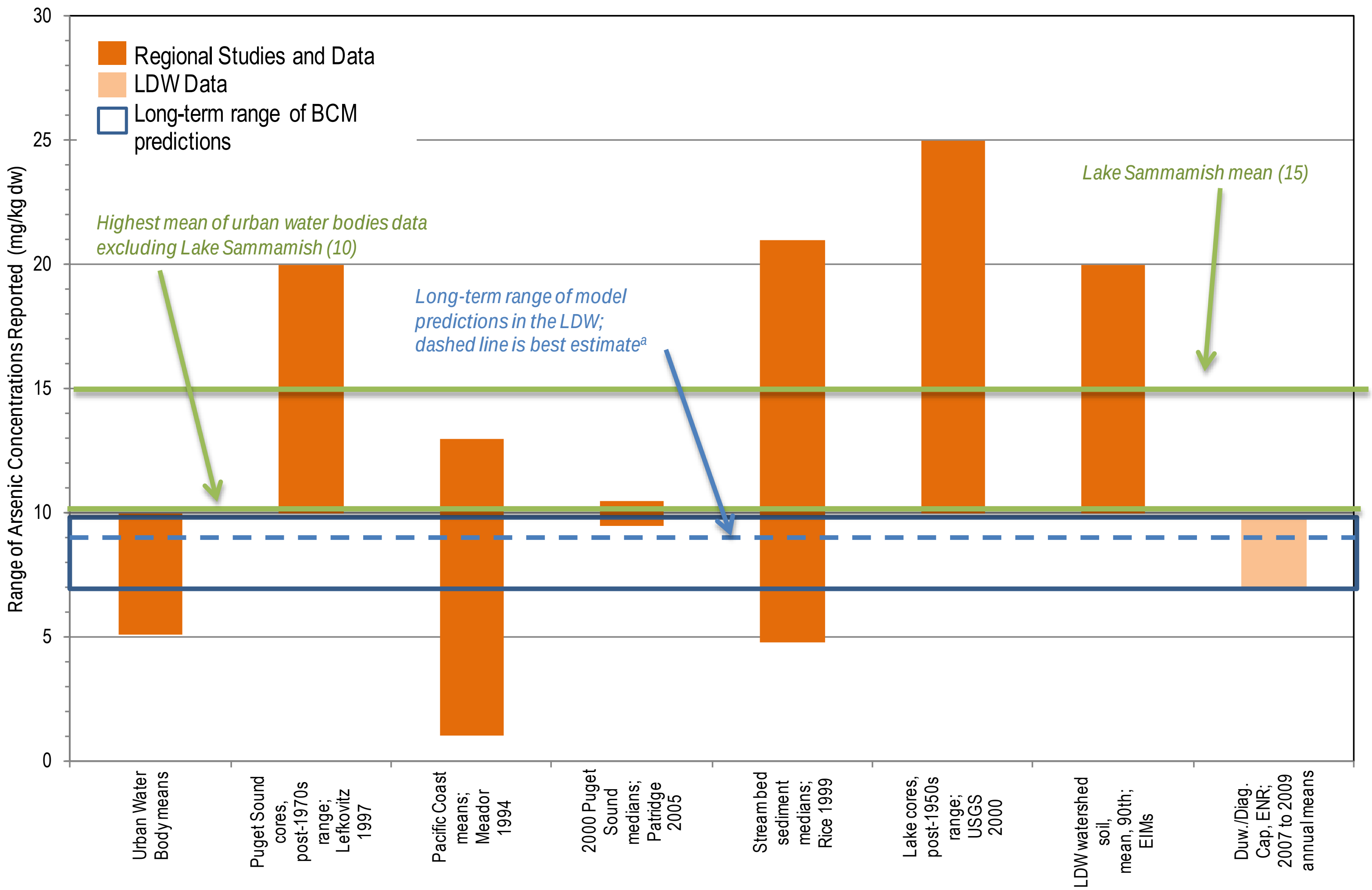
DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0 | **FIGURE J-3**

Figure J-4a Regional and Local Range of Total PCB Concentrations



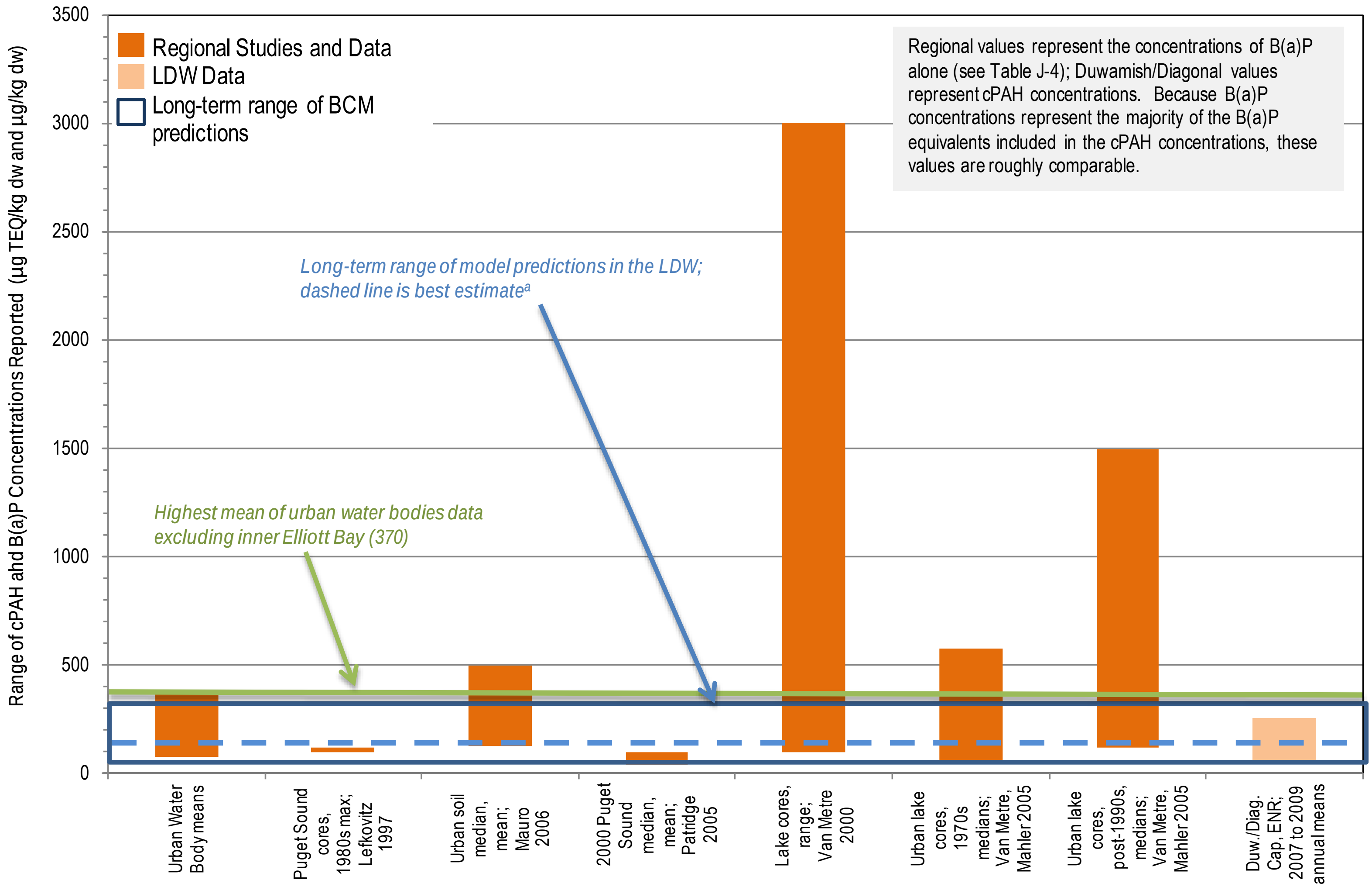
Notes: 1. Media are surface sediments, unless otherwise noted. See Tables J-1, J-4, J-5a, and J-5b for data.
a. Long-term range of BCM predictions is based on the 45-year site-wide SWAC after remediation of Alternative 6R, using the low and the high input parameters.

Figure J-4b Regional and Local Range of Arsenic Concentrations



Notes: 1. Media are sediments, unless otherwise noted. See Tables J-1, J-4, J-5a, and J-5b for data.
a. Long-term range of BCM predictions is based on the 45-year site-wide SWAC after remediation of Alternative 6R, using the low and the high input parameters.

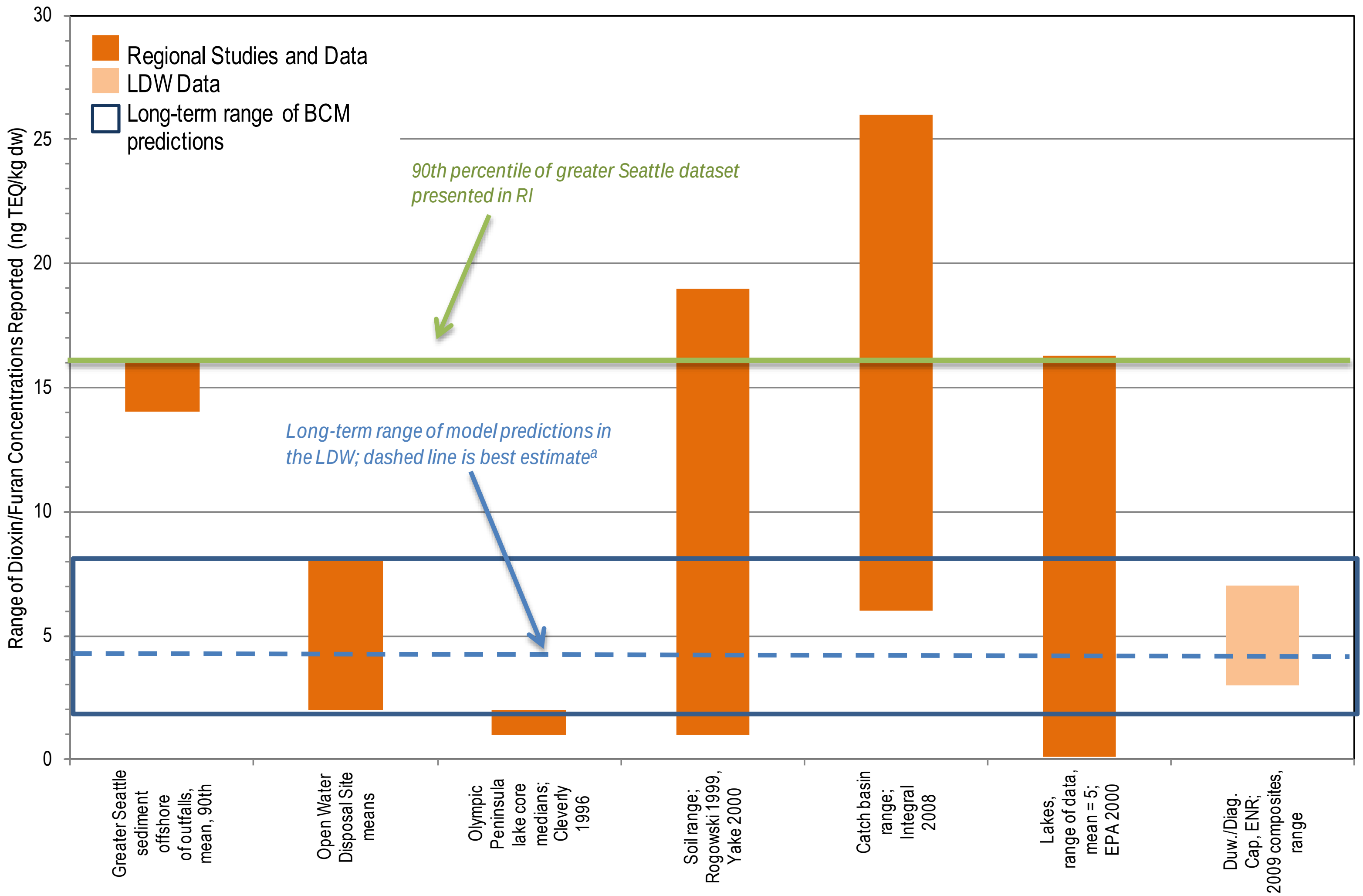
Figure J-4c Regional and Local Range of cPAH and B(a)P Concentrations



Notes: 1. Media are sediments, unless otherwise noted. See Tables J-1, J-4, J-5a, and J-5b for data.

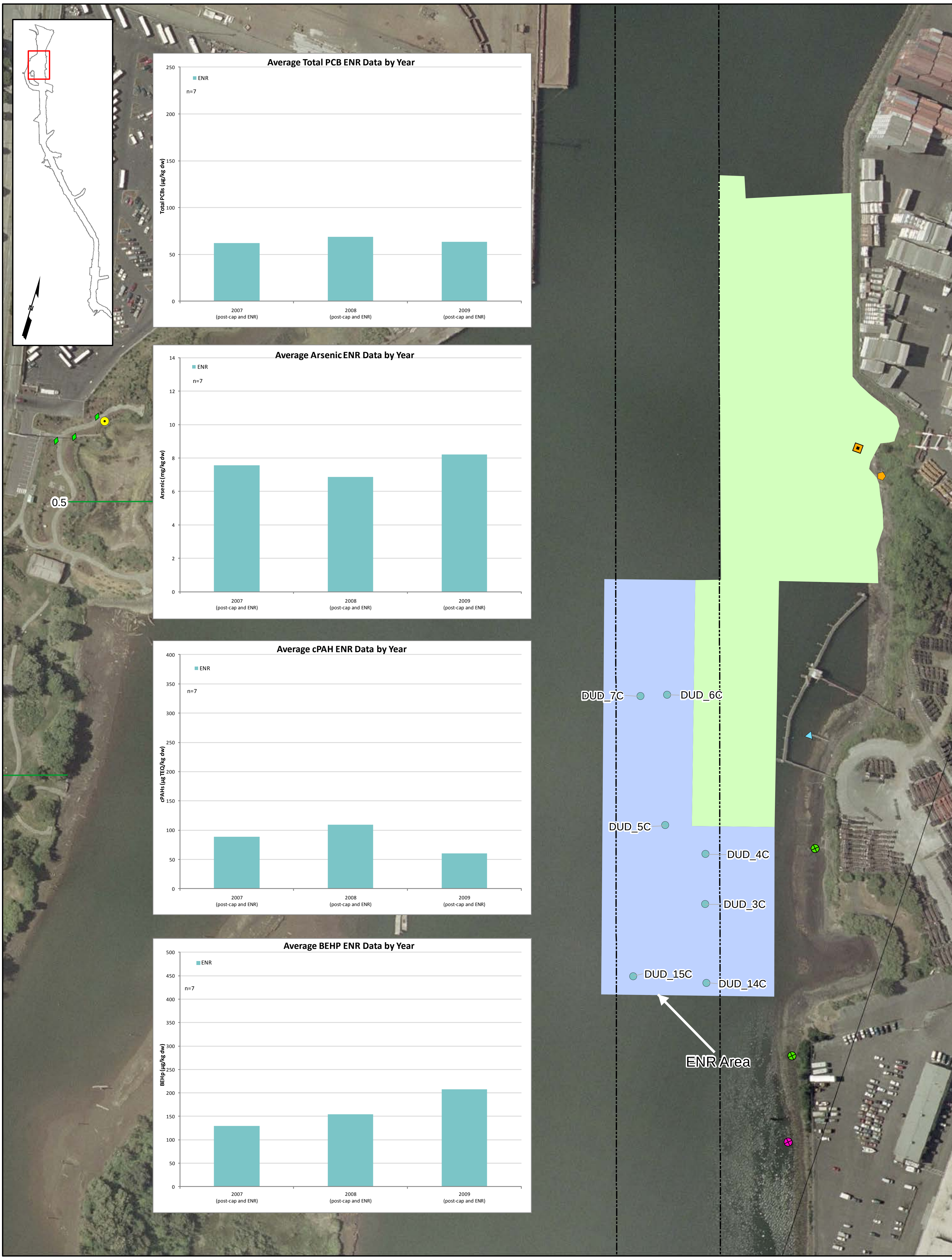
a. Long-term range of BCM predictions is based on the 45-year site-wide SWAC after remediation of Alternative 6R., using the low and the high input parameters.

Figure J-4d Regional and Local Range of Dioxin/Furan Concentrations



Notes: 1. Media are sediments, unless otherwise noted. See Tables J-2, J-3, and J-4 for data.

a. Long-term range of BCM predictions is based on the 45-year site-wide SWAC after remediation of Alternative 6R, using the low and the high input parameters.



Notes:
1. USGS 2002 photograph provided by Windward Environmental.
2. CSO= combined sewer overflow; EOF= emergency overflow; ENR= enhanced natural recovery.
3. A 2009 dioxin/furan composite sample on the ENR area had a concentration of 3.3 ng TEQ/kg dw.
4. Cap data are shown on Figure J-5b.
5. Data from 2005 and 2006 not shown because storm drain cleaning caused elevated concentrations in 2006. The 2007 through 2009 data shown are more indicative of recontamination potential.

Outfall Location

- Private storm drain
- Permitted private storm drain
- Public storm drain
- CSO/storm drain
- EOF
- Abandoned
- Pipe of unresolved origin and/or use

Legend

- Dredge and Cap (2003-2004)
- Thin-layer Sand Placement; ENR (2005)

Sampling Location

- ENR
- River Mile Marker
- Navigation Channel

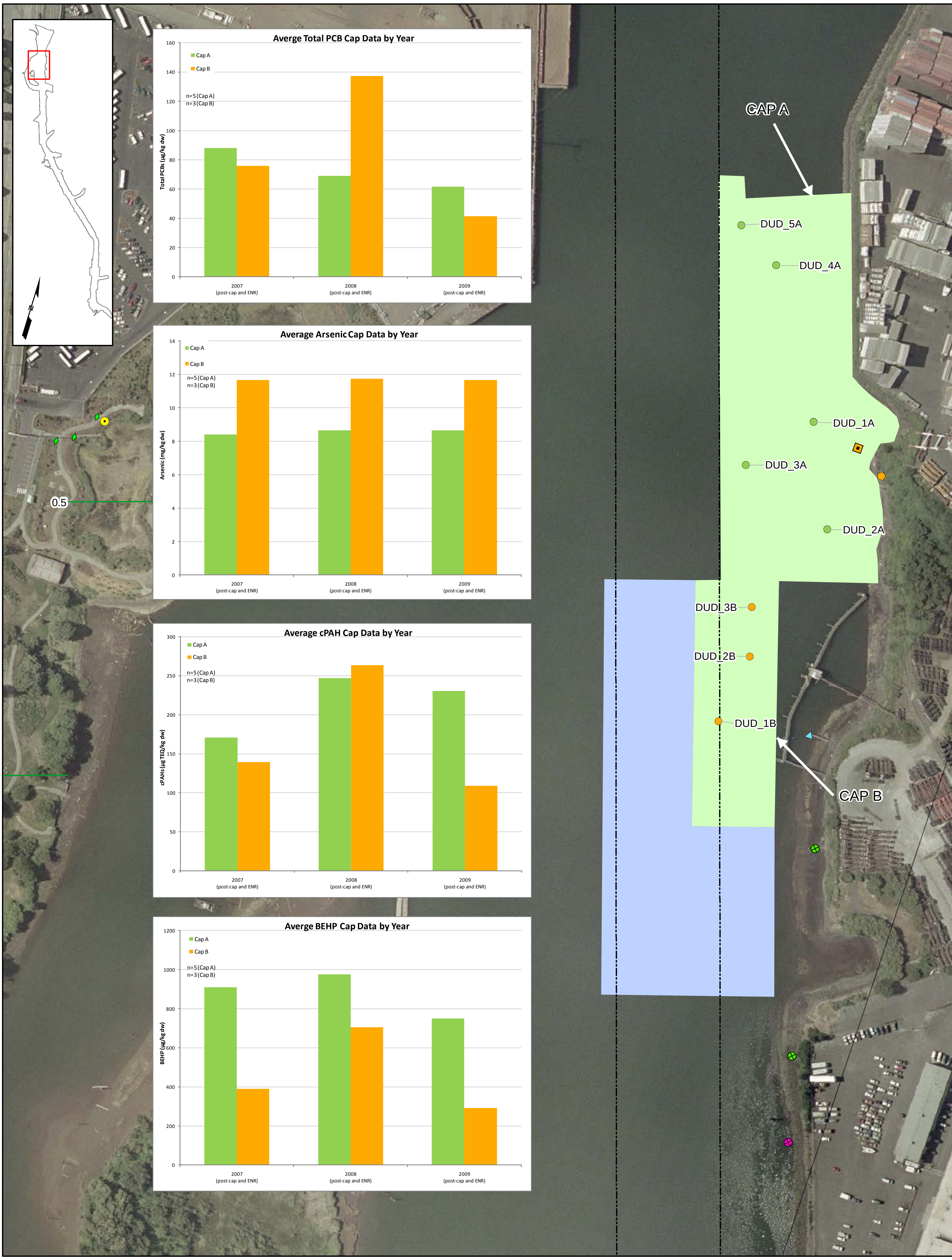
0 120 240 480 Feet

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\FigureJ-5aSurfsedDDAvgAV2.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.48			**Post-Remedy Surface Sediment Averages Over Time on the Duwamish/Diagonal ENR Area**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 1	**FIGURE J-5a**



Notes:
1. USGS 2002 photograph provided by Windward Environmental.
2. CSO= combined sewer overflow; EOF= emergency overflow; ENR= enhanced natural recovery.
3. Two dioxin/furan composite samples on Caps A and B had concentrations of 7.0 and 5.1 ng TEQ/kg dw, respectively.
4. ENR data are shown on Figure J-5a.
5. Data from 2005 and 2006 not shown because storm drain cleaning caused elevated concentrations in 2006. The 2007 through 2009 data shown are more indicative of recontamination potential.

Outfall Location

- Private storm drain
- Permitted private storm drain
- Public storm drain
- CSO/storm drain
- EOF
- Abandoned
- Pipe of unresolved origin and/or use

Legend

- Dredge and Cap (2003-2004)
- Thin-layer Sand Placement; ENR (2005)

Sampling Location

- Cap A
- Cap B
- River Mile Marker
- Navigation Channel

Feet
0 120 240 480

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

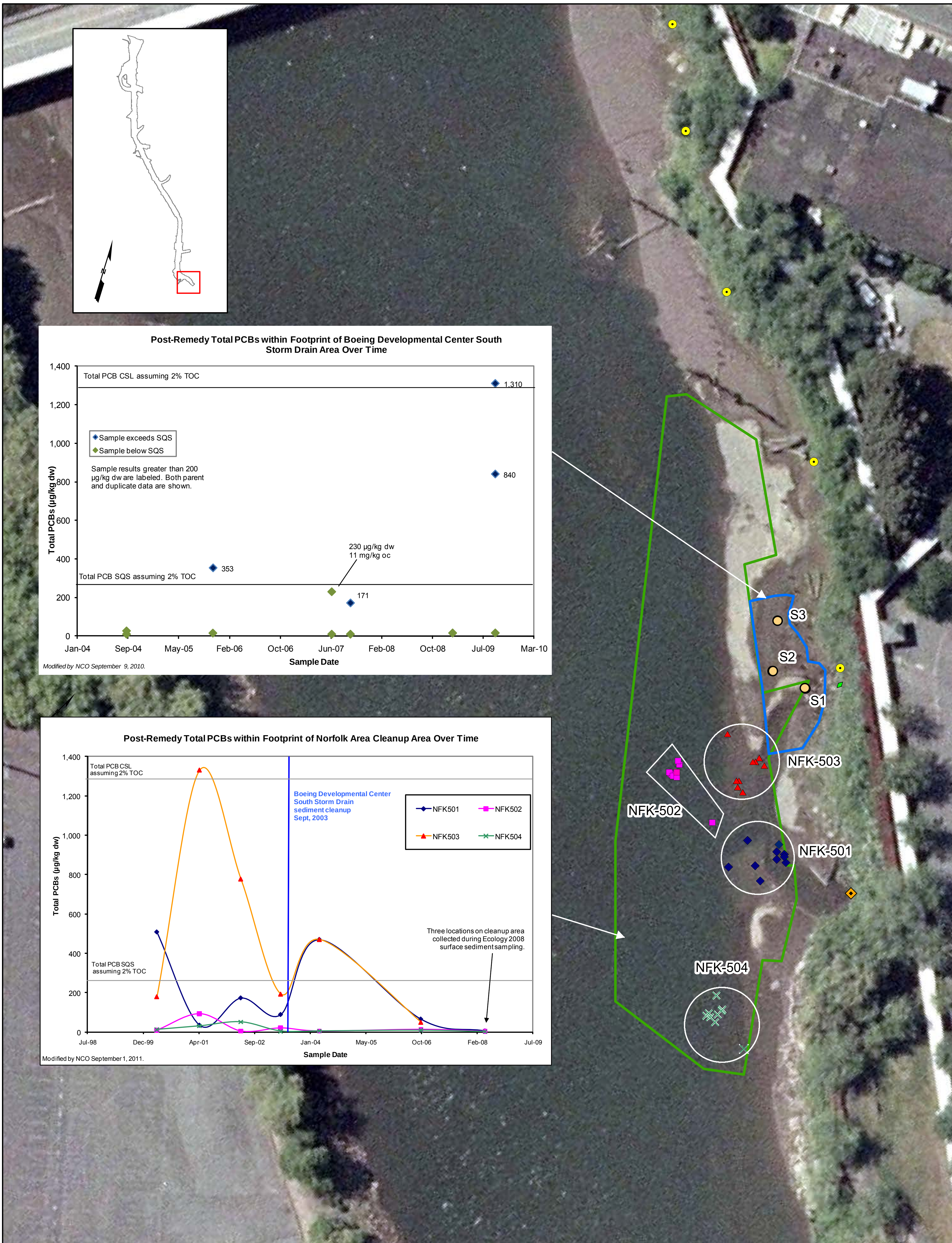
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Post-Remedy Surface Sediment Averages Over Time on the Duwamish/Diagonal EAA Caps

FIGURE J-5b

I:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\Figure J-5b\SurfsedDDAvgBV2.mxd



Notes:
1. USGS 2002 photograph provided by Windward Environmental.
2. Data in the FS Access database.
3. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.
4. CSO = combined sewer overflow, BDC SSD = Boeing Developmental Center south storm drain, SD = storm drain.

Outfall Location

- CSO/SD
- Permitted private storm drain
- Pipe of unresolved origin and/or use

Feet
0 25 50 100

Legend

- Boeing Developmental Center (BDC) South Storm Drain Sediment Cleanup Area (2003)
- BDC SSD Sample Location
- Norfolk CSO/SD Sediment Cleanup Area (1999)
- NFK501 Sample Location
- NFK502 Sample Location
- NFK503 Sample Location
- NFK504 Sample Location

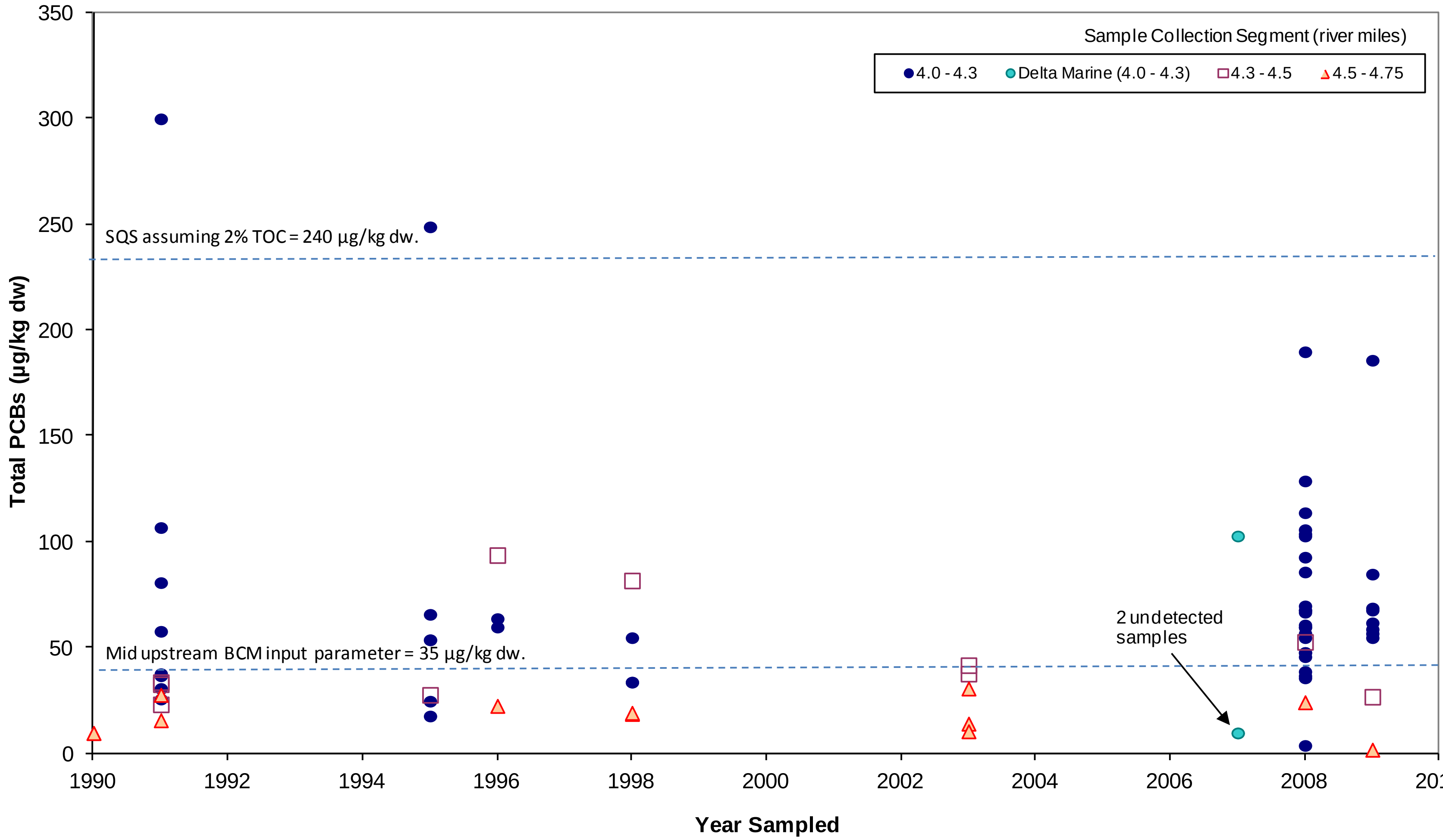
AECOM

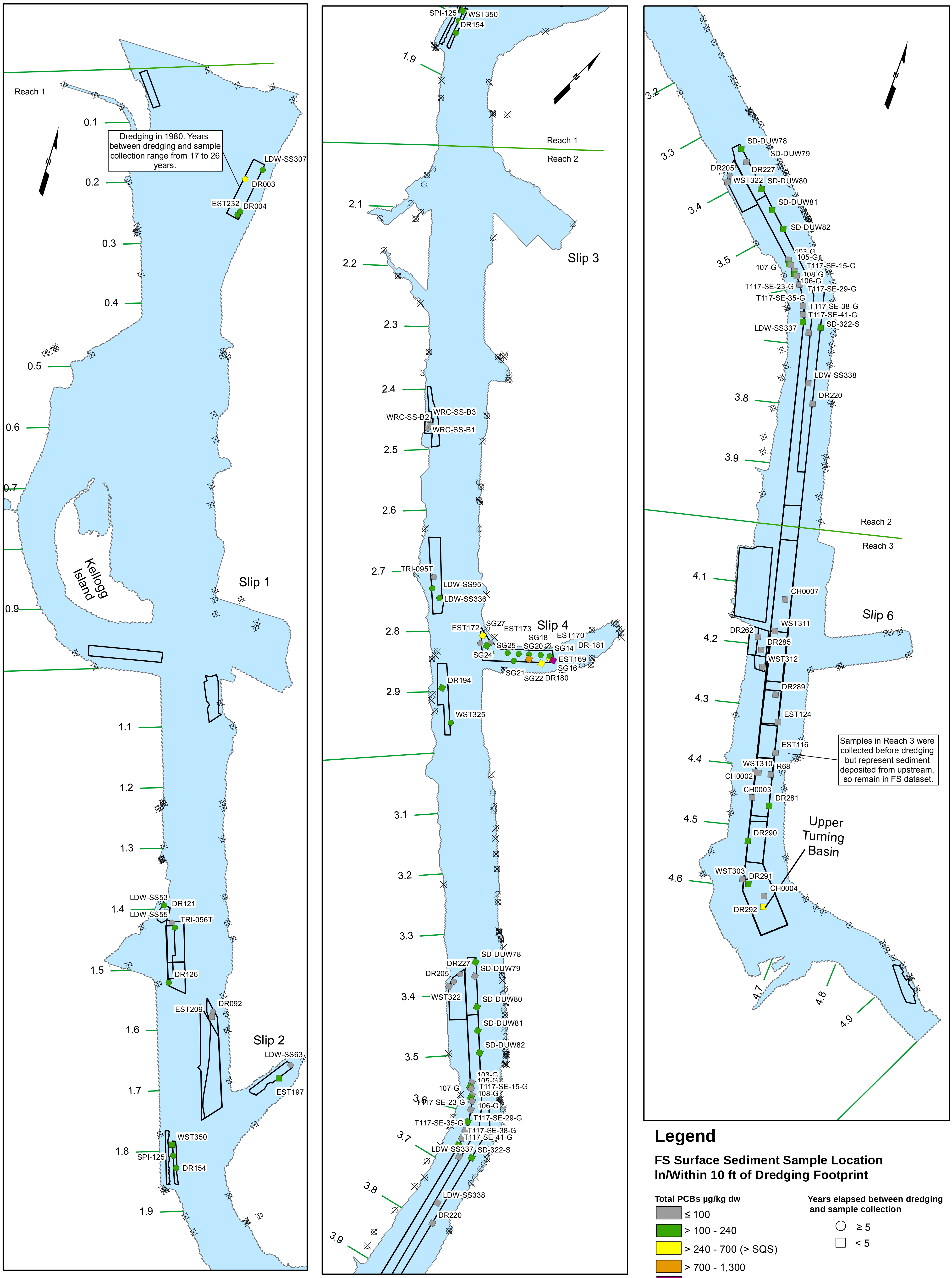
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.49	**Post-Remedy Surface Sediment Total PCB Trends at Norfolk Area**
DATE: 10/31/12 · DWRN:MVI/sea · Revision: 0	**FIGURE J-6**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\FigureJ-6NorfolkCSO.mxd

Figure J-7 Dredged Material Characterization Data – Total PCBs by Location and Year in Navigation Channel above RM 4.0





Legend

FS Surface Sediment Sample Location In/Within 10 ft of Dredging Footprint

Total PCBs µg/kg dw
- ≤ 100
- > 100 - 240
- > 240 - 700 (> SQS)
- > 700 - 1,300
- > 1,300 (> CSL)

Years elapsed between dredging and sample collection
- ○ ≥ 5
- □ < 5

Outfall Location

Maintenance Dredging Event Within Last 30 Years

Road

Navigation Channel

River Mile Marker

Feet
0 200 400 800

Notes:
1. Time elapsed between dredging and sample collection ranges from 1 to 26 years.
2. SQS value of 240 µg/kg dw based on conversion of 12 mg/kg oc to a dry weight value using 2% TOC.
3. Outfalls shown were identified during a City of Seattle low-tide survey in 2003 (Herrera 2004). Some locations were initially identified using drainage maps from Ecology's National Pollutant Discharge Elimination System (NPDES) permit files and other relevant agency databases. These locations were later surveyed in the field. Review of agency files and interviews with agency and LDWG personnel provided additional outfall-specific information. Some locations were field-verified by LDWG members; some additional outfall locations were identified during these subsequent verifications.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

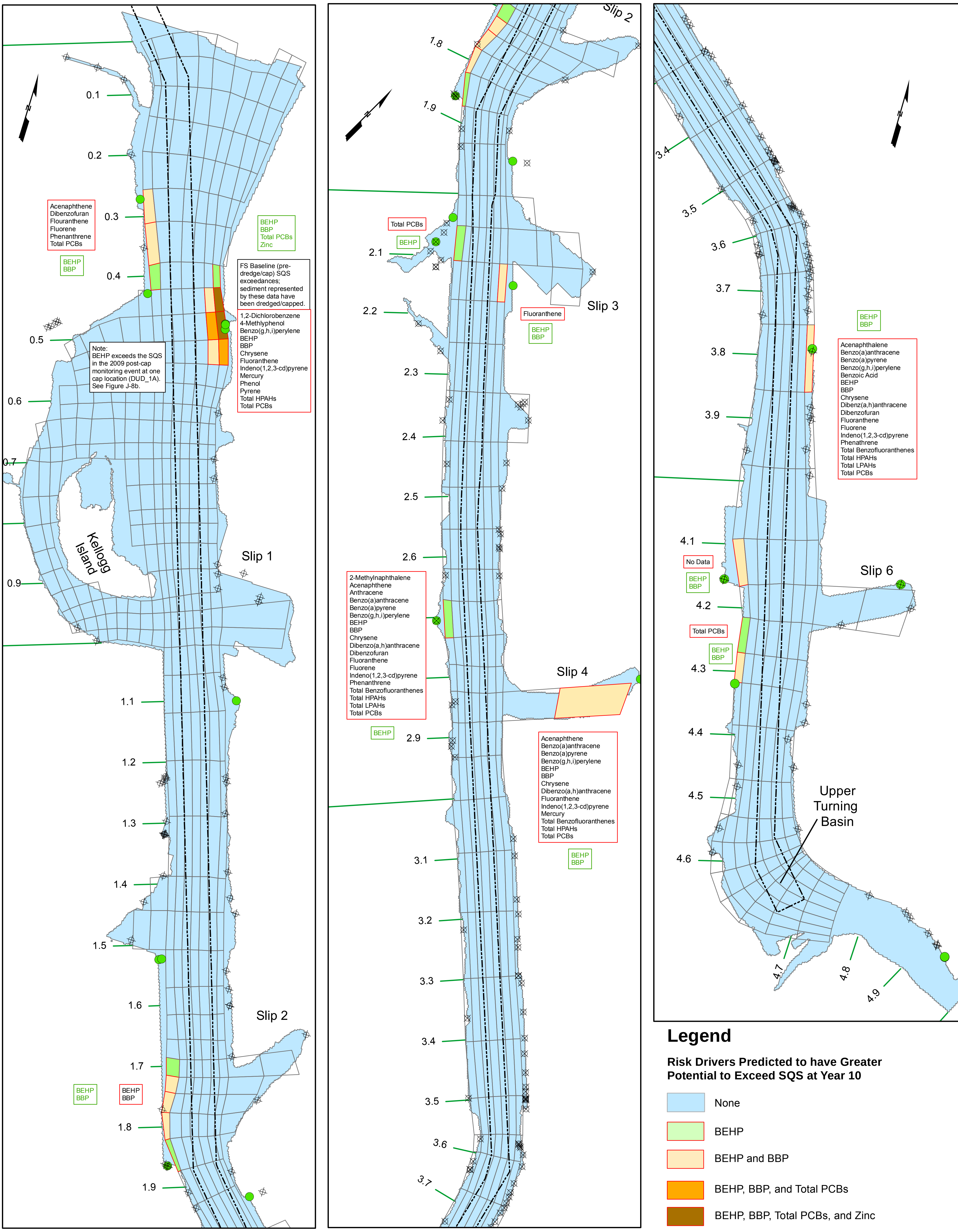
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Surface Sediment Total PCB Data Collected After Maintenance Dredging

FIGURE J-8

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\FigureJ-8PostDredgePCB.mxd



Legend

Risk Drivers Predicted to have Greater Potential to Exceed SQS at Year 10

- None
- BEHP
- BEHP and BBP
- BEHP, BBP, and Total PCBs
- BEHP, BBP, Total PCBs, and Zinc
- Grid Cell with ≥ 5.4% Lateral Source at Year 10

Modeled Redistributed Lateral Load Discharge Location

- Individual Discharge Location (CSOs, Storm Drains, and Tributaries)
- Waterfront Area Modeled Location
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 10-year run (QEA Feb. 2009); see Section 5.
2. Calculations to determine the minimum lateral percentage required to result in a Year 10 exceedance of the SQS, when the bed concentration is assumed to be zero.
3. Used high BCM lateral values for total PCBs and arsenic and recommended BCM input parameters for other risk drivers. These vary by risk driver; see Table J-8.
4. BEHP = bis(2-ethylhexyl)phthalate; BBP = butylbenzyl phthalate; CSO = combined sewer overflow; HPAHs = high molecular weight polycyclic aromatic hydrocarbons; LPAHs = low molecular weight polycyclic aromatic hydrocarbons; STM = sediment transport model.

Risk Driver	Estimated Lateral Percentage (required to cause possible SQS exceedance)
BEHP	5.4
Butyl Benzyl Phtalate	9.1
Total PCB	21.5
Zinc	62.2

0 200 400 800 Feet

Risk drivers predicted to exceed SQS with year 10 predictions — BEHP BBP

BEHP BBP Total PCBs — Risk drivers exceeding the SQS in the FS dataset, in grid cells predicted to have greater recontamination potential

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

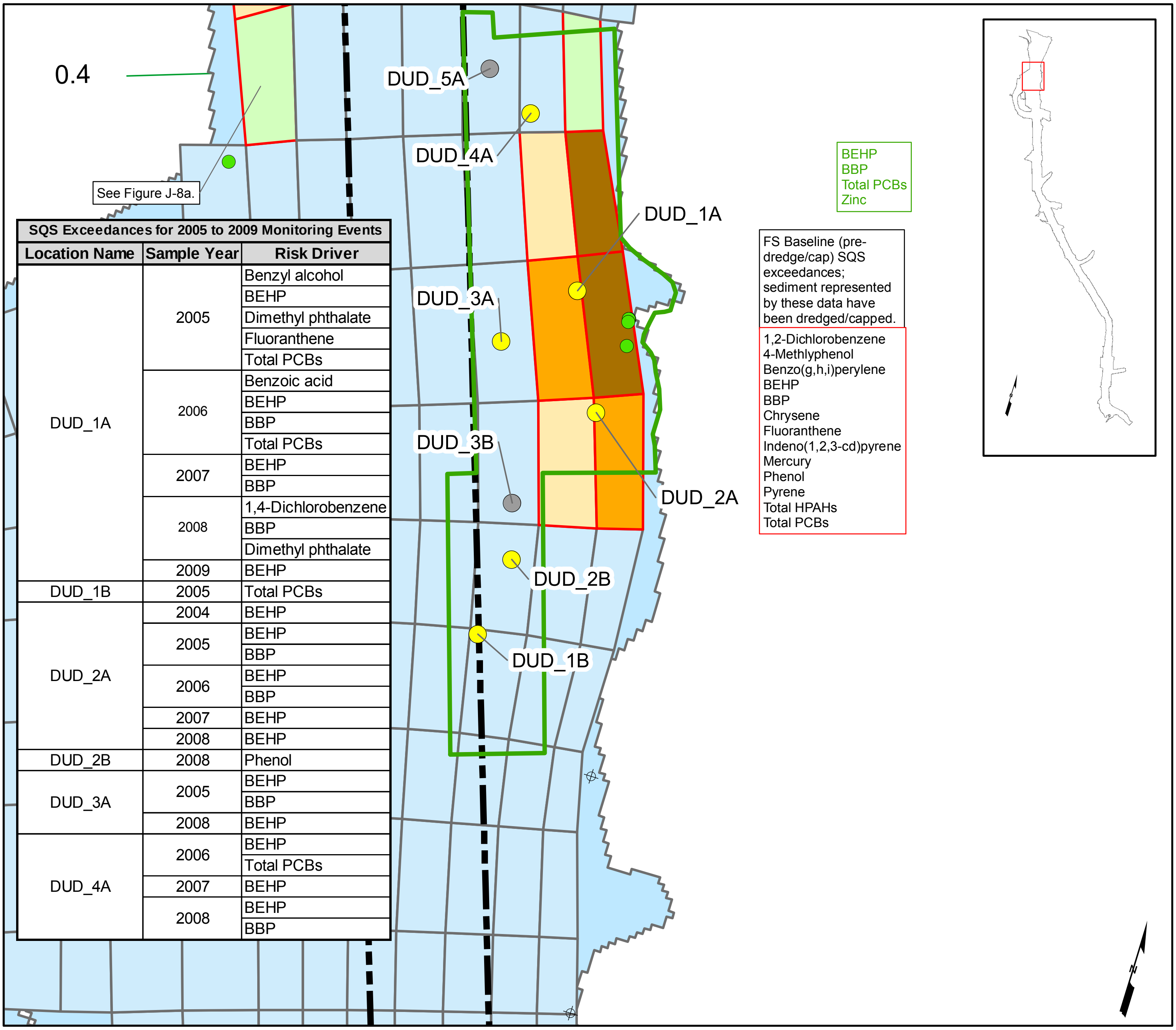
Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

DATE: 10/31/12 | DWRN:DE/sea | Revision: 0

STM Grid Cells With Greater Potential for Recontamination

FIGURE J-9a

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix J\FigureJ-9a_10YSTMLaterallyChem.mxd



SQS Exceedances for 2005 to 2009 Monitoring Events

Location Name	Sample Year	Risk Driver
DUD_1A	2005	Benzyl alcohol
		BEHP
		Dimethyl phthalate
		Fluoranthene
		Total PCBs
	2006	Benzoic acid
		BEHP
		BBP
		Total PCBs
	2007	BEHP
		BBP
	2008	1,4-Dichlorobenzene
		BBP
		Dimethyl phthalate
	2009	BEHP
DUD_1B	2005	Total PCBs
DUD_2A	2004	BEHP
	2005	BEHP
		BBP
	2006	BEHP
		BBP
	2007	BEHP
	2008	BEHP
DUD_2B	2008	Phenol
DUD_3A	2005	BEHP
		BBP
	2008	BEHP
DUD_4A	2006	BEHP
		Total PCBs
	2007	BEHP
	2008	BEHP
		BBP

Notes:
1. STM GIS shapefile from 10-year run (QEA Feb. 2009); see Section 5.
2. Calculations to determine the minimum lateral percentage required to result in a Year 10 exceedance of the SQS, when the bed concentration is assumed to be zero.
3. Used high BCM lateral values for total PCBs and arsenic and recommended BCM input parameters for other risk drivers. These vary by risk driver; see Table J-8.
4. BEHP = bis(2-ethylhexyl)phthalate; BBP = butylbenzyl phthalate; CSO = combined sewer overflow; EAA=early action area; HPAHs = high molecular weight polycyclic aromatic hydrocarbons; STM = sediment transport model.

Risk Driver	Estimated Lateral Percentage (required to cause possible SQS exceedance)
BEHP	5.4
Butyl Benzyl Phtalate	9.1
Total PCB	21.5
Zinc	62.2

Risk drivers predicted to exceed SQS with year 10 predictions — BEHP BBP

BEHP BBP Total PCBs — Risk drivers exceeding the SQS in the FS dataset, in grid cells predicted to have greater recontamination potential

Redistributed Lateral Load Discharge Location

- Discharge Location (CSOs, Storm Drains, and Tributaries) Modeled in STM
- Waterfront Area Modeled Location
- Navigation Channel
- River Mile Marker

Legend

Risk Drivers Predicteded to have Greater Potential to Exceed SQS at Year 10

- None
- BEHP
- BEHP and BBP
- BEHP, BBP, and Total PCBs
- BEHP, BBP, Total PCBs, and Zinc
- Grid Cell with ≥ 5.4% Lateral Source at Year 10
- Duwamish/Diagonal EAA

Monitoring Location and SQS Status during 2005 to 2009 Post-cap Monitoring Events

- > SQS for at least 1 Risk Driver
- ≤ SQS for all Risk Drivers

Feet
0 55 110 220

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\FigureJ-9b_10YSTMLateralbyChem.mxd

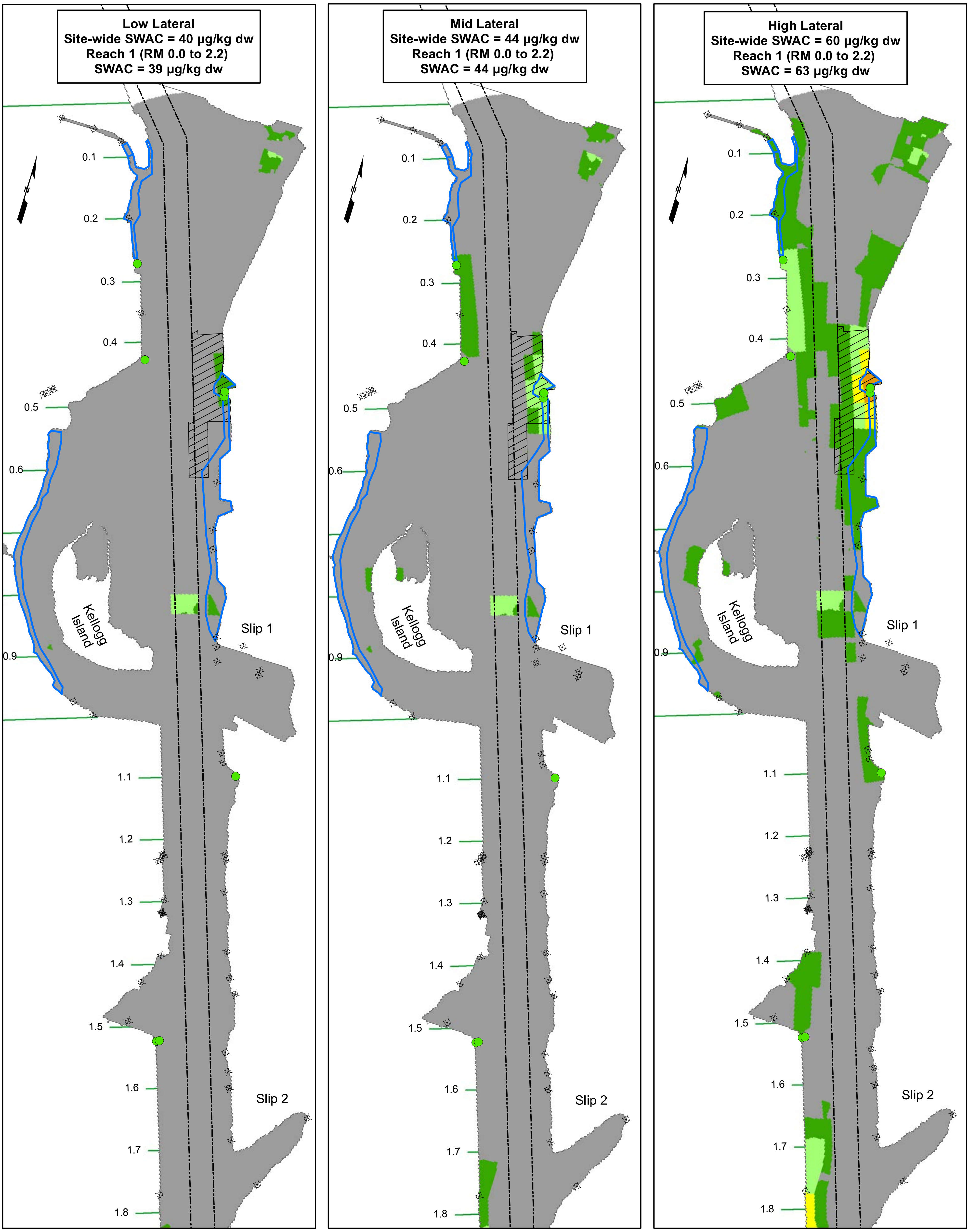
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.49

STM Grid Cells With Greater Potential for Recontamination in the Duwamish/Diagonal EAA

DATE: 10/31/12 | DWRN:DE/sea | Revision: 0 | **FIGURE J-9b**



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Year 30 total PCB concentrations calculated using the following input parameters (µg /kg dw):
   a. Mid upstream: 35
   b. Low, mid, high lateral: 100, 300, 1,000
   c. Post-remedy bed sediment replacement: 60

Early Action Area
Beach Play Area

Modeled Redistributed Lateral Load Discharge Location

Individual Discharge Location (CSOs, Storm Drains, and Tributaries)
Waterfront Area Modeled Location
Navigation Channel
River Mile Marker

0 200 400 800 Feet

Legend

Interpolated Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 to 100
- > 100 to 240
- > 240 to 480
- > 480 to 720
- > 720 to 1,300
- > 1,300

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\Figure J-10aComparisonPostAlt5PCBReach1.mxd

AECOM

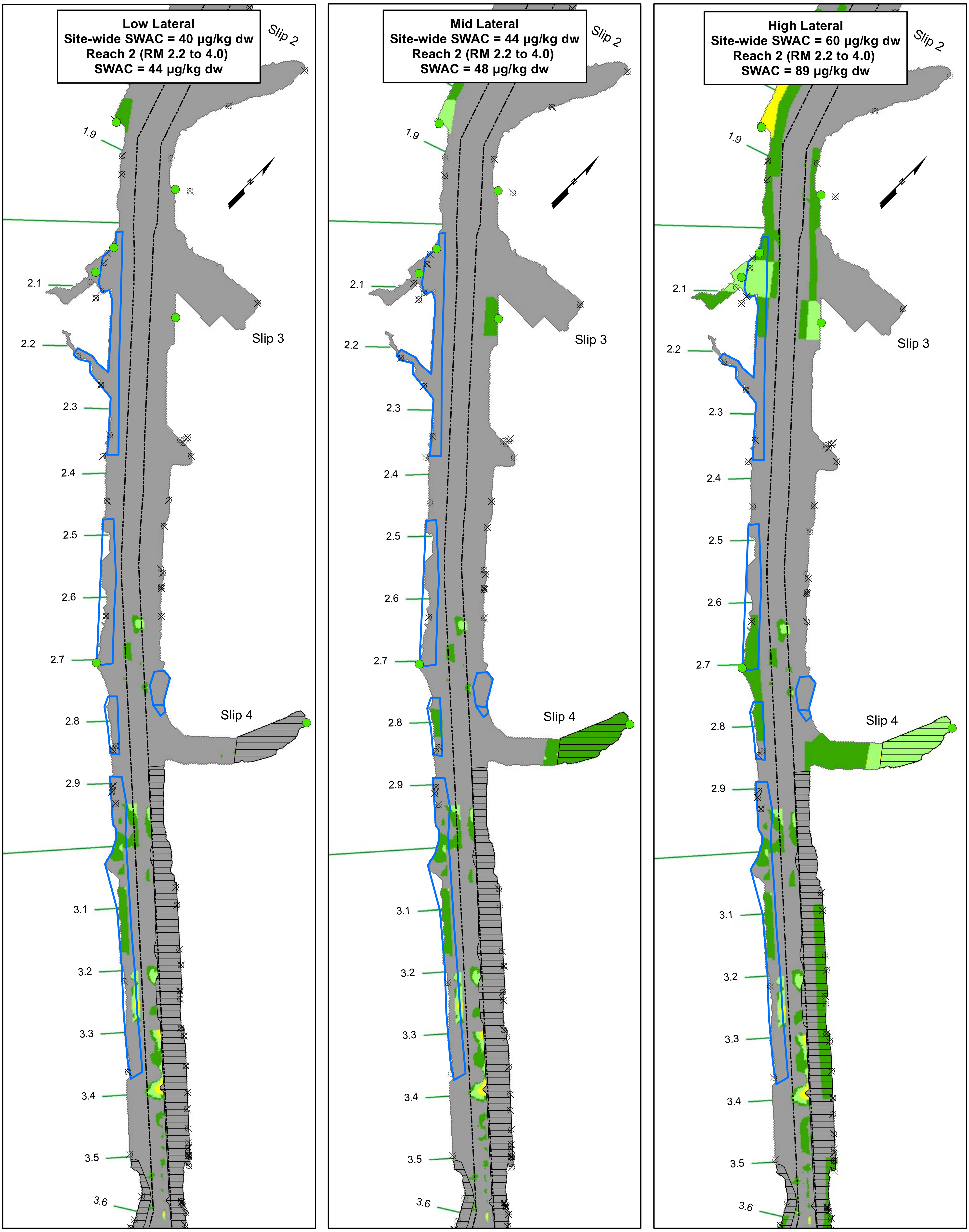
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Predicted Total PCB Surface Sediment Concentrations 30 Years after Remediation of Alternative 5 with Varying Lateral Inputs (RM 0 to 1.8)

FIGURE J-10a



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Year 30 total PCB concentrations calculated using the following input parameters (µg /kg dw):
   a. Mid upstream: 35
   b. Low, mid, high lateral: 100, 300, 1,000
   c. Post-remedy bed sediment replacement: 60

Early Action Area

Beach Play Area

Modeled Redistributed Lateral Load Discharge Location

Individual Discharge Location (CSOs, Storm Drains, and Tributaries)

Waterfront Area Modeled Location

Navigation Channel

River Mile Marker

0 200 400 800 Feet

Legend

Interpolated Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 to 100
- > 100 to 240
- > 240 to 480
- > 480 to 720
- > 720 to 1,300
- > 1,300

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\Figure J-10bComparisonPostAlt5PCBReach2.mxd

AECOM

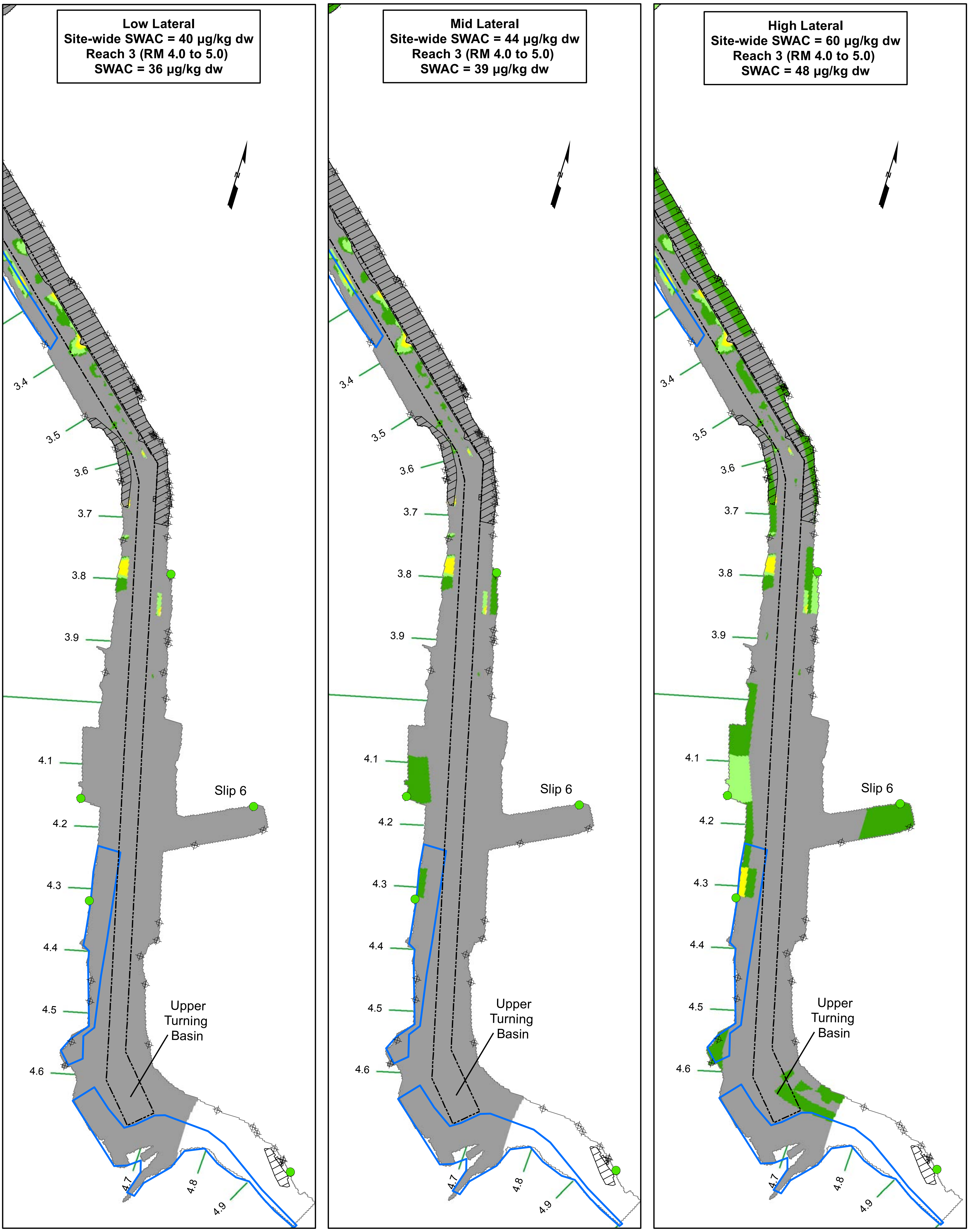
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

Predicted Total PCB Surface Sediment Concentrations 30 Years after Remediation of Alternative 5 with Varying Lateral Inputs (RM 1.8 to 3.6)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE J-10b



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Year 30 total PCB concentrations calculated using the following input parameters (µg /kg dw):
   a. Mid upstream: 35
   b. Low, mid, high lateral: 100, 300, 1,000
   c. Post-remedy bed sediment replacement: 60

Early Action Area
Beach Play Area

Modeled Redistributed Lateral Load Discharge Location

Individual Discharge Location (CSOs, Storm Drains, and Tributaries)
Waterfront Area Modeled Location
Navigation Channel
River Mile Marker

Legend

Interpolated Total PCB Concentration (µg/kg dw)

- ≤ 60
- > 60 to 100
- > 100 to 240
- > 240 to 480
- > 480 to 720
- > 720 to 1,300
- > 1,300

Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix J\Figure J-10cComparisonPostAlt5PCBReach3.mxd

AECOM

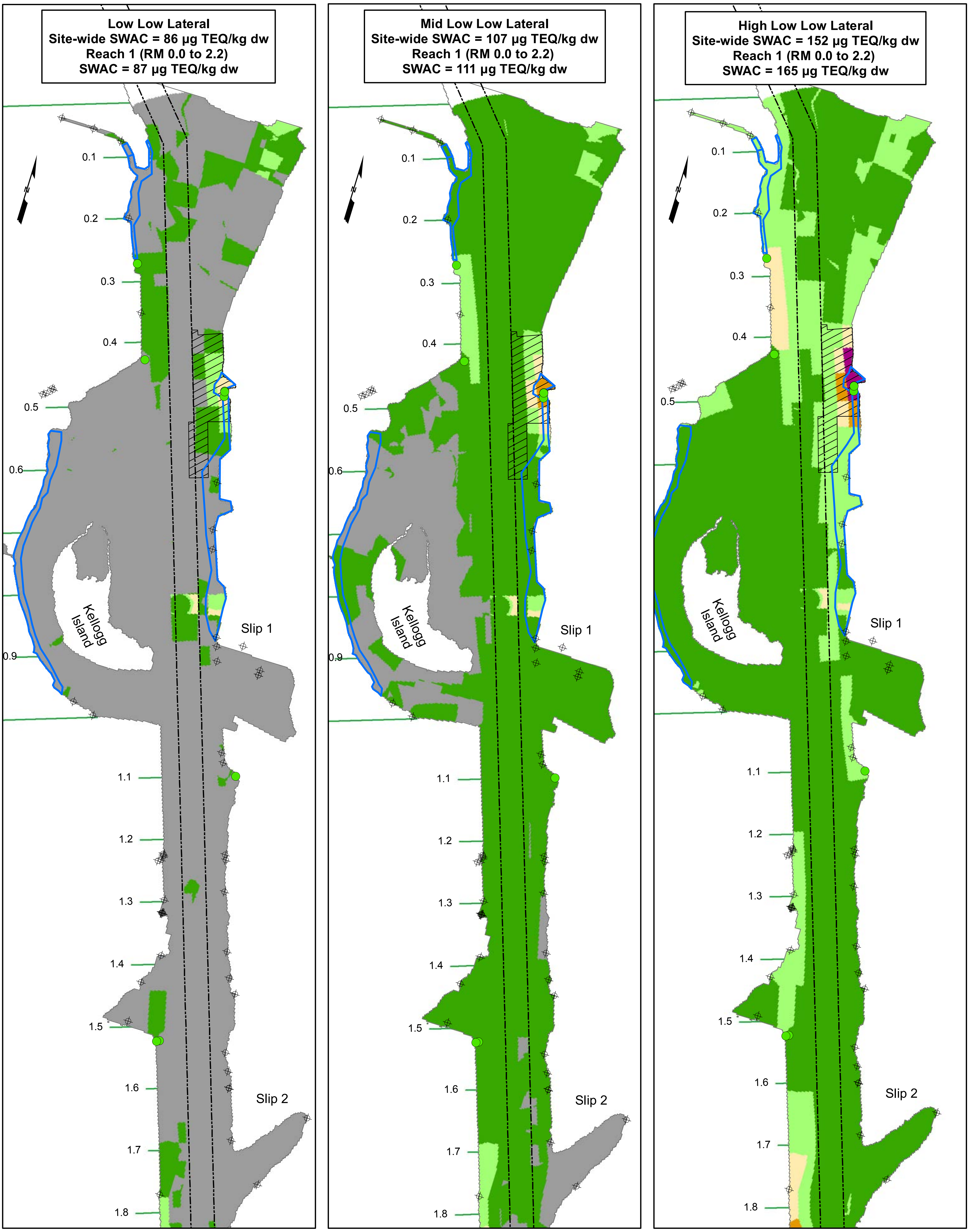
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

Predicted Total PCB Surface Sediment Concentrations 30 Years after Remediation of Alternative 5 with Varying Lateral Inputs (RM 3.6 to 4.75)

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE J-10c



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Year 30 cPAH concentrations calculated using the following input parameters (µg TEQ/kg dw):
   a. Mid upstream: 70
   b. Low, mid, high lateral: 500, 1,400, 3,400
   c. Post-remedy bed sediment replacement: 140

Modeled Redistributed Lateral Load Discharge Location

- Individual Discharge Location (CSOs, Storm Drains, and Tributaries)
- Waterfront Area Modeled Location
- Navigation Channel
- River Mile Marker

Legend

Interpolated cPAH Concentration (µg TEQ/kg dw)

- ≤ 90
- > 90 to 150
- > 150 to 380
- > 380 to 900
- > 900 to 1,500
- > 1,500
- Early Action Area
- Beach Play Area

Feet
0 200 400 800

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix J\Figure J-11aComparisonPostAltScPAHReach1.mxd

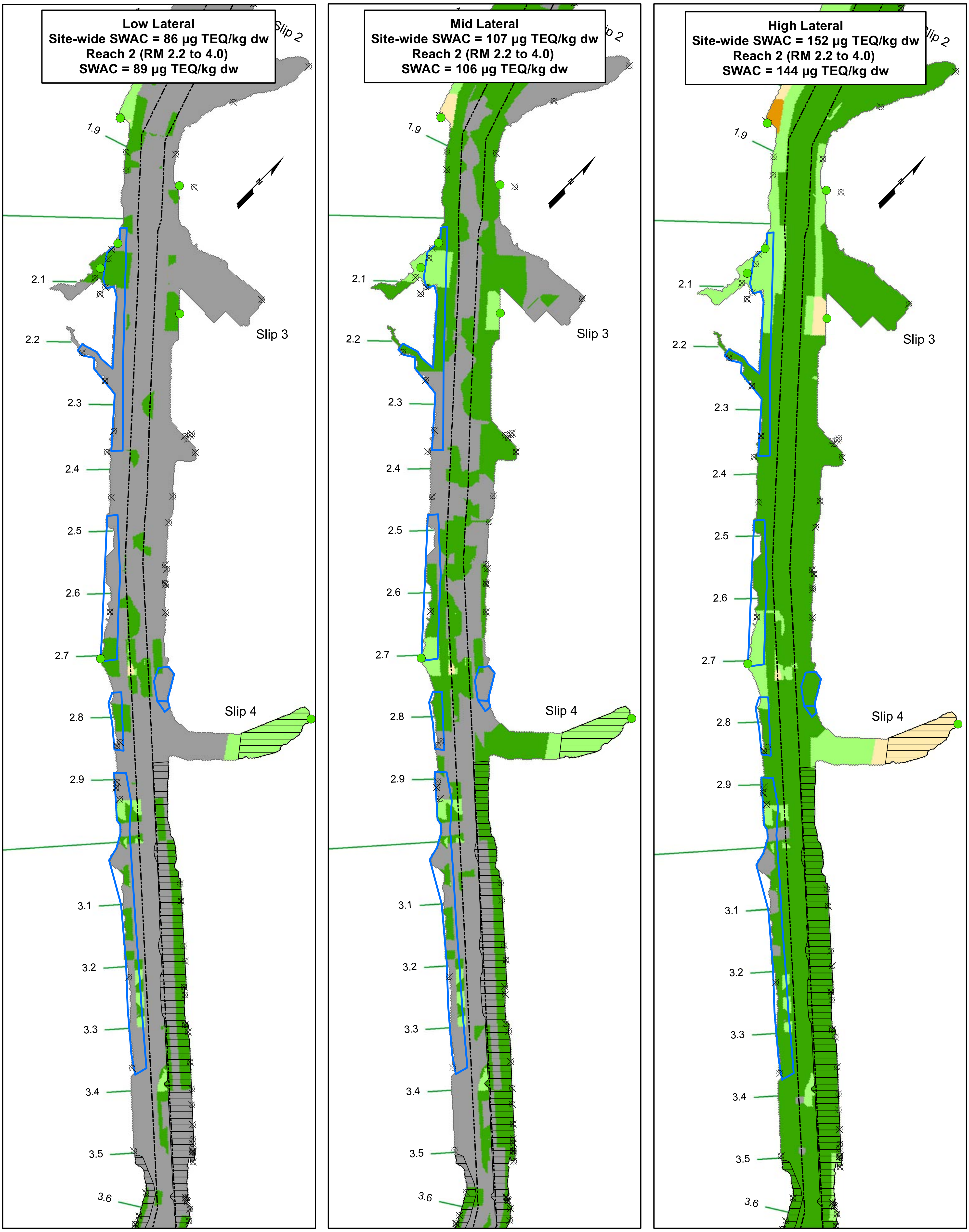
AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

Predicted cPAH Surface Sediment Concentrations 30 Years after Remediation of Alternative 5 with Varying Lateral Inputs (RM 0 to 1.8)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE J-11a**



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Year 30 cPAH concentrations calculated using the following input parameters (µg TEQ/kg dw):
   a. Mid upstream: 70
   b. Low, mid, high lateral: 500, 1,400, 3,400
   c. Post-remedy bed sediment replacement: 140

Modeled Redistributed Lateral Load Discharge Location

- Individual Discharge Location (CSOs, Storm Drains, and Tributaries)
- Waterfront Area Modeled Location
- Navigation Channel
- River Mile Marker

Legend

Interpolated cPAH Concentration (µg TEQ/kg dw)

- ≤ 90
- > 90 to 150
- > 150 to 380
- > 380 to 900
- > 900 to 1,500
- > 1,500
- Early Action Area
- Beach Play Area

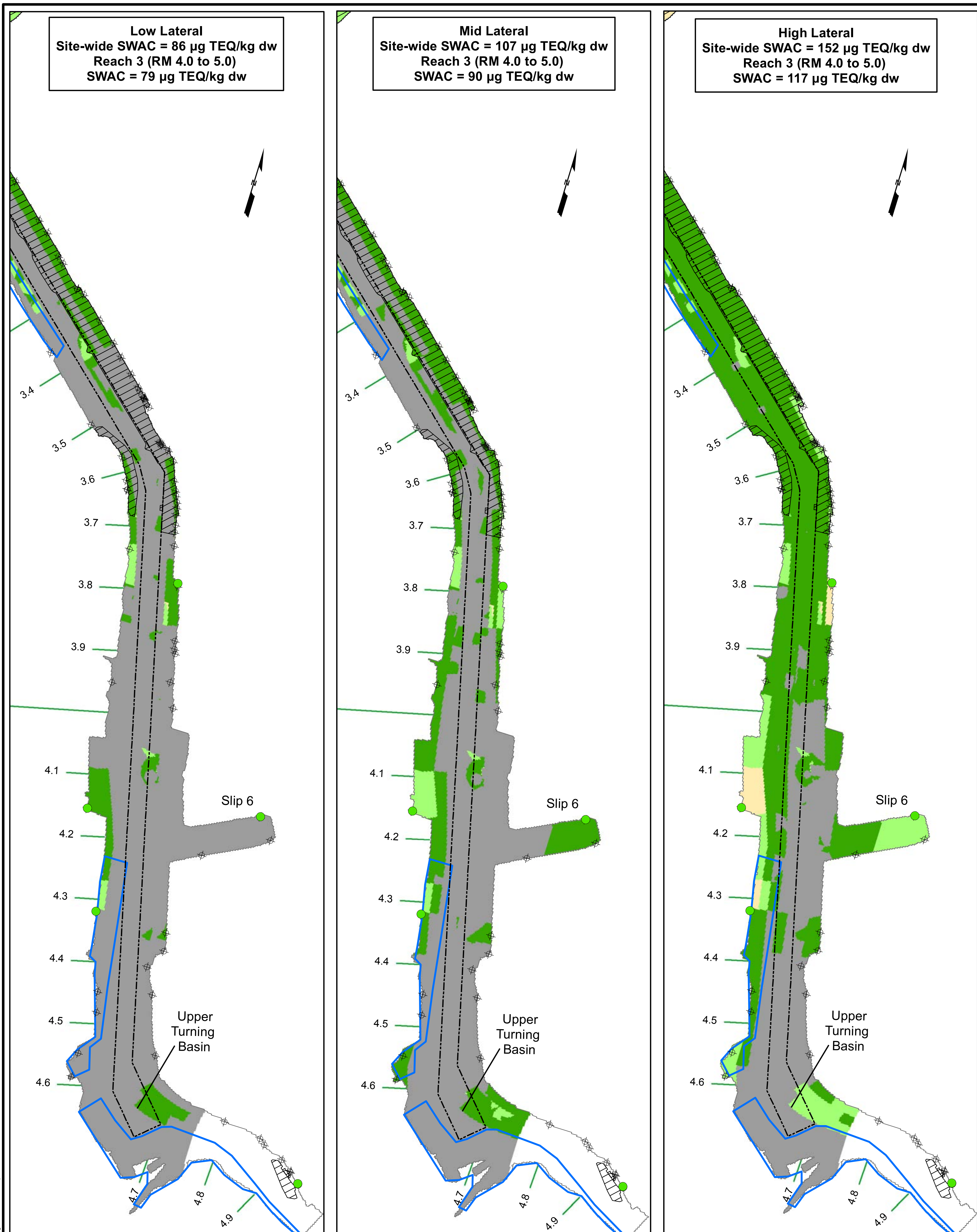
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-14.48			**Predicted cPAH Surface Sediment Concentrations 30 Years after Remediation of Alternative 5 with Varying Lateral Inputs (RM 1.8 to 3.6)**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE J-11b**

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix J\Figure J-11bComparisonPostAlt5cPAHReach2.mxd



Notes:
1. STM GIS shapefile from 30-year run (QEA Feb. 2009).
2. Year 30 cPAH concentrations calculated using the following input parameters (µg TEQ/kg dw):
   a. Mid upstream: 70
   b. Low, mid, high lateral: 500, 1,400, 3,400
   c. Post-remedy bed sediment replacement: 140

Modeled Redistributed Lateral Load Discharge Location

- Individual Discharge Location (CSOs, Storm Drains, and Tributaries)
- Waterfront Area Modeled Location
- Navigation Channel
- River Mile Marker

Legend

Interpolated cPAH Concentration (µg TEQ/kg dw)

- ≤ 90
- > 90 to 150
- > 150 to 380
- > 380 to 900
- > 900 to 1,500
- > 1,500
- Early Action Area
- Beach Play Area

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-14.48

Predicted cPAH Surface Sediment Concentrations 30 Years after Remediation of Alternative 5 with Varying Lateral Inputs (RM 3.6 to 4.75)

DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE J-11c**

Lower Duwamish Waterway Group

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

Appendix K
Lower Duwamish Waterway Conceptual Monitoring Program

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

List of Tables

K.1 Introduction

This appendix presents the rationale and conceptual structure for a multi-component Lower Duwamish Waterway (LDW) monitoring program. The conceptual monitoring program serves solely as the basis for estimating the costs of monitoring associated with each remedial alternative (Appendix I). Because it is solely for the limited purpose of costing, the program uses several simplifying assumptions and is not intended to represent the specific scope, timing, and duration of monitoring that will eventually occur in the LDW. The remedy selected by the Agencies will include a monitoring program with a statistical basis for demonstrating compliance with applicable criteria and standards and the success of remedial alternatives, as well as provisions for adjusting the monitoring program to support adaptive management decisions. These details will be determined in the Record of Decision (ROD) and during remedial design.[1]

The monitoring program described herein is sufficiently broad, detailed, and consistent with guidance to fulfill feasibility study (FS)-level scope and cost-estimation objectives. The scope of this appendix is limited to sediment chemistry, porewater chemistry, sediment toxicity, water quality, fish and shellfish tissue chemistry, and physical inspections. Physical maintenance, repairs, and potential adaptive management contingency measures for each remedy component are discussed separately in Sections 9, 10, and 11 of the FS. The temporal elements of this monitoring program (as described in the following sections) include:

- Baseline monitoring
- Construction monitoring
- Post-construction performance monitoring
- Operation and maintenance (O&M) monitoring
- Long-term monitoring.

This appendix sets forth assumptions regarding quantities and frequencies of sampling and reporting that form the basis for cost estimation. Remedial design-level data collection does not fall within the types of monitoring discussed in this appendix. In addition, this appendix does not address monitoring associated with pilot testing technologies, such as adding granular activated carbon, to reduce bioavailability of risk-driver contaminants. This appendix also does not fully address potential adjustments to

---

1 This appendix does not consider monitoring associated with nearshore or upland source control. Nearshore source control (e.g., identifying, remediating, or stabilizing erodible banks) is a presumed component of remedial design. The scope of upland source control work, which will involve numerous parties other than those performing the LDW remedy, is beyond the scope of the FS.

the monitoring program needed to assess the long-term effectiveness of such an approach if it were selected as a component of the remedy.

K.1.1 Performance Objectives for Monitoring

The purpose of monitoring is to collect and analyze repeated observations or measures (chemical, physical, or biological) over time to evaluate changes and trends in site conditions and progress toward achieving the cleanup objectives[2] (EPA 2004). Within this definition, monitoring may have both short-term and long-term objectives and may be linked to technology performance objectives or compliance with applicable or relevant and appropriate requirements (ARARs) and cleanup objectives. The U.S. Environmental Protection Agency (EPA) requires monitoring "to verify that no unacceptable exposures to potential hazards posed by site conditions will occur in the future" and indicates that "the 5-year review should be a review of monitoring data to evaluate whether the remedy continues to provide for adequate, risk-based protection of human health and the environment (40 CFR 300.430 (f)(4)(ii))" (EPA 2004).

The objectives of this conceptual monitoring program, in providing a reasonable basis for the cost estimates in Appendix I, include:

- Establishing baseline conditions to be compared to results of future compliance monitoring.
- Assuring protection of human health and the environment during construction activities and complying with regulatory requirements (construction monitoring).
- Assuring that the remedy remains protective in the long term, e.g., evaluate contaminant migration to surface sediments/surface water via either recontamination from external sources or from break-through of containment technologies.
- Evaluating long-term remedy effectiveness and achievement of cleanup objectives that ensure protection of human health and the environment (long-term monitoring).

Specific parameters/media and associated performance objectives and thresholds are discussed below based on the type of monitoring. The types of monitoring and links to the purpose of either long-term monitoring or technology performance are shown in Table K-1. Upon completion of monitoring events, trends will be evaluated to eventually support management decisions for the site. The definition of project success and the performance metrics for determining success will be developed by EPA and the

2 Cleanup objective in this FS is used to mean the preliminary remediation goal (PRG) or as close as practicable to the PRG where the PRG is not predicted to be achievable. This FS uses long-term model-predicted concentrations as estimates of "as close as practicable" to PRGs. Additional details regarding cleanup objectives can be found in Section 9.1.2.3.

Washington State Department of Ecology (Ecology) in the ROD, and may be redefined during the 5-year reviews as new data are collected.

K.1.2 Cost Assumptions

Remedial design and sampling costs are included as a line item under capital costs (Appendix I). Remedial design is applied as a percentage (20%) of the capital costs, and includes predesign sampling and analysis costs. Verification monitoring will be conducted during remedial design; the associated scope and costs are incorporated as a line item in remedial design costs (Appendix I) and are not discussed in this section.

Data collection and frequency assumptions for the five monitoring components described in this appendix are summarized in Table K-2. Table K-2 illustrates the scale of application for each monitoring element. Baseline and long-term monitoring have LDW-wide applications common to all remedial alternatives. They are used to assess the overall condition of the LDW in relation to achievement of the cleanup goals set forth in the ROD. The other three monitoring categories apply at the area- or project-specific level.

For cost estimation, the FS adopts this framework as the cleanup moves from construction to long-term monitoring. It is important to recognize that while the various monitoring types have different objectives and their costs are estimated separately, they are not mutually exclusive. Project-specific and LDW-wide sampling will overlap in certain areas, allowing data to be applied for multiple uses (e.g., to achieve both project-specific and LDW-wide monitoring objectives).

K.1.3 Consistency with MTCA

The five types of monitoring defined in Table K-2 are consistent with the three types of compliance monitoring requirements described in the Washington State Model Toxics Control Act (MTCA) (Washington Administrative Code [WAC] 173-340-410):

- Protection monitoring confirms that human health and the environment are adequately protected during construction (corresponds to construction monitoring).

- Performance monitoring confirms that remedial actions have achieved the cleanup standards or other performance standards (corresponds to post-construction performance monitoring).

- Confirmational monitoring confirms the long-term effectiveness of a remedial action after the performance standards and/or remediation levels have been achieved. This would include monitoring of disposal, isolation, or containment sites to ensure protection (corresponds to O&M monitoring and long-term monitoring).

Table K-3 cross-references MTCA compliance monitoring requirements with the five types of monitoring identified and described in this appendix.

K.2 Baseline Monitoring

The objective of baseline monitoring is to establish a site-wide basis for comparing pre- and post-remediation conditions. Baseline monitoring occurs before remediation commences and is distinct from project-specific remedial design sampling and data collection.[3]

The FS sediment dataset includes a large body of data spanning almost 20 years (1991 to 2009) that will inform the scope for baseline monitoring. However, the data are skewed (i.e., unevenly distributed) both geospatially and temporally. The pronounced rates at which sediment from the Green/Duwamish River system accumulates in the LDW (as estimated by the sediment transport model [STM] and discussed in Section 5.1) suggest that conditions may be improved through natural recovery by the time the ROD is issued. Therefore, a new statistically-based LDW-wide baseline dataset that is spatially consistent with future data collection efforts will be required to establish a baseline condition and provide a basis for comparison with post-remediation data. Because the data are collected for trend analysis, no specific threshold criteria are used to evaluate these data.

The sampling design for baseline monitoring should facilitate evaluation of site conditions following completion of cleanups at the early action areas (EAAs) and the aggregate benefits derived from remedial actions over time and relevant spatial scales (i.e., site-wide, potential clamming areas, and beach play areas). A site-wide bathymetric survey and sampling/analysis of sediment, surface water, and fish and shellfish tissue are assumed. In addition, placeholder scope and costs are assumed for additional yet to be defined baseline, upstream, and long-term monitoring surveys (Table K-2 and Appendix I).

K.3 Construction Monitoring

Construction monitoring during remediation is: area-specific, short term, and used to evaluate whether the project is being constructed in accordance with plans and specifications (i.e., performance of contractor, equipment, and environmental controls). For dredging and capping operations, the objective of construction monitoring is to evaluate water quality near the operations to determine whether the resuspension of

[3] Baseline monitoring will occur shortly after the ROD is issued. Remedial design sampling will occur before active remediation in specific project areas and will therefore occur later than and at smaller spatial scales than baseline sampling. Verification monitoring will be concurrent with remedial design sampling.

contaminated sediments and their downgradient movement are being adequately controlled.

Construction monitoring occurs during active portions of a given remedy (i.e., dredging, capping, and enhanced natural recovery [ENR]/*in situ* treatment) and is assumed to be project specific and to consist of:

- Daily field-based water quality monitoring in the immediate vicinity of the active remediation to demonstrate compliance with water quality certification requirements (e.g., physical measures such as turbidity).
- Intermittent collection of downcurrent water column samples for chemical analyses (e.g., polychlorinated biphenyls [PCBs]). The need for chemical analyses will be based on the screening results from the daily field-based water quality monitoring during dredging and sand placement activities. A portion of these samples will be submitted for chemical analyses regardless of the field-based monitoring results.
- Construction quality control to verify achievement of design specifications (e.g., cap area coverage and thickness) intermittently during construction and post-construction. Bathymetric surveys will be used to determine whether target sediments are being removed in dredging operations and whether cap materials are being placed in the design location and at the specified design thickness.

Construction monitoring will be developed on a case-by-case basis for specific areas being remediated and will likely vary (e.g., parameters and frequency) in accordance with the magnitude of contamination. For FS purposes, construction monitoring is assumed to occur during the full duration of each construction season, which in turn, is based on the construction period estimates developed in Section 8 of the FS. FS cost assumptions are outlined in Table K-2.

K.4 Post-construction Performance Monitoring

The objective of post-construction performance monitoring is to demonstrate whether, after construction, specific cleanup projects comply with project requirements and design specifications (e.g., surface sediment contaminant of concern (COC) concentrations are below the remedial action levels (RALs); average ENR thickness must be at least 6 inches over the intended spatial area). This monitoring focuses on assessing the sediment concentrations of COCs in the actively remediated footprint (i.e., dredging, capping, ENR/*in situ* treatment).[4] Sampling is also assumed for areas peripheral to dredge footprints to support dredge residuals management decisions

[4] Other project requirements such as cap or ENR application thicknesses may also be verified as part of construction monitoring (Section K.3).

(e.g., need for and extent of thin-layer sand placement). Post-construction monitoring varies slightly for different remedial technologies and consists of:

- **Dredging:** Surface sediment sampling and analyses for COCs, grain size, and total organic carbon (TOC) to confirm post-dredge bed conditions; bathymetric surveys to confirm dredge depths.
- **ENR/*In Situ* Treatment and Capping:** Surface sediment sampling and analyses for COCs, grain size, and TOC; ENR/*in situ* treatment/cap thickness verification using a combination of tools, including bathymetric surveys, sediment cores, diver surveys, staking, or settling plates (Anchor 2007).

Post-construction performance monitoring occurs at the end of construction in a specific project area and at the conclusion of each construction season for projects that are only partially completed. A single project-specific bathymetric survey is assumed at the conclusion of construction. FS cost assumptions are outlined in Table K-2.

K.5 Operation and Maintenance (O&M) Monitoring

The objective of O&M monitoring is to verify that areas requiring management (i.e., dredging, capping, ENR/*in situ* treatment, or monitored natural recovery [MNR]) remain protective. Cap and ENR/*in situ* treatment areas are physically inspected (e.g., diver surveys, bathymetric surveys) to check for evidence of instability and scour. Chemical analyses of surface sediments in all managed areas are used to evaluate recovery status and whether recontamination is occurring. Sediment sampling results will be compared to the RALs and cleanup levels established in the ROD. Additional trends will be evaluated using MNR monitoring data.

The scope of O&M monitoring depends on the remedial action undertaken. The spatial density of samples, frequency, and duration of monitoring are expected to vary (Table K-4). For example, a more intensive program (longer duration and greater sample density) is anticipated for areas undergoing ENR/*in situ* treatment and MNR than for areas remediated by dredging or capping.

Detailed O&M monitoring requirements will be defined during remedial design. For FS cost estimation purposes, the assumed rationale for O&M monitoring is as follows (see Tables K-2 and K-4 for data requirements and collection frequencies):

- **Dredging** – Surface sediment grabs and chemical analyses for COCs are collected to assess whether recontamination is occurring.[5]

---

[5] Sediment toxicity testing, while not considered a primary test parameter for actively remediated areas, may prove useful in some situations (e.g., to supplement analyses for COCs where recontamination indicates that one or more Sediment Management Standards [SMS] contaminants exceed the sediment quality standards [SQS]).

- **Capping** – Inspections and chemical analyses for COCs in the surface and subsurface sediment and porewater[6] are conducted to assess cap conditions and identify potential concerns with cap surface chemistry, including erosion, settlement/compaction, recontamination, and contaminant flux through the cap. In the event that monitoring indicates recontamination beyond acceptable levels, continued monitoring is needed to verify the extent of recontamination or to establish temporal trends. Physical inspections assess any changes in the cap from erosion or settlement. Potential adaptive management contingency actions based on monitoring and inspection include continued monitoring to establish trends and repair by placement of additional granular material. The FS cost estimate assumes a fixed percentage of the total cap area of each alternative will need supplemental sand placement to ensure cap protectiveness based on monitoring results (Appendix I).

- **ENR/*In Situ* Treatment** – Surface sediment grabs and porewater samples with chemical analyses for COCs are obtained to assess conditions over time. In the event that monitoring indicates recontamination beyond acceptable levels, continued monitoring is needed to verify the extent of recontamination, establish temporal trends, or to inform planning for repairs or contingency actions. The FS cost estimates assume a fixed percentage of the total ENR area of each alternative fails to achieve project-specific goals and reverts to dredging based on monitoring results (Appendix I). The same assumptions are applied to ENR/*in situ* treatment areas. [7]

- **MNR** – MNR requires the most O&M sampling because performance depends solely on natural processes and is thus subject to greater uncertainty compared to dredging, capping, and ENR. Surface sediment grabs with chemical analyses for COCs and toxicity testing are obtained to assess conditions over time. Where monitoring indicates that recovery is progressing adequately toward goals, O&M monitoring continues until recovery is documented and is then discontinued. If monitoring demonstrates an unacceptable rate of recovery, adaptive management contingency actions may be warranted. The FS cost estimates assume a fixed

---

6 Recent innovations in porewater sampling techniques, such as solid phase microextraction (SPME) could be used as a cost-effective tool for monitoring porewater chemistry in cap and ENR areas. Porewater data can be used to assess bioavailability or potential breakthrough of contaminants (e.g., polycyclic aromatic hydrocarbons [PAHs]) through cap material (ASTM 2007, Hawthorne 2005). A recent study assessed the use of the SPME method at the Pacific Sound Resources Superfund capping site in Seattle (Reible 2010).

7 The remedial design plan may select capping technologies to adaptively manage ENR areas instead of dredging, depending on site conditions.

percentage of the total MNR area of each alternative fails to achieve project-specific goals and reverts to dredging based on monitoring results (Appendix I).[8]

K.6 Long-term Monitoring

Long-term monitoring evaluates sediment, surface water, and tissue quality at the site during and following completion of all remedial actions until EPA and Ecology conclude that remedial action is sufficiently completed and monitoring is no longer required. Fish and shellfish tissue COC concentrations will be used to assess long-term trends in reducing COC concentrations as a function of sediment remediation and source control and in reducing associated human and ecological risks from seafood consumption. Water quality results will be compared to ARARs for surface water.

The scope of a long-term monitoring program is the same as baseline monitoring, and is largely independent of the specific remedial action, although data from other elements of the monitoring program (described in the previous sections) will complement and contribute to the long-term monitoring datasets. Sample numbers and collection frequency will vary by exposure area and media (Tables K-2 and K-5) to:

- Evaluate sediment quality site-wide and in the potential clamming and beach play areas
- Evaluate surface water quality and compliance with surface water quality ARARs
- Evaluate fish and shellfish tissue quality.

Long-term monitoring is expected to inform periodic reviews (typically no less frequently than every 5 years) to allow EPA and Ecology to assess the effectiveness of the remedial actions. Timing of long-term monitoring will need to consider this review cycle. These periodic reviews can inform adaptive management decisions that may be required to achieve the cleanup objectives. In addition, interim monitoring is assumed for longer duration remedial alternatives to determine achievement of cleanup objectives prior to completion of construction, assess chemical trends, and enable risk communication to stakeholders during construction activities.

Table K-2 presents the scope, sample types, number of samples, and sample testing requirements for each of the different monitoring types (surface sediment, surface water, and tissue) assumed for cost purposes in this FS.

[8] The remedial design plan may select ENR or capping technologies to adaptively manage MNR areas instead of dredging, depending on site conditions.

K.6.1 LDW Surface Sediment Quality

Surface sediment sampling approaches for the different exposure areas are described below. In addition, a field study is an assumed component of baseline and long-term monitoring to evaluate the relationship between sediment and clam tissue concentrations of arsenic and carcinogenic polycyclic aromatic hydrocarbons (cPAHs) in potential clamming areas. While no specific data quality objectives or experimental design are described herein, a lump sum cost for a field study is included in the cost estimates for the remedial alternatives (see Appendix I).

K.6.1.1 LDW-Wide Exposure Area

For FS cost estimation purposes, a random stratified design for sample collection is assumed. While a more sophisticated approach may ultimately be developed post-FS (e.g., stratified into reaches, exposure areas) to better manage data skewness and variance, a simple stratified random sampling approach is acceptable for FS purposes for the following reasons:

- Remedial design data collected from contaminated areas designated for cleanup will complement site-wide randomly acquired baseline data and thereby further address data skewness.
- Remediation of the EAAs (Alternative 1) and other hot spots (e.g., those managed by Alternatives 2R and 2R-CAD) is expected to substantially reduce data skewness. Also, project-specific data collected through other types of monitoring (e.g., O&M) will complement site-wide randomly acquired data.

Separating the site into strata acknowledges the skewed distribution of the LDW surface sediment concentration data (Kern 2010). The stratified design assumes two types of data with similar attributes: 1) monitoring data collected from remediated areas at moderate data density, frequency, and variance; and 2) monitoring data collected from unremediated areas at lower data density, with lower variance expected in the range of concentrations observed. Thus, for site-wide baseline and long-term monitoring, 100 surface sediment samples are assumed per sampling event,[9] although the actual population for any given event may be much larger for the reasons mentioned above. Samples will be analyzed for chemical and physical parameters (Table K-2).

[9] One hundred site-wide samples (supplemented with area-specific samples) should have the ability to measure a minimum detectable difference of 25% between the mean of trend data, with a beta = 0.1 and an alpha = 0.05. The 95% upper confidence level on the mean will be used to evaluate future monitoring data.

K.6.1.2 Potential Clamming Areas

The potential clamming areas occupy approximately 105 acres of the LDW. For this FS, the potential clamming areas are assumed to be represented by 25 randomly collected samples[10] per event. All sediment samples (collected over a 0- to 45-cm depth for point of compliance) will be analyzed for the parameters shown in Table K-2. This FS assumes collection of discrete or composite samples; various compositing schemes could be considered during design.

Additionally, a field study will be conducted to evaluate the relationship between sediment and clam tissue concentrations of arsenic and cPAHs in the potential clamming areas. Results will be used to evaluate seafood consumption risks for arsenic and cPAHs. The specifics of this field study will be developed subsequent to the FS; costs are currently approximated as a lump sum in Appendix I.

K.6.1.3 Beach Play Areas

The eight beach play areas individually range from 1 to 10 acres. For cost estimation purposes, the FS assumes that baseline and long-term monitoring will utilize one composite sample from each beach play area collected from multiple locations to a depth of 45 cm. All composite samples will be analyzed for the parameters shown in Table K-2. An incremental composite sampling scheme may be considered during design as an alternative way of evaluating "average" concentrations over large spatial areas, but this type of remedial design is beyond the scope of this FS.

K.6.2 LDW Surface Water and Tissue Quality

Surface water sampling is distributed across the LDW at four locations (one upstream and one in each of the three LDW reaches) to assess ambient conditions over time relative to surface water quality ARARs. Samples may be collected as discrete or depth-integrated composite samples; the scope will be determined during remedial design, and will be consistent with baseline sampling. Surface water samples will be analyzed for the chemical parameters shown in Table K-2.

Fish and shellfish tissue sampling are assumed to be of similar scope and magnitude to work conducted in 2005 and 2007 as part of the RI baseline sampling (Windward 2006, 2009). Based on the scope of these previous surveys, the FS assumes about 75 composite tissue samples per event will be collected from various species and tissue types (e.g., whole-body and fillet).[11] Results will be used to assess achievement of cleanup objectives for RAO 1 (human health seafood consumption) and RAO 4 (ecological seafood consumption by river otter). After several years of monitoring (following construction), the frequency of tissue monitoring could be reduced as determined by evaluating trends from the monitoring data (see Table K-5 assumptions).

---

[10] Samples may be discrete and/or composite. Assume roughly one sample for every four acres.

[11] The tissue samples will be composite samples collected from fish trawls and crab traps in several subareas for a total of 75 composite samples.

K.6.3 Incoming Sediment and Surface Water Quality from Upstream

It is anticipated that long-term trends in surface sediment concentrations will eventually reach a point of diminishing reduction, representing a state of relative equilibrium. Beyond this point, additional remediation or source control activities are not expected to further improve sediment contaminant concentrations. At that time, a multi-media sampling effort will be conducted upstream in the Green/Duwamish River to determine the quality of incoming sediment to the LDW. Results will be compared to data collected during a similar baseline sampling event. Another objective of this future data collection effort is to confirm whether further reductions in the LDW are possible. This information is important in determining the closure strategy for the site and overall success of the remedy. Details of the upstream sampling will be determined in collaboration with EPA and Ecology. Assessment of the quality of incoming sediment from lateral sources will also be important for evaluating source control efforts. However, the scope, frequency, and cost for this effort will be determined on a project-specific basis and is not developed in this appendix.

The scope of the upstream sampling is not developed in this appendix, but will likely incorporate methodologies already established by Ecology (Ecology 2008) and surface water sampling events conducted by King County over the past several years (King County 2002). As such, media will include surface water and suspended solids collected over specific time and flow periods. For the purpose of costing the remedial alternatives, a placeholder cost estimate of $600,000 was assumed for this study across Alternatives 2 through 6 (approximately 10 percent of the total long-term monitoring costs) per sampling event and is included in Appendix I.

K.7 Summary

In summary, a large quantity of data will be collected in the LDW into the future to assess trends, provide risk communication, evaluate remedy construction and technology performance, and evaluate progress toward, or achievement of, cleanup objectives. Table K-6 compiles all of the sampling events described in this appendix, presented by year and remedial alternative. This outline provides sufficient detail to evaluate costs and differences among the alternatives with respect to monitoring requirements.

K.8 References

Anchor 2007. *Duwamish/Diagonal Sediment Remediation Project. 2005 Monitoring Report*. Elliott Bay/Duwamish Restoration Program Panel. Prepared for King County Department of Natural Resources. Prepared by Anchor Environmental, Seattle, WA. May 2007.

ASTM 2007. *Standard Test Method for Determination of Parent and Alkyl Polycyclic Aromatics in Sediment Pore Water Using Solid Phase Microextraction and Gas*

Chromatography/Mass Spectrometry in Selected Ion Monitoring Mode. Method D7363-07 ,Volume 11.02. American Society of Standard Testing Materials International, West Conshohocken, PA, USA. pp 1-23. August 2007.

Ecology 2008. *Quality Assurance Project Plan. Contaminant Loading to the Lower Duwamish Waterway from Suspended Sediment in the Green River*. Publication No. 08-03-114. Washington State Department of Ecology, Olympia, WA. September 2008.

Ecology 1991. *Sediment Cleanup Standards User Manual*. First Edition. Management Standards. Chapter 173-204 Washington Administrative Code (WAC). Washington State Department of Ecology, Sediment Management Unit, Olympia, WA. December 1991.

Environmental Protection Agency (EPA) 2004. *Guidance for Monitoring at Hazardous Waste Sites: Framework for Monitoring Plan Development and Implementation.* Office of Solid Waste and Emergency Response, OSWER Directive No. 9355.4-28. U.S. Environmental Protection Agency. January 2004.

Environmental Protection Agency (EPA) 2005. *Contaminated Sediment Remediation Guidance For Hazardous Waste Sites*. Office of Solid Waste and Emergency Response. EPA-540-R-05-012, OSWER 9355.0-85. December 2005. Available online at http://www.epa.gov/superfund/resources/sediment/guidance.htm.

Hawthorne, S.B., C.B. Grabanski, D.J. Miller, and J.P. Kreitinger 2005. Solid Phase Microextraction of Parent and Alkyl Polycyclic Aromatic Hydrocarbons in Milliliter Sediment Pore Water Samples and Determine of K_{DOC} Values. In: *Env. Sci. Technol.*: 2795-2803. 2005.

Kern J. 2010. *Coverage Rates for Selected Upper Confidence Limit Methods for Mean of Total PCBs in Sediments*. Prepared for Assessment and Restoration Division Office of Response and Restoration, National Oceanic and Atmospheric Administration. Seattle, WA. March 30, 2010.

King County 2002. *Green – Duwamish Watershed Water Quality Assessment. Comprehensive Monitoring Program. Sampling and Analysis Plan.* Prepared by the King County Department of Natural Resources and Parks. Water and Land Resources Division, Seattle, WA. May 30, 2002.

Reible D. 2010. Final Report on SPME Calibration Study. *Solid Phase Microextraction Technique for Porewater at the PSR Sediment Cap Site.* Prepared for U.S. Army Corps of Engineers Seattle District. Prepared by D. Reible, University of Texas. March 1, 2010.

Windward 2006. Lower Duwamish Waterway Remedial Investigation. *Data report: Chemical Analysis of Fish and Crab Tissue Samples Collected in 2005*. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. April 19, 2006.

Windward 2009. Lower Duwamish Waterway Remedial Investigation. *Data report: Chemical Analyses of Fish, Crab, and Clam Tissue Samples and Co-located Sediment Samples Collected in 2007*. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. March 5, 2009.

Table K-1 Purpose of Monitoring and Links to Performance Objectives

A. Site-wide Monitoring and Associated RAOs

Media	Remedial Action Objectives				Source Control	Scale of Monitoring	
	RAO 1	RAO 2	RAO 3	RAO 4		Site-wide and Exposure Area	Area-specific
Sediment	X	X	X	X	X	X	X
Surface Water	X			X	X	X	
Tissue	X			X		X	

Notes:
1. These monitoring program elements, baseline and long-term monitoring, are consistent across all technologies.

B. Technology Performance Monitoring

Type of Monitoring/Media	Technology				Scale of Monitoring
	Dredging	Capping	ENR/ *In Situ* Treatment	MNR	Area-specific
Construction and Post-Construction					
Sediment	X	X	X		X
Surface Water	X	X	X		X
O&M Technology Performance					
Bathymetry	X	X	X	X	X
Physical Inspections		X	X	X	X
Sediment		X	X	X	X
Porewater		X	X		X

Notes:
1. The designation ENR/*in situ* treatment indicates that either technology or both may be used.
2. No construction or post-construction monitoring is assumed for MNR, because MNR is passive remediation.

ENR = enhanced natural recovery; MNR = monitored natural recovery; O&M = operation and maintenance; RAO = remedial action objective

Table K-2 Conceptual LDW Monitoring Program, Used for Cost Estimation

Monitoring Category[a]	Parameters	Sample Collection and Analysis Assumptions	Sampling Frequency Assumptions and Objectives[b]
Baseline and Long-term[b]	Bathymetry	Bank-to-bank and site-wide multi-beam bathymetric surveys (supplemented with land-based survey data for intertidal areas as needed).	One survey to establish preremedy conditions. Another survey 5 to 10 years into remedy construction as a check on net sedimentation rates and scour areas.
	Sediment Chemistry and Toxicity	LDW-wide: 100 randomly collected surface sediment samples analyzed for the following parameters: • Group A parameters [c] – 100% of samples • Group B parameters [d] – 25% of samples Potential Clamming Areas: 25 randomly collected samples (discrete and/or composites) analyzed for total PCBs, arsenic, cPAHs, and dioxins/furans. Beach Play Areas: Single composite samples from each of 8 beach play areas analyzed for total PCBs, arsenic, cPAHs, and dioxins/furans.	Sampling occurs over large-scale areas (linked to the exposure areas) to assess compliance with cleanup objectives and ARARs, and to evaluate risk reduction over time. Baseline monitoring: one round of sampling to occur before construction to establish baseline conditions after EAAs have been completed. It also includes verification monitoring in areas expected to be below the SQS. Results can be used to evaluate changes in site conditions after completion of EAAs. One upstream survey event to assess incoming sediment quality. Interim monitoring: no sampling during construction for alternatives that take less than 10 years to implement. For longer duration alternatives (4R, 5R, 6C, and 6R), collect samples every 5 to 10 years during construction for information on chemical trends. • See Table K-5 for sampling frequency. Long-term (after construction) monitoring: sampling occurs at regular intervals after the active portion of the remedy is completed to assess compliance with cleanup objectives and ARARs, and to evaluate trends. Sampling begins 1 to 2 years after construction to allow immediate effects from construction to subside. One upstream survey event after LDW equilibrium is reached to assess incoming sediment quality. • See Table K-5 for sampling frequency.
	Surface Water Quality	Surface water samples collected for analyses of priority pollutant metals, cPAHs, TSS, and PCB congeners at four stations in the LDW	Baseline monitoring: one round of sampling to occur before construction to establish baseline conditions after EAAs have been completed. One upstream survey event to assess incoming suspended solids and water quality. Interim monitoring: collect surface water samples at regular intervals during construction to assess trends, evaluate source control efforts, and acquire synoptic data with tissue. • See Table K-5 for sampling frequency. Long-term monitoring: same as above for sediment chemistry (4 stations). One upstream survey event after LDW equilibrium is reached to assess incoming suspended solids and water quality. • See Table K-5 for sampling frequency.[b]

Table K-2 Conceptual LDW Monitoring Program, Used for Cost Estimation (continued)

Monitoring Category[a]	Parameters	Sample Collection and Analysis Assumptions	Sampling Frequency Assumptions and Objectives[b]
Baseline and Long Term[b] *(continued)*	Tissue[e,f]	Collect 75 fish and shellfish tissue samples (discrete and/or composite) from selected areas consistent with 2007 RI sampling design and scope. Analyze as follows: • PCBs as Aroclors, lipids, solids – 100% of all tissue samples • Arsenic, cPAHs – 100% of clam tissue samples (30% of other tissue type samples) • PCBs as congeners, other chemicals[g] – 33% of samples	Baseline monitoring: one sampling event 1 to 2 years following completion of EAAs to establish preremedy conditions for future comparisons. Interim monitoring: collect samples during the active portion of remedy to enable risk communication from dredge operations. • See Table K-5 for sampling frequency. Long-term monitoring: collect samples after the active portion of the remedy is completed for all alternatives. The duration of sampling depends on the construction period and the time predicted to achieve long-term model-predicted concentrations. • See Table K-5 for sampling frequency.
	Other Surveys	Assume undefined scope for additional misc. surveys yet to be determined during remedial design. These may include benthic infauna surveys, sediment profile imaging camera surveys, sediment cores, or physical assessments.	One event for baseline and one additional event at 5 to 10 years into remedy construction.
Construction	Water Quality	Assume four monitoring stations, three for the dredge that operates in deep water and one for the dredge operating in shallow water closer to the banks. Monitor field parameters (e.g., turbidity, pH) at each location: • Downstream mixing zone boundary (far-field) and halfway between mixing zone boundary and operating area (near-field) of deep-water dredge • Upstream reference area • Near-field downstream of the shallow-water dredge. Collect composite water column samples for chemical analyses from each location. Assume 30% of the samples will be analyzed for PCBs, arsenic, TSS, and cPAHs. Screening results may trigger a portion of these samples. Monitoring costs are prorated on a per-day basis (see Appendix I).	Daily during construction operation, assuming two dredging and material placement operations spatially separated so that separate points of compliance are needed. Results used to assess compliance with construction permits. Assume one sampling event for every station each day during each field season for a total number of 352 (88 days × 4 samples/day = 352). One of the stations is an upstream reference area. Samples are used to assess potential impacts associated with dredging, capping, or ENR operations. Field costs calculated on a per-day basis, totaling 88 days per season. Monitoring costs are prorated on a per-day basis (see Appendix I).

Table K-2 Conceptual LDW Monitoring Program, Used for Cost Estimation (continued)

Monitoring Category[a]	Parameters	Sample Collection and Analysis Assumptions	Sampling Frequency Assumptions and Objectives[b]
Post-Construction	Sediment Chemistry	The total number of surface sediment samples varies by alternative and is determined by the size of the active remedial footprint (four samples per acre). Immediate post-construction performance testing as follows: • Group A parameters[c] – 100% of samples • Group B parameters[d] – 25% of samples	One sampling event at the end of each construction season (i.e., for partially completed projects) and at the end of each individual construction project to compare to RALs and to determine compliance with design specifications.
	Thickness of Placed Material	Verify the thickness of placed material for cap or ENR areas by sediment cores, bathymetric surveys, diver inspection, or settlement plates. Assume 4 samples per acre for sediment cores. Other physical testing parameters could be considered during design.	At the end of construction to confirm material is placed per project specifications.
	Bathymetry	One bathymetric survey for each construction area.	At the end of construction to confirm compliance with depth clearance requirements and/or restoration to grade.
Operation and Maintenance (O&M)	Sediment Chemistry, Porewater, and Diver Inspection	• Dredge: Two surface samples per acre • Cap: Two surface samples per acre. One sediment core and one porewater sample per acre; inspection by diver at same locations • *ENR/in situ* treatment: Diver inspection and four surface sediment and porewater samples per acre • MNR(10): Four surface samples per acre; periodic physical inspection (by diver) if deemed necessary based on chemistry and grain size results • MNR(20): Same as MNR(10) but longer duration. Additional sampling at Years 15 and 20. Note: Same parameter Groups A and B as for post-construction monitoring (see above) for dredging, capping, ENR/*in situ*, and MNR.	Sampling frequency is different for each remedial technology. Sampling occurs within project-specific remedial footprints to assess technology performance and recontamination potential. For ENR/*in situ* treatment area, porewater sampling will assess bioavailability of contaminants within the treatment area; compare results to RALs and surface water criteria. • See Table K-4 for sampling frequency.
	Bathymetry/ Other Physical Surveys	Physical inspection may be conducted by bathymetry, probing, settlement plate, video camera, or other device. Assume: • MNR(10): one physical inspection per 5 acres • MNR(20): same as MNR(10).	Bathymetry and other physical surveys may be employed to assess the extent of potential scour areas. Assessments occur within project-specific remedial footprints. Assume the same frequency as for sediment chemistry sampling. The FS assumes a portion of the footprint will require physical surveys.

Table K-2 Conceptual LDW Monitoring Program, Used for Cost Estimation (continued)

Notes:

a. See Appendix I for details regarding frequency and duration of monitoring costs and assumptions. Construction monitoring costs are determined by the number of work seasons. Post-construction and O&M monitoring are area-specific and determined by the size of the remedial footprint. All monitoring assumptions and costs are only for FS purposes and are subject to refinement in the ROD and during remedial design.

b. Timing of sampling events should be designed with consideration of 5-year review cycle to allow data to be used during this evaluation.

c. Group A parameters: total PCBs (as Aroclors), arsenic, cPAHs, all SMS contaminants, and associated conventional parameters (e.g., TOC, grain size, percent solids).

d. Group B parameters: other COCs related to seafood consumption COCs – pesticides, etc. (see Section 3 of the FS for list), plus dioxins/furans, and sediment toxicity tests.

e. A field study is also anticipated to evaluate the relationship between sediment and clam tissue concentrations of arsenic and cPAHs in potential clamming areas. No specific experimental design is assumed for the FS. Field-study costs are approximated as a lump sum value (see Appendix I).

f. The purpose of tissue sampling is to assess cleanup effectiveness relative to RAO 1 cleanup objectives. Tissue sampling monitors concentrations of risk-driver contaminants in tissue, and thus monitors the reduction in human health risks, rather than calculating a prescribed percent reduction. Without a prescribed percent reduction, comparison to baseline is less important than whether future tissue concentrations are in line with changes in sediment concentrations. It is acknowledged that concentrations in tissues will have some year-to-year variability. A subset of the tissue samples will be analyzed as whole-body samples to evaluate RAO 4 cleanup objectives (river otter, ecological seafood consumption risks).

g. Other COCs include, but are not necessarily limited to, dioxins/furans.

ARARs = applicable or relevant and appropriate requirements; COC = contaminant of concern; cPAH = carcinogenic polycyclic aromatic hydrocarbon; EAA = early action area; ENR = enhanced natural recovery; FS = feasibility study; LDW = Lower Duwamish Waterway; MNR = monitored natural recovery; O&M = operation and maintenance; PCB = polychlorinated biphenyl; RAL = remedial action level; RAO = remedial action objective; RI = remedial investigation; ROD = Record of Decision; SQS = sediment quality standards; TOC = total organic carbon; TSS = total suspended solids.

Table K-3 Comparison of Monitoring Criteria and Terminologies Used in this FS Compared to MTCA

Monitoring Objective	Type of Monitoring Described in this FS In part, based on EPA contaminated sediment remediation guidance for hazardous wastes sites (EPA 2005) and EPA guidance for monitoring at hazardous waste sites: framework for monitoring plan development and implementation (EPA 2004)	Type of MTCA Compliance Monitoring "shall be required until residual hazardous substances concentrations no longer exceed site cleanup levels established under WAC 173-340 through 173-340-760" [173-340-410][a]
Establish baseline conditions for future compliance monitoring	Baseline monitoring	n/a
Refine the nature and extent of contaminated areas and remedial action boundaries after the FS; confirm recovery processes	Remedial design sampling and verification monitoring[b]	n/a
Protect human health and the environment during construction	Construction monitoring (area-specific short-term monitoring during construction)	Protection monitoring
Verify that remedial action levels or remediation levels have been achieved before demobilizing from the site	Post-construction performance monitoring (area-specific performance immediately following active remediation)	Performance monitoring
Confirm that natural recovery processes are occurring as predicted to achieve cleanup objectives	Operation & maintenance monitoring	Performance monitoring
Monitor the stability of a cap area to ensure isolation and containment and of an ENR area to ensure recovery	Operation & maintenance monitoring	Confirmational monitoring
Monitor surface sediments over time for potential recontamination	Long-term monitoring	Confirmational monitoring
Monitor tissues over time to assess risk reduction	Long-term monitoring	Confirmational monitoring
Determine how ongoing sources at or near a site may affect the success of active cleanup and/or natural recovery	Source control evaluation within upland drainage basins – conducted by the Source Control Work Group in parallel to baseline, remedy design, and long-term monitoring; may include other responsible parties	Source control monitoring (but not a component of compliance monitoring) (Ecology 1991)

Notes:

a. Demonstrating the ability to achieve cleanup standards involves the point of compliance, how long it takes to achieve cleanup levels (time to achieve cleanup objectives or restoration time frame under MTCA), and monitoring to ensure that cleanup standards have been achieved and will continue to be achieved in the future [WAC 173-340-700].

b. Remedial design sampling and verification monitoring are not addressed in this appendix, but are included in the FS as a percentage of capital costs for each remedial alternative (Appendix I).

Shading indicates scope is included in the FS detailed cost estimates for monitoring.

Table K-4 Conceptual O&M Monitoring Frequency by Remedial Technology

Remedial Technology	O&M Monitoring for Technology Performance[a]																						
	Sample Density (# of samples/acre)[b]	Media	During Construction[c]	Sample Intervals (years post-construction[d])																			
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Dredge	2	SS			√			√															
Cap	2	SS			√			√					√										
	1	SC																					
	1	PW																					
	n/a	physical																					
ENR or ENR/*in-situ* treatment	4	SS			√			√					√										
	4	PW																					
	n/a	physical																					
MNR(10) MNR(20)[e]	4	SS	√		√	√		√		√			√					√					√
	n/a	physical	√		√	√		√		√			√					√					√

Notes:

1. The monitoring assumptions provided in this appendix are conceptual and only for FS costing purposes. They are subject to refinement in the ROD and will be finalized during remedial design.

a. See Appendix I for details on O&M monitoring cost estimates for each remedial alternative. Total sample numbers and types vary by remedial technology (as identified in this table) and the areas over which remedial technologies are applied.

b. See Table K-2 for analytical parameters. Surface sediment monitoring may include diver inspections.

c. At a minimum, MNR monitoring begins at the end of the overall remedy construction along with other types of O&M monitoring in active areas (the appendix and costs are based on this assumption). However, it could start earlier in some MNR areas (before the end of construction) if a particular MNR area has minimal potential for recontamination from active remedy construction activities.

d. Timing of sampling events can be adjusted to ensure availability of data for consideration during 5-year project reviews.

e. Sampling for MNR(10) ends at Year 10. Sampling for MNR(20) extends out to Year 20.

n/a = not applicable; MNR = monitored natural recovery; O&M = operation and maintenance; physical = physical inspection surveys, including bathymetric surveys (area-wide) and other physical inspections to ensure limited scour; PW = porewater sample; ROD = Record of Decision; SS = surface sediment grab sample; SC = subsurface sediment core

Table K-5 Conceptual Baseline and Long-term Monitoring Frequency LDW-wide by Alternative

Remedial Alternative	Media	Baseline	Time from Start of Construction (years)																																												
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
2R/2R-CAD	SS	SS				PC		SS					SS					SS					SS					SS																			
	T	T			T			T		T			T					T					T					T																			
	SW	SW						SW					SW					SW					SW					SW																			
3C	SS	SS			PC		SS					SS					SS					SS					SS																				
	T	T			T		T		T			T					T					T					T																				
	SW	SW					SW					SW					SW					SW					SW																				
3R	SS	SS						PC		SS					SS					SS					SS					SS																	
	T	T			T					T		T			T					T					T					T																	
	SW	SW								SW					SW					SW					SW					SW																	
4C	SS	SS						PC		SS					SS					SS					SS					SS																	
	T	T			T					T		T			T					T					T					T																	
	SW	SW								SW					SW					SW					SW					SW																	
5C	SS	SS							PC		SS					SS					SS					SS					SS																
	T	T			T						T		T			T					T					T					T																
	SW	SW									SW					SW					SW					SW					SW																
4R	SS	SS								SS			PC		SS					SS					SS					SS																	
	T	T			T					T					T		T			T					T					T																	
	SW	SW								SW					SW					SW					SW					SW																	
6C	SS	SS								SS					SS			PC		SS					SS					SS																	
	T	T			T					T					T					T		T			T					T																	
	SW	SW								SW					SW					SW					SW					SW																	
5R/5R-T	SS	SS								SS					SS				PC		SS					SS					SS																
	T	T			T					T					T						T		T			T					T																
	SW	SW								SW					SW						SW					SW					SW																
6R	SS	SS								SS					SS					SS										SS										SS				PC		SS	
	T	T			T					T					T					T										T										T						T	
	SW	SW								SW					SW					SW										SW										SW						SW	

Notes:

Indicates approximate construction period in years (see Table K-2 for construction and post-construction sampling)

SS = surface sediment grab sample collection and chemical analysis
T = collection and chemical analysis of 75 fish and shellfish tissue samples (composite) from selected areas consistent with 2007 RI sampling design and scope
SW = collection and chemical analysis of surface water samples
PC = Post-construction sediment sampling prior to site demobilization

1. See Table K-2 for chemical analyses suite, number of samples, and purpose of sampling.
2. The monitoring assumptions provided in this appendix are conceptual and only for feasibility study (FS) costing purposes. They are subject to refinement in the Record of Decision and will be finalized during remedial design.
3. For the FS, it is assumed that long-term monitoring ends when preliminary remediation goals are met or reach as close as technically practicable to them (i.e., surface sediment concentrations reach long-term, model-predicted concentrations). The last round of sampling is collected prior to the 5-year review.
4. The first sampling event shown on this table (baseline) will also include an upstream sediment/water sample collection event to evaluate incoming sediment quality. The last sampling event shown on this table will also include an upstream sediment/water collection effort.

Table K-6 Summary of All Monitoring Events by Year

Remedial Alternative	Preconstruction	Time from Start of Construction (years)																																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
2R/2R-CAD	B/U	D	D	D/R	D/P		O/M/R	M	R	O/M		M/R			O/M		R			M		R			M		R/U																			
3C	B/U	D	D	D/R/P		O/M/R	M	R	O/M		M/R			O/M		R			M		R			M		R/U																				
3R	B/U	D	D	D/R	D	D	D/P		O/R	M	R	O/M		M/R			O/M		R			M		R			M		R/U																	
4C	B/U	D	D	D/R	D	D	D/P		O/M/R	M	R	O/M		M/R			O/M		R					R					R/U																	
5C	B/U	D	D	D/R	D	D	D	D/P		O/M/R		R	O/M		R			O/M		R					R					R/U																
4R	B/U	D	D	D/R	D	D	D	D	D/R	D	D	D/P		O/M/R	M	R	O/M		R/M			O/M		R					R/U																	
6C	B/U	D	D	D/R	D	D	D	D	D/R	D	D	D	D	D/R	D	D	D/P		O/M/R		R	O/M		R			O/M		R/U																	
5R/5R-T	B/U	D	D	D/R	D	D	D	D	D/R	D	D	D	D	D/R	D	D	D	D/P		O/M/R		R	O/M		R					R/U																
6R	B/U	D	D	D/R	D	D	D	D	D/R	D	D	D	D	D/R	D	D	D	D	D/R	D	D	D	D	D	D	D	D	D	D/R	D	D	D	D	D	D	D	D	D	D	D	D	D	D/P		R/U	

Notes:

Indicates approximate construction period in years

Type of Monitoring (see Table K-2 for description)

- B = baseline or preconstruction: surface sediment, tissue, surface water, physical
- D = during construction: surface water
- P = Post-construction for each construction area: surface sediment, bathymetry; frequency could be every year for each subarea completed
- O = O&M for active remedial technologies employed (i.e., dredge, cap, ENR/*in situ* treatment) after active remediation has been completed for the alternative: multi-media
- M = MNR O&M (includes years when other O&M is not being conducted): surface sediment
- R = interim and long-term after active remediation has been completed for the alternative: surface sediment, tissue, surface water
- U = upstream multi-media sampling event(s) to assess the quality of incoming sediment, suspended solids, and surface water

1. See Table K-2 for chemical analyses suite, number of samples, and purpose of sampling.
2. The monitoring assumptions provided in this appendix are conceptual and only for FS costing purposes. They are subject to refinement in the Record of Decision and will be finalized during remedial design.

CAD = contained aquatic disposal; O&M = operation and maintenance

Lower Duwamish Waterway Group

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

Appendix L
Estimation of Short-term Effectiveness Metrics

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

AECOM Environment
710 Second Avenue, Suite 1000, Seattle, WA 98104
T 206.624.9349 F 206.623.3793 www.aecom.com

Memorandum

Date: October 31, 2012

To: Lower Duwamish Waterway Group

From: AECOM

Subject: Estimation of Short-term Effectiveness Metrics, Feasibility Study for the Lower Duwamish Waterway

Introduction

This memorandum presents the methods and key metrics used for evaluating short-term effectiveness of the remedial alternatives developed in Section 8 and evaluated in Sections 9 and 10 of the Lower Duwamish Waterway (LDW) feasibility study (FS). The U.S. Environmental Protection Agency (EPA) Region 10 *Clean and Green Policy* (EPA 2010a) states that the environmental benefits of federal cleanup programs may be enhanced by promoting technologies and practices that are sustainable. Specific objectives of the Green Remediation policy are to: 1) protect human health and the environment by achieving remedial action goals; 2) support sustainable human and ecological use and reuse of remediated land; 3) minimize impacts to water quality and water resources; 4) reduce air toxics emissions and greenhouse gas production; 5) minimize material use and waste production; and 6) conserve natural resources and energy. EPA's green remediation policies and guidelines will be consulted in the development of specific mitigation measures and in the adoption of sustainable practices during the remedial design phase.

The scope of this study is to evaluate and compare the potential impacts of the remedial alternatives with respect to key metrics and to identify best practices for their mitigation. This analysis was performed on an MS Excel platform and utilized metrics associated with the following factors:

- Gas emissions
  - Carbon dioxide (CO_2) emissions
  - Carbon monoxide (CO) emissions
  - Nitrogen oxides (NO_x) emissions
  - Sulphur oxides (SO_x) emissions
  - Particulate matter with a diameter of 10 micrometers (µm) or less (PM_{10}) emissions
- Workplace accidents
  - Expected number of accidents during remediation activities
  - Expected number of deadly accidents during remediation activities
- Energy consumption
- Carbon footprint
- Resources consumed and disposal capacity utilized.

Section 9 evaluates these metrics for each remedial alternative under *Short-term Effectiveness, Environmental Impacts*. Section 9 also includes information about additional short-term effectiveness metrics, such as release of contaminants into the water column during dredging and potential mitigation measures.

Calculation Approach for Short-term Effectiveness Metrics

Remediation Activities Evaluated

Various activities associated with the active remedial alternatives under consideration for the LDW were subdivided into primary, secondary, and tertiary activities, as depicted in Figure L-1 (EPA 2009). Short-term effectiveness analyses were developed for the primary and secondary activities, but were not developed for tertiary activities.

Brief summaries of the primary, secondary, and tertiary activities are provided below:

- Primary Activities (On-site Work)
  - Cap with clean sand material using barge-mounted derrick crane/bucket and barge-mounted precision excavator.
  - Dredge sediments using barge-mounted derrick-crane/bucket and barge-mounted precision excavator.
  - Transload sediment to the off-loading facility by barge and tugboat. Handle dredged material on the barge using front-end loaders. Off-load the material at the transloading area (by crane) into containers and load containers onto trucks.
- Secondary Activities (Off-site Work)
  - Transport containers by truck to railcar intermodal facility followed by rail transport to regional landfill (as one loaded trip and one unloaded trip). Off-load containers from railcar to trucks for transport to the landfill cell.
  - Transport clean sand and aggregate from quarry to the LDW.
- Tertiary Activities (Not Included in the Short-term Effectiveness Analyses)
  - Mining of aggregate for capping, enhanced natural recovery (ENR), and residuals management
  - Manufacturing of construction equipment; construction materials, fuels, lubricants, staging equipment, and support facilities
  - Transport workers to/from site
  - Electricity generation for consumption at the site
  - Landfill management.

All of the equipment in the primary and secondary activities is assumed to be operated using hydrocarbon fuels.

Tertiary activities are those activities that are not directly related to the on-site activities but that are related to the overall remedy at the site. These include construction and staging equipment, site preparation, site closure, support facilities, and materials necessary to implement the active remedial alternatives. These activities are outside the scope of the short-term effectiveness analyses as described by Toffoletto et al. (2005) and Cadotte et al. (2007). Noise factor calculations are also beyond the scope of the short-term effectiveness analyses and are not included in this FS because industry-related exposure factors are not readily available. Management of a landfill is also beyond the scope of the FS because it is managed as an operations requirement by the landfill. Electricity consumed on site is not included in the short-term effectiveness metrics because it is considered to be a small portion of the total energy used on site.

Inventory of Metrics

Air pollutant emissions include estimates of CO_2 emissions, the most important greenhouse gas (GHG), followed by water vapor, NO_x, CO, SO_x, and PM_{10}. These estimates are calculated using an emission factor approach, where the emission factors represent the mass of pollutant emitted per unit of activity and are normally referred to as “default” emissions. The major uncertainty for an emission factor is related to the degree of similarity between the target equipment/process the factor is used for and the equipment/process the factor was derived from. Estimation of activity (e.g., throughput, operating hours, etc.) requires knowledge of the equipment and facilities involved. Usually, emission factors estimate CO_2 emissions more accurately than CO, NO_x, SO_x, and PM_{10} emissions, whose estimates are affected by specific characteristics of the fuel, equipment, and the operating conditions (World Resource Institute 2007).

Energy consumption refers to thermal and electrical energy consumption. Thermal energy consumption arises from fuel combustion, based on the average heating value for diesel fuel (158 megajoules per gallon [MJ/gal]), and it is directly related to the amount of diesel fuel consumed during the project. Electrical energy consumption is related to the electricity purchased from the grid and is estimated as the product of equipment power demand and utilization time.

Workplace accidents represent the expected number of work-related accidents and deaths during the activities. This information is calculated using available data for workplace activities similar to those planned for the remediation of the LDW.

Carbon footprint, for the purpose of this FS, is defined as the forested area necessary to absorb the CO_2 produced during the remediation activities, based on the sequestration rate for Douglas fir. Carbon is stored by plants as they photosynthesize atmospheric CO_2 into plant biomass. Subsequently, some of this plant biomass is indirectly stored as soil organic carbon during decomposition processes. The sequestration rate is a function of the form of biomass as dry matter (dm) and usually estimated as 2.02 grams (g) CO_2/1 g dm, and the annual vegetation growth rate. For Douglas fir, the sequestration rate is 2.09 metric tons of CO_2 sequestered per acre per year.

Input Data Requirements

Two categories of data were compiled to perform the short-term effectiveness analyses: background and site-specific (Goedkoop et al. 2008a). The background data are comprised of generic factors and constants found in databases and literature. The site-specific data relate to the manner in which the remedial alternatives are assumed to be implemented (e.g., number and characteristics of equipment, labor requirements, production rates, and transportation distances).

Background data used for the calculations were obtained mostly from EPA (1995a, 1995b) and the U.S. Department of Labor (USDOL 2007, 2008). In particular, the EPA report documents gas emission factors related to different sources (stationary internal combustion engines or mobile sources), dust emission equations for heavy construction and plowing operations, and transport on paved and unpaved roads.

The metrics were calculated based on the activities scheduled for each remedial alternative. Background data and site-specific data, as classified for the planned activities, are reported in Tables L-1 and L-2, respectively.

Results

Table L-3 presents the summary output for the remedial alternatives. Alternative 2R-CAD results in the lowest GHG (CO_2) emissions (approximately 17,000 metric tons). Alternative 6R is estimated to result in the highest GHG emissions (approximately 140,000 metric tons). Table L-3 also includes other air pollutant emissions, the energy required to excavate and transport material, and the required landfill volume needed to dispose of the dredged material generated by each of the remedial alternatives. The air emissions, energy consumption, and landfill space used increase in proportion to the dredged volume of the alternatives. In general, the combined-technology alternatives (indicated by a “C”) result in fewer emissions, use less landfill space, and consume less energy than the removal-emphasis alternatives (indicated by an “R”).

This table also estimates the carbon footprint for each alternative expressed in acre-years, where one acre-year represents the amount of CO_2 sequestered by one acre of Douglas fir forest for one year. This results in Alternative 2R-CAD having the lowest carbon footprint (approximately 4,000 acre-years) and Alternative 6R having the largest carbon footprint (approximately 33,000 acre-years).

Although workplace accidents have not been traditionally considered, short-term effectiveness analyses should evaluate social, economic, and environmental concerns. Workplace accidents are a realistic outcome of remedial activities, and the number of accidents is assumed to be proportional to the duration of remedial activities.

Table L-4 summarizes the CO_2 emissions for the remedial alternatives and possible best management practices (BMPs) that all the remedial alternatives could apply to minimize the carbon footprint during construction. The pie charts in Table L-4 represent the percentage of CO_2 produced by each activity (i.e., dredging, transloading, transporting, dredging, capping, and miscellaneous) for each remedial alternative. Miscellaneous activities include emissions from small-scale construction equipment (e.g., front-end loaders). The percentages of CO_2 emissions for each activity category are similar among the various remedial alternatives. As noted in the table, higher percentages of CO_2 emissions are associated with dredging (14 to 32%) and transportation of dredged material to the disposal facility (44 to 69%).

Discussion

In general, particulate and CO_2 air emissions are generated through internal combustion in construction equipment, and dust created by transportation and construction activities. SO_x emissions depend on the sulphur content of the fuel. If the sulphur content of the fuel is reduced, then SO_x emissions will decrease.

The primary source of particulate and CO_2 air emissions is fuel consumption during on-site and off-site activities. Transportation accounts for the largest portion of these emissions. The FS assumes that rail and barge transport will be used to the maximum extent possible. Rail and barge transport is the most efficient way to reduce project emissions for both particulates and CO_2, as compared to long-haul trucking.

The EPA publication *Clean Fuel & Emission Technologies for Site Cleanup* (EPA 2010b) identifies a number of BMPs for reducing air emissions. These BMPs generally fall into four categories:

- Effective operation and maintenance to ensure efficiency of vehicles and field equipment
- Advanced diesel technologies

- Alternative fuels and fuel additives
- Fuel-efficient or alternative fuel vehicles.

All of these BMPs are potentially applicable for remedial alternatives in the LDW to reduce CO_2 and particulate air emissions. A reduction in CO_2 emissions can be achieved by using biodiesel in the smaller construction equipment (e.g., front-end loaders). The use of biodiesel is limited to small-scale equipment because of its solvent properties. When first introduced into an existing system, biodiesel will remove deposits within the fuel tank and fuel lines, clog existing filters, and thereby create waste and safety issues. This causes biodiesel to be impractical for use in large-scale equipment, especially at higher grades of biodiesel[1] (NBB 2010). Some electric dredges are currently in use that would reduce emissions associated with dredging activities; however, this technology is new and not widely used. Electric dredges would also require further construction design and might not be applicable to the entire LDW because of navigation restrictions. Examples of advanced diesel technologies include retrofitting diesel engines with diesel particulate filters. Fuel-efficient or alternative fuel vehicles such as small trucks or hybrid cars may be considered for site management and monitoring activities.

SO_x emissions depend on the sulphur content of the fuel. For SO_x, 95% of emissions are in the form of SO_2, with 1% to 5% being SO_3. If the sulphur content of the fuel is reduced through emission controls or fuel refinements such as low sulphur fuel, then SO_x emissions will decrease. Emissions of CO, NO_x, and PM_{10} are primarily generated through the operation of construction and transportation equipment. CO is present in exhaust gases and is a result of incomplete fuel combustion. NO_x refers to the composite of nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x forms through thermal fixation and chemical bond conversion, both of which take place during combustion. PM_{10} is generated in two ways. The first is through internal combustion in construction equipment, and the second is dust generated by transportation and construction activities. The best way to reduce GHG and particulate emissions is through the use of BMPs, as described here.

BMPs that can be specified during remedial design to further increase short-term effectiveness include:

- Recycle uncontaminated materials removed from the LDW (i.e., metals, construction debris, tires, etc.).
- Limit on-site vehicle speed to reduce particle suspension and increase fuel efficiency (EPA 2008a).
- Select properly sized and powered equipment.
- Based on availability, consider Tier 2 engines for equipment (likely to have a cost premium associated with this option).
- Select fuel-efficient equipment/vehicles and alternative fuel vehicles (electric, hybrid, compressed natural gas) (EPA 2010b).
- Select equipment fitted with advanced emission control systems (diesel oxidation catalyst, diesel particulate matter filter, partial diesel particulate filter, diesel multi-stage filter, selective catalytic reduction) (EPA 2010b).
- Select efficient modes of transportation for movement of materials (e.g., rail/barge vs. truck transport).

---

[1] Biodiesel grades range from B2 (containing 2% biodiesel and 98% diesel fuel) up to B100 (containing 99.9% biodiesel).

- Optimize the transloading process by selecting efficient modes of transportation for movement of materials (e.g., rail vs. truck transport).
- Select lower GHG-emitting fuel sources (e.g., biodiesel) for small equipment and trucks.
- Use ultra-low sulphur fuel in site equipment to reduce SO_x emissions.
- Provide alternatives to diesel-powered generators for use during construction.
- Research salvage of existing structures.
- Impose idling restrictions on construction equipment to increase fuel efficiency and reduce GHG emissions.
- Conduct routine equipment and vehicle maintenance.
- Accurately delineate contaminated sediment and sediment management areas to minimize dredging volume.
- Perform construction sequentially in a manner intended to reduce unnecessary movement of construction equipment.
- Analyze various alternative technologies that could reduce energy consumption, waste, and emissions.
- Select a landfill that collects methane (EPA 2010a).
- Incorporate sustainable site design (EPA 2010a).
- Use Environmental Management System (EMS) practices (EPA 2010a).
- Survey on-site for potential material to backfill excavated/capped areas and re-use on-site material when possible (EPA 2008b).
- Select equipment and processes that minimize water use, and promote reuse and water conservation.
- Adopt environmentally preferable purchasing practices (construction products and other miscellaneous items).
- Select suitable types of equipment and vehicles capable of handling alternative fuels (ultra low sulphur diesel, biomass-based renewable fuel) and fuel additives (emulsified diesel, cetane enhancers) to improve fuel economy and lower GHG emissions (EPA 2010b).
- Select reused, reusable, recycled, and recyclable materials to the greatest extent practical.
- Purchase renewable energy credits.
- Use additional environmental training and meetings for construction personnel to address environmental concerns.
- Select contractors/subcontractors that use EMS practices.

A number of the operation and maintenance BMPs may be applicable to all of the remedial alternatives during construction. These include:

- Reduce vehicle idling.
- Maintain equipment.

- Follow transportation and site management plans that emphasize fuel efficiency and proper fuel handling.
- Obtain materials and equipment locally to minimize shipping and mobilization distance.
- Encourage construction personnel to carpool to and from the site.

As shown in Table L-4, the portions of the pie chart that will likely be most influenced in terms of CO_2 reduction are the miscellaneous and transportation activity categories because small-scale equipment and trucks are associated with these activities. By using biodiesel in small-scale equipment/trucks and following the BMPs listed above, some reductions in CO_2 emissions may be achieved. CO_2 emissions could be reduced by approximately 3% (for all the activities combined for a given remedial alternative) by using B20 grade biodiesel (20% biodiesel). For the other activities depicted in the pie chart, BMPs such as the use of biodiesel are likely to have insignificant effects in terms of CO_2 reduction because of the nature of heavy equipment and transportation conveyances used to perform these activities.

Another aspect of construction is ensuring the safety of all personnel. To prevent accidents, safety BMPs such as the following could be used:

- Complete a safety plan and ensure that all personnel are familiar with it.
- Provide proper safety equipment.
- Perform daily safety tailgate meetings to discuss potential hazards.
- Perform regular safety audits.
- Maintain a Site Safety Officer on-site at all times.

References

Cadotte M., L. Deschênes, and R. Samson 2007. "*Selection of a Remediation Scenario for a Diesel-Contaminated Site Using LCA*", Int. J. LCA, Ecomed publishers, 2007, 12(4), 239-251. http://discover-decouvrir.cisti-icist.nrc-cnrc.gc.ca/eng/article/?id=7042929.

Environmental Protection Agency (EPA) 1995a. *Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources*, AP 42, Fifth Edition. January 1995.

Environmental Protection Agency 1995b. *Compilation of Air Pollutant Emission Factors, Volume II, Appendix H: Highway Mobile Source Emission Factor Tables*, AP 42, Fifth Edition. January 1995.

Environmental Protection Agency 2008a. *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites.* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, EPA 542-R-08-002. April 2008.

Environmental Protection Agency 2008b. *Green Remediation: Best Management Practices for Excavation and Surface Restoration.* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, EPA 542-F-08-0102. December 2008.

Environmental Protection Agency 2009. *Green Remediation: Estimating the Environmental Footprint at a Corrective Action Cleanup, Pilot Study at Romic East Palo Alto.* February 25, 2009.

Environmental Protection Agency 2010a. *Region 10 Superfund, RCRA, LUST, and Brownfields Clean and Green Policy.* July 2010.

Environmental Protection Agency 2010b. *Green Remediation Best Management Practices: Clean Fuel & Emission Technologies for Site Cleanup.* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response (5102G). EPA 542-F-10-008. August 2010.

Environmental Protection Agency 2010c. Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural & Forestry Practices. http://www.epa.gov/sequestration/rates.html. Downloaded July 16, 2012.

Goedkoop M.,et.al. 2008a, "*Simapro 7 - Introduction into LCA*," PRé Consultants, February 2008.

Goedkoop M.,et.al. 2008b, "*Simapro Database Manual Methods Library*" PRé Consultants, May 2008.

National Biodiesel Board (NBB) 2010. *Biodiesel FAQs*, http://www.biodiesel.org/what-is-biodiesel/biodiesel-faq's website accessed August 2012.

Toffoletto L., L. Deschênes, and R. Samson 2005, "*LCA of Ex-Situ Bioremediation of Diesel-Contaminated Soil*," Int. J. LCA, Ecomed publishers, 10(6), 406-416, 2005.

U.S. Department of Labor (USDOL) 2007. Supplemental News Release Tables – SNR05, Industry Injury and Illness Data. 2007.

U.S. Department of Labor (USDOL) 2008. Census of Fatal Occupational Injuries, 2008.

World Resources Institute 2006. Designing a Customized Greenhouse Gas Calculation Tool. The Greenhouse Gas Protocol.

Zhou, Xiaoping and Miles A. Hemstrom 2009. Estimating aboveground tree biomass on forest land in the Pacific Northwest: a comparison of approaches. Res. Pap. PNW-RP-584. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

Table L-1 Background Input Data

1 DREDGING			
Description	Units	Value	References
Emission factor for CO_2	lb/gal	26.635	*SimaPro 7 Database Manual: The Franklin US98 LCI Library* - Inland Vessel transportation (Goedkoop et al. 2008b)
Emission factor for CO	lb/gal	0.13	
Emission factor for NO_x	lb/gal	0.31	
Emission factor for SO_x	lb/gal	0.04	
Emission factor for PM_{10}	lb/gal	0.45	
Emission factor for CO_2	lb/gal	29.168	*SimaPro 7 Database Manual: The Franklin US98 LCI Library* - Excavation with a hydraulic digger (Goedkoop et al. 2008b)
Emission factor for CO	lb/gal	0.1447	
Emission factor for NO_x	lb/gal	0.3417	
Emission factor for SO_x	lb/gal	0.04627	
Emission factor for PM_{10}	lb/gal	0.0489	
Work accidents rate for inland water freight transportation	accidents/ worker/year	0.03600	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for water transportation	accidents/ worker/year	0.00030	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for heavy and civil engineering construction	accidents/ worker/year	0.05100	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for operating engineers and other construction equipment operators	accidents/ worker/year	0.00011	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	158.041	Commonly accepted heating values for diesel fuel

Table L-1 Background Input Data (continued)

2 TRANSLOADING			
Description	Units	Value	References
Emission factor for CO_2	lb/gal	24.4	*U.S. Life Cycle Inventory Database:* Airborne emissions from transportation fuel combustion- Barge – Diesel (EPA 1995b)
Emission factor for CO	lb/gal	0.0307	
Emission factor for NO_x	lb/gal	0.311	
Emission factor for SO_x	lb/gal	0.00539	
Emission factor for PM_{10}	lb/gal	0.00771	
Work accidents rate for inland water freight transportation	accidents/ worker/year	0.03600	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for water transportation	accidents/ worker/year	0.00030	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for heavy and civil engineering construction	accidents/ worker/year	0.05100	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for operating engineers and other construction equipment operators	accidents/ worker/year	0.00011	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	158.041	Commonly accepted heating values for diesel fuel

Table L-1 Background Input Data (continued)

3 TRANSPORTATION			
Description	Units	Value	References
Emission factor for CO_2	lb/gal	24.4	*U.S. Life Cycle Inventory Database:* Airborne emissions from transportation fuel combustion- Medium-Heavy-Duty Truck – Diesel (EPA 1995b)
Emission factor for CO	lb/gal	0.0389	
Emission factor for NO_x	lb/gal	0.163	
Emission factor for SOx	lb/gal	0.00539	
Emission factor for PM_{10}	lb/gal	0.0282	
Emission factor for CO_2	lb/gal	24.4	*U.S. Life Cycle Inventory Database:* Airborne emissions from transportation fuel combustion- Locomotive – Diesel (EPA 1995b)
Emission factor for CO	lb/gal	0.0632	
Emission factor for NO_x	lb/gal	0.642	
Emission factor for SOx	lb/gal	0.00539	
Emission factor for PM_{10}	lb/gal	0.016	
Emission factor for CO_2	lb/gal	24.4	*U.S. Life Cycle Inventory Database:* Airborne emissions from transportation fuel combustion- Barge – Diesel (EPA 1995b)
Emission factor for CO	lb/gal	0.0307	
Emission factor for NOx	lb/gal	0.311	
Emission factor for SOx	lb/gal	0.00539	
Emission factor for PM_{10}	lb/gal	0.00771	
Work accidents rate for general freight trucking, local	accidents/ worker/year	0.05200	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for truck transportation	accidents/ worker/year	0.00026	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for rail transportation	accidents/ worker/year	0.02200	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for rail transportation	accidents/ worker/year	0.00006	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for inland water freight transportation	accidents/ worker/year	0.036	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*

Table L-1 Background Input Data (continued)

3 TRANSPORTATION			
Description	Units	Value	References
Deadly work accidents rate for water transportation	accidents/ worker/year	0.000299	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	158.041	Commonly accepted heating values for diesel fuel

4 SEDIMENT CAPPING			
Description	Units	Value	References
Emission factor for CO_2	lb/gal	29.168	*LCA Database Manual:* The Franklin US98 LCI Library - Excavation model -Excavation Hydraulic digger (Cadotte et al. 2007)
Emission factor for CO	lb/gal	0.1447	
Emission factor for NO_x	lb/gal	0.3417	
Emission factor for SO_x	lb/gal	0.04627	
Emission factor for PM_{10}	lb/gal	0.0489	
Emission factor for CO_2	lb/gal	26.635	*SimaPro 7 Database Manual: The Franklin US98 LCI Library* - Inland Vessel transportation (Goedkoop et al. 2008b)
Emission factor for CO	lb/gal	0.13	
Emission factor for NO_x	lb/gal	0.31	
Emission factor for SO_x	lb/gal	0.04	
Emission factor for PM_{10}	lb/gal	0.45	
Work accidents rate for inland water freight transportation	accidents/ worker/year	0.03600	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for water transportation	accidents/ worker/year	0.00030	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for heavy and civil engineering construction	accidents/ worker/year	0.05100	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for operating engineers and other construction equipment operators	accidents/ worker/year	0.00011	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	158.041	Commonly accepted heating values for diesel fuel

Table L-1 Background Input Data (continued)

4 SEDIMENT CAPPING			
Description	Units	Value	References
Emission factor for CO_2	lb/gal	29.168	*LCA Database Manual:* The Franklin US98 LCI Library- Excavation model -Excavation Hydraulic digger (Cadotte et al. 2007)
Emission factor for CO	lb/gal	0.1447	
Emission factor for NO_x	lb/gal	0.3417	
Emission factor for SO_x	lb/gal	0.04627	
Emission factor for PM_{10}	lb/gal	0.0489	
Emission factor for CO_2	lb/gal	26.635	*SimaPro 7 Database Manual: The Franklin US98 LCI Library* - Inland Vessel transportation (Goedkoop et al. 2008b)
Emission factor for CO	lb/gal	0.13	
Emission factor for NO_x	lb/gal	0.31	
Emission factor for SO_x	lb/gal	0.04	
Emission factor for PM_{10}	lb/gal	0.45	
Work accidents rate for inland water freight transportation	accidents/ worker/year	0.03600	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for water transportation	accidents/ worker/year	0.00030	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for heavy and civil engineering construction	accidents/ worker/year	0.05100	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for operating engineers and other construction equipment operators	accidents/ worker/year	0.00011	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	158.041	Commonly accepted heating values for diesel fuel

Table L-1 Background Input Data (continued)

5 MISCELLANEOUS			
Description	Units	Value	References
Emission factor for CO_2	lb/gal	29.168	*LCA Database Manual:* The Franklin US98 LCI Library- Excavation model -Excavation Hydraulic digger (Cadotte et al. 2007)
Emission factor for CO	lb/gal	0.1447	
Emission factor for NO_x	lb/gal	0.3417	
Emission factor for SO_x	lb/gal	0.04627	
Emission factor for PM_{10}	lb/gal	0.0489	
Work accidents rate for heavy and civil engineering construction	accidents/ worker/year	0.05100	*U.S. Department of Labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)*
Deadly work accidents rate for operating engineers and other construction equipment operators	accidents/ worker/year	0.00011	*U.S. Department of Labor,* Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	158.041	Commonly accepted heating values for diesel fuel

CARBON FOOTPRINT			
Description	Units	Value	References
CO_2 absorbed	$g_{CO2}/g_{biomass}$	2.02	Assumes 55% carbon in the total biomass of Douglas fir (Alfredo Provini et al., Ecologia Applicata, 2003, and Zhou & Hemstrom 2009).
Sequestration rate for Douglas fir in Pacific Coast	metric ton dm/acre year	2.09	Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural & Forestry Practices (EPA 2010c)

Notes:

Distance: average distance is the total distance travelled; one way is the distance to the landfill from the site (will be doubled for calculations).

CO = carbon monoxide; CO_2 = carbon dioxide; dm = dry matter; EPA = U.S. Environmental Protection Agency; gal = gallon; lb = pound; MJ = megajoules; NO_x = nitrogen oxides; PM_{10} = particulate matter with a diameter of 10 µm or less; SO_x = sulphur oxides.

Table L-2 Site-specific Data Input for the Remedial Alternatives

1 DREDGING													
Description	Equipment	Units	Alt 2R-CAD[a]	Alt 3C	Alt 4C	Alt 5C	Alt 6C	Alt 2R	Alt 3R	Alt 4R	Alt 5R	Alt 5R-T[b]	Alt 6R
Volume removed below -10 ft MLLW[c]	barge-mounted derrick crane	cy	809,245	368,429	516,868	564,757	1,234,251	438,245	572,773	863,588	1,237,489	1,237,489	2,957,381
Volume removed above -10 ft MLLW[d]	barge-mounted backhoe	cy	146,082	122,810	172,288	188,252	411,417	146,082	190,925	287,862	412,496	412,496	985,793
Fuel consumption	barge-mounted derrick crane	gal/hr	25	25	25	25	25	25	25	25	25	25	25
	barge-mounted backhoe	gal/hr	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
	survey boat	gal/hr	8	8	8	8	8	8	8	8	8	8	8
Dredging rate[e]	barge-mounted derrick crane	cy/hr	55	55	55	55	55	55	55	55	55	55	55
	barge-mounted backhoe	cy/hr	39	39	39	39	39	39	39	39	39	39	39
Total time required for survey operation	survey boat	hr	918	472	663	724	1,584	562	735	1,108	1,588	1,588	3,795
Number of Water Equipment Operators	—	worker	3	3	3	3	3	3	3	3	3	3	3
Number of Construction Equipment Operators	—	worker	3	3	3	3	3	3	3	3	3	3	3

Table L-2 Site-specific Data Input for the Remedial Alternatives (continued)

2 TRANSLOADING													
Description	Equipment	Units	Alt 2R-CAD[a]	Alt 3C	Alt 4C	Alt 5C	Alt 6C	Alt 2R	Alt 3R	Alt 4R	Alt 5R	Alt 5R-T[b]	Alt 6R
Volume transloaded[f]	tug/barge	cy	955,326	491,239	689,156	753,009	1,645,668	584,326	763,698	1,151,450	1,649,985	1,237,489	3,943,174
Offloading volume material to lined containers[g]	derrick crane	cy	274,326	491,239	689,156	753,009	1,645,668	584,326	763,698	1,151,450	1,649,985	1,237,489	3,943,174
Fuel consumption	tug full engine	gal/hr	85	85	85	85	85	85	85	85	85	85	85
	derrick crane	gal/hr	25	25	25	25	25	25	25	25	25	25	25
Distance from the site to the offloading area	tugs	miles	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Speed	tugs	miles/hr	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Barge capacity	barge	cy	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Offloading rate by derrick crane[e]	derrick crane	cy/hr	110	110	110	110	110	110	110	110	110	110	110
Number of water equipment operators	—	worker	3	3	3	3	3	3	3	3	3	3	3
Number of construction equipment operators	—	worker	3	3	3	3	3	3	3	3	3	3	3

Table L-2 Site-specific Data Input for the Remedial Alternatives (continued)

3 TRANSPORTATION														
Description	Equipment	Units	Alt 2R-CAD[a]	Alt 3C	Alt 4C	Alt 5C	Alt 6C	Alt 2R	Alt 3R	Alt 4R	Alt 5R	Alt 5R-T[b]	Alt 6R
Volume transported	truck[h]	cy	274,326	491,239	689,156	753,009	1,645,668	584,326	763,698	1,151,450	1,649,985	1,237,489	3,943,174
	train[i]	cy	274,326	491,239	689,156	753,009	1,645,668	584,326	763,698	1,151,450	1,649,985	1,237,489	3,943,174
	tug/barge[j]	cy	198,208	268,917	470,460	579,232	1,126,528	124,208	263,690	433,330	588,346	1,000,842	1,190,788
Distance	truck (round trip)	miles	12	12	12	12	12	12	12	12	12	12	12
	train (round trip)	miles	568.6	568.6	568.6	568.6	568.6	568.6	568.6	568.6	568.6	568.6	568.6
Fuel consumption	truck	gal/miles	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	train	gal/miles	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	tug	gal/hr	85	85	85	85	85	85	85	85	85	85	85
Load capacity	truck	cy	20	20	20	20	20	20	20	20	20	20	20
	railcar	cy	67	67	67	67	67	67	67	67	67	67	67
Transportation rate	tug	cy/hr	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7	122.7
Speed	truck	miles/hr	40	40	40	40	40	40	40	40	40	40	40
	train	miles/hr	50	50	50	50	50	50	50	50	50	50	50
Number of trucks used for transportation	truck	—	7	7	7	7	7	7	7	7	7	7	7
Number of operators for truck transportation	—	worker	7	7	7	7	7	7	7	7	7	7	7
Number of operators for rail transportation	—	worker	8	8	8	8	8	8	8	8	8	8	8
Number of water equipment operators	—	worker	2	2	2	2	2	2	2	2	2	2	2

Table L-2 Site-specific Data Input for the Remedial Alternatives (continued)

4 SEDIMENT CAPPING													
Description	Equipment	Units	Alt 2R-CAD[a]	Alt 3C	Alt 4C	Alt 5C	Alt 6C	Alt 2R	Alt 3R	Alt 4R	Alt 5R	Alt 5R-T[b]	Alt 6R
Volume placed below -10 ft MLLW	barge-mounted derrick crane[k]	cy	470,946	188,241	329,322	405,462	788,569	86,946	184,583	303,331	411,842	411,842	833,551
	precision excavator[k]	cy	18,631	40,338	70,569	86,885	168,979	18,631	39,554	65,000	88,252	88,252	178,618
Volume placed above -10 ft MLLW	precision excavator[k]	cy	18,631	40,338	70,569	86,885	168,979	18,631	39,554	65,000	88,252	88,252	178,618
Fuel consumption	barge-mounted derrick crane	gal/hr	25	25	25	25	25	25	25	25	25	25	25
	precision excavator	gal/hr	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
	survey boat	gal/hr	8	8	8	8	8	8	8	8	8	8	8
C = Capping placement rate [e]	barge-mounted derrick crane	cy/hr	163	163	163	163	163	163	163	163	163	163	163
	precision excavator	cy/hr	128	128	128	128	128	128	128	128	128	128	128
Total time required for survey operation	survey boat	hr	145	196	343	423	822	91	192	316	429	429	869
Number of water equipment operators	—	worker	3	3	3	3	3	3	3	3	3	3	3
Number of construction equipment operators	—	worker	3	3	3	3	3	3	3	3	3	3	3

Table L-2 Site-specific Data Input for the Remedial Alternatives (continued)

5 MISCELLANEOUS														
Description	Equipment	Units	Alt 2R-CAD[a]	Alt 3C	Alt 4C	Alt 5C	Alt 6C	Alt 2R	Alt 3R	Alt 4R	Alt 5R	Alt 5R-T[b]	Alt 6R
Volume	loader[l]	cy	274,326	491,239	689,156	753,009	1,645,668	584,326	763,698	1,151,450	1,649,985	1,237,489	3,943,174
Fuel consumption	loader	gal/hr	7	7	7	7	7	7	7	7	7	7	7
Excavation rate[e]	loader	cy/hr	200	200	200	200	200	200	200	200	200	200	200
Number of construction equipment operators	—	worker	2	2	2	2	2	2	2	2	2	2	2

Notes:

1. Values used in all calculations were not rounded.

a. Alternative 2R-CAD assumes that 370,000 cy of sediment will be dredged to construct the CAD. This extra sediment is assumed to be disposed of at the open water disposal site in Elliott Bay. 311,000 cy of contaminated sediment will be placed in the CAD, reducing the amount of sediment sent to the landfill. 74,000 cy of clean import capping material will be used to cover the CAD.
b. Alternative 5R-Treatment assumes that half of the volume dredged in Alternative 5R will be suitable for soil washing. Half of the sediment that undergoes treatment is assumed to require off-site disposal, the other half is assumed to be clean sand. This results in Alternative 5R-T transporting 25% less sediment to the landfill than 5R. Emissions or energy consumed by the soil washing process were not calculated because data required for these calculations were not available.
c. This volume represents the volume of sediment below -10 ft MLLW to be dredged (assumed to be 75% of total dredged material).
d. This volume represents the volume of sediment above -10 ft MLLW to be dredged (assumed to be 25% of total dredged material). This is the volume that the tug/barge combination transports from the dredge site to the transloading facility.
e. Dredge and cap equipment rates are consistent with those developed in Appendix I with exclusion of the effective working time factor (see Tables I-5 and I-6 of Appendix I). The offloading rate by derrick crane was assumed to be twice the derrick crane dredging rate. The loader production rate was based on the 100 HP loader/ 2 cy bucket capacity provided in the SiteWise™ Tool for Green and Sustainable Remediation developed jointly by U.S. Navy, U.S. Army Corps of Engineers, and Battelle (SiteWise™ Version 2.0).
f. This is the volume of dredged material that is barged from the dredging site to the transloading facility except for Alternative 2R-CAD. In Alternative 2R-CAD, approximately 371,000 CY is assumed to be transported to the DMMP site in Elliott Bay for open water disposal.
g. This is the volume of dredged material offloaded from the barge by a derrick crane at the transloading facility.
h. This is the volume of dredged material that is transported by truck from the transloading facility to the train transfer station in Seattle, WA (8 miles round trip), and further transferred by truck from the landfill offloading site to the landfill cell in Roosevelt, WA (4 miles round trip).
i. This is the volume of material transferred from the train transfer station in Seattle, WA to the offloading facility in Roosevelt, WA.
j. This is the volume of clean capping material barged in from the commercial quarry to the project site.
k. These volumes represent the volume of clean material for capping, ENR, and backfill required. The material is assumed to be placed by barge mounted derrick crane below -10 ft MLLW (assumed to be 70% of total material), precision excavator below -10 ft MLLW (assumed to be 15% of total material), and precision excavator above -10 ft MLLW (assumed to be 15% of total material).
l. This is the volume of contaminated sediment to be handled by a front end loader at the landfill facility.

C = combined-technology alternative; CAD = contained aquatic disposal; cy = cubic yard; DMMP = Dredged Material Management Program; ENR = enhanced natural recovery; ft = feet; gal = gallon; HP = horsepower; lb = pound; MLLW = mean lower low water; hr = hour; R = removal emphasis alternative; R-T = removal emphasis with treatment.

Table L-3 Short-term Effectiveness Metrics Summary Output

Summary			Alt 2R-CAD		Alt 3C		Alt 4C		Alt 5C		Alt 6C	
Gas Emission	CO_2 emissions	metric ton	E_{CO2}	17,020	E_{CO2}	18,516	E_{CO2}	26,857	E_{CO2}	29,964	E_{CO2}	64,162
	CO emissions	metric ton	E_{CO}	53	E_{CO}	49	E_{CO}	71	E_{CO}	79	E_{CO}	170
	NO_x emissions	metric ton	E_{NOx}	284	E_{NOx}	364	E_{NOx}	522	E_{NOx}	578	E_{NOx}	1,246
	SO_x emissions	metric ton	E_{SOx}	13	E_{SOx}	9	E_{SOx}	13	E_{SOx}	14	E_{SOx}	30
	PM_{10} emissions	metric ton	E_{PM10}	18	E_{PM10}	15	E_{PM10}	22	E_{PM10}	25	E_{PM10}	53
Energy	Energy consumption	MJ	E	2.28E+08	E	2.56E+08	E	3.72E+08	E	4.15E+08	E	8.89E+08
Landfill	Volume (20% bulking factor)	cy	LF	329,191	LF	589,487	LF	826,987	LF	903,611	LF	1,974,802
Work Accidents	Expected number of accidents during remediation activities	—	N_I	8.94E+00	N_I	1.32E+01	N_I	1.86E+01	N_I	2.04E+01	N_I	4.43E+01
	Expected number of deadly accidents during remediation activities	—	N_F	2.80E-02	N_F	4.28E-02	N_F	6.05E-02	N_F	6.64E-02	N_F	1.45E-01
Carbon Footprint		Acre-Years	EF	4,029	EF	4,384	EF	6,358	EF	7,094	EF	15,190

Notes:

Green text indicates the lowest effects.

Red text indicates the highest effects.

C = combined-technology alternative; CAD = contained aquatic disposal; CO = carbon monoxide; CO_2 = carbon dioxide; cy = cubic yard; µm = micrometer; MJ = megajoule; NO_x = nitrogen oxides; PM_{10} = particulate matter with a diameter of 10 µm or less; SO_x = sulphur oxides.

Table L-3 Short-term Effectiveness Metrics Summary Output (continued)

Summary			Alt 2R		Alt 3R		Alt 4R		Alt 5R		Alt 5R-T		Alt 6R	
Gas Emission	CO_2 emissions	metric ton	E_{CO2}	20,167	E_{CO2}	27,318	E_{CO2}	41,525	E_{CO2}	59,196	E_{CO2}	51,226	E_{CO2}	139,421
	CO emissions	metric ton	E_{CO}	55	E_{CO}	74	E_{CO}	112	E_{CO}	160	E_{CO}	138	E_{CO}	379
	NO_x emissions	metric ton	E_{NOx}	410	E_{NOx}	547	E_{NOx}	830	E_{NOx}	1,185	E_{NOx}	973	E_{NOx}	2,806
	SO_x emissions	metric ton	E_{SOx}	10	E_{SOx}	13	E_{SOx}	20	E_{SOx}	28	E_{SOx}	26	E_{SOx}	66
	PM_{10} emissions	metric ton	E_{PM10}	17	E_{PM10}	23	E_{PM10}	35	E_{PM10}	50	E_{PM10}	44	E_{PM10}	118
Energy	Energy consumption	MJ	E	2.79E+08	E	3.78E+08	E	5.75E+08	E	8.28E+08	E	7.07E+08	E	1.93E+09
Landfill	Volume (20% bulking factor)	cy	LF	701,191	LF	916,438	LF	1,381,740	LF	1,979,982	LF	1,484,987	LF	4,731,809
Work Accidents	Expected number of accidents during remediation activities	—	N_I	1.54E+01	N_I	2.03E+01	N_I	3.06E+01	N_I	4.39E+01	N_I	3.40E+01	N_I	1.05E+02
	Expected number of deadly accidents during remediation activities	—	N_F	5.00E-02	N_F	6.58E-02	N_F	9.94E-02	N_F	1.42E-01	N_F	1.11E-01	N_F	3.39E-01
Carbon Footprint		Acre-Years	EF	4,775	EF	6,468	EF	9,831	EF	14,015	EF	12,128	EF	33,008

Notes:

Green text indicates the lowest effects.

Red text indicates the highest effects.

CO = carbon monoxide; CO_2 = carbon dioxide; cy = cubic yard; µm = micrometer; MJ = megajoule; NO_x = nitrogen oxides; PM_{10} = particulate matter with a diameter of 10 µm or less; R = removal emphasis alternative; R-T = removal-emphasis with treatment; SO_x = sulphur oxides.

Table L-4 Summary of Carbon Dioxide Emissions by Remedial Alternative and Methods to Reduce Emissions

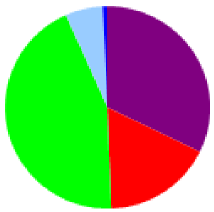
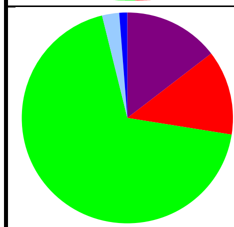
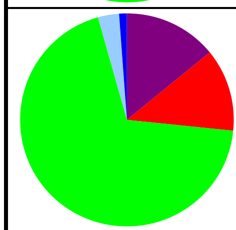
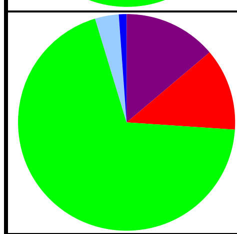
Total Carbon (CO_2) Footprint	Remedial Alternative	CO_2 Amounts (metric tons) (percentage of total [a])						Methods to Reduce/Limit Carbon Footprint and Best Management Practices (BMPs)
		Dredging	Transloading	Transportation	Capping	Miscellaneous	Total	
	Alt 2R-CAD	5,481 (32%)	2,940 (17%)	7,462 (44%)	1,010 (6%)	127 (1%)	17,020	<u>CO_2 Reduction BMPs</u> 1. Use biodiesel in small-scale construction equipment and trucks. <u>Remedial Design BMPs</u> 1. Collect location-specific data. 2. Accurately delineate contaminated sediment and sediment management areas to minimize dredging volume. 3. Perform construction sequentially. 4. Analyze alternative technologies. 5. Select a landfill that collects methane. 6. Incorporate sustainable site design. 7. Use Environmental Management System Practices. 8. Recycle uncontaminated materials. 9. Use renewable energy resources. 10. Limit on-site vehicle speeds. 11. Select properly sized equipment. 12. Select fuel-efficient equipment/vehicles and alternative fuel vehicles. 13. Select equipment fitted with advanced emission control systems. 14. Consider Tier 2 engines for equipment.
	Alt 3C	2,703 (15%)	2,395 (13%)	12,702 (69%)	489 (3%)	227 (1%)	18,516	
	Alt 4C	3,792 (14%)	3,355 (13%)	18,535 (69%)	856 (3%)	319 (1%)	26,857	
	Alt 5C	4,143 (14%)	3,667 (12%)	20,751 (69%)	1,054 (3%)	349 (1%)	29,964	

Table L-4 Summary of Carbon Dioxide Emissions by Remedial Alternative and Methods to Reduce Emissions (continued)

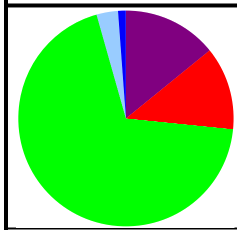
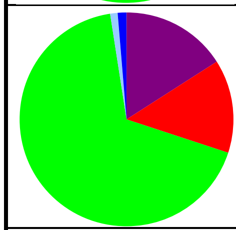
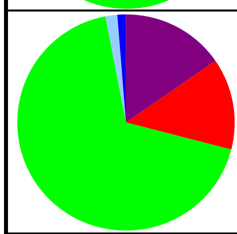
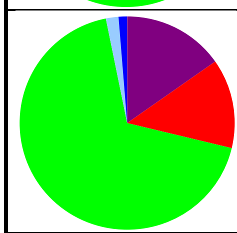
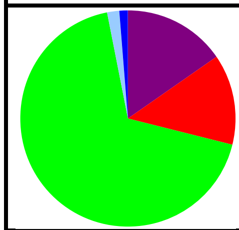
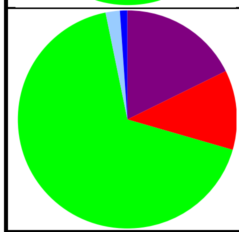
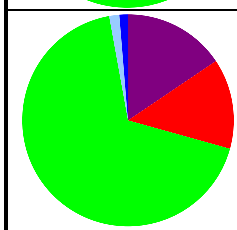
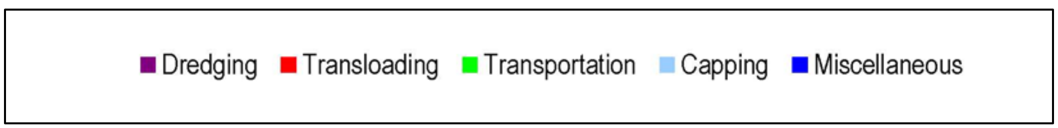
Total Carbon (CO_2) Footprint	Remedial Alternative	CO_2 Amounts (metric tons) (percentage of total [a])						Methods to Reduce/Limit Carbon Footprint and Best Management Practices (BMPs)
		Dredging	Transloading	Transportation	Capping	Miscellaneous	Total	
	Alt 6C	9,055 (14%)	8,012 (12%)	44,283 (69%)	2,050 (3%)	762 (1%)	64,162	15. Select efficient modes of transportation for movement of materials. 16. Select lower GHG emitting fuel sources (i.e. biodiesel). 17. Consider alternatives to diesel-powered generators. 18. Consider salvaging existing structures. 19. Search on-site for potential backfill and reuse on-site material when possible. 20. Select equipment and processes that minimize the usage of water, and promote water reuse and conservation. 21. Adopt environmentally preferable purchasing practices. 22. Select suitable types of equipment and vehicles capable of handling alternative fuels and fuel additives (i.e., ultra low sulphur fuel). 23. Optimization of the transloading process by selecting efficient modes of transportation for movement of materials (e.g., rail vs. truck transport).
	Alt 2R	3,215 (16%)	2,847 (14%)	13,608 (67%)	226 (1%)	271 (1%)	20,167	
	Alt 3R	4,202 (15%)	3,720 (14%)	18,562 (68%)	480 (2%)	354 (1%)	27,318	
	Alt 4R	6,336 (15%)	5,606 (13%)	28,261 (68%)	789 (2%)	533 (1%)	41,525	

Table L-4 Summary of Carbon Dioxide Emissions by Remedial Alternative and Methods to Reduce Emissions (continued)

Total Carbon (CO_2) Footprint	Remedial Alternative	CO_2 Amounts (metric tons) (percentage of total [a])						Methods to Reduce/Limit Carbon Footprint and Best Management Practices (BMPs)
		Dredging	Transloading	Transportation	Capping	Miscellaneous	Total	
	Alt 5R	9,079 (15%)	8,034 (14%)	40,248 (68%)	1,071 (2%)	764 (1%)	59,196	Construction BMPs 1. Impose idling restrictions on construction equipment. 2. Conduct regular equipment and vehicle maintenance. 3. Develop transportation and site management plans that emphasize fuel efficiency and handling.
	Alt 5R-T	9,079 (18%)	6,025 (12%)	34,478 (67%)	1,071 (2%)	573 (1%)	51,226	
	Alt 6R	21,697 (16%)	19,195 (14%)	94,536 (68%)	2,167 (2%)	1,826 (1%)	139,421	

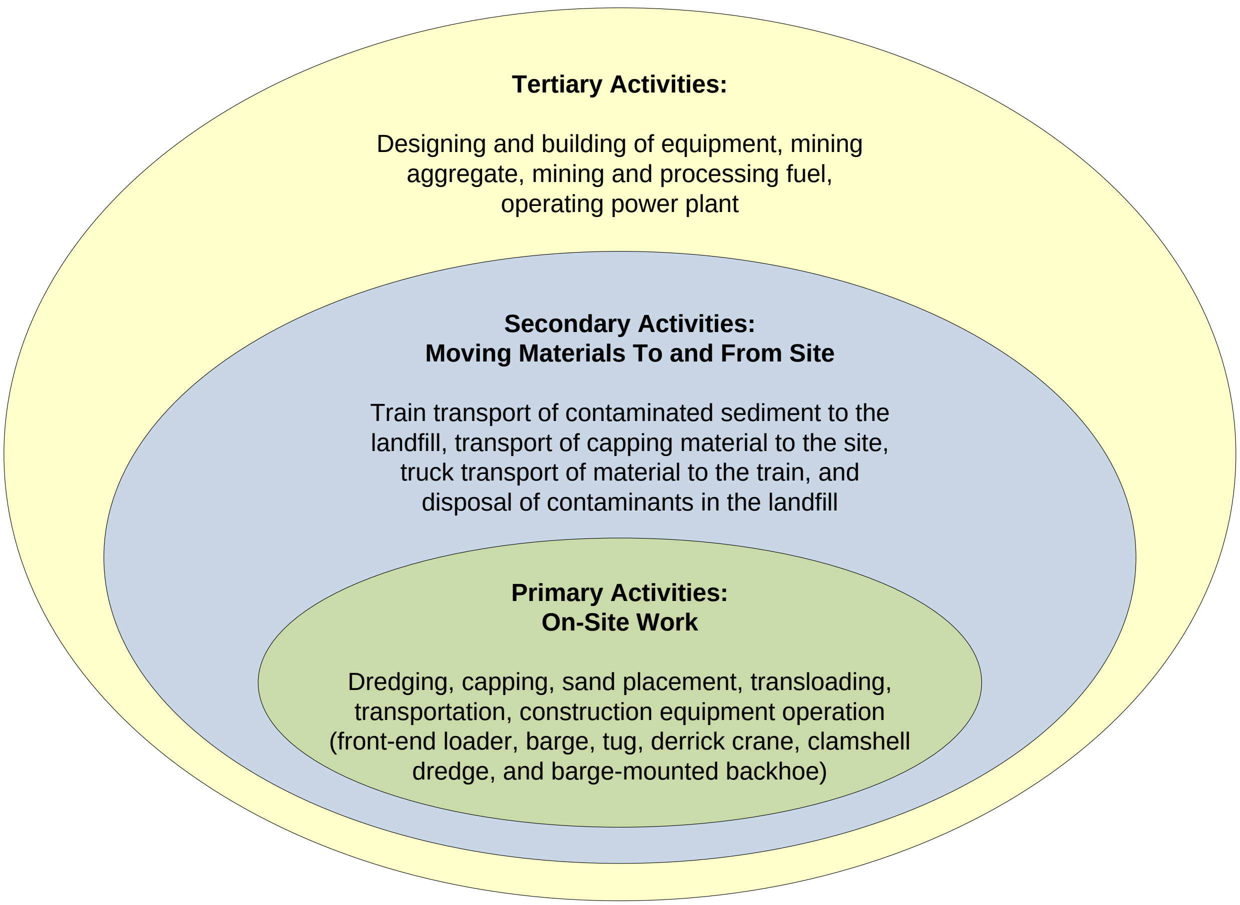
Notes:



a. Percentages shown in this table are rounded. Therefore, hand-calculated totals of these percentages may slightly exceed or fall short of 100%.

BMPs = best management practices; C = combined-technology alternative; CAD = contained aquatic disposal; CO_2 = carbon dioxide; GHG = greenhouse gas; R = removal emphasis alternative; R-T = removal-emphasis with treatment.

Figure L-1 Life Cycle of the Remediation Activities Concept Diagram



Lower Duwamish Waterway Group

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

Appendix M
Other Analyses

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Table of Contents

Introduction

This appendix presents supporting information and memoranda for the Lower Duwamish Waterway Feasibility Study (LDW FS), which include other predicted model results, residual risk tables, and additional analyses for the remedial alternatives. Appendix M is organized as follows:

- **Part 1 (Remaining Bed Composition Model [BCM] Output, Residual Risks, and Bed Replacement Value Sensitivity Runs):** Predicted concentrations of the four human health risk drivers in surface sediment during and following construction and the associated excess cancer risks and non-cancer hazard quotients are presented in Part 1 of this Appendix. These include predicted surface sediment concentrations of the four human health risk drivers for three LDW reaches[1] (Table M-1) and surface sediment concentrations and associated risk for intertidal areas above minus 4 ft MLLW elevation (Table M-2). For these evaluations, the BCM was applied to natural processes only. No variation in bed composition prediction associated with anthropogenic activity was included. The effects of anthropogenic activity on predicted concentration of the human health risk drivers are discussed in Section 10. For each remedial alternative, Tables M-3 and M-4 present estimated total PCB risks for alternative human health seafood consumption scenarios (i.e., other than the reasonable maximum exposure [RME] scenarios presented in Section 9 of the FS). Table M-5 series presents estimated risks for human health direct contact scenarios for each risk driver (only cumulative excess cancer risks were shown in Table 9-8). Section 9 of the FS includes model-predicted surface sediment concentrations for the human health risk drivers and the associated risks predicted based on use of the mid-bed composition model (BCM) input parameters. BCM sensitivity around those values is presented in this appendix using the low and high input parameters for upstream, lateral, and post-bed sediment replacement values. Specifically, low and high sensitivity of spatially-weighted average concentrations (SWACs) of the human health risk drivers and corresponding excess cancer risks for human health direct contact RME scenarios are presented in the Table M-6 series and the Table M-7 series. Finally, sensitivity runs specific to the post-remedy bed sediment replacement values using total PCBs are presented in Table M-8 and Figures M-1 through M-24. Tables M-9a and M-9b provide the summary statistics for subsurface total PCB concentrations remaining within AOPC 1 and AOPC 2, outside of EAAs, and the dredge and cap footprints. Tables M-9c and M-9d provide the summary statistics for subsurface total PCB concentrations remaining within the cap and partial cap and dredge footprints. These tables and figures support remedial alternative analyses presented in Sections 9 and 10 of the FS.

[1] The three LDW reaches are River Mile [RM] 0 to 2.2, RM 2.2 to 4 and RM 4 to 5 based on the physical conceptual site model, hydrodynamic model, and sediment transport model developed for the LDW.

- **Part 2 (Memorandum – Estimate of PCB Export from the Lower Duwamish Waterway):** This memorandum presents estimated PCB exports resulting from losses during remedial dredging. It also presents estimated PCB exports from upstream- and lateral-source sediment, and those losses associated with resuspended bed-source sediments (resulting from natural erosion). PCB exports are also discussed in Section 9.1.2.3 (Short-Term Effectiveness) of the FS.
- **Part 3 (Memorandum – Change in Total PCB Mass in Surface Sediment for Remedial Alternatives Calculated Using the Bed Composition Model):** This memorandum discusses the mass of total PCBs remaining in the top 10 cm of surface sediment following remediation for each alternative, and the change in mass compared to baseline conditions. These mass estimates do not include the influence of anthropogenic activity on the mixing of sediments. Other estimates of residual risks remaining in surface sediments are also discussed in Section 9.1.2.1 (Long-term Effectiveness and Permanence) and Section 9.3.5 (uncertainty section).
- **Part 4 (Food Web Model Sensitivity):** This part of Appendix M presents the food web model output and associated predicted seafood consumption risks based on different assumptions of total PCB concentrations in water, as shown in Figure 1. Figure 2 presents the food web model output and associated predicted seafood consumption risks based on low, mid, and high BCM inputs for upstream, lateral, and post-bed sediment replacement values. These sensitivity runs are discussed in Section 9.3.2 (Changes in Tissue Concentrations for Total PCBs) of the FS.
- **Part 5 (Memorandum – Potential Increase in Surface Sediment Concentrations Due to Disturbance of Subsurface Sediments):** This memorandum was developed to address agency concerns regarding the potential for remaining subsurface sediment contamination to be exposed following active remediation. Methods are presented for estimating the potential effect of deep disturbance events on the long-term model-predicted surface weighted average sediment concentrations (SWAC) for total PCBs. These results are evaluated as one component of long-term effectiveness for the remedial alternatives in Section 9.1.2.1 (Long-term Effectiveness and Permanence).

Part 1: Bed Replacement Value Runs

List of Tables

List of Figures

Table M-1 Effectiveness Evaluation – Predicted Post-Construction Arsenic, Total PCB, cPAH, and Dioxin/Furan SWACs by Reach

Arsenic (mg/kg dw) (RAO 2)

Alternative	Active Area in FS Study Area (acres)	Construc-tion Period (years)	Netfishing Direct Contact 10^{-6} RBTC = 3.7 PRG = Background = 7.0																													
			Reach 1 Baseline = 17										Reach 2 Baseline = 16										Reach 3 Baseline = 10									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
			0 [a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	17	13	11	9.9	9.5	9.4	9.3	9.3	9.2	9.2	16	12	11	11	12	11	11	10	10	11	10	9.4	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 3C	58	3	17	11	9.9	9.5	9.3	9.2	9.2	9.2	9.2	9.1	16	9.5	9.3	9.2	9.2	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 4C	107	6	17	10	9.8	9.5	9.3	9.2	9.2	9.2	9.2	9.1	16	9.6	9.3	9.2	9.2	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 5C	157	7	17	10	9.8	9.4	9.3	9.2	9.2	9.2	9.2	9.1	16	9.6	9.3	9.2	9.2	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 6C	302	16	17	10	9.8	9.4	9.1	9.1	9.1	9.1	9.1	9.1	16	9.6	9.3	9.2	9.2	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 2R	32	4	17	11	10	9.6	9.4	9.3	9.2	9.2	9.2	9.1	16	9.5	9.3	9.2	9.2	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 3R	58	6	17	11	9.9	9.5	9.3	9.2	9.2	9.2	9.2	9.1	16	9.5	9.3	9.2	9.2	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 4R	107	11	17	11	9.9	9.5	9.3	9.2	9.2	9.2	9.2	9.1	16	9.5	9.4	9.2	9.2	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.0
Alternative 5R	157	17	17	11	9.9	9.5	9.4	9.3	9.3	9.2	9.2	9.1	16	9.5	9.4	9.2	9.3	9.2	9.2	9.2	9.1	9.1	10	9.3	9.2	9.1	9.2	9.1	9.1	9.1	9.1	9.0
Alternative 6R	302	42	17	11	9.9	9.5	9.4	9.3	9.2	9.2	9.1	9.1	16	9.5	9.4	9.2	9.3	9.2	9.2	9.1	9.1	9.1	10	9.3	9.2	9.1	9.2	9.1	9.1	9.1	9.1	9.0

Total PCBs (µg/kg dw) (RAOs 1, 2 and 4)

Alternative	Active Area in FS Study Area (acres)	Construc-tion Period (years)	Site-wide Netfishing Direct Contact: PRG = 10^{-6} RBTC = 1,300 Seafood Consumption - Human: PRG = Background = 2 Seafood Consumption - Ecological (otter): PRG = 128 - 159																													
			Reach 1 Baseline = 250										Reach 2 Baseline = 660										Reach 3 Baseline = 56									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
			0 [a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	190	120	84	60	51	48	48	46	45	43	220	98	67	57	61	55	52	47	47	46	56	40	40	38	38	38	39	38	38	37
Alternative 3C	58	3	190	99	73	55	48	45	45	44	44	42	220	83	61	54	57	53	50	45	45	44	56	41	40	38	38	38	38	38	38	37
Alternative 4C	107	6	190	83	64	51	46	44	44	44	43	42	220	76	57	51	54	50	48	44	44	43	56	41	40	38	38	38	38	38	38	37
Alternative 5C	157	7	190	83	58	49	45	44	44	44	43	42	220	76	57	50	53	50	48	44	44	43	56	41	40	38	38	38	38	38	38	37
Alternative 6C	302	16	190	83	58	47	36	39	41	42	42	41	220	76	57	36	41	41	42	41	41	40	56	41	40	35	38	38	38	38	38	37
Alternative 2R	32	4	190	106	77	58	50	47	47	46	45	43	220	85	63	55	58	54	51	46	46	45	56	40	40	38	38	38	39	38	38	37
Alternative 3R	58	6	190	99	73	55	48	45	45	44	44	42	220	83	61	54	57	53	50	45	45	44	56	41	40	38	38	38	38	38	38	37
Alternative 4R	107	11	190	99	73	53	47	45	45	44	44	42	220	83	59	51	54	50	48	44	44	43	56	41	41	38	38	38	38	38	38	37
Alternative 5R	157	17	190	99	73	53	48	45	45	44	44	42	220	83	59	51	54	50	48	44	44	43	56	41	41	38	39	38	38	38	38	37
Alternative 6R	302	42	190	99	73	53	48	45	43	41	38	39	220	83	59	51	54	39	38	40	41	40	56	41	41	38	39	35	38	38	38	37

Table M-1 Effectiveness Evaluation – Predicted Post-Construction Arsenic, Total PCB, cPAH, and Dioxin/Furan SWACs by Reach

cPAHs (µg TEQ/kg dw) (RAO 2)

Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	Netfishing Direct Contact; 10^{-6} RBTC = 380; PRG = 380																													
			Reach 1, Baseline = 450										Reach 2, Baseline = 370										Reach 3, Baseline = 200									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
			0[a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	430	280	200	140	120	110	110	110	110	102	280	150	130	120	130	120	120	107	108	104	200	107	97	87	90	86	92	85	87	81
Alternative 3C	58	3	430	230	170	130	110	109	110	110	109	101	280	130	120	106	110	108	108	100	101	96	200	100	94	86	90	86	88	84	87	81
Alternative 4C	107	6	430	200	150	120	109	107	110	110	109	101	280	130	110	104	110	106	106	100	101	95	200	100	94	86	90	86	88	84	86	81
Alternative 5C	157	7	430	200	150	120	108	106	110	110	108	101	280	130	110	104	110	106	106	100	101	95	200	100	95	86	90	86	88	84	86	81
Alternative 6C	302	16	430	200	150	120	105	104	108	108	107	100	280	130	110	104	104	102	103	98	100	94	200	100	95	85	89	86	88	84	86	81
Alternative 2R	32	4	430	250	180	130	120	110	110	110	110	102	280	140	120	110	120	110	110	103	104	99	200	103	96	86	90	86	90	85	87	81
Alternative 3R	58	6	430	230	170	130	110	109	110	110	109	101	280	130	120	106	110	108	108	100	101	96	200	100	94	86	90	86	88	84	87	81
Alternative 4R	107	11	430	230	170	120	110	108	110	110	109	101	280	130	120	103	110	106	106	100	101	95	200	100	96	86	90	86	88	84	86	81
Alternative 5R	157	17	430	230	170	120	120	110	110	110	109	101	280	130	120	103	110	106	106	100	101	95	200	100	96	86	91	86	88	84	86	81
Alternative 6R	302	42	430	230	170	120	120	110	110	110	108	100	280	130	120	103	110	107	104	98	100	94	200	100	96	86	91	85	88	84	86	81

Dioxin/Furan (ng TEQ/kg dw) (RAOs 1 and 2)

Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	Site-wide; Netfishing Direct Contact: PRG = 10^{-6} RBTC = 37; Seafood Consumption - Human: PRG = Background = 2																													
			Reach 1, Baseline = 39										Reach 2, Baseline = 9.7										Reach 3, Baseline = 4.8									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
			0[a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[a]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	36	18	10	6.2	5.2	4.8	4.7	4.6	4.5	4.4	8	5	4.7	4.4	4.6	4.5	4.5	4.4	4.4	4.3	5	4	4.3	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 3C	58	3	36	6.8	5.7	4.9	4.6	4.5	4.5	4.5	4.5	4.4	8	4.7	4.5	4.3	4.5	4.4	4.4	4.3	4.3	4.2	5	4.2	4.2	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 4C	107	6	36	6.0	5.3	4.7	4.5	4.5	4.5	4.5	4.5	4.4	8	4.4	4.3	4.3	4.4	4.4	4.4	4.3	4.3	4.2	5	4.2	4.2	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 5C	157	7	36	6.0	4.9	4.5	4.4	4.4	4.5	4.5	4.5	4.4	8	4.4	4.3	4.3	4.4	4.4	4.4	4.3	4.3	4.2	5	4.2	4.2	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 6C	302	16	36	6.0	4.9	4.5	4.3	4.3	4.4	4.4	4.4	4.3	8	4.4	4.3	4.1	4.3	4.3	4.3	4.3	4.3	4.2	5	4.2	4.2	4.0	4.1	4.2	4.2	4.1	4.2	4.1
Alternative 2R	32	4	36	7.2	5.9	5.0	4.7	4.6	4.6	4.5	4.5	4.4	8	4.8	4.5	4.4	4.5	4.5	4.5	4.3	4.3	4.3	5	4.2	4.3	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 3R	58	6	36	6.8	5.7	4.9	4.6	4.5	4.5	4.5	4.5	4.4	8	4.7	4.5	4.3	4.5	4.4	4.4	4.3	4.3	4.2	5	4.2	4.2	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 4R	107	11	36	6.8	5.7	4.7	4.5	4.5	4.5	4.5	4.5	4.4	8	4.7	4.3	4.3	4.4	4.4	4.4	4.3	4.3	4.2	5	4.2	4.2	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 5R	157	17	36	6.8	5.7	4.7	4.4	4.4	4.5	4.5	4.5	4.4	8	4.7	4.3	4.3	4.4	4.4	4.4	4.3	4.3	4.2	5	4.2	4.2	4.1	4.2	4.2	4.2	4.2	4.2	4.1
Alternative 6R	302	42	36	6.8	5.7	4.7	4.4	4.4	4.4	4.4	4.4	4.3	8	4.7	4.3	4.3	4.4	4.3	4.3	4.3	4.3	4.2	5	4.2	4.2	4.1	4.2	4.1	4.2	4.1	4.2	4.1

Notes:
1. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
2. Reach 1 = RM 0 to RM 2.2; Reach 2 = RM 2.2 to RM. 4.0; Reach 3 = RM 4.0 to RM 5.0 from STM report (QEA 2008).
3. BCM model area = 430 acres and FS study area = 441 acres

a. The 5-year model-predicted intervals associated with the BCM SWAC output are indexed to the start of construction for Alternatives 2 through 6. BCM SWAC output shown for Alternative 1 after EAA construction is completed.

(shaded) BCM output used as approximation (estimate) of concentrations after construction.

BCM = bed composition model; C = combined technology; cPAH = carcinogenic polycyclic aromatic hydrocarbon; dw = dry weight; EAA = early action area; FS = feasibility study; kg = kilograms; µg = micrograms; mg = milligrams; ng = nanograms; PCB = polychlorinated biphenyl; PRG = preliminary remediation goal; R = removal emphasis; RAO = remedial action objective; RBTC = risk-based threshold concentration; RM = river mile; STM = sediment transport model; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent;
UCL95 = 95% upper confidence limit

Table M-2 Effectiveness Evaluation – Predicted Post-Construction Arsenic, Total PCB, cPAH, and Dioxin/Furan SWACs and Resulting Individual Chemical Risks in Intertidal Areas

Arsenic (mg/kg dw)

Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	Intertidal SWAC [a] Baseline = 15										Intertidal Risk [a]									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
			0 [b]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [b]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	15	12	11	11	10	10	10	10	10.2	10	1E-05	9E-06	9E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06
Alternative 3C	58	3	15	10	9.4	9.3	9.2	9.2	9.2	9.2	9.2	9.1	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 4C	107	6	15	10	9.4	9.3	9.2	9.2	9.2	9.2	9.2	9.2	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 5C	157	7	15	10	9.5	9.3	9.3	9.2	9.2	9.2	9.2	9.2	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 6C	302	16	15	10	9.5	9.3	9.2	9.2	9.2	9.2	9.2	9.1	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 2R	32	4	15	10	10	9.3	9.3	9.2	9.2	9.2	9.2	9.2	1E-05	8E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 3R	58	6	15	10	9.4	9.3	9.2	9.2	9.2	9.2	9.2	9.1	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 4R	107	11	15	10	9.4	9.3	9.3	9.2	9.2	9.2	9.2	9.2	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 5R	157	17	15	10	9.4	9.3	9.3	9.3	9.2	9.2	9.2	9.2	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06
Alternative 6R	302	42	15	10	9.4	9.3	9.3	9.2	9.2	9.2	9.2	9.1	1E-05	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06	7E-06

Total PCBs (µg/kg dw)

Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	Intertidal SWAC [a] Baseline = 500										Intertidal Risk [a]									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
			0 [b]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [b]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	185	93	67	54	51	50	49	47	47	45	4E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08
Alternative 3C	58	3	185	68	57	50	48	47	47	45	45	44	4E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08
Alternative 4C	107	6	185	63	54	48	46	46	46	44	45	43	4E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08	9E-08
Alternative 5C	157	7	185	63	53	47	46	45	45	44	44	43	4E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08	9E-08	9E-08
Alternative 6C	302	16	185	63	53	44	41	42	43	42	43	42	4E-07	1E-07	1E-07	9E-08	8E-08	8E-08	9E-08	8E-08	9E-08	8E-08
Alternative 2R	32	4	185	74	60	52	49	48	48	46	46	45	4E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08
Alternative 3R	58	6	185	68	57	50	48	47	47	45	45	44	4E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08
Alternative 4R	107	11	185	68	56	49	47	46	46	44	45	43	4E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08	9E-08
Alternative 5R	157	17	185	68	56	49	48	46	46	45	45	43	4E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08
Alternative 6R	302	42	185	68	56	49	48	44	44	42	41	41	4E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	8E-08	8E-08	8E-08

Table M-2 Effectiveness Evaluation – Predicted Post-Construction Arsenic, Total PCB, cPAH, and Dioxin/Furan SWACs and Resulting Individual Chemical Risks in Intertidal Areas

cPAHs (µg TEQ/kg dw)

Alternative	Active Area in FS Study Area (acres)	Construc-tion Period (years)	Intertidal SWAC [a] Baseline = 410										Intertidal Risk [a]									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
			0 [b]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [b]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	331	206	161	130	124	120	120	115	116	109	2E-06	1E-06	1E-06	9E-07	8E-07	8E-07	8E-07	8E-07	8E-07	7E-07
Alternative 3C	58	3	331	144	126	111	110	109	110	107	109	102	2E-06	1E-06	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07
Alternative 4C	107	6	331	139	123	110	109	108	110	107	109	102	2E-06	9E-07	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07
Alternative 5C	157	7	331	139	125	109	109	108	110	107	109	102	2E-06	9E-07	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07
Alternative 6C	302	16	331	139	125	108	108	107	109	107	108	101	2E-06	9E-07	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07
Alternative 2R	32	4	331	182	148	122	118	115	115	110	112	105	2E-06	1E-06	1E-06	8E-07	8E-07	8E-07	8E-07	7E-07	7E-07	7E-07
Alternative 3R	58	6	331	144	126	111	110	109	110	107	109	102	2E-06	1E-06	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07
Alternative 4R	107	11	331	144	127	111	110	108	110	107	109	102	2E-06	1E-06	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07
Alternative 5R	157	17	331	144	127	111	113	110	112	108	109	102	2E-06	1E-06	8E-07	7E-07	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07
Alternative 6R	302	42	331	144	127	111	113	109	110	108	109	102	2E-06	1E-06	8E-07	7E-07	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07

Dioxin/Furan (ng TEQ/kg dw)

Alternative	Active Area in FS Study Area (acres)	Construc-tion Period (years)	Intertidal SWAC [a] Baseline = 29										Intertidal Risk [a]									
			Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
			0 [b]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [b]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	27	13	8.1	5.5	4.9	4.7	4.6	4.5	4.5	4.4	2E-06	1E-06	6E-07	4E-07	4E-07	4E-07	4E-07	3E-07	3E-07	3E-07
Alternative 3C	58	3	27	5.3	5.0	4.6	4.5	4.4	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 4C	107	6	27	5.2	4.9	4.5	4.5	4.4	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 5C	157	7	27	5.2	4.6	4.4	4.4	4.4	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 6C	302	16	27	5.2	4.6	4.4	4.3	4.3	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 2R	32	4	27	5.7	5.2	4.7	4.6	4.5	4.5	4.4	4.4	4.3	2E-06	4E-07	4E-07	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 3R	58	6	27	5.3	5.0	4.6	4.5	4.4	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 4R	107	11	27	5.3	4.9	4.5	4.5	4.4	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 5R	157	17	27	5.3	4.9	4.5	4.4	4.4	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Alternative 6R	302	42	27	5.3	4.9	4.5	4.4	4.3	4.4	4.4	4.4	4.3	2E-06	4E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07

Notes:

1. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
2. BCM model area = 430 acres and FS study area = 441 acres

a. Intertidal SWACs and individual contaminant risk information are provided for informational purposes. Excess cancer risks are calculated using tribal clamming exposure assumptions.

b. The 5-year model-predicted intervals associated with the BCM SWAC output are indexed to the start of construction for Alternatives 2 through 6.
BCM SWAC output shown for Alternative 1 after EAA construction is completed.

BCM output used as approximation (estimate) of concentrations/risks after construction.

BCM = bed composition model; C = combined technology; cPAH = carcinogenic polycyclic aromatic hydrocarbon; dw = dry weight; EAA = early action area; FS = feasibility study; kg = kilogram; µg = micrograms; mg = milligrams; ng = nanograms; PCB = polychlorinated biphenyl; PRG = preliminary remediation goal; R = removal emphasis; RAO = remedial action objective; RBTC = risk-based threshold concentration; RM = river mile; STM = sediment transport model; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent; UCL95 = 95% upper confidence limit

Table M-3 Excess Cancer Risks for non-RME Seafood Consumption Scenarios Associated with Alternative-Specific Residual Sediment Total PCB SWACs Over Time

Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	Adult Tribal CT (Tulalip data)										Child Tribal CT (Tulalip data)									
			Time from Beginning of Construction (years) [a]										Time from Beginning of Construction (years) [a]									
			0	5	10	15	20	25	30	35	40	45	0	5	10	15	20	25	30	35	40	45
EAA-Alternative 1	29	<5	5×10^{-4}	4×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	7×10^{-5}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 3C	58	3	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 4C	107	6	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 5C	157	7	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 6C	302	16	5×10^{-4}			2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}			3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 2R	32	4	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 3R	58	6	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 4R	107	11	5×10^{-4}		2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}		4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 5R	157	17	5×10^{-4}			2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}			4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 6R	302	42	5×10^{-4}								2×10^{-4}	2×10^{-4}	1×10^{-4}								3×10^{-5}	3×10^{-5}

Alternative	Adult API CT										Adult Tribal (Suquamish data)									
	Time from Beginning of Construction (years) [a]										Time from Beginning of Construction (years) [a]									
	0	5	10	15	20	25	30	35	40	45	0	5	10	15	20	25	30	35	40	45
EAA-Alternative 1	2×10^{-4}	1×10^{-4}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	2×10^{-4}	1×10^{-4}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}
Alternative 3C	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 4C	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 5C	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 6C	2×10^{-4}			5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}			5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 2R	2×10^{-4}	9×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	9×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 3R	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 4R	2×10^{-4}		7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}		7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 5R	2×10^{-4}			6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}			6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 6R	2×10^{-4}								5×10^{-5}	5×10^{-5}	2×10^{-4}								5×10^{-5}	5×10^{-5}

Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	One Meal Per Month																			
			Benthic Fish										Pelagic Fish									
			Time from Beginning of Construction (years) [a]										Time from Beginning of Construction (years) [a]									
			0	5	10	15	20	25	30	35	40	45	0	5	10	15	20	25	30	35	40	45
EAA-Alternative 1	29	<5	5×10^{-4}	4×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	7×10^{-5}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 3C	58	3	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 4C	107	6	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 5C	157	7	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 6C	302	16	5×10^{-4}			2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}			3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 2R	32	4	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 3R	58	6	5×10^{-4}	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}	5×10^{-5}	4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 4R	107	11	5×10^{-4}		2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}		4×10^{-5}	4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 5R	157	17	5×10^{-4}			2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	1×10^{-4}			4×10^{-5}	4×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}	3×10^{-5}
Alternative 6R	302	42	5×10^{-4}								2×10^{-4}	2×10^{-4}	1×10^{-4}								3×10^{-5}	3×10^{-5}

Alternative	One Meal Per Month																			
	Crab										Clam									
	Time from Beginning of Construction (years) [a]										Time from Beginning of Construction (years) [a]									
	0	5	10	15	20	25	30	35	40	45	0	5	10	15	20	25	30	35	40	45
EAA-Alternative 1	2×10^{-4}	1×10^{-4}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	2×10^{-4}	1×10^{-4}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}
Alternative 3C	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 4C	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 5C	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 6C	2×10^{-4}			5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}			5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 2R	2×10^{-4}	9×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	9×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 3R	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}	8×10^{-5}	7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 4R	2×10^{-4}		7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}		7×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 5R	2×10^{-4}			6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}	2×10^{-4}			6×10^{-5}	6×10^{-5}	6×10^{-5}	6×10^{-5}	5×10^{-5}	5×10^{-5}	5×10^{-5}
Alternative 6R	2×10^{-4}								5×10^{-5}	5×10^{-5}	2×10^{-4}								5×10^{-5}	5×10^{-5}

Notes:

1. Excess cancer risks were estimated using non-RME seafood consumption total PCB tissue concentrations in the food web model (Windward 2010), alternative-specific total PCB SWACs in surface sediment (Table 9-2a), and assumed surface water dissolved PCB concentrations of 0.6 ng/L, except 0.9 ng/L for Year 0 for all alternatives and Year 5 for Alternative 1.

2. Significant figures are displayed in accordance with the conventions established in the HHRA.

3. Risks were not estimated for construction period because of uncertainties in total PCB tissue concentrations during construction. Fish/shellfish tissue concentrations are expected to remain elevated in total PCBs for up to 2 years as a result of construction impacts (e.g., sediment resuspension).

a. The 5-year model-predicted intervals associated with the BCM SWAC output (for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimation for Alternative 1 uses the BCM SWAC output after EAA construction is completed.

10^{-3}	Colored cells indicate residual excess cancer risk rounded to the nearest order of magnitude.
10^{-4}	
10^{-5}	
5×10^{-4}	Gray indicates alternative under construction. Red font indicates risk estimate based on the end of construction PCB SWAC.

API = Asian Pacific Islander; C = combined; CT = central tendency; BCM = bed composition model; EAA = early action area; HHRA = human health risk assessment; R = removal; RME = reasonable maximum exposure; SWAC = spatially-weighted average concentration

Table M-4 Non-Cancer Hazard Quotients for non-RME Seafood Consumption Scenarios Associated with Alternative-Specific Residual Sediment Total PCB SWACs Over Time

			Adult Tribal CT (Tulalip data)										Child Tribal CT (Tulalip data)										Adult API CT										Adult Tribal (Suquamish data)									
			Time from Beginning of Construction (years) [a]										*Time from Beginning of Construction (years)* [a]										*Time from Beginning of Construction (years)* [a]										*Time from Beginning of Construction (years)* [a]									
Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	13	9	6	5	5	5	5	5	5	5	29	19	13	11	11	10	10	10	10	10	9	6	4	4	3	3	3	3	3	3	9	6	4	4	3	3	3	3	3	3
Alternative 3C	58	3	13	7	6	5	5	5	5	5	5	4	29	15	12	11	10	10	10	10	10	10	9	5	4	3	3	3	3	3	3	3	9	5	4	3	3	3	3	3	3	3
Alternative 4C	107	6	13	6	5	5	5	5	5	5	5	4	29	14	12	10	10	10	10	10	10	9	9	4	4	3	3	3	3	3	3	3	9	4	4	3	3	3	3	3	3	3
Alternative 5C	157	7	13	6	5	5	5	5	5	5	5	4	29	14	11	10	10	10	10	10	10	9	9	4	4	3	3	3	3	3	3	3	9	4	4	3	3	3	3	3	3	3
Alternative 6C	302	16	13			4	4	4	4	4	4	4	29			10	9	9	9	9	9	9	9			3	3	3	3	3	3	3	9			3	3	3	3	3	3	3
Alternative 2R	32	4	13	7	6	5	5	5	5	5	5	5	29	16	13	11	11	10	10	10	10	10	9	5	4	4	3	3	3	3	3	3	9	5	4	4	3	3	3	3	3	3
Alternative 3R	58	6	13	7	6	5	5	5	5	5	5	4	29	15	12	11	10	10	10	10	10	10	9	5	4	3	3	3	3	3	3	3	9	5	4	3	3	3	3	3	3	3
Alternative 4R	107	11	13		6	5	5	5	5	5	5	4	29		12	11	10	10	10	10	10	9	9		4	3	3	3	3	3	3	3	9		4	3	3	3	3	3	3	3
Alternative 5R	157	17	13			5	5	5	5	5	5	4	29			11	10	10	10	10	10	9	9			3	3	3	3	3	3	3	9			3	3	3	3	3	3	3
Alternative 6R	302	42	13								4	4	29								9	9	9								3	3	9								3	3

			One Meal Per Month																																							
			Benthic Fish										Pelagic Fish										Crab										Clam									
			Time from Beginning of Construction (years) [a]										*Time from Beginning of Construction (years)* [a]										*Time from Beginning of Construction (years)* [a]										*Time from Beginning of Construction (years)* [a]									
Alternative	Active Area in FS Study Area (acres)	Construction Period (years)	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
EAA-Alternative 1	29	<5	1.1	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.9	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	1.1	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.9	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4
Alternative 3C	58	3	1.1	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	1.1	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Alternative 4C	107	6	1.1	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	1.1	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Alternative 5C	157	7	1.1	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	1.1	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Alternative 6C	302	16	1.1			0.4	0.3	0.4	0.4	0.4	0.4	0.4	1.3			0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.1			0.4	0.3	0.4	0.4	0.4	0.4	0.4	1.3			0.4	0.4	0.4	0.4	0.4	0.4	0.4
Alternative 2R	32	4	1.1	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	1.1	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4
Alternative 3R	58	6	1.1	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	1.1	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Alternative 4R	107	11	1.1		0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3		0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	1.1		0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3		0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Alternative 5R	157	17	1.1			0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3			0.5	0.5	0.4	0.4	0.4	0.4	0.4	1.1			0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.3			0.5	0.5	0.4	0.4	0.4	0.4	0.4
Alternative 6R	302	42	1.1								0.4	0.4	1.3								0.4	0.4	1.1								0.4	0.4	1.3								0.4	0.4

Notes:

1. Non-cancer hazard quotients were estimated using non-RME seafood consumption total PCB tissue concentrations in the food web model (Windward 2010), alternative-specific total PCB SWACs in surface sediment (Table 9-2a), and assumed surface water dissolved total PCB concentrations of 0.6 ng/L, except 0.9 ng/L for Year 0 for all alternatives and Year 5 for Alternative 1.
2. All tabulated values are hazard quotients.
3. Hazard quotients were not estimated for construction period because of uncertainties in PCB tissue concentrations during construction. Fish/shellfish tissue concentrations are expected to remain elevated in total PCBs for up to 2 years as a result of construction impacts (e.g., sediment resuspension).

a. The 5-year model-predicted intervals associated with the BCM SWAC output (for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimation for Alternative 1 uses the BCM SWAC output after EAA construction is completed.

HQ >1
HQ ≤1
} Colored cells indicate residual non-cancer hazard quotient.

0.4 Gray indicates alternative under construction. Red font indicates hazard quotient estimate based on the end of construction PCB SWAC.

API = Asian Pacific Islander; BCM = bed composition model; C = combined; CT = central tendency; EAA = early action area; HQ = hazard quotient; R = removal; RME = reasonable maximum exposure; SWAC = spatially-weighted average concentration.

Table M-5a Total PCB Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Combined Alternatives

Risk for Each Alternative — EAAs-Alternative 1 — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	8×10^{-8}	6×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	1×10^{-7}	8×10^{-8}	5×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	5×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	2×10^{-7}	6×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	7×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Risk for Each Alternative — Alternative 3 Combined (3 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	6×10^{-8}	5×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	5×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Risk for Each Alternative — Alternative 4 Combined (6 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	6×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	5×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Risk for Each Alternative — Alternative 5 Combined (7 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	6×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	5×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Risk for Each Alternative — Alternative 6 Combined (16 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	6×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	8×10^{-8}	8×10^{-8}	8×10^{-8}	8×10^{-8}	8×10^{-8}	8×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	5×10^{-8}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Table M-5a Total PCB Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Removal Alternatives

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 2 Removal (4 years[b]) — *Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	8×10^{-8}	6×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	5×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	7×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 3 Removal (6 years[b]) — *Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	6×10^{-8}	5×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	5×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 4 Removal (11 years[b]) — *Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	6×10^{-8}	5×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	5×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 5 Removal (17 years[b]) — *Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}	9×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	6×10^{-8}	5×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	5×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 6 Removal (42 years[b]) — *Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Tribal Clamming	8×10^{-6}	4×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	9×10^{-8}	8×10^{-8}	8×10^{-8}	8×10^{-8}
Beach 1	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 2	1×10^{-7}	2×10^{-7}	6×10^{-8}	5×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 3	1×10^{-7}	6×10^{-8}	5×10^{-8}	5×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}	4×10^{-8}
Beach 4[d]	6×10^{-4}	6×10^{-7}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}
Beach 5	1×10^{-7}	7×10^{-8}	4×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	2×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}	3×10^{-8}
Beach 6	5×10^{-7}	3×10^{-7}	4×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 7	5×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}
Beach 8	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}	2×10^{-8}

$\leq 1 \times 10^{-6}$ Colored cells indicate residual excess cancer risk.

Notes:
1. Total PCB risk estimates are based on SWACs for netfishing, tribal clamming, and individual beaches predicted by the BCM and for each alternative.
2. The BCM total PCB input values used for the predicted future concentrations following start of construction are: 35 µg/kg dw (upstream), 300 µg/kg dw (lateral), and post-remedy bed sediment replacement values of 60 µg/kg dw for AOPC 1 and 20 µg/kg dw for AOPC 2.
3. Individual beach play areas are actively remediated in the first 5 years by Alternative 3.

a. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).
b. Construction period.

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.
d. The large differences between the baseline risks and the SWAC-based risk estimates at Beach 4 result from removing the two highest PCB-concentration samples at Beach 4 from the FS dataset for interpolating PCB concentrations. After construction of Alternative 2, the locations with the highest PCB concentrations would have undergone active remediation.

AOPC = area of potential concern; BCM = bed composition model; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; µg = micrograms; PCB = polychlorinated biphenyl; RI = remedial investigation; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent; UCL95 = 95% upper confidence limit

Table M-5b Arsenic Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Combined Alternatives

		Risk for Each Alternative									
		EAAs-Alternative 1									
	Baseline	*Time from Beginning of Construction (years)*									
Exposure Area	Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Tribal Clamming	2×10^{-5}	1×10^{-5}	8×10^{-6}	8×10^{-6}	8×10^{-6}	8×10^{-6}	8×10^{-6}	8×10^{-6}	8×10^{-6}	8×10^{-6}	8×10^{-6}
Beach 1	5×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	6×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	4×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	3×10^{-5}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

		Risk for Each Alternative									
		Alternative 3 Combined (3 years[b])									
	Baseline	*Time from Beginning of Construction (years)*									
Exposure Area	Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	2×10^{-5}	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	5×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	6×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	4×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	3×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

		Risk for Each Alternative									
		Alternative 4 Combined (6 years[b])									
	Baseline	*Time from Beginning of Construction (years)*									
Exposure Area	Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	2×10^{-5}	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	5×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	6×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	4×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	3×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

		Risk for Each Alternative									
		Alternative 5 Combined (7 years[b])									
	Baseline	*Time from Beginning of Construction (years)*									
Exposure Area	Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	2×10^{-5}	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	5×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	6×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	4×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	3×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

		Risk for Each Alternative									
		Alternative 6 Combined (16 years[b])									
	Baseline	*Time from Beginning of Construction (years)*									
Exposure Area	Risk[a]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	2×10^{-5}	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	5×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	6×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	4×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	3×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

Table M-5b Arsenic Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Removal Alternatives

		Risk for Each Alternative									
		Alternative 2 Removal (4 years[b])									
	Baseline	*Time from Beginning of Construction (years)*									
Exposure Area	Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	2×10^{-5}	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	5×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	6×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	4×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	3×10^{-5}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

	Alternative 3 Removal (6 years[b])									
	Time from Beginning of Construction (years)									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	5×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

	Alternative 4 Removal (11 years[b])									
	Time from Beginning of Construction (years)									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

		Risk for Each Alternative									
		Alternative 5 Removal (17 years[b])									
	Baseline	*Time from Beginning of Construction (years)*									
Exposure Area	Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	2×10^{-5}	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	5×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	6×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	4×10^{-6}	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	3×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

	Alternative 6 Removal (42 years[b])									
	Time from Beginning of Construction (years)									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Tribal Clamming	1×10^{-5}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}	7×10^{-6}
Beach 1	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 2	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 3	5×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 4	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 5	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 6	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 7	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Beach 8	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}

$>1 \times 10^{-6}$ Colored cells indicate predicted residual risk

Notes:

1. Arsenic risk estimates are based on SWACs for netfishing, tribal clamming, and individual beaches predicted by the BCM and for each alternative.

2. The BCM arsenic input values used for the predicted future concentrations following start of construction are: 9 mg/kg dw (upstream), 13 mg/kg dw (lateral), and post-remedy bed sediment replacement values of 10 mg/kg dw for AOPC 1 and 9 mg/kg dw for AOPC 2.

3. Direct contact excess cancer risk at 1×10^{-6} cannot be achieved because 1) risk threshold is below natural background, and 2) the concentration of the upstream sediment input is assumed to be 9 mg/kg dw, which corresponds to a risk of 3×10^{-6}.

4. Individual beach play areas are actively remediated in the first 5 years by Alternative 3.

a. Baseline risks for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing and tribal clamming scenarios, and Table 3-6b for beach play scenarios).

b. Construction period.

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

AOPC = area of potential concern; BCM = bed composition model; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; mg = milligrams; RI = remedial investigation; SWAC = spatially-weighted average concentration;
TEQ = toxic equivalent; UCL95 = 95% upper confidence limit

Table M-5c cPAH Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Combined Alternatives

Risk for Each Alternative — EAAs-Alternative 1 — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	6×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	5×10^{-6}	4×10^{-6}	2×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 3	1×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Risk for Each Alternative — Alternative 3 Combined (3 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	5×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Risk for Each Alternative — Alternative 4 Combined (6 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Risk for Each Alternative — Alternative 5 Combined (7 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Risk for Each Alternative — Alternative 6 Combined (16 years[b]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Table M-5c cPAH Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Removal Alternatives

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 2 Removal (4 years[b]), Time from Beginning of Construction (years)									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	5×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	1×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	3×10^{-6}	2×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 3 Removal (6 years[b]), Time from Beginning of Construction (years)									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	5×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 4 Removal (11 years[b]), Time from Beginning of Construction (years)									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	5×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 5 Removal (17 years[b]), Time from Beginning of Construction (years)									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	5×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}
Beach 3	1×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative: Alternative 6 Removal (42 years[b]), Time from Beginning of Construction (years)									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9×10^{-7}	5×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Tribal Clamming	5×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Beach 1	4×10^{-6}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 2	8×10^{-5}	8×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 3	1×10^{-5}	4×10^{-6}	4×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}	2×10^{-6}
Beach 4	1×10^{-5}	4×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 5	3×10^{-5}	4×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 6	8×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-7}	9×10^{-7}	9×10^{-7}
Beach 7	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Beach 8	3×10^{-6}	2×10^{-6}	9×10^{-7}	8×10^{-7}	8×10^{-7}	9×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}	8×10^{-7}

$> 1 \times 10^{-6}$	Colored cells indicate residual excess cancer risk.
$\leq 1 \times 10^{-6}$	

Notes:

1. cPAH risk estimates are based on SWACs for netfishing, tribal clamming, and individual beaches predicted by the BCM and for each alternative.
2. The BCM cPAH input values used for the predicted future concentrations following start of construction are: 70 µg TEQ/kg dw (upstream), 1400 µg TEQ/kg dw (lateral), and post-remedy bed sediment replacement value of 140 µg TEQ/kg dw for AOPC 1 and 100 µg TEQ/kg dw for AOPC 2.
3. All hot spots in beaches are actively remediated to achieve RAO 2 at the end of construction. Some beaches are shown to have excess cancer risks that slightly exceed the 1×10^{-6} threshold at the end of construction. This is an artifact of using a post-remedy bed sediment replacement value of 140 µg TEQ/kg. Given the uncertainty in this value and the fact that the beaches are actively remediated, it is assumed that risk from cPAHs at these beaches will be 1×10^{-6} following construction.

a. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

b. Construction period.

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

AOPC = area of potential concern; BCM = bed composition model; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; µg = micrograms; PCB = polychlorinated biphenyl; RI = remedial investigation; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent; UCL95 = 95% upper confidence limit

Table M-5d Dioxin/Furan Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Combined Alternatives

Exposure Area	Baseline Risk[a]	Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[b])										Alternative 4 Combined (6 years[b])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6×10^{-7}	4×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	6×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	6×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Tribal Clamming	1×10^{-4}	2×10^{-6}	1×10^{-6}	7×10^{-7}	4×10^{-7}	4×10^{-7}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	2×10^{-6}	4×10^{-7}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	2×10^{-6}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Beach 1	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 2	3×10^{-6}	8×10^{-7}	6×10^{-7}	4×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 3	1×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 4	1×10^{-5}	2×10^{-6}	5×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 5	1×10^{-6}	2×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 6	3×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}
Beach 7	1×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 8	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}

Exposure Area	Baseline Risk[a]	Risk for Each Alternative																			
		Alternative 5 Combined (7 years[b])										Alternative 6 Combined (16 years[b])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	6×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Tribal Clamming	1×10^{-4}	2×10^{-6}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	2×10^{-6}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Beach 1	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 2	3×10^{-6}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	2×10^{-7}	1×10^{-7}
Beach 3	1×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 4	1×10^{-5}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 5	1×10^{-6}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 6	3×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}
Beach 7	1×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 8	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}

Table M-5d Dioxin/Furan Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Removal Alternatives

Risk for Each Alternative — Alternative 2 Removal (4 years[b]); *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Tribal Clamming	1×10^{-4}	2×10^{-6}	4×10^{-7}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Beach 1	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 2	3×10^{-6}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 3	1×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 4	1×10^{-5}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 5	1×10^{-6}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 6	3×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 7	1×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 8	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}

Risk for Each Alternative — Alternative 3 Removal (6 years[b]); *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Tribal Clamming	1×10^{-4}	2×10^{-6}	4×10^{-7}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Beach 1	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 2	3×10^{-6}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 3	1×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 4	1×10^{-5}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 5	1×10^{-6}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 6	3×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}
Beach 7	1×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 8	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}

Risk for Each Alternative — Alternative 4 Removal (11 years[b]); *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Tribal Clamming	1×10^{-4}	2×10^{-6}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Beach 1	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 2	3×10^{-6}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 3	1×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 4	1×10^{-5}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 5	1×10^{-6}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 6	3×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}
Beach 7	1×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 8	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}

Risk for Each Alternative — Alternative 5 Removal (17 years[b]); *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Tribal Clamming	1×10^{-4}	2×10^{-6}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Beach 1	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 2	3×10^{-6}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 3	1×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 4	1×10^{-5}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 5	1×10^{-6}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 6	3×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}
Beach 7	1×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 8	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}

Risk for Each Alternative — Alternative 6 Removal (42 years[b]); *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[a]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Tribal Clamming	1×10^{-4}	2×10^{-6}	4×10^{-7}	4×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Beach 1	1×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 2	3×10^{-6}	8×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 3	1×10^{-7}	3×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 4	1×10^{-5}	2×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 5	1×10^{-6}	2×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}
Beach 6	3×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}	2×10^{-7}	1×10^{-7}
Beach 7	1×10^{-7}	9×10^{-8}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Beach 8	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}

$> 1 \times 10^{-6}$	Colored cells indicate residual excess cancer risk.
$\leq 1 \times 10^{-6}$	

Notes:

1. Dioxin/furan risk estimates are based on SWACs for netfishing, tribal clamming, and individual beaches predicted by the BCM and for each alternative.
2. The BCM dioxin/furan input values used for the predicted future concentrations following start of construction are: 4 ng TEQ/kg dw (upstream), 20 ng TEQ/kg dw (lateral), and 4 ng TEQ/kg dw (post-remedy bed sediment replacement value).
3. Individual beach play areas are actively remediated in the first 5 years by Alternative 3.

a. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

b. Construction period.

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

AOPC = area of potential concern; BCM = bed composition model; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; ng TEQ/kg dw = nangrams toxic equivalent per kilogram; RI = remedial investigation; SWAC = spatially-weighted average concentration; UCL95 = 95% upper confidence limit

Table M-6a Low Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Combined Alternatives

	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	176	83	46	27	22	17	16	13	12	11	176	64	37	23	18	15	13	11	10	9	176	51	30	19	16	13	12	10	10	9
Tribal Clamming	191	73	40	26	22	19	18	15	14	14	191	42	28	21	17	16	15	13	13	13	191	36	24	19	15	14	14	12	12	12
Beach 1	51	35	24	15	11	9	9	9	9	8	51	28	20	14	10	9	9	9	9	8	51	28	20	14	10	9	9	9	9	8
Beach 2	278	178	113	62	36	25	20	15	12	9	278	95	64	40	25	18	15	12	10	8	278	66	45	30	19	14	12	10	9	7
Beach 3	99	63	42	26	22	21	21	19	19	17	99	58	39	25	22	21	21	19	19	17	99	37	28	23	21	20	21	19	19	17
Beach 4[d]	1099	265	77	21	22	16	12	9	8	7	1099	41	17	10	10	9	7	8	8	7	1099	32	14	10	9	8	7	8	8	7
Beach 5	123	52	39	39	38	37	36	31	32	34	123	45	37	37	36	35	35	30	31	33	123	38	30	30	29	29	28	24	25	26
Beach 6	448	95	38	25	27	24	15	10	9	9	448	30	12	10	8	8	7	6	6	6	448	30	12	10	8	8	7	6	6	6
Beach 7	46	10	9	8	8	8	9	7	7	7	46	10	9	8	8	8	9	7	7	7	46	10	9	8	8	8	9	7	7	7
Beach 8	49	6	6	6	6	5	5	5	5	5	49	8	6	5	6	5	5	5	5	5	49	8	6	5	6	5	5	5	5	5

		Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1E-07	6E-08	4E-08	2E-08	2E-08	1E-08	1E-08	1E-08	9E-09	8E-09	1E-07	5E-08	3E-08	2E-08	1E-08	1E-08	1E-08	8E-09	8E-09	7E-09	1E-07	4E-08	2E-08	1E-08	1E-08	1E-08	9E-09	8E-09	7E-09	7E-09
Tribal Clamming	8×10^{-6}	4E-07	1E-07	8E-08	5E-08	4E-08	4E-08	4E-08	3E-08	3E-08	3E-08	4E-07	8E-08	6E-08	4E-08	3E-08	3E-08	3E-08	3E-08	3E-08	3E-08	4E-07	7E-08	5E-08	4E-08	3E-08	3E-08	3E-08	2E-08	2E-08	2E-08
Beach 1	3×10^{-8}	3E-08	2E-08	1E-08	9E-09	6E-09	6E-09	5E-09	5E-09	5E-09	5E-09	3E-08	2E-08	1E-08	8E-09	6E-09	5E-09	5E-09	5E-09	5E-09	5E-09	3E-08	2E-08	1E-08	8E-09	6E-09	5E-09	5E-09	5E-09	5E-09	5E-09
Beach 2	1×10^{-7}	2E-07	1E-07	7E-08	4E-08	2E-08	1E-08	1E-08	9E-09	7E-09	5E-09	2E-07	6E-08	4E-08	2E-08	1E-08	1E-08	9E-09	7E-09	6E-09	5E-09	2E-07	4E-08	3E-08	2E-08	1E-08	8E-09	7E-09	6E-09	5E-09	4E-09
Beach 3	1×10^{-7}	6E-08	4E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	6E-08	3E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	6E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08
Beach 4[d]	6×10^{-4}	6E-07	2E-07	5E-08	1E-08	1E-08	1E-08	7E-09	5E-09	5E-09	4E-09	6E-07	2E-08	1E-08	6E-09	6E-09	5E-09	4E-09	5E-09	5E-09	4E-09	6E-07	2E-08	8E-09	6E-09	5E-09	5E-09	4E-09	4E-09	5E-09	4E-09
Beach 5	1×10^{-7}	7E-08	3E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	7E-08	3E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	7E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	1E-08	1E-08	2E-08
Beach 6	5×10^{-7}	3E-07	6E-08	2E-08	1E-08	2E-08	1E-08	9E-09	6E-09	5E-09	6E-09	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09
Beach 7	5×10^{-8}	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09
Beach 8	6×10^{-8}	3E-08	4E-09	3E-09	3E-09	4E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-08	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-08	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09

Table M-6a Low Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Combined Alternatives

Exposure Area	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	176	51	26	17	15	13	12	10	9	9	176	51	26	15	10	9	9	8	8	8
Tribal Clamming	191	36	24	17	15	14	13	11	11	11	191	36	24	16	12	11	11	10	10	10
Beach 1	51	28	24	15	11	10	9	9	9	8	51	28	24	15	10	9	9	9	9	8
Beach 2	278	66	43	28	18	14	12	10	9	7	278	66	43	28	11	9	8	8	7	6
Beach 3	99	37	29	22	21	20	21	19	19	17	99	37	29	22	21	20	21	19	19	17
Beach 4[d]	1099	32	16	10	9	8	7	8	8	7	1099	32	16	10	9	8	8	8	8	7
Beach 5	123	38	31	29	28	28	27	24	24	26	123	38	31	22	21	20	20	17	18	19
Beach 6	448	30	12	10	8	8	7	6	6	6	448	30	12	10	8	8	7	6	6	6
Beach 7	46	10	9	8	8	8	9	7	7	7	46	10	9	7	8	7	8	7	7	7
Beach 8	49	8	8	5	6	5	5	5	5	5	49	8	8	5	6	5	5	5	5	5

Exposure Area	Baseline Risk[b]	Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1E-07	4E-08	2E-08	1E-08	1E-08	1E-08	9E-09	8E-09	7E-09	7E-09	1E-07	4E-08	2E-08	1E-08	8E-09	7E-09	7E-09	6E-09	6E-09	6E-09
Tribal Clamming	8×10^{-6}	4E-07	7E-08	5E-08	3E-08	3E-08	3E-08	3E-08	2E-08	2E-08	2E-08	4E-07	7E-08	5E-08	3E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08
Beach 1	3×10^{-8}	3E-08	2E-08	1E-08	9E-09	6E-09	6E-09	5E-09	5E-09	5E-09	5E-09	3E-08	2E-08	1E-08	9E-09	6E-09	5E-09	5E-09	5E-09	5E-09	5E-09
Beach 2	1×10^{-7}	2E-07	4E-08	3E-08	2E-08	1E-08	8E-09	7E-09	6E-09	5E-09	4E-09	2E-07	4E-08	3E-08	2E-08	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09
Beach 3	1×10^{-7}	6E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	6E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08
Beach 4[d]	6×10^{-4}	6E-07	2E-08	9E-09	6E-09	5E-09	5E-09	4E-09	5E-09	5E-09	4E-09	6E-07	2E-08	9E-09	6E-09	5E-09	5E-09	5E-09	5E-09	5E-09	4E-09
Beach 5	1×10^{-7}	7E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	1E-08	1E-08	2E-08	7E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08
Beach 6	5×10^{-7}	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09
Beach 7	5×10^{-8}	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	5E-09	4E-09	4E-09	4E-09
Beach 8	6×10^{-8}	3E-08	5E-09	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-08	5E-09	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09

Table M-6a Low Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Removal Alternatives

	SWAC for Each Alternative																													
	Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	176	70	41	25	20	16	15	12	11	10	176	64	37	23	18	15	13	11	10	9	176	64	36	20	16	13	12	10	10	9
Tribal Clamming	191	49	32	23	19	17	16	14	13	13	191	42	28	21	17	16	15	13	13	13	191	42	27	19	16	14	14	12	12	12
Beach 1	51	35	24	15	11	9	9	9	9	8	51	28	20	14	10	9	9	9	9	8	51	28	20	14	10	9	9	9	9	8
Beach 2	278	127	83	49	30	21	17	13	11	9	278	95	64	40	25	18	15	12	10	8	278	95	64	31	20	15	13	11	9	8
Beach 3	99	58	39	25	22	21	21	19	19	17	99	58	39	25	22	21	21	19	19	17	99	58	39	27	23	21	21	19	19	17
Beach 4[d]	1099	42	17	10	10	9	7	8	8	7	1099	41	17	10	10	9	7	8	8	7	1099	41	17	9	9	8	7	8	8	7
Beach 5	123	51	39	39	38	37	36	31	32	34	123	45	37	37	36	35	35	30	31	33	123	45	31	30	29	29	28	24	25	26
Beach 6	448	95	38	25	27	24	15	10	9	9	448	30	12	10	8	8	7	6	6	6	448	30	12	10	8	8	7	6	6	6
Beach 7	46	10	9	8	8	8	9	7	7	7	46	10	9	8	8	8	9	7	7	7	46	10	9	8	8	8	9	7	7	7
Beach 8	49	6	6	6	6	5	5	5	5	5	49	8	6	5	6	5	5	5	5	5	49	8	6	5	6	5	5	5	5	5

		Risk for Each Alternative																													
		Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
	Baseline	*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1E-07	5E-08	3E-08	2E-08	2E-08	1E-08	1E-08	9E-09	9E-09	8E-09	1E-07	5E-08	3E-08	2E-08	1E-08	1E-08	1E-08	8E-09	8E-09	7E-09	1E-07	5E-08	3E-08	2E-08	1E-08	1E-08	9E-09	8E-09	7E-09	7E-09
Tribal Clamming	8×10^{-6}	4E-07	1E-07	6E-08	5E-08	4E-08	3E-08	3E-08	3E-08	3E-08	3E-08	4E-07	8E-08	6E-08	4E-08	3E-08	3E-08	3E-08	3E-08	3E-08	3E-08	4E-07	8E-08	5E-08	4E-08	3E-08	3E-08	3E-08	2E-08	2E-08	2E-08
Beach 1	3×10^{-8}	3E-08	2E-08	1E-08	9E-09	6E-09	6E-09	5E-09	5E-09	5E-09	5E-09	3E-08	2E-08	1E-08	8E-09	6E-09	5E-09	5E-09	5E-09	5E-09	5E-09	3E-08	2E-08	1E-08	8E-09	6E-09	5E-09	5E-09	5E-09	5E-09	5E-09
Beach 2	1×10^{-7}	2E-07	7E-08	5E-08	3E-08	2E-08	1E-08	1E-08	8E-09	6E-09	5E-09	2E-07	6E-08	4E-08	2E-08	1E-08	1E-08	9E-09	7E-09	6E-09	5E-09	2E-07	6E-08	4E-08	2E-08	1E-08	9E-09	8E-09	6E-09	5E-09	4E-09
Beach 3	1×10^{-7}	6E-08	3E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	6E-08	3E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08	6E-08	3E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	1E-08
Beach 4[d]	6×10^{-4}	6E-07	2E-08	1E-08	6E-09	6E-09	5E-09	4E-09	5E-09	5E-09	4E-09	6E-07	2E-08	1E-08	6E-09	6E-09	5E-09	4E-09	5E-09	5E-09	4E-09	6E-07	2E-08	1E-08	5E-09	5E-09	5E-09	4E-09	4E-09	5E-09	4E-09
Beach 5	1×10^{-7}	7E-08	3E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	7E-08	3E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08	7E-08	3E-08	2E-08	2E-08	2E-08	2E-08	2E-08	1E-08	1E-08	2E-08
Beach 6	5×10^{-7}	3E-07	6E-08	2E-08	1E-08	2E-08	1E-08	9E-09	6E-09	5E-09	6E-09	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09
Beach 7	5×10^{-8}	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09
Beach 8	6×10^{-8}	3E-08	4E-09	3E-09	3E-09	4E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-08	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-08	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-09

Table M-6a Low Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Removal Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	176	64	36	20	17	14	12	10	10	9	176	64	36	20	17	12	11	10	9	8
Tribal Clamming	191	42	27	19	17	15	14	12	12	11	191	42	27	19	17	13	12	11	10	10
Beach 1	51	28	20	14	16	12	11	10	9	8	51	28	20	14	16	12	11	10	9	8
Beach 2	278	95	64	31	21	16	13	11	9	8	278	95	64	31	21	16	13	10	9	7
Beach 3	99	58	39	27	26	23	22	20	19	17	99	58	39	27	26	23	22	20	19	17
Beach 4[d]	1099	41	17	9	11	9	8	8	8	7	1099	41	17	9	11	9	8	8	8	7
Beach 5	123	45	31	30	31	28	28	24	24	26	123	45	31	30	31	21	20	17	18	19
Beach 6	448	30	12	10	8	8	7	6	6	6	448	30	12	10	8	8	7	6	6	6
Beach 7	46	10	9	8	8	8	9	7	7	7	46	10	9	8	8	7	8	7	7	7
Beach 8	49	8	6	5	8	5	5	5	5	5	49	8	6	5	8	5	5	5	5	5

		Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Baseline	*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-6}	1E-07	5E-08	3E-08	2E-08	1E-08	1E-08	9E-09	8E-09	7E-09	7E-09	1E-07	5E-08	3E-08	2E-08	1E-08	9E-09	8E-09	7E-09	7E-09	6E-09
Tribal Clamming	8×10^{-6}	4E-07	8E-08	5E-08	4E-08	3E-08	3E-08	3E-08	2E-08	2E-08	2E-08	4E-07	8E-08	5E-08	4E-08	3E-08	3E-08	2E-08	2E-08	2E-08	2E-08
Beach 1	3×10^{-8}	3E-08	2E-08	1E-08	8E-09	9E-09	7E-09	6E-09	6E-09	6E-09	5E-09	3E-08	2E-08	1E-08	8E-09	9E-09	7E-09	6E-09	6E-09	6E-09	5E-09
Beach 2	1×10^{-7}	2E-07	6E-08	4E-08	2E-08	1E-08	9E-09	8E-09	6E-09	5E-09	5E-09	2E-07	6E-08	4E-08	2E-08	1E-08	9E-09	8E-09	6E-09	5E-09	4E-09
Beach 3	1×10^{-7}	6E-08	3E-08	2E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08	6E-08	3E-08	2E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08
Beach 4[d]	6×10^{-4}	6E-07	2E-08	1E-08	5E-09	7E-09	5E-09	5E-09	5E-09	5E-09	4E-09	6E-07	2E-08	1E-08	5E-09	7E-09	5E-09	5E-09	5E-09	5E-09	4E-09
Beach 5	1×10^{-7}	7E-08	3E-08	2E-08	2E-08	2E-08	2E-08	2E-08	1E-08	1E-08	2E-08	7E-08	3E-08	2E-08	2E-08	2E-08	1E-08	1E-08	1E-08	1E-08	1E-08
Beach 6	5×10^{-7}	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09	3E-07	2E-08	7E-09	6E-09	5E-09	5E-09	4E-09	4E-09	4E-09	4E-09
Beach 7	5×10^{-8}	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	6E-09	4E-09	4E-09	4E-09	3E-08	6E-09	5E-09	4E-09	5E-09	4E-09	5E-09	4E-09	4E-09	4E-09
Beach 8	6×10^{-8}	3E-08	5E-09	3E-09	3E-09	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09	3E-08	5E-09	3E-09	3E-09	5E-09	3E-09	3E-09	3E-09	3E-09	3E-09

Notes:

1. Low BCM input parameters (µg/kg dw total PCBs): upstream = 5; lateral = 100; post-remedy bed sediment replacement value = 30 (AOPC 1), 10 (AOPC 2).
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres
4. Significant figures are displayed in accordance with the conventions established in the HHRA.

$\leq 1 \times 10^{-6}$ Colored cells indicate residual excess cancer risk.

a. Construction period.

b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

d. The large differences between the baseline risks and the SWAC-based risk estimates at Beach 4 result from removing the two highest PCB-concentration samples at Beach 4 from the FS dataset for interpolating PCB concentrations. After construction of Alternative 2, the locations with the highest PCB concentrations would have undergone active remediation.

AOPC = area of potential concern; BCM = bed composition model; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; LDW = Lower Duwamish Waterway; µg = micrograms; PCB = polychlorinated biphenyl; RI = remedial investigation; STM = sediment transport model; SWAC = spatially-weighted average concentration; 95UCL = 95% upper confidence limit

Table M-6b Low Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Combined Alternatives

	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	11	9	8	8	8	8	8	8	8	16	9	8	8	7	7	7	7	7	7	16	9	8	8	7	7	7	7	7	7
Tribal Clamming	13	10	9	9	9	9	9	8	8	8	13	8	8	8	7	7	7	7	7	7	13	8	8	8	7	7	7	7	7	7
Beach 1	8	8	8	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7
Beach 2	13	11	9	8	8	7	7	7	7	7	13	10	9	8	8	7	7	7	7	7	13	10	9	8	8	7	7	7	7	7
Beach 3	10	9	8	8	8	8	8	8	8	8	10	9	8	8	8	8	8	8	8	8	10	9	8	8	8	8	8	8	8	8
Beach 4	7	7	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7
Beach 5	9	8	7	7	7	7	7	7	7	7	9	8	7	7	7	7	7	7	7	7	9	8	8	8	8	8	8	7	7	7
Beach 6	12	8	7	7	7	7	7	7	7	7	12	9	7	7	7	7	7	7	7	7	12	9	7	7	7	7	7	7	7	7
Beach 7	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7
Beach 8	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7

		Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	3E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Tribal Clamming	2×10^{-5}	1E-05	8E-06	7E-06	7E-06	7E-06	7E-06	7E-06	6E-06	6E-06	7E-06	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06
Beach 1	5×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 2	6×10^{-6}	5E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	5E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	5E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 3	4×10^{-6}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 4	4×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 5	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	3×10^{-5}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 7	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Table M-6b Low Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Combined Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	9	8	8	7	7	7	7	7	7	16	9	8	8	7	7	7	7	7	7
Tribal Clamming	13	8	8	8	7	7	7	7	7	7	13	8	8	8	7	7	7	7	7	7
Beach 1	8	7	8	7	7	7	7	7	7	7	8	7	8	7	7	7	7	7	7	7
Beach 2	13	10	9	8	8	7	7	7	7	7	13	10	9	8	8	7	7	7	7	7
Beach 3	10	9	8	8	8	8	8	8	8	8	10	9	8	8	8	8	8	8	8	8
Beach 4	7	8	8	7	7	7	7	7	7	7	7	8	8	7	7	7	7	7	7	7
Beach 5	9	8	8	8	8	8	8	7	7	7	9	8	8	8	8	8	7	7	7	7
Beach 6	12	9	7	7	7	7	7	7	7	7	12	9	7	7	7	7	7	7	7	7
Beach 7	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7
Beach 8	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7

		Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Tribal Clamming	2×10^{-5}	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06
Beach 1	5×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 2	6×10^{-6}	5E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	5E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 3	4×10^{-6}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 4	4×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 5	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	3×10^{-5}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 7	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Table M-6b Low Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Removal Alternatives

SWAC for Each Alternative

Exposure Area	Alternative 2 Removal (4 years[a]) – *Time from Beginning of Construction (years)*									
	0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	9	8	8	7	7	7	7	7	7
Tribal Clamming	13	8	8	8	7	7	7	7	7	7
Beach 1	8	8	8	7	7	7	7	7	7	7
Beach 2	13	10	9	8	8	7	7	7	7	7
Beach 3	10	9	8	8	8	8	8	8	8	8
Beach 4	7	8	7	7	7	7	7	7	7	7
Beach 5	9	8	7	7	7	7	7	7	7	7
Beach 6	12	8	7	7	7	7	7	7	7	7
Beach 7	8	7	7	7	7	7	7	7	7	7
Beach 8	8	7	7	7	7	7	7	7	7	7

Exposure Area	Alternative 3 Removal (6 years[a]) – *Time from Beginning of Construction (years)*									
	0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	9	8	8	7	7	7	7	7	7
Tribal Clamming	13	8	8	8	7	7	7	7	7	7
Beach 1	8	7	7	7	7	7	7	7	7	7
Beach 2	13	10	9	8	8	7	7	7	7	7
Beach 3	10	9	8	8	8	8	8	8	8	8
Beach 4	7	8	7	7	7	7	7	7	7	7
Beach 5	9	8	7	7	7	7	7	7	7	7
Beach 6	12	9	7	7	7	7	7	7	7	7
Beach 7	8	7	7	7	7	7	7	7	7	7
Beach 8	8	7	7	7	7	7	7	7	7	7

Exposure Area	Alternative 4 Removal (11 years[a]) – *Time from Beginning of Construction (years)*									
	0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	9	8	8	7	7	7	7	7	7
Tribal Clamming	13	8	8	8	7	7	7	7	7	7
Beach 1	8	7	7	7	7	7	7	7	7	7
Beach 2	13	10	9	8	8	7	7	7	7	7
Beach 3	10	9	8	8	8	8	8	8	8	8
Beach 4	7	8	8	7	7	7	7	7	7	7
Beach 5	9	8	8	8	8	8	8	7	7	7
Beach 6	12	9	7	7	7	7	7	7	7	7
Beach 7	8	7	7	7	7	7	7	7	7	7
Beach 8	8	7	7	7	7	7	7	7	7	7

Risk for Each Alternative

Exposure Area	Baseline Risk[b]	Alternative 2 Removal (4 years[a]) – *Time from Beginning of Construction (years)*									
		0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Tribal Clamming	2×10^{-5}	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06
Beach 1	5×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 2	6×10^{-6}	5E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 3	4×10^{-6}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 4	4×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 5	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	3×10^{-5}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 7	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Exposure Area	Alternative 3 Removal (6 years[a]) – *Time from Beginning of Construction (years)*									
	0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Tribal Clamming	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06
Beach 1	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 2	5E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 3	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 4	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 5	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 7	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 8	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Exposure Area	Alternative 4 Removal (11 years[a]) – *Time from Beginning of Construction (years)*									
	0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Tribal Clamming	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06
Beach 1	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 2	5E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 3	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 4	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 5	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 7	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 8	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Table M-6b Low Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Removal Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	9	8	8	8	7	7	7	7	7	16	9	8	8	8	7	7	7	7	7
Tribal Clamming	13	8	8	8	8	7	7	7	7	7	13	8	8	8	8	7	7	7	7	7
Beach 1	8	7	7	7	8	7	7	7	7	7	8	7	7	7	8	7	7	7	7	7
Beach 2	13	10	9	8	8	8	8	7	7	7	13	10	9	8	8	8	8	7	7	7
Beach 3	10	9	8	8	8	8	8	8	8	8	10	9	8	8	8	8	8	8	8	8
Beach 4	7	8	8	7	7	7	7	7	7	7	7	8	8	7	7	7	7	7	7	7
Beach 5	9	8	8	8	8	8	8	7	7	7	9	8	8	8	8	8	8	7	7	7
Beach 6	12	9	7	7	7	7	7	7	7	7	12	9	7	7	7	7	7	7	7	7
Beach 7	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7
Beach 8	8	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7

		Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	4E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Tribal Clamming	2×10^{-5}	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	1E-05	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06
Beach 1	5×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 2	6×10^{-6}	5E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	5E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 3	4×10^{-6}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 4	4×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 5	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	3×10^{-5}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 7	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Notes:

1. Low BCM input parameters (mg/kg dw arsenic): upstream = 7; lateral = 9; post-remedy bed sediment replacement value = 9 (AOPC 1), 8 (AOPC 2).
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres.

$> 1 \times 10^{-6}$ and $\leq 1 \times 10^{-5}$ Colored cells indicate residual excess cancer risk.

4. Significant figures are displayed in accordance with the conventions established in the HHRA.
5. Direct contact excess cancer risk at 1×10^{-6} cannot be achieved because 1) risk threshold is below natural background, and 2) the concentration of the upstream sediment input is estimated to be 7 mg/kg dw, which corresponds to a risk of 3×10^{-6}.

a. Construction period.
b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).
c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to -spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

AOPC = area of potential concern; BCM = bed composition model; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; LDW = Lower Duwamish Waterway; mg = milligrams; RI = remedial investigation; STM = sediment transport model; SWAC = spatially-weighted average concentration; 95UCL = 95% upper confidence limit

Table M-6c Low Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Combined Alternatives

Exposure Area	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	353	192	125	85	73	66	64	59	57	54	353	147	101	74	65	60	59	55	54	52	353	124	88	67	62	58	57	54	54	51
Tribal Clamming	286	154	111	85	76	72	69	64	64	62	286	89	73	63	61	59	59	56	56	55	286	85	71	62	60	58	58	55	56	54
Beach 1	397	274	184	114	79	68	63	61	59	55	397	72	66	59	54	54	54	55	56	53	397	72	66	59	54	54	54	55	56	53
Beach 2	752	476	301	169	106	81	71	61	55	49	752	99	81	66	56	52	51	49	47	46	752	95	78	65	55	52	50	49	47	46
Beach 3	370	253	187	140	135	131	130	117	116	111	370	232	177	136	134	131	130	117	116	111	370	207	164	133	132	130	130	117	116	111
Beach 4	382	130	75	54	57	56	47	52	54	50	382	89	64	53	55	54	48	52	54	50	382	73	60	52	53	54	48	52	54	50
Beach 5	385	142	90	79	79	75	72	65	65	65	385	89	74	71	71	70	69	63	64	65	385	81	70	69	69	68	68	63	64	64
Beach 6	531	164	97	81	81	78	61	54	54	54	531	70	50	48	47	46	46	45	45	44	531	70	50	48	47	46	46	45	45	44
Beach 7	74	52	53	49	52	50	60	50	51	48	74	52	53	49	52	50	60	50	51	48	74	52	53	49	52	50	60	50	51	48
Beach 8	184	47	43	42	44	43	42	40	41	40	184	49	43	42	43	43	42	40	41	40	184	49	43	42	43	43	42	40	41	40

Exposure Area	Baseline Risk[b]	Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9E-07	5E-07	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	1E-07	9E-07	4E-07	3E-07	2E-07	2E-07	2E-07	2E-07	1E-07	1E-07	1E-07	9E-07	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	1E-07	1E-07	1E-07
Tribal Clamming	5×10^{-6}	2E-06	1E-06	7E-07	6E-07	5E-07	5E-07	5E-07	4E-07	4E-07	4E-07	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 1	4×10^{-6}	4E-06	3E-06	2E-06	1E-06	9E-07	8E-07	7E-07	7E-07	7E-07	6E-07	4E-06	8E-07	7E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	4E-06	8E-07	7E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 2	8×10^{-5}	8E-06	5E-06	3E-06	2E-06	1E-06	9E-07	8E-07	7E-07	6E-07	5E-07	8E-06	1E-06	9E-07	7E-07	6E-07	6E-07	6E-07	5E-07	5E-07	5E-07	8E-06	1E-06	9E-07	7E-07	6E-07	6E-07	6E-07	5E-07	5E-07	5E-07
Beach 3	1×10^{-5}	4E-06	3E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	4E-06	3E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	4E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Beach 4	1×10^{-5}	4E-06	1E-06	8E-07	6E-07	6E-07	6E-07	5E-07	6E-07	6E-07	6E-07	4E-06	1E-06	7E-07	6E-07	6E-07	6E-07	5E-07	6E-07	6E-07	6E-07	4E-06	8E-07	7E-07	6E-07	6E-07	6E-07	5E-07	6E-07	6E-07	6E-07
Beach 5	3×10^{-5}	4E-06	2E-06	1E-06	9E-07	9E-07	8E-07	8E-07	7E-07	7E-07	7E-07	4E-06	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	7E-07	7E-07	7E-07	4E-06	9E-07	8E-07	8E-07	8E-07	8E-07	8E-07	7E-07	7E-07	7E-07
Beach 6	8×10^{-5}	6E-06	2E-06	1E-06	9E-07	9E-07	9E-07	7E-07	6E-07	6E-07	6E-07	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07
Beach 7	1×10^{-6}	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07
Beach 8	3×10^{-6}	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07

Table M-6c Low Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Combined Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	353	124	81	64	60	57	57	54	53	51	353	124	81	61	54	53	54	52	52	50
Tribal Clamming	286	85	70	61	59	58	57	55	55	53	286	85	70	59	57	56	56	54	54	52
Beach 1	397	72	71	61	56	55	55	57	57	54	397	72	71	61	54	54	55	56	56	54
Beach 2	752	95	76	64	55	51	50	48	47	46	752	95	76	64	50	48	48	47	46	45
Beach 3	370	207	144	125	129	128	129	117	116	111	370	207	144	125	128	128	129	117	116	111
Beach 4	382	73	61	52	54	54	50	53	55	50	382	73	61	52	53	54	52	53	55	50
Beach 5	385	81	71	68	68	67	67	63	64	64	385	81	71	62	61	60	61	58	58	58
Beach 6	531	70	50	48	47	46	46	45	45	44	531	70	50	48	47	46	46	45	45	44
Beach 7	74	52	53	49	52	50	60	50	51	48	74	52	53	47	52	50	55	50	51	48
Beach 8	184	49	46	42	43	43	42	40	41	40	184	49	46	42	43	43	42	40	41	40

		Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9E-07	3E-07	2E-07	2E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	9E-07	3E-07	2E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Tribal Clamming	5×10^{-6}	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	3E-07
Beach 1	4×10^{-6}	4E-06	8E-07	8E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	4E-06	8E-07	8E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 2	8×10^{-5}	8E-06	1E-06	8E-07	7E-07	6E-07	6E-07	6E-07	5E-07	5E-07	5E-07	8E-06	1E-06	8E-07	7E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07
Beach 3	1×10^{-5}	4E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	4E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Beach 4	1×10^{-5}	4E-06	8E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	4E-06	8E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 5	3×10^{-5}	4E-06	9E-07	8E-07	8E-07	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	4E-06	9E-07	8E-07	7E-07	7E-07	7E-07	7E-07	6E-07	6E-07	6E-07
Beach 6	8×10^{-5}	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07
Beach 7	1×10^{-6}	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	6E-07	6E-07	6E-07	5E-07
Beach 8	3×10^{-6}	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07

Table M-6c Low Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Removal Alternatives

	SWAC for Each Alternative																													
	Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	353	168	113	79	69	63	61	57	56	53	353	147	101	74	65	60	59	55	54	52	353	147	100	68	62	58	57	54	54	51
Tribal Clamming	286	131	97	77	70	66	64	59	59	58	286	89	73	63	61	59	59	56	56	55	286	89	73	62	60	58	58	55	56	54
Beach 1	397	274	184	114	79	68	63	61	59	55	397	72	66	59	54	54	54	55	56	53	397	72	66	59	54	54	54	55	56	53
Beach 2	752	237	163	106	76	64	59	54	51	47	752	99	81	66	56	52	51	49	47	46	752	99	81	67	57	53	51	49	48	46
Beach 3	370	232	177	136	134	131	130	117	116	111	370	232	177	136	134	131	130	117	116	111	370	232	177	136	134	131	131	117	116	111
Beach 4	382	111	70	54	56	55	47	52	54	50	382	89	64	53	55	54	48	52	54	50	382	89	62	52	54	54	48	52	54	50
Beach 5	385	137	88	78	78	74	72	64	65	65	385	89	74	71	71	70	69	63	64	65	385	89	72	69	69	68	68	63	64	64
Beach 6	531	164	97	81	81	78	61	54	54	54	531	70	50	48	47	46	46	45	45	44	531	70	51	48	47	46	46	45	45	44
Beach 7	74	52	53	49	52	50	60	50	51	48	74	52	53	49	52	50	60	50	51	48	74	52	53	49	52	50	60	50	51	48
Beach 8	184	47	43	42	44	43	42	40	41	40	184	49	43	42	43	43	42	40	41	40	184	49	43	42	43	43	42	40	41	40

		Risk for Each Alternative																													
		Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9E-07	4E-07	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	1E-07	1E-07	9E-07	4E-07	3E-07	2E-07	2E-07	2E-07	2E-07	1E-07	1E-07	1E-07	9E-07	4E-07	3E-07	2E-07	2E-07	2E-07	2E-07	1E-07	1E-07	1E-07
Tribal Clamming	5×10^{-6}	2E-06	9E-07	6E-07	5E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 1	4×10^{-6}	4E-06	3E-06	2E-06	1E-06	9E-07	8E-07	7E-07	7E-07	7E-07	6E-07	4E-06	8E-07	7E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	4E-06	8E-07	7E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 2	8×10^{-5}	8E-06	3E-06	2E-06	1E-06	8E-07	7E-07	7E-07	6E-07	6E-07	5E-07	8E-06	1E-06	9E-07	7E-07	6E-07	6E-07	6E-07	5E-07	5E-07	5E-07	8E-06	1E-06	9E-07	7E-07	6E-07	6E-07	6E-07	5E-07	5E-07	5E-07
Beach 3	1×10^{-5}	4E-06	3E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	4E-06	3E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	4E-06	3E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Beach 4	1×10^{-5}	4E-06	1E-06	8E-07	6E-07	6E-07	6E-07	5E-07	6E-07	6E-07	6E-07	4E-06	1E-06	7E-07	6E-07	6E-07	6E-07	5E-07	6E-07	6E-07	6E-07	4E-06	1E-06	7E-07	6E-07	6E-07	6E-07	5E-07	6E-07	6E-07	6E-07
Beach 5	3×10^{-5}	4E-06	2E-06	1E-06	9E-07	9E-07	8E-07	8E-07	7E-07	7E-07	7E-07	4E-06	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	7E-07	7E-07	7E-07	4E-06	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	7E-07	7E-07	7E-07
Beach 6	8×10^{-5}	6E-06	2E-06	1E-06	9E-07	9E-07	9E-07	7E-07	6E-07	6E-07	6E-07	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07
Beach 7	1×10^{-6}	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07
Beach 8	3×10^{-6}	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07

Table M-6c Low Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Removal Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	353	147	100	68	62	58	57	54	54	51	353	147	100	68	62	57	56	54	52	50
Tribal Clamming	286	89	73	62	61	59	58	55	56	54	286	89	73	62	61	57	57	54	55	53
Beach 1	397	72	66	59	59	57	57	57	57	54	397	72	66	59	59	57	57	57	56	54
Beach 2	752	99	81	67	59	54	52	50	48	46	752	99	81	67	59	54	52	50	48	46
Beach 3	370	232	177	136	133	131	131	117	116	111	370	232	177	136	133	131	131	117	116	111
Beach 4	382	89	62	52	55	54	51	53	55	50	382	89	62	52	55	54	51	53	55	50
Beach 5	385	89	72	69	70	67	67	63	64	64	385	89	72	69	70	62	61	58	58	58
Beach 6	531	70	51	48	47	46	46	45	45	44	531	70	51	48	47	46	46	45	45	44
Beach 7	74	52	53	49	52	50	60	50	51	48	74	52	53	49	52	48	55	50	51	48
Beach 8	184	49	43	42	46	43	42	40	41	40	184	49	43	42	46	43	42	40	41	40

		Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	9E-07	4E-07	3E-07	2E-07	2E-07	2E-07	2E-07	1E-07	1E-07	1E-07	9E-07	4E-07	3E-07	2E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Tribal Clamming	5×10^{-6}	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	2E-06	6E-07	5E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 1	4×10^{-6}	4E-06	8E-07	7E-07	7E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	4E-06	8E-07	7E-07	7E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 2	8×10^{-5}	8E-06	1E-06	9E-07	7E-07	7E-07	6E-07	6E-07	6E-07	5E-07	5E-07	8E-06	1E-06	9E-07	7E-07	7E-07	6E-07	6E-07	6E-07	5E-07	5E-07
Beach 3	1×10^{-5}	4E-06	3E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	4E-06	3E-06	2E-06	2E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Beach 4	1×10^{-5}	4E-06	1E-06	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	4E-06	1E-06	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 5	3×10^{-5}	4E-06	1E-06	8E-07	8E-07	8E-07	7E-07	7E-07	7E-07	7E-07	7E-07	4E-06	1E-06	8E-07	8E-07	8E-07	7E-07	7E-07	6E-07	6E-07	6E-07
Beach 6	8×10^{-5}	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	6E-06	8E-07	6E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07
Beach 7	1×10^{-6}	8E-07	6E-07	6E-07	5E-07	6E-07	6E-07	7E-07	6E-07	6E-07	5E-07	8E-07	6E-07	6E-07	5E-07	6E-07	5E-07	6E-07	6E-07	6E-07	5E-07
Beach 8	3×10^{-6}	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07	2E-06	5E-07	5E-07	5E-07	5E-07	5E-07	5E-07	4E-07	5E-07	4E-07

Notes:

1. Low BCM input parameters (µg TEQ/kg dw cPAHs): upstream = 40; lateral = 500; post-remedy bed sediment replacement value = 70 (AOPC 1), 50 (AOPC 2).
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres.
4. Significant figures are displayed in accordance with the conventions established in the HHRA.

$> 1 \times 10^{-6}$ and $\leq 1 \times 10^{-5}$	Colored cells indicate residual excess cancer risk.
$\leq 1 \times 10^{-6}$	

a. Construction period.

b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to -spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

AOPC = area of potential concern; BCM = bed composition model; cPAH = carcinogenic polycyclic aromatic hydrocarbon; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; LDW = Lower Duwamish Waterway; µg = micrograms; RI = remedial investigation; STM = sediment transport model; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent; UCL95 = 95% upper confidence limit

Table M-6d Low Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Combined Alternatives

	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	11	6	4	3	3	3	2	2	2	24	4	3	3	3	2	2	2	2	2	24	4	3	3	2	2	2	2	2	2
Tribal Clamming	30	13	7	4	3	3	3	2	2	2	30	4	3	3	2	2	2	2	2	2	30	4	3	3	2	2	2	2	2	2
Beach 1	5	4	3	3	2	2	2	2	2	2	5	3	3	2	2	2	2	2	2	2	5	3	3	2	2	2	2	2	2	2
Beach 2	23	15	10	6	4	3	3	3	2	2	23	7	5	4	3	3	3	2	2	2	23	6	5	3	3	3	2	2	2	2
Beach 3	7	5	4	3	3	3	3	3	3	3	7	4	4	3	3	3	3	3	3	3	7	4	4	3	3	3	3	3	3	3
Beach 4	47	13	5	3	3	3	2	2	2	2	47	3	3	2	2	2	2	2	2	2	47	3	2	2	2	2	2	2	2	2
Beach 5	6	3	3	2	3	2	2	2	2	2	6	2	2	2	2	2	2	2	2	2	6	2	2	2	2	2	2	2	2	2
Beach 6	8	4	3	3	3	3	3	2	2	2	8	2	2	2	2	2	2	2	2	2	8	2	2	2	2	2	2	2	2	2
Beach 7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Beach 8	4	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2

		Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6E-07	3E-07	2E-07	1E-07	8E-08	7E-08	7E-08	6E-08	6E-08	6E-08	6E-07	1E-07	9E-08	7E-08	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-07	1E-07	8E-08	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Tribal Clamming	1×10^{-4}	2E-06	1E-06	5E-07	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	2E-07	1E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 2	3×10^{-6}	8E-07	5E-07	4E-07	2E-07	1E-07	1E-07	1E-07	1E-07	9E-08	8E-08	8E-07	2E-07	2E-07	1E-07	1E-07	1E-07	9E-08	9E-08	8E-08	8E-08	8E-07	2E-07	2E-07	1E-07	1E-07	9E-08	9E-08	8E-08	8E-08	8E-08
Beach 3	1×10^{-7}	2E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Beach 4	1×10^{-5}	2E-06	5E-07	2E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	2E-06	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-06	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 5	1×10^{-6}	2E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08	8E-08	9E-08	8E-08	2E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 6	3×10^{-7}	3E-07	1E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08
Beach 7	1×10^{-7}	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 8	1×10^{-7}	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08

Table M-6d Low Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Combined Alternatives

Exposure Area	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
	0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	4	3	2	2	2	2	2	2	2	24	4	3	2	2	2	2	2	2	2
Tribal Clamming	30	4	3	2	2	2	2	2	2	2	30	4	3	2	2	2	2	2	2	2
Beach 1	5	3	3	2	2	2	2	2	2	2	5	3	3	2	2	2	2	2	2	2
Beach 2	23	6	4	3	3	2	2	2	2	2	23	6	4	3	2	2	2	2	2	2
Beach 3	7	4	3	3	3	3	3	3	3	3	7	4	3	3	3	3	3	3	3	3
Beach 4	47	3	2	2	2	2	2	2	2	2	47	3	2	2	2	2	2	2	2	2
Beach 5	6	2	2	2	2	2	2	2	2	2	6	2	2	2	2	2	2	2	2	2
Beach 6	8	2	2	2	2	2	2	2	2	2	8	2	2	2	2	2	2	2	2	2
Beach 7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Beach 8	4	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2

Exposure Area	Baseline Risk[b]	Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
		0 [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6E-07	1E-07	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-07	1E-07	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Tribal Clamming	1×10^{-4}	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	2E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 2	3×10^{-6}	8E-07	2E-07	1E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-07	2E-07	1E-07	1E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08
Beach 3	1×10^{-7}	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Beach 4	1×10^{-5}	2E-06	1E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-06	1E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 5	1×10^{-6}	2E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-07	8E-08	8E-08	7E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 6	3×10^{-7}	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08
Beach 7	1×10^{-7}	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	9E-08	8E-08	8E-08	7E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 8	1×10^{-7}	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08

Table M-6d Low Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Removal Alternatives

SWAC for Each Alternative

Exposure Area	Alternative 2 Removal (4 years[a]) Time from Beginning of Construction (years) 0[c]	5	10	15	20	25	30	35	40	45
Site-wide Netfishing	24	5	4	3	3	2	2	2	2	2
Tribal Clamming	30	4	3	3	3	2	2	2	2	2
Beach 1	5	4	3	3	2	2	2	2	2	2
Beach 2	23	8	6	4	3	3	3	2	2	2
Beach 3	7	4	4	3	3	3	3	3	3	3
Beach 4	47	3	3	2	2	2	2	2	2	2
Beach 5	6	3	3	2	2	2	2	2	2	2
Beach 6	8	4	3	3	3	3	3	2	2	2
Beach 7	2	2	2	2	2	2	2	2	2	2
Beach 8	4	2	2	2	2	2	2	2	2	2

Exposure Area	Alternative 3 Removal (6 years[a]) Time from Beginning of Construction (years) 0[c]	5	10	15	20	25	30	35	40	45
Site-wide Netfishing	24	4	3	3	3	2	2	2	2	2
Tribal Clamming	30	4	3	3	2	2	2	2	2	2
Beach 1	5	3	3	2	2	2	2	2	2	2
Beach 2	23	7	5	4	3	3	3	2	2	2
Beach 3	7	4	4	3	3	3	3	3	3	3
Beach 4	47	3	3	2	2	2	2	2	2	2
Beach 5	6	2	2	2	2	2	2	2	2	2
Beach 6	8	2	2	2	2	2	2	2	2	2
Beach 7	2	2	2	2	2	2	2	2	2	2
Beach 8	4	2	2	2	2	2	2	2	2	2

Exposure Area	Alternative 4 Removal (11 years[a]) Time from Beginning of Construction (years) 0[c]	5	10	15	20	25	30	35	40	45
Site-wide Netfishing	24	4	3	3	2	2	2	2	2	2
Tribal Clamming	30	4	3	3	2	2	2	2	2	2
Beach 1	5	3	3	2	2	2	2	2	2	2
Beach 2	23	7	5	3	3	3	2	2	2	2
Beach 3	7	4	4	3	3	3	3	3	3	3
Beach 4	47	3	2	2	2	2	2	2	2	2
Beach 5	6	2	2	2	2	2	2	2	2	2
Beach 6	8	2	2	2	2	2	2	2	2	2
Beach 7	2	2	2	2	2	2	2	2	2	2
Beach 8	4	2	2	2	2	2	2	2	2	2

Risk for Each Alternative

Exposure Area	Baseline Risk[b]	Alternative 2 Removal (4 years[a]) Time from Beginning of Construction (years) 0[c]	5	10	15	20	25	30	35	40	45
Site-wide Netfishing	2×10^{-5}	6E-07	1E-07	1E-07	8E-08	7E-08	7E-08	7E-08	6E-08	6E-08	6E-08
Tribal Clamming	1×10^{-4}	2E-06	3E-07	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	2E-07	1E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 2	3×10^{-6}	8E-07	3E-07	2E-07	1E-07	1E-07	1E-07	9E-08	9E-08	8E-08	8E-08
Beach 3	1×10^{-7}	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Beach 4	1×10^{-5}	2E-06	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 5	1×10^{-6}	2E-07	1E-07	9E-08	9E-08	9E-08	9E-08	9E-08	8E-08	9E-08	8E-08
Beach 6	3×10^{-7}	3E-07	1E-07	1E-07	1E-07	1E-07	1E-07	9E-08	9E-08	9E-08	9E-08
Beach 7	1×10^{-7}	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 8	1×10^{-7}	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08

Exposure Area	Alternative 3 Removal (6 years[a]) Time from Beginning of Construction (years) 0[c]	5	10	15	20	25	30	35	40	45
Site-wide Netfishing	6E-07	1E-07	9E-08	7E-08	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08
Tribal Clamming	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	2E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 2	8E-07	2E-07	2E-07	1E-07	1E-07	1E-07	9E-08	9E-08	8E-08	8E-08
Beach 3	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Beach 4	2E-06	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 5	2E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 6	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08
Beach 7	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 8	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08

Exposure Area	Alternative 4 Removal (11 years[a]) Time from Beginning of Construction (years) 0[c]	5	10	15	20	25	30	35	40	45
Site-wide Netfishing	6E-07	1E-07	9E-08	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Tribal Clamming	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	2E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 2	8E-07	2E-07	2E-07	1E-07	1E-07	9E-08	9E-08	8E-08	8E-08	8E-08
Beach 3	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Beach 4	2E-06	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 5	2E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 6	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08
Beach 7	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 8	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08

Table M-6d Low Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Removal Alternatives

Exposure Area	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	4	3	3	2	2	2	2	2	2	24	4	3	3	2	2	2	2	2	2
Tribal Clamming	30	4	3	3	2	2	2	2	2	2	30	4	3	3	2	2	2	2	2	2
Beach 1	5	3	3	2	2	2	2	2	2	2	5	3	3	2	2	2	2	2	2	2
Beach 2	23	7	5	3	3	2	2	2	2	2	23	7	5	3	3	2	2	2	2	2
Beach 3	7	4	4	3	3	3	3	3	3	3	7	4	4	3	3	3	3	3	3	3
Beach 4	47	3	2	2	2	2	2	2	2	2	47	3	2	2	2	2	2	2	2	2
Beach 5	6	2	2	2	2	2	2	2	2	2	6	2	2	2	2	2	2	2	2	2
Beach 6	8	2	2	2	2	2	2	2	2	2	8	2	2	2	2	2	2	2	2	2
Beach 7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Beach 8	4	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2

Exposure Area	Baseline Risk[b]	Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	6E-07	1E-07	9E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-07	1E-07	9E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Tribal Clamming	1×10^{-4}	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	2E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-07	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 2	3×10^{-6}	8E-07	2E-07	2E-07	1E-07	9E-08	9E-08	8E-08	8E-08	8E-08	8E-08	8E-07	2E-07	2E-07	1E-07	9E-08	9E-08	8E-08	8E-08	7E-08	7E-08
Beach 3	1×10^{-7}	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	2E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07
Beach 4	1×10^{-5}	2E-06	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-06	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 5	1×10^{-6}	2E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	2E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 6	3×10^{-7}	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	3E-07	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08
Beach 7	1×10^{-7}	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Beach 8	1×10^{-7}	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	1E-07	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08	7E-08

Notes:

1. Low BCM input parameters (ng TEQ/kg dw dioxins/furans): upstream = 2; lateral = 10; post-remedy bed sediment replacement value = 2.
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres
4. Significant figures are displayed in accordance with the conventions established in the HHRA.

$> 1 \times 10^{-6}$ and $\leq 1 \times 10^{-5}$	Colored cells indicate residual excess cancer risk.
$\leq 1 \times 10^{-6}$	

a. Construction period.

b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to -spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

AOPC = area of potential concern; BCM = bed composition model; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilogram; LDW = Lower Duwamish Waterway; ng = nanograms; RI = remedial investigation; STM = sediment transport model; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent;95UCL = 95% upper confidence limit

Table M-7a High Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Combined Alternatives

Exposure Area	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	180	138	120	106	104	103	104	103	103	98	180	121	112	101	101	100	102	101	102	97	180	109	105	98	99	99	101	101	101	97
Tribal Clamming	199	133	115	104	104	103	104	102	103	99	199	103	104	99	100	100	101	100	101	97	199	98	101	97	99	99	100	100	101	97
Beach 1	51	76	93	98	101	104	102	107	110	106	51	76	92	97	101	104	104	109	111	106	51	76	92	97	101	104	104	109	111	106
Beach 2	278	208	162	126	108	101	98	95	93	90	278	133	118	105	98	95	94	93	92	90	278	108	102	95	93	92	92	91	91	89
Beach 3	108	170	177	159	161	165	172	177	178	159	108	162	174	157	161	165	172	177	178	159	108	145	165	153	159	164	174	178	178	159
Beach 4[d]	1099	341	172	113	118	114	97	105	109	100	1099	114	112	101	106	107	95	104	109	100	1099	104	109	100	105	106	95	104	109	100
Beach 5	123	100	96	92	93	93	94	93	94	91	123	91	93	90	92	92	94	92	94	91	123	86	90	86	88	88	90	90	91	87
Beach 6	448	159	114	101	104	101	96	91	91	89	448	90	89	87	89	88	90	88	89	87	448	90	89	87	89	88	90	88	89	87
Beach 7	46	95	100	94	100	99	118	101	102	96	46	95	100	94	100	99	118	101	102	96	46	95	100	94	100	99	118	101	102	96
Beach 8	49	78	80	80	80	80	81	80	81	80	49	79	80	80	80	80	81	80	81	80	49	79	80	80	80	80	81	80	81	80

Exposure Area	Baseline Risk[b]	Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	1E-07	9E-08	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	7E-08	1E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	7E-08
Tribal Clamming	1×10^{-4}	4E-07	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08
Beach 2	3×10^{-6}	2E-07	1E-07	1E-07	7E-08	6E-08	6E-08	6E-08	6E-08	5E-08	5E-08	2E-07	8E-08	7E-08	6E-08	6E-08	6E-08	6E-08	5E-08	5E-08	5E-08	2E-07	6E-08	6E-08	6E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 3	1×10^{-7}	6E-08	1E-07	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08	6E-08	1E-07	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08	6E-08	9E-08	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08
Beach 4[d]	1×10^{-5}	6E-07	2E-07	1E-07	7E-08	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-07	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-07	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Beach 5	1×10^{-6}	7E-08	6E-08	6E-08	5E-08	5E-08	5E-08	6E-08	5E-08	6E-08	5E-08	7E-08	5E-08	5E-08	5E-08	5E-08	5E-08	6E-08	5E-08	6E-08	5E-08	7E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 6	3×10^{-7}	3E-07	9E-08	7E-08	6E-08	6E-08	6E-08	6E-08	5E-08	5E-08	5E-08	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 7	1×10^{-7}	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08
Beach 8	1×10^{-7}	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08

Table M-7a High Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Combined Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	180	109	101	96	98	99	101	101	101	97	180	109	101	86	84	91	96	98	99	95
Tribal Clamming	199	98	99	96	98	99	100	100	101	96	199	98	99	92	90	93	96	97	99	95
Beach 1	51	76	94	99	101	105	107	111	112	107	51	76	94	99	95	101	104	109	111	106
Beach 2	278	108	101	95	92	91	92	91	91	89	278	108	101	95	69	76	81	84	86	86
Beach 3	108	145	164	153	159	164	175	179	178	160	108	145	164	153	156	162	175	179	178	159
Beach 4[d]	1099	104	104	100	105	106	100	105	109	100	1099	104	104	91	103	106	102	106	109	100
Beach 5	123	86	89	86	88	88	90	90	91	87	123	86	89	74	82	82	85	85	86	82
Beach 6	448	90	89	87	89	88	90	88	89	87	448	90	89	87	89	88	90	88	89	87
Beach 7	46	95	100	94	100	99	118	101	102	96	46	95	100	84	99	98	109	100	102	96
Beach 8	49	79	81	80	80	80	81	80	81	80	49	79	81	80	80	80	81	80	81	80

		Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	1E-07	8E-08	8E-08	7E-08	8E-08	8E-08	8E-08	8E-08	8E-08	7E-08	1E-07	8E-08	8E-08	7E-08	6E-08	7E-08	7E-08	8E-08	8E-08	7E-08
Tribal Clamming	1×10^{-4}	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	3E-08	4E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	7E-08	6E-08	3E-08	4E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08
Beach 2	3×10^{-6}	2E-07	6E-08	6E-08	6E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	2E-07	6E-08	6E-08	6E-08	4E-08	4E-08	5E-08	5E-08	5E-08	5E-08
Beach 3	1×10^{-7}	6E-08	9E-08	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08	6E-08	9E-08	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08
Beach 4[d]	1×10^{-5}	6E-07	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-07	6E-08	6E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Beach 5	1×10^{-6}	7E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	7E-08	5E-08	5E-08	4E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 6	3×10^{-7}	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 7	1×10^{-7}	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08	3E-08	6E-08	6E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Beach 8	1×10^{-7}	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08

Table M-7a High Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Removal Alternatives

	SWAC for Each Alternative																													
	Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	180	125	115	103	103	102	103	102	102	98	180	121	112	101	101	100	102	101	102	97	180	121	110	98	99	99	101	101	101	97
Tribal Clamming	199	109	107	101	102	101	102	101	102	98	199	103	104	99	100	100	101	100	101	97	199	103	103	97	99	99	100	100	101	97
Beach 1	51	76	93	98	101	104	102	107	110	106	51	76	92	97	101	104	104	109	111	106	51	76	92	97	101	104	104	109	111	106
Beach 2	278	161	135	113	102	97	96	94	93	90	278	133	118	105	98	95	94	93	92	90	278	133	118	96	93	92	92	91	91	89
Beach 3	108	162	174	157	161	165	172	177	178	159	108	162	174	157	161	165	172	177	178	159	108	162	174	151	158	163	174	178	178	159
Beach 4[d]	1099	117	112	101	106	107	92	104	109	100	1099	114	112	101	106	107	95	104	109	100	1099	114	108	100	105	106	95	104	109	100
Beach 5	123	98	96	91	93	93	94	93	94	91	123	91	93	90	92	92	94	92	94	91	123	91	89	86	88	88	90	90	91	87
Beach 6	448	159	114	101	104	101	96	91	91	89	448	90	89	87	89	88	90	88	89	87	448	90	89	87	89	88	90	88	89	87
Beach 7	46	95	100	94	100	99	118	101	102	96	46	95	100	94	100	99	118	101	102	96	46	95	100	94	100	99	118	101	102	96
Beach 8	49	78	80	80	80	80	81	80	81	80	49	79	80	80	80	80	81	80	81	80	49	79	80	80	80	80	81	80	81	80

		Risk for Each Alternative																													
		Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	1E-07	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	1E-07	9E-08	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	7E-08	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	7E-08
Tribal Clamming	1×10^{-4}	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08
Beach 2	3×10^{-6}	2E-07	9E-08	8E-08	7E-08	6E-08	6E-08	6E-08	6E-08	5E-08	5E-08	2E-07	8E-08	7E-08	6E-08	6E-08	6E-08	6E-08	5E-08	5E-08	5E-08	2E-07	8E-08	7E-08	6E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 3	1×10^{-7}	6E-08	1E-07	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08	6E-08	1E-07	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08	6E-08	1E-07	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08
Beach 4[d]	1×10^{-5}	6E-07	7E-08	7E-08	6E-08	6E-08	6E-08	5E-08	6E-08	6E-08	6E-08	6E-07	7E-08	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-07	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Beach 5	1×10^{-6}	7E-08	6E-08	6E-08	5E-08	5E-08	5E-08	6E-08	5E-08	6E-08	5E-08	7E-08	5E-08	5E-08	5E-08	5E-08	5E-08	6E-08	5E-08	6E-08	5E-08	7E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 6	3×10^{-7}	3E-07	9E-08	7E-08	6E-08	6E-08	6E-08	6E-08	5E-08	5E-08	5E-08	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 7	1×10^{-7}	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08
Beach 8	1×10^{-7}	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08

Table M-7a High Sensitivity of LDW Total PCB SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Total PCB SWACs

Removal Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[b]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	180	121	110	98	98	99	101	101	101	97	180	121	110	98	98	93	94	93	93	92
Tribal Clamming	199	103	103	97	98	98	100	100	101	96	199	103	103	97	98	95	97	96	95	93
Beach 1	51	76	92	97	98	103	105	110	111	106	51	76	92	97	98	103	105	110	104	104
Beach 2	278	133	118	96	93	92	92	91	91	89	278	133	118	96	93	92	92	80	74	79
Beach 3	108	162	174	151	157	163	175	179	178	159	108	162	174	151	157	163	175	179	174	159
Beach 4[d]	1099	114	108	100	102	106	100	105	109	100	1099	114	108	100	102	106	92	104	109	100
Beach 5	123	91	89	86	88	88	90	90	91	87	123	91	89	86	88	76	83	85	86	83
Beach 6	448	90	89	87	89	88	90	88	89	87	448	90	89	87	89	88	90	88	89	87
Beach 7	46	95	100	94	100	99	118	101	102	96	46	95	100	94	100	87	107	100	102	95
Beach 8	49	79	80	80	81	80	81	80	81	80	49	79	80	80	81	80	81	80	81	80

		Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[b]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	1E-07	9E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08	7E-08	1E-07	9E-08	8E-08	8E-08	8E-08	7E-08	7E-08	7E-08	7E-08	7E-08
Tribal Clamming	1×10^{-4}	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	4E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 1	1×10^{-7}	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	3E-08	4E-08	5E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08
Beach 2	3×10^{-6}	2E-07	8E-08	7E-08	6E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	2E-07	8E-08	7E-08	6E-08	5E-08	5E-08	5E-08	5E-08	4E-08	5E-08
Beach 3	1×10^{-7}	6E-08	1E-07	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08	6E-08	1E-07	1E-07	9E-08	9E-08	1E-07	1E-07	1E-07	1E-07	9E-08
Beach 4[d]	1×10^{-5}	6E-07	7E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-08	6E-07	7E-08	6E-08	6E-08	6E-08	6E-08	5E-08	6E-08	6E-08	6E-08
Beach 5	1×10^{-6}	7E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	7E-08	5E-08	5E-08	5E-08	5E-08	4E-08	5E-08	5E-08	5E-08	5E-08
Beach 6	3×10^{-7}	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-07	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08
Beach 7	1×10^{-7}	3E-08	6E-08	6E-08	6E-08	6E-08	6E-08	7E-08	6E-08	6E-08	6E-08	3E-08	6E-08	6E-08	6E-08	6E-08	5E-08	6E-08	6E-08	6E-08	6E-08
Beach 8	1×10^{-7}	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	3E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08	5E-08

Notes:
1. High BCM input parameters (µg/kg dw total PCBs): upstream = 80; lateral = 1,000; post-remedy bed sediment replacement value = 90 (AOPC 1), 40 (AOPC 2).
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres

$\leq 1 \times 10^{-6}$ Colored cells indicate residual excess cancer risk.

4. Significant figures are displayed in accordance with the conventions established in the HHRA.

a. Construction period.

b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

d. The large differences between the baseline risks and the SWAC-based risk estimates at Beach 4 result from removing the two highest PCB-concentration samples at Beach 4 from the FS dataset for interpolating PCB concentrations. After construction of Alternative 2, the locations with the highest PCB concentrations would have undergone active remediation.

BCM = bed composition model; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; STM = sediment transport model; SWAC = spatially-weighted average concentration

Table M-7b High Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Combined Alternatives

	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	13	12	11	11	11	11	11	11	11	16	11	11	10	10	10	10	10	10	10	16	11	11	10	10	10	10	10	10	10
Tribal Clamming	13	12	12	12	12	12	12	12	12	12	13	10	10	10	10	10	10	10	10	10	13	10	10	10	10	10	10	10	10	10
Beach 1	8	9	10	10	10	11	10	11	11	11	8	9	10	10	10	10	10	11	11	11	8	9	10	10	10	10	10	11	11	11
Beach 2	13	12	11	11	10	10	10	10	10	10	13	11	11	11	10	10	10	10	10	10	13	11	11	11	10	10	10	10	10	10
Beach 3	11	12	12	12	12	12	12	12	12	12	11	12	12	12	12	12	12	12	12	12	11	12	12	12	12	12	12	12	12	12
Beach 4	7	10	10	10	10	11	10	10	11	10	7	10	11	10	11	11	10	11	11	10	7	10	11	10	11	11	10	11	11	10
Beach 5	9	9	10	9	9	9	9	10	10	9	9	10	10	9	10	10	10	10	10	10	9	10	10	10	10	10	10	10	10	10
Beach 6	12	10	10	10	10	10	10	10	10	10	12	11	10	10	10	10	10	10	10	10	12	11	10	10	10	10	10	10	10	10
Beach 7	8	10	10	10	10	10	11	10	10	10	8	10	10	10	10	10	11	10	10	10	8	10	10	10	10	10	11	10	10	10
Beach 8	8	10	10	10	10	10	10	10	10	10	8	10	10	10	10	10	10	10	10	10	8	10	10	10	10	10	10	10	10	10

		Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Tribal Clamming	2×10^{-5}	1E-05	9E-06	9E-06	9E-06	9E-06	9E-06	9E-06	9E-06	9E-06	9E-06	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06
Beach 1	5×10^{-6}	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 2	6×10^{-6}	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 3	4×10^{-6}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 4	4×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 5	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	4E-06	3E-06
Beach 6	3×10^{-5}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 7	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 8	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06

Table M-7b High Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Combined Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	11	11	10	10	10	10	10	10	10	16	11	11	10	10	10	10	10	10	10
Tribal Clamming	13	10	11	10	10	10	10	10	10	10	13	10	11	10	10	10	10	10	10	10
Beach 1	8	9	10	10	10	11	11	11	11	11	8	9	10	10	10	11	11	11	11	11
Beach 2	13	11	11	11	11	10	10	10	10	10	13	11	11	11	10	10	10	10	10	10
Beach 3	11	12	12	12	12	12	12	12	12	12	11	12	12	12	12	12	12	12	12	12
Beach 4	7	10	11	10	11	11	10	11	11	10	7	10	11	10	11	11	10	11	11	10
Beach 5	9	10	10	10	10	10	10	10	10	10	9	10	10	10	10	10	10	10	10	10
Beach 6	12	11	10	10	10	10	10	10	10	10	12	11	10	10	10	10	10	10	10	10
Beach 7	8	10	10	10	10	10	11	10	10	10	8	10	10	10	10	10	11	10	10	10
Beach 8	8	10	10	10	10	10	10	10	10	10	8	10	10	10	10	10	10	10	10	10

		Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Tribal Clamming	2×10^{-5}	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06
Beach 1	5×10^{-6}	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 2	6×10^{-6}	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 3	4×10^{-6}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 4	4×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 5	3×10^{-6}	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 6	3×10^{-5}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 7	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 8	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06

Table M-7b High Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Removal Alternatives

SWAC for Each Alternative

Exposure Area	Alternative 2 Removal (4 years[a]) – Time from Beginning of Construction (years)									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	11	11	11	10	10	11	10	10	10
Tribal Clamming	13	10	10	10	10	10	10	10	10	10
Beach 1	8	9	10	10	10	11	10	11	11	11
Beach 2	13	11	11	11	10	10	10	10	10	10
Beach 3	11	12	12	12	12	12	12	12	12	12
Beach 4	7	10	11	10	11	11	10	11	11	10
Beach 5	9	9	10	9	9	9	9	10	10	9
Beach 6	12	10	10	10	10	10	10	10	10	10
Beach 7	8	10	10	10	10	10	11	10	10	10
Beach 8	8	10	10	10	10	10	10	10	10	10

Exposure Area	Alternative 3 Removal (6 years[a]) – Time from Beginning of Construction (years)									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	11	11	10	10	10	10	10	10	10
Tribal Clamming	13	10	10	10	10	10	10	10	10	10
Beach 1	8	9	10	10	10	10	10	11	11	11
Beach 2	13	11	11	11	10	10	10	10	10	10
Beach 3	11	12	12	12	12	12	12	12	12	12
Beach 4	7	10	11	10	11	11	10	11	11	10
Beach 5	9	10	10	9	10	10	10	10	10	10
Beach 6	12	11	10	10	10	10	10	10	10	10
Beach 7	8	10	10	10	10	10	11	10	10	10
Beach 8	8	10	10	10	10	10	10	10	10	10

Exposure Area	Alternative 4 Removal (11 years[a]) – Time from Beginning of Construction (years)									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	11	11	11	10	10	10	10	10	10
Tribal Clamming	13	10	10	10	10	10	10	10	10	10
Beach 1	8	9	10	10	10	10	10	11	11	11
Beach 2	13	11	11	11	10	10	10	10	10	10
Beach 3	11	12	12	12	12	12	12	12	12	12
Beach 4	7	10	11	10	11	11	10	11	11	10
Beach 5	9	10	10	10	10	10	10	10	10	10
Beach 6	12	11	10	10	10	10	10	10	10	10
Beach 7	8	10	10	10	10	10	11	10	10	10
Beach 8	8	10	10	10	10	10	10	10	10	10

Risk for Each Alternative

Exposure Area	Baseline Risk[b]	Alternative 2 Removal (4 years[a]) – Time from Beginning of Construction (years)									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Tribal Clamming	2×10^{-5}	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06
Beach 1	5×10^{-6}	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 2	6×10^{-6}	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 3	4×10^{-6}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 4	4×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 5	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	3×10^{-5}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 7	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 8	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06

Exposure Area	Alternative 3 Removal (6 years[a]) – Time from Beginning of Construction (years)									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Tribal Clamming	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06
Beach 1	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 2	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 3	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 4	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 5	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach 6	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 7	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 8	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06

Exposure Area	Alternative 4 Removal (11 years[a]) – Time from Beginning of Construction (years)									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Tribal Clamming	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06
Beach 1	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 2	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 3	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 4	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 5	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	4E-06	4E-06	3E-06
Beach 6	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 7	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 8	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06

Table M-7b High Sensitivity of LDW Arsenic SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Arsenic SWACs

Removal Alternatives

Exposure Area	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
	0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	16	11	11	11	11	10	11	10	10	10	16	11	11	11	11	10	10	10	10	10
Tribal Clamming	13	10	10	10	11	10	11	10	10	10	13	10	10	10	11	10	10	10	10	10
Beach 1	8	9	10	10	11	11	11	11	11	11	8	9	10	10	11	11	11	11	11	11
Beach 2	13	11	11	11	11	11	10	10	10	10	13	11	11	11	11	11	10	10	10	10
Beach 3	11	12	12	12	12	12	12	12	12	12	11	12	12	12	12	12	12	12	12	12
Beach 4	7	10	11	10	11	11	10	11	11	10	7	10	11	10	11	11	10	11	11	10
Beach 5	9	10	10	10	10	10	10	10	10	10	9	10	10	10	10	10	10	10	10	10
Beach 6	12	11	10	10	10	10	10	10	10	10	12	11	10	10	10	10	10	10	10	10
Beach 7	8	10	10	10	10	10	11	10	10	10	8	10	10	10	10	10	11	10	10	10
Beach 8	8	10	10	10	10	10	10	10	10	10	8	10	10	10	10	10	10	10	10	10

Exposure Area	Baseline Risk[b]	Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
		0[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	6×10^{-6}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Tribal Clamming	2×10^{-5}	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	1E-05	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06	8E-06
Beach 1	5×10^{-6}	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 2	6×10^{-6}	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	5E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 3	4×10^{-6}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 4	4×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 5	3×10^{-6}	3E-06	3E-06	4E-06	3E-06	4E-06	3E-06	4E-06	4E-06	4E-06	3E-06	3E-06	3E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 6	3×10^{-5}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 7	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach 8	3×10^{-6}	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06

Notes:

1. High BCM input parameters (mg/kg dw arsenic): upstream = 10; lateral = 30; post-remedy bed sediment replacement value = 11 (AOPC 1), 10 (AOPC 2).
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres

$> 1 \times 10^{-6}$ and $\leq 1 \times 10^{-5}$ Colored cells indicate residual excess cancer risk.

4. Significant figures are displayed in accordance with the conventions established in the HHRA.
5. Direct contact excess cancer risk at 1×10^{-6} cannot be achieved because 1) risk threshold is below natural background, and 2) the concentration of the upstream sediment input is estimated to be 10 mg/kg dw, which corresponds to a risk of 4×10^{-6}.

a. Construction period.
b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).
c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

BCM = bed composition model; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; STM = sediment transport model; SWAC = spatially-weighted average concentration

Table M-7c High Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Combined Alternatives

	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	362	361	352	328	328	330	339	339	340	325	362	312	328	314	320	325	333	335	338	322	362	286	315	305	317	323	332	335	337	322
Tribal Clamming	303	335	340	323	328	329	333	332	336	321	303	264	302	299	313	317	322	324	329	314	303	258	300	297	313	317	323	325	329	314
Beach 1	397	403	398	373	360	363	351	368	375	359	397	205	282	308	335	349	349	367	374	359	397	205	282	308	335	349	349	367	374	359
Beach 2	752	567	452	364	327	315	312	308	306	300	752	199	237	256	278	287	294	297	300	297	752	201	238	254	279	287	294	298	300	297
Beach 3	390	588	616	560	573	585	608	617	618	559	390	559	603	551	571	584	609	618	618	559	390	528	587	535	569	583	616	621	620	560
Beach 4	382	366	371	339	356	360	307	349	367	338	382	298	354	331	353	358	317	352	368	339	382	269	347	328	352	358	321	352	368	339
Beach 5	385	289	265	242	250	247	249	256	258	242	385	221	248	233	243	243	249	257	259	243	385	212	250	236	248	248	255	262	265	249
Beach 6	531	361	329	313	319	316	309	303	306	299	531	200	276	273	290	291	300	297	299	291	531	200	276	273	290	291	300	297	299	291
Beach 7	74	314	336	318	336	332	398	340	345	323	74	314	336	318	336	332	398	340	345	323	74	314	336	318	336	332	398	340	345	323
Beach 8	284	267	272	270	270	272	273	271	273	271	284	262	272	270	270	272	273	271	273	271	284	262	272	270	270	272	273	271	273	271

		Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	1E-06	9E-07	9E-07	9E-07	9E-07	9E-07	9E-07	9E-07	9E-07	9E-07	1E-06	8E-07	9E-07	8E-07	8E-07	9E-07	9E-07	9E-07	9E-07	8E-07	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	9E-07	9E-07	9E-07	8E-07
Tribal Clamming	5×10^{-6}	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Beach1	4×10^{-6}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	2E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	2E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach2	8×10^{-5}	8E-06	6E-06	5E-06	4E-06	4E-06	4E-06	3E-06	3E-06	3E-06	3E-06	8E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	8E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach3	1×10^{-5}	4E-06	7E-06	7E-06	6E-06	6E-06	7E-06	7E-06	7E-06	7E-06	6E-06	4E-06	6E-06	7E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06	4E-06	6E-06	7E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06
Beach4	1×10^{-5}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach5	3×10^{-5}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach6	8×10^{-5}	6E-06	4E-06	4E-06	3E-06	4E-06	4E-06	3E-06	3E-06	3E-06	3E-06	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach7	1×10^{-6}	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Table M-7c High Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Combined Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	362	286	300	302	315	321	332	335	337	322	362	286	300	275	279	303	320	328	333	320
Tribal Clamming	303	258	290	296	312	316	324	325	329	314	303	258	290	287	293	305	315	321	327	313
Beach 1	397	205	263	309	331	347	356	371	376	360	397	205	263	309	310	335	349	367	374	359
Beach 2	752	201	233	254	277	286	294	298	300	297	752	201	233	254	222	249	268	280	288	290
Beach 3	390	528	553	526	563	580	618	622	620	560	390	528	553	526	551	575	615	621	620	560
Beach 4	382	269	322	327	351	358	336	356	369	339	382	269	322	299	346	356	344	358	369	339
Beach 5	385	212	238	237	248	248	257	263	266	250	385	212	238	216	246	248	257	264	267	251
Beach 6	531	200	276	273	290	291	300	297	299	291	531	200	276	273	290	291	300	297	299	291
Beach 7	74	314	336	318	336	332	398	340	345	323	74	314	336	284	334	332	367	338	344	323
Beach 8	284	262	265	270	270	272	273	271	273	271	284	262	265	270	270	272	273	271	273	271

		Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	9E-07	9E-07	9E-07	8E-07	1E-06	8E-07	8E-07	7E-07	7E-07	8E-07	8E-07	9E-07	9E-07	8E-07
Tribal Clamming	5×10^{-6}	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Beach1	4×10^{-6}	4E-06	2E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	2E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach2	8×10^{-5}	8E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	8E-06	2E-06	3E-06	3E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach3	1×10^{-5}	4E-06	6E-06	6E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06	4E-06	6E-06	6E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06
Beach4	1×10^{-5}	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach5	3×10^{-5}	4E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	2E-06	3E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach6	8×10^{-5}	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach7	1×10^{-6}	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	8E-07	3E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Table M-7c High Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Removal Alternatives

	SWAC for Each Alternative																													
	Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	362	334	339	321	324	327	335	337	339	323	362	312	328	314	320	325	333	335	338	322	362	312	320	302	315	321	331	334	337	322
Tribal Clamming	303	309	326	313	322	324	327	327	332	317	303	264	302	299	313	317	322	324	329	314	303	264	298	296	312	316	322	324	329	314
Beach 1	397	403	398	373	360	363	351	368	375	359	397	205	282	308	335	349	349	367	374	359	397	205	282	308	335	349	349	367	374	359
Beach 2	752	332	316	298	298	299	302	302	303	299	752	199	237	256	278	287	294	297	300	297	752	199	237	249	274	284	292	296	299	297
Beach 3	390	559	603	551	571	584	609	618	618	559	390	559	603	551	571	584	609	618	618	559	390	559	603	508	555	576	612	619	619	559
Beach 4	382	332	362	335	354	359	311	350	367	339	382	298	354	331	353	358	317	352	368	339	382	298	332	330	351	358	321	352	368	339
Beach 5	385	280	263	241	249	247	250	256	258	242	385	221	248	233	243	243	249	257	259	243	385	221	241	237	247	248	255	262	265	249
Beach 6	531	361	329	313	319	316	309	303	306	299	531	200	276	273	290	291	300	297	299	291	531	200	276	273	290	290	300	297	299	291
Beach 7	74	314	336	318	336	332	398	340	345	323	74	314	336	318	336	332	398	340	345	323	74	314	336	318	336	332	398	340	345	323
Beach 8	284	267	272	270	270	272	273	271	273	271	284	262	272	270	270	272	273	271	273	271	284	262	272	270	270	272	273	271	273	271

		Risk for Each Alternative																													
		Alternative 2 Removal (4 years[a])										Alternative 3 Removal (6 years[a])										Alternative 4 Removal (11 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	1E-06	9E-07	9E-07	8E-07	9E-07	9E-07	9E-07	9E-07	9E-07	9E-07	1E-06	8E-07	9E-07	8E-07	8E-07	9E-07	9E-07	9E-07	9E-07	8E-07	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	9E-07	9E-07	9E-07	8E-07
Tribal Clamming	5×10^{-6}	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Beach1	4×10^{-6}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	2E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	2E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach2	8×10^{-5}	8E-06	4E-06	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	8E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	8E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach3	1×10^{-5}	4E-06	6E-06	7E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06	4E-06	6E-06	7E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06	4E-06	6E-06	7E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06
Beach4	1×10^{-5}	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach5	3×10^{-5}	4E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach6	8×10^{-5}	6E-06	4E-06	4E-06	3E-06	4E-06	4E-06	3E-06	3E-06	3E-06	3E-06	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach7	1×10^{-6}	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Table M-7c High Sensitivity of LDW cPAH SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on cPAH SWACs

Removal Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	362	312	320	302	302	315	328	332	336	321	362	312	320	302	302	302	309	311	310	310
Tribal Clamming	303	264	298	296	299	311	321	323	329	314	303	264	298	296	299	303	315	315	313	307
Beach 1	397	205	282	308	298	329	343	364	372	358	397	205	282	308	298	329	343	364	348	351
Beach 2	752	199	237	249	263	277	287	293	297	296	752	199	237	249	263	277	287	259	245	264
Beach 3	390	559	603	508	534	566	609	618	618	559	390	559	603	508	534	566	609	618	605	557
Beach 4	382	298	332	330	327	352	334	355	369	339	382	298	332	330	327	352	309	350	367	338
Beach 5	385	221	241	237	236	246	255	263	266	250	385	221	241	237	236	225	252	263	267	252
Beach 6	531	200	276	273	290	290	300	297	299	291	531	200	276	273	290	290	300	297	299	291
Beach 7	74	314	336	318	336	332	398	340	345	323	74	314	336	318	336	294	364	338	344	323
Beach 8	284	262	272	270	263	272	273	271	273	271	284	262	272	270	263	272	273	271	273	271

		Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	1×10^{-6}	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	9E-07	9E-07	9E-07	8E-07	1E-06	8E-07	8E-07	8E-07	8E-07	8E-07	8E-07	8E-07	8E-07	8E-07
Tribal Clamming	5×10^{-6}	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06	2E-06
Beach1	4×10^{-6}	4E-06	2E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	2E-06	3E-06	3E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06
Beach2	8×10^{-5}	8E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	8E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach3	1×10^{-5}	4E-06	6E-06	7E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06	4E-06	6E-06	7E-06	6E-06	6E-06	6E-06	7E-06	7E-06	7E-06	6E-06
Beach4	1×10^{-5}	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06
Beach5	3×10^{-5}	4E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	4E-06	2E-06	3E-06	3E-06	3E-06	2E-06	3E-06	3E-06	3E-06	3E-06
Beach6	8×10^{-5}	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	6E-06	2E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06
Beach7	1×10^{-6}	8E-07	3E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	4E-06	8E-07	3E-06	4E-06	4E-06	4E-06	3E-06	4E-06	4E-06	4E-06	4E-06
Beach8	3×10^{-6}	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06	3E-06

Notes:

1. High BCM input parameters (µg TEQ/kg dw cPAHs): upstream = 270; lateral = 3,400; post-remedy bed sediment replacement value = 200 (AOPC 1), 140 (AOPC 2).
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres
4. Significant figures are displayed in accordance with the conventions established in the HHRA.

Legend	
$> 1 \times 10^{-6}$ and $\leq 1 \times 10^{-5}$	Colored cells indicate residual excess cancer risk.
$\leq 1 \times 10^{-6}$	

a. Construction period.

b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

BCM = bed composition model; cPAH = carcinogenic polycyclic aromatic hydrocarbon; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; µg = micrograms; STM = sediment transport model; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent.

Table M-7d High Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Combined Alternatives

	SWAC for Each Alternative																													
	EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	15	11	9	9	9	9	9	9	9	24	8	9	8	8	9	9	9	9	8	24	8	8	8	8	8	9	9	9	8
Tribal Clamming	30	17	12	9	9	9	9	8	9	8	30	8	8	8	8	8	8	8	8	8	30	8	8	8	8	8	8	8	8	8
Beach 1	5	7	8	8	9	9	9	9	9	9	5	7	8	8	9	9	9	9	9	9	5	7	8	8	9	9	9	9	9	9
Beach 2	23	17	14	11	10	9	9	9	9	8	23	9	9	9	9	8	8	8	8	8	23	9	9	8	8	8	8	8	8	8
Beach 3	8	10	11	10	11	11	11	11	11	11	8	9	10	10	11	11	11	11	11	11	8	9	10	10	11	11	11	11	11	11
Beach 4	47	18	11	9	9	9	9	9	9	9	47	8	9	9	9	9	8	9	9	9	47	8	9	8	9	9	9	9	9	9
Beach 5	6	7	7	6	7	7	7	7	7	7	6	6	6	6	6	6	6	7	7	6	6	6	6	6	6	6	7	7	7	7
Beach 6	8	9	9	9	9	9	9	9	9	9	8	6	8	8	8	8	8	8	8	8	8	6	8	8	8	8	8	8	8	8
Beach 7	2	8	9	8	9	9	9	9	9	9	2	8	9	8	9	9	9	9	9	9	2	8	9	8	9	9	9	9	9	9
Beach 8	4	8	8	8	8	8	8	8	8	8	4	8	8	8	8	8	8	8	8	8	4	8	8	8	8	8	8	8	8	8

		Risk for Each Alternative																													
		EAAs-Alternative 1										Alternative 3 Combined (3 years[a])										Alternative 4 Combined (6 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0* [c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	7E-07	4E-07	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Tribal Clamming	1×10^{-4}	2E-06	1E-06	9E-07	7E-07	7E-07	7E-07	7E-07	7E-07	7E-07	6E-07	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	7E-07	6E-07	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	7E-07	6E-07
Beach 1	1×10^{-7}	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 2	3×10^{-6}	8E-07	6E-07	5E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 3	1×10^{-7}	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	3E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	3E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 4	1×10^{-5}	2E-06	6E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 5	1×10^{-6}	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 6	3×10^{-7}	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 7	1×10^{-7}	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 8	1×10^{-7}	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07

Table M-7d High Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Combined Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	8	8	8	8	8	9	9	9	8	24	8	8	8	8	8	8	9	9	8
Tribal Clamming	30	8	8	8	8	8	8	8	8	8	30	8	8	8	8	8	8	8	8	8
Beach 1	5	7	7	8	8	9	9	9	9	9	5	7	7	8	8	9	9	9	9	9
Beach 2	23	9	8	8	8	8	8	8	8	8	23	9	8	8	7	8	8	8	8	8
Beach 3	8	9	10	10	11	11	11	11	11	11	8	9	10	10	10	11	11	11	11	11
Beach 4	47	8	8	8	9	9	9	9	9	9	47	8	8	8	9	9	9	9	9	9
Beach 5	6	6	6	6	6	6	7	7	7	7	6	6	6	6	7	7	7	7	7	7
Beach 6	8	6	8	8	8	8	8	8	8	8	8	6	8	8	8	8	8	8	8	8
Beach 7	2	8	9	8	9	9	9	9	9	9	2	8	9	8	9	9	9	9	9	9
Beach 8	4	8	8	8	8	8	8	8	8	8	4	8	8	8	8	8	8	8	8	8

		Risk for Each Alternative																			
		Alternative 5 Combined (7 years[a])										Alternative 6 Combined (16 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0*[c]	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Tribal Clamming	1×10^{-4}	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	7E-07	6E-07	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 1	1×10^{-7}	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 2	3×10^{-6}	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 3	1×10^{-7}	3E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	3E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 4	1×10^{-5}	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 5	1×10^{-6}	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	3E-07	3E-07	2E-07
Beach 6	3×10^{-7}	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 7	1×10^{-7}	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 8	1×10^{-7}	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07

Table M-7d High Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Removal Alternatives

SWAC for Each Alternative

Alternative 2 Removal (4 years[a]) — *Time from Beginning of Construction (years)*

Exposure Area	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	9	9	8	8	9	9	9	9	8
Tribal Clamming	30	8	9	8	8	8	8	8	8	8
Beach 1	5	7	8	8	9	9	9	9	9	9
Beach 2	23	10	9	9	9	9	9	8	8	8
Beach 3	8	9	10	10	11	11	11	11	11	11
Beach 4	47	8	9	9	9	9	8	9	9	9
Beach 5	6	6	7	6	7	7	7	7	7	7
Beach 6	8	9	9	9	9	9	9	9	9	9
Beach 7	2	8	9	8	9	9	9	9	9	9
Beach 8	4	8	8	8	8	8	8	8	8	8

Alternative 3 Removal (6 years[a]) — *Time from Beginning of Construction (years)*

Exposure Area	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	8	9	8	8	9	9	9	9	8
Tribal Clamming	30	8	8	8	8	8	8	8	8	8
Beach 1	5	7	8	8	9	9	9	9	9	9
Beach 2	23	9	9	9	9	8	8	8	8	8
Beach 3	8	9	10	10	11	11	11	11	11	11
Beach 4	47	8	9	9	9	9	8	9	9	9
Beach 5	6	6	6	6	6	6	6	7	7	6
Beach 6	8	6	8	8	8	8	8	8	8	8
Beach 7	2	8	9	8	9	9	9	9	9	9
Beach 8	4	8	8	8	8	8	8	8	8	8

Alternative 4 Removal (11 years[a]) — *Time from Beginning of Construction (years)*

Exposure Area	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	8	8	8	8	8	9	9	9	8
Tribal Clamming	30	8	8	8	8	8	8	8	8	8
Beach 1	5	7	8	8	9	9	9	9	9	9
Beach 2	23	9	9	8	8	8	8	8	8	8
Beach 3	8	9	10	10	10	11	11	11	11	11
Beach 4	47	8	8	9	9	9	9	9	9	9
Beach 5	6	6	6	6	6	6	7	7	7	7
Beach 6	8	6	8	8	8	8	8	8	8	8
Beach 7	2	8	9	8	9	9	9	9	9	9
Beach 8	4	8	8	8	8	8	8	8	8	8

Risk for Each Alternative

Alternative 2 Removal (4 years[a]) — *Time from Beginning of Construction (years)*

Exposure Area	Baseline Risk[b]	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Tribal Clamming	1×10^{-4}	2E-06	6E-07	7E-07	6E-07	6E-07	6E-07	6E-07	6E-07	7E-07	6E-07
Beach 1	1×10^{-7}	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 2	3×10^{-6}	8E-07	4E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 3	1×10^{-7}	3E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 4	1×10^{-5}	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 5	1×10^{-6}	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 6	3×10^{-7}	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 7	1×10^{-7}	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 8	1×10^{-7}	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07

Alternative 3 Removal (6 years[a]) — *Time from Beginning of Construction (years)*

Exposure Area	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Tribal Clamming	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	7E-07	6E-07
Beach 1	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 2	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 3	3E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 4	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 5	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 6	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 7	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 8	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07

Alternative 4 Removal (11 years[a]) — *Time from Beginning of Construction (years)*

Exposure Area	*0 [c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Tribal Clamming	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	7E-07	6E-07
Beach 1	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 2	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 3	3E-07	3E-07	4E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 4	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 5	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Beach 6	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 7	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 8	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07

Table M-7d High Sensitivity of LDW Dioxin/Furan SWACs to BCM Chemical Input Values and Excess Cancer Risks for Direct Contact Based on Dioxin/Furan SWACs

Removal Alternatives

	SWAC for Each Alternative																			
	Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
	Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	24	8	8	8	8	8	8	9	9	8	24	8	8	8	8	8	8	8	8	8
Tribal Clamming	30	8	8	8	8	8	8	8	8	8	30	8	8	8	8	8	8	8	8	8
Beach 1	5	7	8	8	8	8	9	9	9	9	5	7	8	8	8	8	9	9	9	9
Beach 2	23	9	9	8	8	8	8	8	8	8	23	9	9	8	8	8	8	8	7	8
Beach 3	8	9	10	10	10	11	11	11	11	11	8	9	10	10	10	11	11	11	11	11
Beach 4	47	8	8	9	8	9	9	9	9	9	47	8	8	9	8	9	8	9	9	9
Beach 5	6	6	6	6	6	6	7	7	7	7	6	6	6	6	6	6	7	7	7	7
Beach 6	8	6	8	8	8	8	8	8	8	8	8	6	8	8	8	8	8	8	8	8
Beach 7	2	8	9	8	9	9	9	9	9	9	2	8	9	8	9	8	9	9	9	9
Beach 8	4	8	8	8	8	8	8	8	8	8	4	8	8	8	8	8	8	8	8	8

		Risk for Each Alternative																			
		Alternative 5 Removal (17 years[a])										Alternative 6 Removal (42 years[a])									
		Time from Beginning of Construction (years)										*Time from Beginning of Construction (years)*									
Exposure Area	Baseline Risk[b]	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*	*0[c]*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*45*
Site-wide Netfishing	2×10^{-5}	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	7E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07
Tribal Clamming	1×10^{-4}	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	2E-06	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07	6E-07
Beach 1	1×10^{-7}	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 2	3×10^{-6}	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	8E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 3	1×10^{-7}	3E-07	3E-07	4E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07	3E-07	3E-07	4E-07	3E-07	4E-07	4E-07	4E-07	4E-07	4E-07	4E-07
Beach 4	1×10^{-5}	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-06	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 5	1×10^{-6}	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	3E-07	3E-07	2E-07
Beach 6	3×10^{-7}	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 7	1×10^{-7}	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	9E-08	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07
Beach 8	1×10^{-7}	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	1E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07

Notes:

1. High BCM input parameters (ng TEQ/kg dw dioxins/furans): upstream = 8; lateral = 40; post-remedy bed sediment replacement value = 6.
2. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
3. BCM area = 430 acres and FS study area = 441 acres
4. Significant figures are displayed in accordance with the conventions established in the HHRA.

$> 1 \times 10^{-6}$ and $\leq 1 \times 10^{-5}$
$\leq 1 \times 10^{-6}$
Colored cells indicate residual excess cancer risk.

a. Construction period.

b. Baseline risks using the RI baseline data for the direct contact scenarios as reported in Section 3 (Table 3-6a for netfishing, tribal clamming scenarios, and beach play scenarios).

c. The 5-year intervals for the BCM-predicted SWACs (and for risk estimation) are indexed to the start of construction for Alternatives 2 through 6. Risk estimates for time 0 (post-EAA/Alternative 1) use the BCM-predicted SWACs after construction of the EAAs. Differences in risks between the baseline risks presented in the HHRA and the risks at time 0 are attributable to: 1) the transition from the HHRA methodology (UCL95 or maximum values) to spatial interpolation methodology (SWACs); 2) the transition from the RI baseline dataset to the FS baseline dataset, which affects the SWACs in netfishing and clamming exposure areas; and 3) active remediation of the EAAs, which affects the SWACs in netfishing, clamming, and the Beach 3 exposure areas.

d. Estimated risk at year 0 increased compared to the baseline risk because of the high post-remedy bed sediment replacement value.

BCM = bed composition model; dw = dry weight; EAA = early action area; FS = feasibility study; HHRA = human health risk assessment; kg = kilograms; ng = nanograms; STM = sediment transport model; SWAC = spatially-weighted average concentration; TEQ = toxic equivalent; UCL95 = 95% upper confindence limit on the mean

Table M-8 Sensitivity of Site-Wide Predicted Total PCB SWACs to BCM Post-Remedy Bed Sediment Replacement Values

Draft Final FS Remedial Alternative	Active Area in FS Study Area (acres)	Construc-tion Period (years)	Sensitivity (Mid(Upst), Mid(Lat), 0(PRBSRV))									Sensitivity (Mid(Upst), Mid(Lat), Low(PRBSRV))									Sensitivity (Mid(Upst), Mid(Lat), Mid(PRBSRV))									Sensitivity (Mid(Upst), Mid(Lat), High(PRBSRV))								
			Time from Start of Construction (years)									*Time from Start of Construction (years)*									*Time from Start of Construction (years)*									*Time from Start of Construction (years)*								
			0	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*
Alternative 3C	86	4	170	76	60	49	47	45	44	43	42	180	81	62	50	48	45	45	43	43	180	86	65	52	49	46	45	44	43	180	91	67	54	50	47	46	44	44
Alternative 5C	186	8	170	57	41	40	42	42	42	41	41	180	66	48	44	44	43	43	42	42	180	75	55	47	46	44	44	43	43	180	84	62	51	48	46	45	44	43
Alternative 6C	328	18	170	57	41	31	29	34	37	38	39	180	66	48	37	34	37	39	40	40	180	75	55	42	38	39	41	41	41	180	84	62	49	44	43	43	42	42
Alternative 3R	86	6	170	76	60	49	47	45	44	43	42	180	81	62	50	48	45	45	43	43	180	86	65	52	49	46	45	44	43	180	91	67	54	50	47	46	44	44
Alternative 5R	186	19	170	76	55	42	38	40	41	41	41	180	81	60	46	43	43	43	42	42	180	86	64	50	48	45	45	43	43	180	91	69	54	53	48	47	45	44
Alternative 6R	328	38	170	76	55	42	38	35	35	35	34	180	81	60	46	43	39	38	38	37	180	86	64	50	48	42	41	40	39	180	91	69	54	53	47	46	44	43

BCM input parameters (µg/kg dw total PCBs)
low: upstream = 5; lateral = 100; post-remedy bed sediment replacement value = 30 (AOPC 1), 10 (AOPC 2)
mid: upstream = 35; lateral = 300; post-remedy bed sediment replacement value = 60 (AOPC 1), 20 (AOPC 2)
high: upstream = 80; lateral = 1,000; post-remedy bed sediment replacement value = 90 (AOPC 1), 40 (AOPC 2)

Notes:

1. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.
2. Total PCB SWACs in µg/kg dw; baseline Total PCB SWAC = 346 µg/kg dw.
3. BCM predictions use base case STM outputs revised June 2010 (Appendix C).
4. BCM area = 430 acres and FS study area = 441 acres

BCM output used as approximation (estimate) of concentrations after construction.

AOPC = area of potential concern; BCM = bed composition model; dw = dry weight; FS = feasibility study; kg = kilograms; µg = micrograms; PRBSRV = post-remedy bed sediment replacement value; STM = sediment transport model; SWAC = spatially-weighted average concentration.

Table M-9a Summary Statistics for Subsurface Total PCB Concentrations Remaining within AOPC 1 and AOPC 2 but Outside of EAAs and the Dredge and Cap Footprints Specific to Each Alternative

Remedial Alternative	Recovery Category	Depth Interval (ft)	Total PCB Concentration (µg/kg dw) n	Minimum	Maximum	Mean	Median	95% UCL	
2R / 2R-CAD	1	0 - 2	51	0.10	1100	192	138	95% Chebyshev (Mean, Sd) UCL	320
		2 - 4	46	0.10	5400	338	140	97.5% Chebyshev (Mean, Sd) UCL	1080
		> 4	16	2.0	2300	417	135	95% Approximate Gamma UCL	853
	2 and 3	0 - 2	98	1.9	3800	500	240	95% Chebyshev (Mean, Sd) UCL	823
		2 - 4	84	0.10	3400	511	220	95% Approximate Gamma UCL	662
		> 4	33	1.9	3300	529	237	95% Approximate Gamma UCL	792
	All	0 - 2	149	0.10	3800	395	170	95% Chebyshev (Mean, Sd) UCL	617
		2 - 4	130	0.10	5400	450	170	95% Chebyshev (Mean, Sd) UCL	742
		> 4	49	1.9	3300	492	227	95% Approximate Gamma UCL	688
3C	1	0 - 2	47	0.10	1100	190	137	95% Chebyshev (Mean, Sd) UCL	327
		2 - 4	44	0.10	5400	347	140	97.5% Chebyshev (Mean, Sd) UCL	1121
		> 4	16	2.0	2300	417	135	95% Approximate Gamma UCL	853
	2 and 3	0 - 2	91	1.9	3800	441	230	95% Chebyshev (Mean, Sd) UCL	754
		2 - 4	77	0.10	3400	486	216	95% Approximate Gamma UCL	641
		> 4	28	2.0	3300	593	275	95% Approximate Gamma UCL	914
	All	0 - 2	138	0.10	3800	356	150	95% Chebyshev (Mean, Sd) UCL	571
		2 - 4	121	0.10	5400	436	158	95% Chebyshev (Mean, Sd) UCL	734
		> 4	44	2.0	3300	529	234	95% Approximate Gamma UCL	753
3R	1	0 - 2	47	0.10	1100	190	137	95% Chebyshev (Mean, Sd) UCL	327
		2 - 4	44	0.10	5400	347	140	97.5% Chebyshev (Mean, Sd) UCL	1121
		> 4	16	2.0	2300	417	135	95% Approximate Gamma UCL	853
	2 and 3	0 - 2	78	1.9	3300	366	199	95% Chebyshev (Mean, Sd) UCL	638
		2 - 4	69	0.10	3400	470	200	95% Chebyshev (Mean, Sd) UCL	859
		> 4	22	9.7	3300	653	318	95% Approximate Gamma UCL	1055
	All	0 - 2	125	0.10	3300	300	150	95% Chebyshev (Mean, Sd) UCL	480
		2 - 4	113	0.10	5400	422	150	95% Chebyshev (Mean, Sd) UCL	739
		> 4	38	2.0	3300	553	234	95% Approximate Gamma UCL	811
4C	1	0 - 2	19	0.10	310	91	91	95% Approximate Gamma UCL	169
		2 - 4	17	0.10	920	136	96	99% Chebyshev (Mean, Sd) UCL	650
		> 4	7	10	230	97	103	95% Student's-t UCL	156
	2 and 3	0 - 2	79	13	3800	485	230	95% Chebyshev (Mean, Sd) UCL	845
		2 - 4	70	0.10	3400	494	199	95% Approximate Gamma UCL	668
		> 4	27	2.0	3300	567	260	95% Approximate Gamma UCL	885
	All	0 - 2	98	0.10	3800	409	153	95% Chebyshev (Mean, Sd) UCL	707
		2 - 4	87	0.10	3400	424	150	95% Chebyshev (Mean, Sd) UCL	748
		> 4	34	2.0	3300	470	227	95% Approximate Gamma UCL	708
4R	1	0 - 2	19	0.10	310	91	91	95% Approximate Gamma UCL	169
		2 - 4	17	0.10	920	136	96	99% Chebyshev (Mean, Sd) UCL	650
		> 4	7	10	230	97	103	95% Student's-t UCL	156
	2 and 3	0 - 2	59	16	3300	409	200	95% Chebyshev (Mean, Sd) UCL	759
		2 - 4	56	0.10	3400	481	184	95% Chebyshev (Mean, Sd) UCL	938
		> 4	19	9.7	3300	735	380	95% Approximate Gamma UCL	1212
	All	0 - 2	78	0.10	3300	332	150	95% Chebyshev (Mean, Sd) UCL	605
		2 - 4	73	0.10	3400	401	140	95% Chebyshev (Mean, Sd) UCL	762
		> 4	26	9.7	3300	563	247	95% Approximate Gamma UCL	900

Table M-9a Summary Statistics for Subsurface Total PCB Concentrations Remaining within AOPC 1 and AOPC 2 but Outside of EAAs and the Dredge and Cap Footprints Specific to Each Alternative

Remedial Alternative	Recovery Category	Depth Interval (ft)	Total PCB Concentration (µg/kg dw)						
			n	Minimum	Maximum	Mean	Median	95% UCL	
5C	1	0 - 2	16	0.10	300	80	75	95% Approximate Gamma UCL	166
		2 - 4	14	0.10	900	133	94	99% Chebyshev (Mean, Sd) UCL	750
		> 4	6	10	200	88	81	95% Student's-t UCL	158
	2 and 3	0 - 2	75	13	3300	399	214	95% Chebyshev (Mean, Sd) UCL	677
		2 - 4	66	0.10	3400	451	184	95% Chebyshev (Mean, Sd) UCL	847
		> 4	26	2	3300	623	318	95% Approximate Gamma UCL	987
	All	0 - 2	91	0.10	3300	343	150	95% Chebyshev (Mean, Sd) UCL	579
		2 - 4	80	0.10	3400	395	139	95% Chebyshev (Mean, Sd) UCL	730
		> 4	32	2	3300	523	236	95% Approximate Gamma UCL	806
5R/5R-T	1	0 - 2	16	0.10	300	80	75	95% Approximate Gamma UCL	166
		2 - 4	14	0.10	900	133	94	99% Chebyshev (Mean, Sd) UCL	750
		> 4	6	10	200	88	81	95% Student's-t UCL	158
	2 and 3	0 - 2	47	16	3300	313	150	95% Chebyshev (Mean, Sd) UCL	636
		2 - 4	43	0.10	3300	363	158	97.5% Chebyshev (Mean, Sd) UCL	908
		> 4	14	9.7	3300	585	275	95% Approximate Gamma UCL	1105
	All	0 - 2	63	0.10	3300	253	136	95% Chebyshev (Mean, Sd) UCL	501
		2 - 4	57	0.10	3300	306	136	95% Chebyshev (Mean, Sd) UCL	606
		> 4	20	9.7	3300	436	193	95% Approximate Gamma UCL	768
6C	1	0 - 2	0	-		-	-	-	-
		2 - 4	0	-		-	-	-	-
		> 4	0	-		-	-	-	-
	2 and 3	0 - 2	20	16	1400	352	254	95% Approximate Gamma UCL	558
		2 - 4	15	0.10	2900	573	45	95% Adjusted Gamma UCL	1904
		> 4	6	9.7	3300	973	558	95% Approximate Gamma UCL	3991
	All	0 - 2	20	16	1400	352	254	95% Approximate Gamma UCL	558
		2 - 4	15	0.10	2900	573	45	95% Adjusted Gamma UCL	1904
		> 4	6	9.7	3300	973	558	95% Approximate Gamma UCL	3991
6R	1	0 - 2	0	-	-	-	-	-	-
		2 - 4	0	-	-	-	-	-	-
		> 4	0	-	-	-	-	-	-
	2 and 3	0 - 2	0	-	-	-	-	-	-
		2 - 4	0	-	-	-	-	-	-
		> 4	0	-	-	-	-	-	-
	All	0 - 2	0	-	-	-	-	-	-
		2 - 4	0	-	-	-	-	-	-
		> 4	0	-	-	-	-	-	-

Notes:

1. Recovery Category 1, 2, and 3 designations were assigned to any area of the LDW, regardless of AOPC or RAL status, and based on a specific recovery assessment (see Section 6). Recovery in Category 1 areas is presumed to be limited. Recovery in Category 2 areas is less certain. Category 3 areas are predicted to recover.
2. Summary statistics for the 0- to 2-ft, 2- to 4-ft, and greater than 4-ft intervals are for the vertically averaged total PCB concentrations within each of those intervals at each remaining core station. Summary statistics were calculated with ProUCL 4.1 software; the ProUCL-recommended UCL was used as the UCL95 in all cases, with the exception of the H-Statistic UCL, use of which was avoided (per ProUCL warning) and overridden by a non-parametric 95% Chebyshev (Mean, Sd) UCL.

AOPC = area of potential concern; C = combined; CAD = contained aquatic disposal; dw = dry weight; EAA = early action area; kg = kilograms; LDW = Lower Duwamish Waterway; µg = micrograms; n = number of cores; R = removal; RAL = remedial action level; R-T = removal with treatment; UCL95 = 95 percent upper confidence limit on the mean

Table M-9b Summary Percentiles for Subsurface Total PCB Concentrations Remaining within AOPC 1 and AOPC 2 but Outside of EAAs and the Dredge and Cap Footprints Specific to Each Alternative

Remedial Alternative	Recovery Category	Depth Interval (ft)	Total PCB Concentration (µg/kg dw)										
				Percentile									
			n	5th	10th	20th	25th	50th	75th	80th	90th	95th	99th
2R / 2R-CAD	1	0 - 2	51	7.1	32	62	97	138	250	300	330	470	1055
		2 - 4	46	2.0	10	88	98	140	268	300	626	988	3465
		> 4	16	8.0	10	58	92	135	409	573	1201	1545	2127
	2 and 3	0 - 2	98	17	38	91	130	240	621	696	1256	2177	3314
		2 - 4	84	3.0	8.8	79	108	220	650	738	1141	2368	3317
		> 4	33	6.6	33	130	160	237	640	730	1072	2092	3294
	All	0 - 2	149	11	36	83	109	170	330	482	986	1374	3228
		2 - 4	130	2.0	10	82	101	170	525	642	992	1743	3371
		> 4	49	5.0	10	99	114	227	573	727	1140	1884	3290
3C	1	0 - 2	47	5.9	23	65	97	137	208	284	322	518	1059
		2 - 4	44	3.2	17	90	101	140	263	294	636	997	3551
		> 4	16	8.0	10	58	92	135	409	573	1201	1545	2127
	2 and 3	0 - 2	91	17	36	79	118	230	431	640	980	1553	3347
		2 - 4	77	2.6	8.2	64	100	216	640	728	1132	2010	3324
		> 4	28	13	71	130	158	275	724	757	1149	2587	3295
	All	0 - 2	138	10	35	74	104	150	316	362	762	1136	3245
		2 - 4	121	2.0	10	71	100	158	500	640	990	1550	3380
		> 4	44	9.7	12	99	114	234	660	750	1240	2127	3291
3R	1	0 - 2	47	5.9	23	65	97	137	208	284	322	518	1059
		2 - 4	44	3.2	17	90	101	140	263	294	636	997	3551
		> 4	16	8.0	10	58	92	135	409	573	1201	1545	2127
	2 and 3	0 - 2	78	15	36	77	117	199	344	548	762	1045	3185
		2 - 4	69	2.3	8.3	55	93	200	570	720	1022	2230	3332
		> 4	22	22	93	123	154	318	732	763	1078	3170	3296
	All	0 - 2	125	10	34	69	103	150	300	325	699	1004	2722
		2 - 4	113	2.0	10	66	96	150	320	596	968	1641	3388
		> 4	38	10	16	97	114	234	700	757	1161	2424	3293
4C	1	0 - 2	19	0.050	3.3	10	21	91	122	141	179	265	299
		2 - 4	17	0.050	6.0	14	32	96	114	143	199	392	814
		> 4	7	10	10	20	34	103	132	143	184	209	230
	2 and 3	0 - 2	79	33	39	83	118	230	540	672	1144	1816	3403
		2 - 4	70	2.3	8.0	44	87	199	639	771	1182	2203	3331
		> 4	27	12	63	123	155	260	680	733	1048	2621	3295
	All	0 - 2	98	12	33	59	81	153	323	548	997	1494	3314
		2 - 4	87	2.0	7.9	35	67	150	410	704	1042	1795	3314
		> 4	34	9.9	12	93	106	227	416	672	948	1853	3293
4R	1	0 - 2	19	0.050	3.3	10	21	91	122	141	179	265	299
		2 - 4	17	0.050	6.0	14	32	96	114	143	199	392	814
		> 4	7	10	10	20	34	103	132	143	184	209	230
	2 and 3	0 - 2	59	35	39	94	118	200	431	604	980	1122	3213
		2 - 4	56	2.0	9.0	62	98	184	518	720	1070	2563	3345
		> 4	19	85	93	146	193	380	753	871	1523	3282	3296
	All	0 - 2	78	10	33	53	68	150	303	376	762	1045	3185
		2 - 4	73	1.9	8.4	37	85	140	270	542	968	1861	3328
		> 4	26	10	34	93	106	247	700	736	1054	2731	3295

Table M-9b Summary Percentiles for Subsurface Total PCB Concentrations Remaining within AOPC 1 and AOPC 2 but Outside of EAAs and the Dredge and Cap Footprints Specific to Each Alternative

Remedial Alternative	Recovery Category	Depth Interval (ft)	Total PCB Concentration (µg/kg dw)										
			n	Percentile									
				5th	10th	20th	25th	50th	75th	80th	90th	95th	99th
5C	1	0 - 2	16	0.050	2.1	10	10	75	108	109	147	196	285
		2 - 4	14	0.050	3.0	10	22	94	110	112	146	425	821
		> 4	6	10	10	10	22	81	111	114	174	205	229
	2 and 3	0 - 2	75	33	39	77	113	214	431	636	980	1348	2708
		2 - 4	66	2.2	7.9	41	75	184	508	640	1055	2205	3335
		> 4	26	12	56	116	153	318	732	770	1192	2785	3295
	All	0 - 2	91	11	34	58	75	150	322	470	860	1217	2580
		2 - 4	80	1.9	7.5	33	61	139	304	583	981	1517	3321
		> 4	32	10	11	93	101	236	660	733	1078	2191	3294
5R/5R-T	1	0 - 2	16	0.050	2.1	10	10	75	108	109	147	196	285
		2 - 4	14	0.050	3.0	10	22	94	110	112	146	425	821
		> 4	6	10	10	10	22	81	111	114	174	205	229
	2 and 3	0 - 2	47	34	38	67	105	150	290	319	715	944	2233
		2 - 4	43	2.0	14	88	105	158	280	512	956	1134	2531
		> 4	14	64	93	107	129	275	700	740	990	1860	3012
	All	0 - 2	63	10	32	44	61	136	260	290	606	846	1862
		2 - 4	57	1.5	6.8	59	88	136	260	286	884	1022	2274
		> 4	20	10	10	86	93	193	481	656	801	1195	2879
6C	1	0 - 2	0	-	-	-	-	-	-	-	-	-	-
		2 - 4	0	-	-	-	-	-	-	-	-	-	-
		> 4	0	-	-	-	-	-	-	-	-	-	-
	2 and 3	0 - 2	20	18	36	57	75	254	511	640	744	1052	1302
		2 - 4	15	1.3	1.9	6.6	8.1	45	650	878	2057	2585	2837
		> 4	6	94	178	346	355	558	997	1084	2182	2731	3170
	All	0 - 2	20	18	36	57	75	254	511	640	744	1052	1302
		2 - 4	15	1.3	1.9	6.6	8.1	45	650	878	2057	2585	2837
		> 4	6	94	178	346	355	558	997	1084	2182	2731	3170
6R	1	0 - 2	0	-	-	-	-	-	-	-	-	-	-
		2 - 4	0	-	-	-	-	-	-	-	-	-	-
		> 4	0	-	-	-	-	-	-	-	-	-	-
	2 and 3	0 - 2	0	-	-	-	-	-	-	-	-	-	-
		2 - 4	0	-	-	-	-	-	-	-	-	-	-
		> 4	0	-	-	-	-	-	-	-	-	-	-
	All	0 - 2	0	-	-	-	-	-	-	-	-	-	-
		2 - 4	0	-	-	-	-	-	-	-	-	-	-
		> 4	0	-	-	-	-	-	-	-	-	-	-

Notes:
1. Recovery Category 1, 2, and 3 designations were assigned to any area of the LDW, regardless of AOPC or RAL status, and based on a specific recovery assessment (see Section 6). Recovery in Category 1 areas is presumed to be limited. Recovery in Category 2 areas is less certain. Category 3 areas are predicted to recover.
2. Summary percentiles for the 0- to 2-ft, 2- to 4-ft, and greater than 4-ft intervals are for the vertically averaged total PCB concentrations within each of those intervals at each remaining core station. Summary statistics were calculated with ProUCL 4.1 software.

AOPC = area of potential concern; C = combined; CAD = contained aquatic disposal; dw = dry weight; EAA = early action area; kg = kilograms; LDW = Lower Duwamish Waterway; µg = micrograms; n = number of cores; R = removal; RAL = remedial action level; R-T = removal with treatment

Table M-9c Summary Descriptive Statistics for Subsurface Total PCB Concentrations Remaining within Cap and Partial Dredge and Cap Footprints

Remedial Alternative	Depth Interval (ft)	Total PCB Concentration (µg/kg dw) n	5th Percentile	10th Percentile	20th Percentile	25th Percentile	Median	Mean	75th Percentile	80th Percentile	90th Percentile	95th Percentile	99th Percentile	95% UCL	
2R / 2R-CAD	0 - 4	0	-	-	-	-	-	-	-	-	-	-	-	-	-
	> 4	0	-	-	-	-	-	-	-	-	-	-	-	-	-
3C	0 - 4	16	140	170	210	229	335	770	788	1020	1265	2317	4399	95% Chebyshev (Mean, Sd) UCL	830
	> 4	14	144	244	301	310	1359	629	1885	2203	3552	4467	5161	95% Approximate Gamma UCL	1444
3R	0 - 4	1	-	-	-	-	240	-	-	-	-	-	-	-	-
	> 4	1	-	-	-	-	2	-	-	-	-	-	-	-	-
4C	0 - 4	29	21	57	93	105	235	582	525	662	1154	2212	4304	95% Chebyshev (Mean, Sd) UCL	640
	> 4	24	127	142	201	279	1050	549	1213	1725	2437	3776	5028	95% Approximate Gamma UCL	1130
4R	0 - 4	1	-	-	-	-	240	-	-	-	-	-	-	-	-
	> 4	1	-	-	-	-	2	-	-	-	-	-	-	-	-
5C	0 - 4	31	21	66	95	135	315	610	670	795	1080	2085	4260	95% Chebyshev (Mean, Sd) UCL	665
	> 4	25	128	143	175	221	980	330	1010	1634	2413	3701	5014	95% Approximate Gamma UCL	1063
5R/5R-T	0 - 4	1	-	-	-	-	240	-	-	-	-	-	-	-	-
	> 4	1	-	-	-	-	2	-	-	-	-	-	-	-	-
6C	0 - 4	56	21	21	74	88	168	426	412	525	883	1505	3710	95% Chebyshev (Mean, Sd) UCL	479
	> 4	43	2	32	114	139	727	300	629	897	2127	3221	4774	95% Chebyshev (Mean, Sd) UCL	809
6R	0 - 4	4	41	46	57	63	80	109	127	149	195	217	235	95% Chebyshev (Mean, Sd) UCL	122
	> 4	2	7	12	22	27	52	52	78	83	93	98	102	95% Student's-t UCL	72

Note:

1. The PCB statistical concentrations for capped and partially dredged/capped areas in the 0- to 4-ft interval is the vertical average of the combination of clean capping material (0 to 2 ft) [with an assumed total PCB concentration of 40 µg/kg dw], and the native sediment (0 to 2 ft in areas to be capped, and 2 to 4 ft in areas to be partially dredged/capped [with the total PCB concentration from those intervals in the subsurface FS baseline dataset]. However, a sediment cap is designed to be 3 ft thick. Summary statistics were calculated with ProUCL 4.1 software.

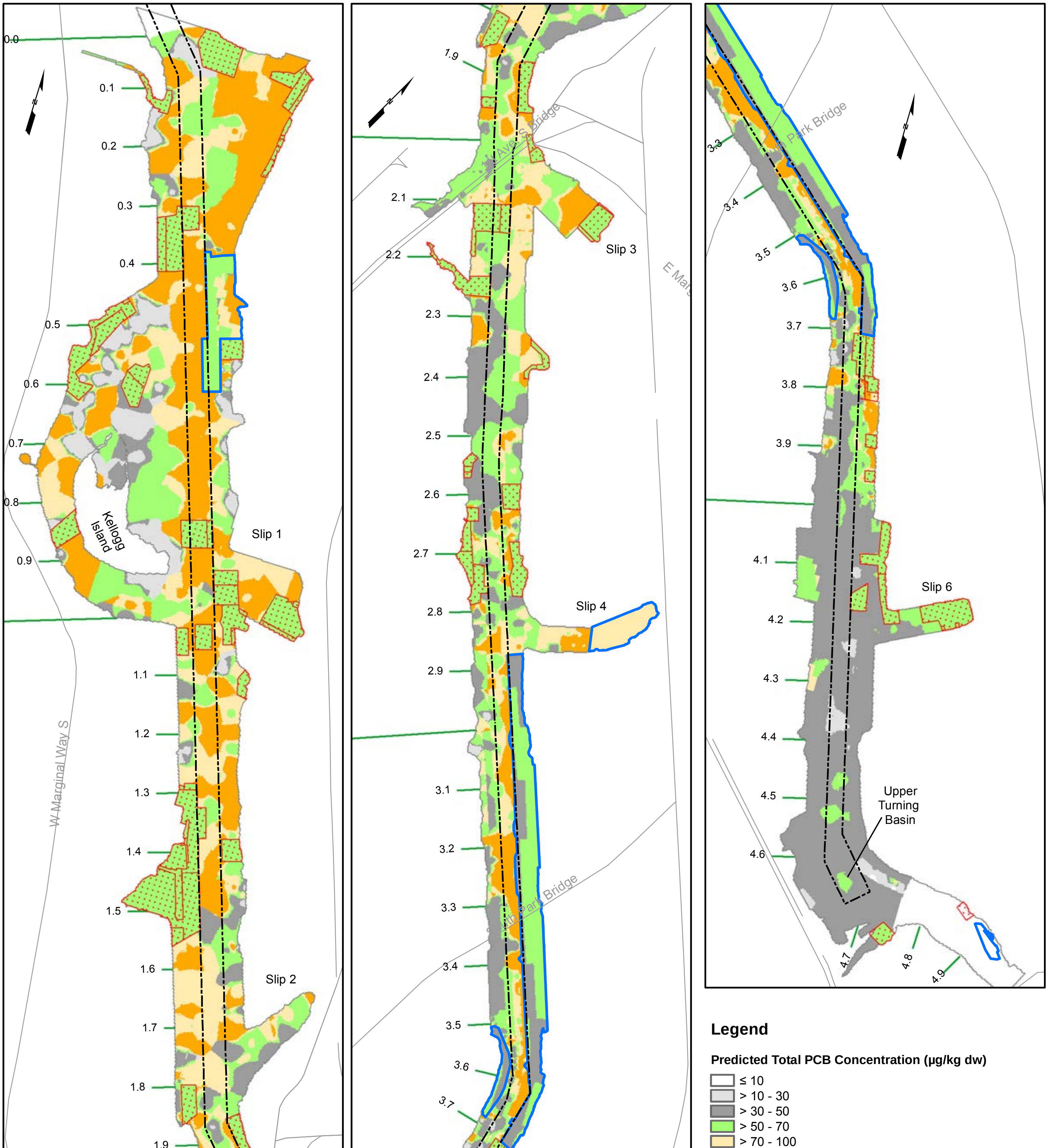
Table M-9d Summary Descriptive Statistics for Subsurface Total PCB Concentrations Outside of AOPCs 1 and 2 (Rest of LDW)

Rest of LDW	Depth Interval (ft)	Total PCB Concentration (µg/kg dw) n	5th Percentile	10th Percentile	20th Percentile	25th Percentile	Median	Mean	75th Percentile	80th Percentile	90th Percentile	95th Percentile	99th Percentile	95% UCL	
	0 - 4	52	13	16	28	33	47	68	75	79	139	152	390	95% Chebyshev (Mean, Sd) UCL	120
	> 4	23	11	15	29	32	48	48	64	68	82	86	102	95% Student's-t UCL	58

Notes:

1. The area that comprises the rest of the LDW (outside of AOPCs 1 and 2) is approximately 110 acres and includes site-wide monitoring and natural recovery.
2. Summary statistics for the 0- to 4-ft, and greater than 4-ft intervals are for the vertically averaged total PCB concentrations within each of those intervals at each remaining core station. Summary statistics were calculated with ProUCL 4.1 software.

AOPC = area of potential concern; C = combined; CAD = contained aquatic disposal; dw = dry weight; EAA = early action area; FS = feasibility study; kg = kilograms; LDW = Lower Duwamish Waterway; µg = micrograms; n = number of cores; R = removal; R-T = removal with treatment; UCL95 = 95 percent upper confidence limit on the mean



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 3C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 5-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 60 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

Feet 0 200 400 800

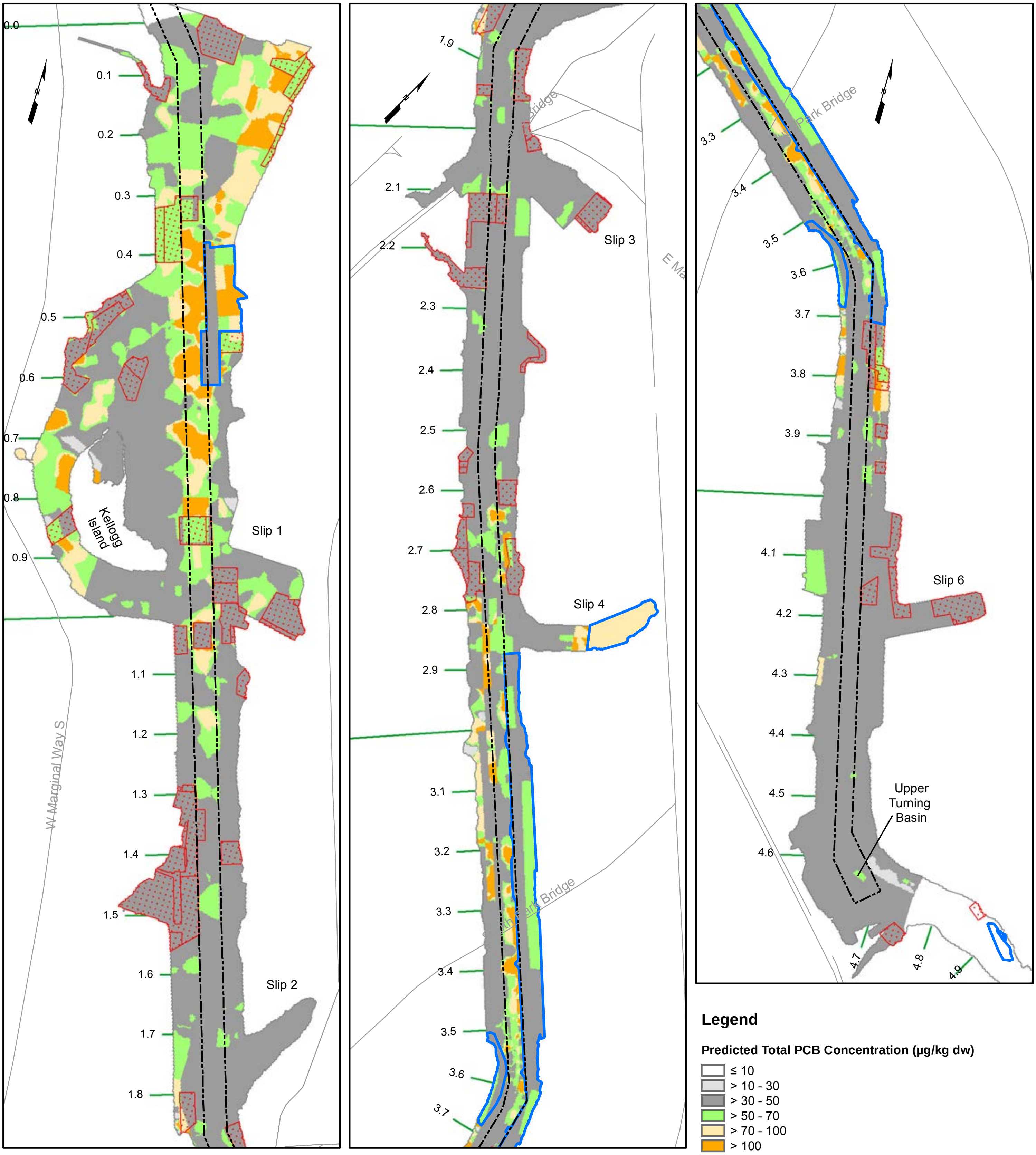
M1-53

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	**Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 5, BRV = mid**
DATE: 10/31/12 DWRN: MVI/sea Revision: 0	**FIGURE M-1**

L:\Lower Duwamish FS\FS_Final_GIS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix M\M-1_Y5PCB_3C_BRVM.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 3C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 15-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 60 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

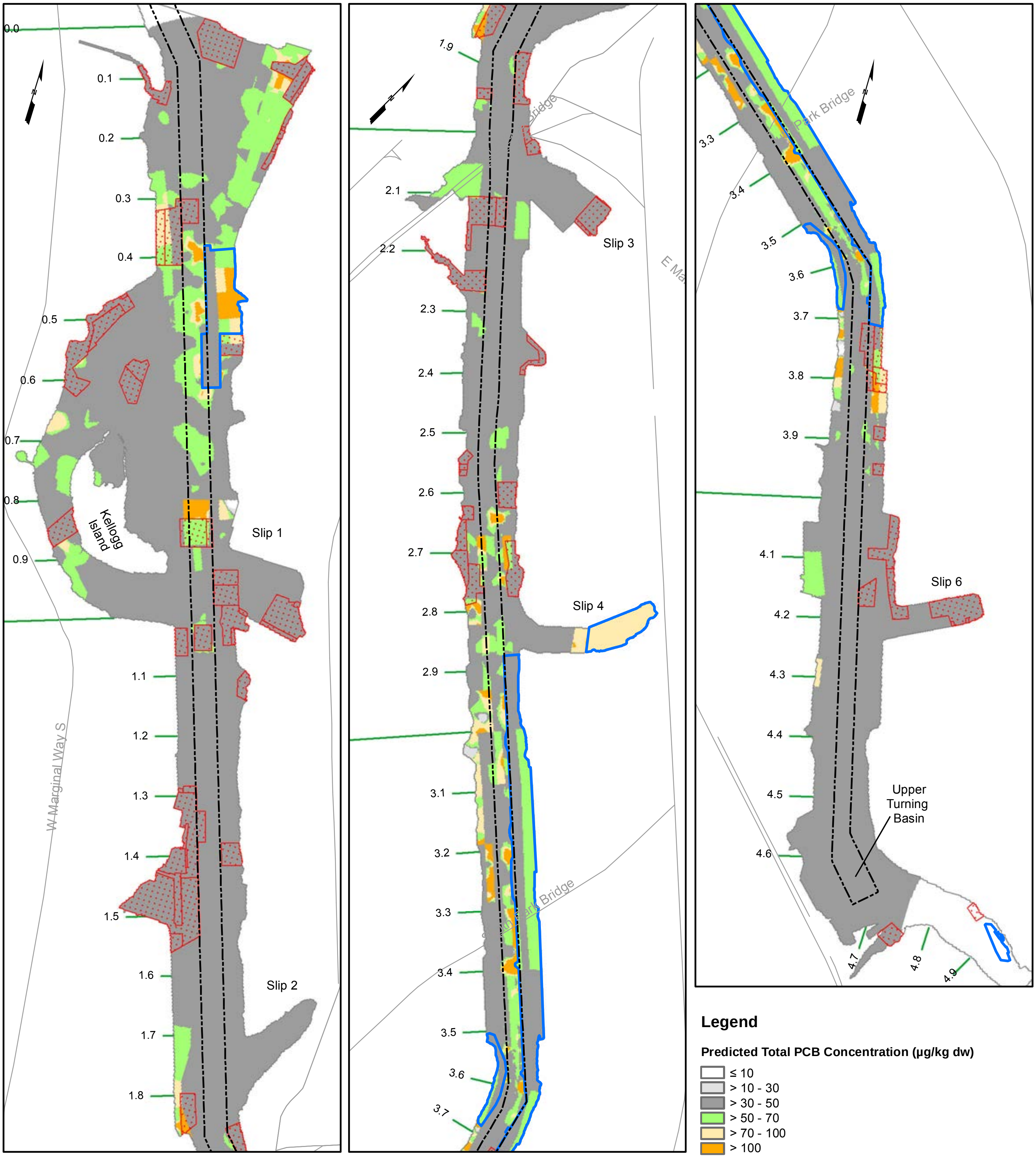
Lower Duwamish Waterway
Final Feasibility Study
60150279-8.4

Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 15, BRV = mid

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE M-2

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-2_Y5PCB_3C_BRVM.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 3C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 25-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 60 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

M1-55

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

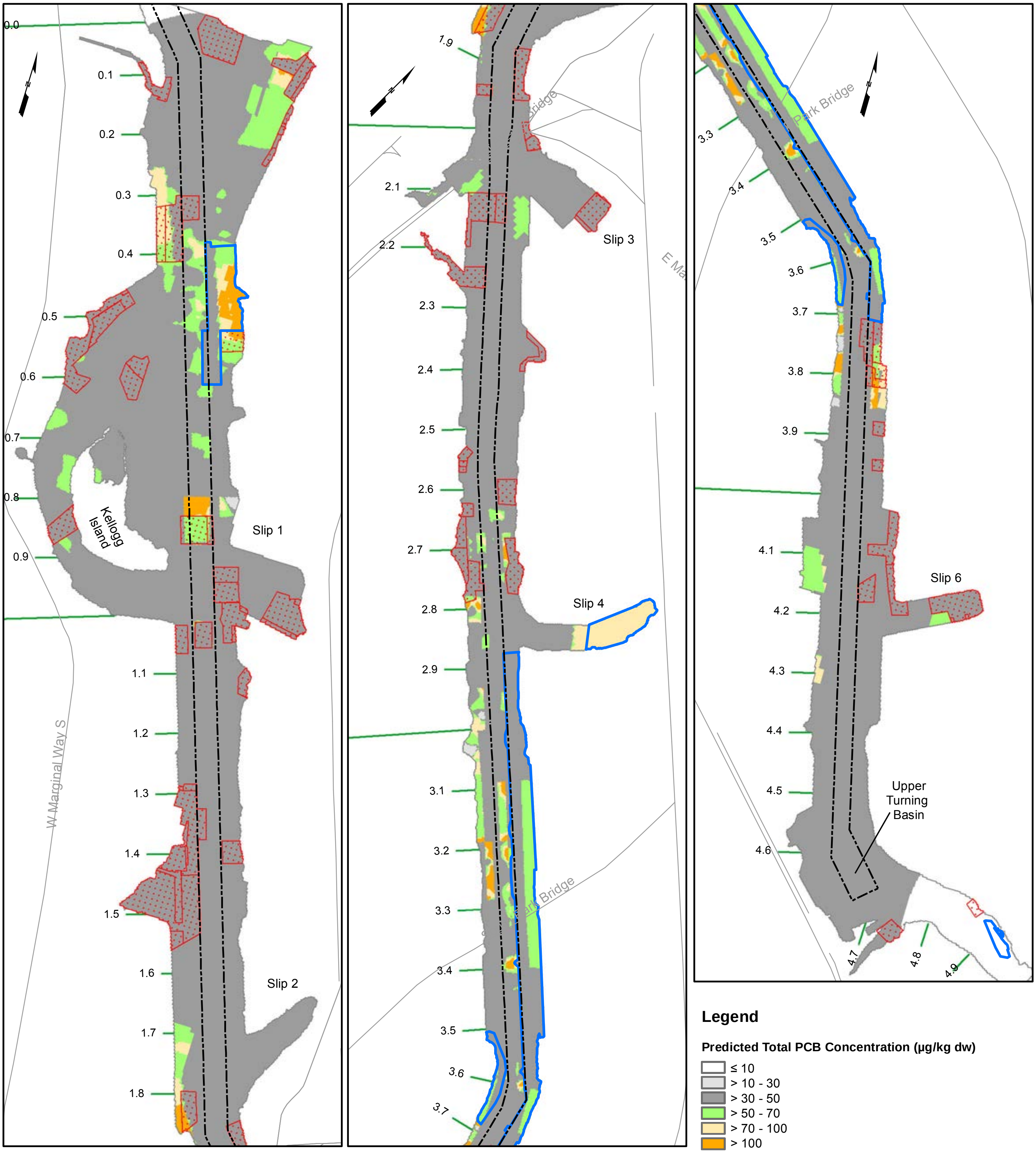
Lower Duwamish Waterway
Final Feasibility Study
60150279-8.4

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 25, BRV = mid

FIGURE M-3

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-3_Y25PCB_3C_BRVM.mxd



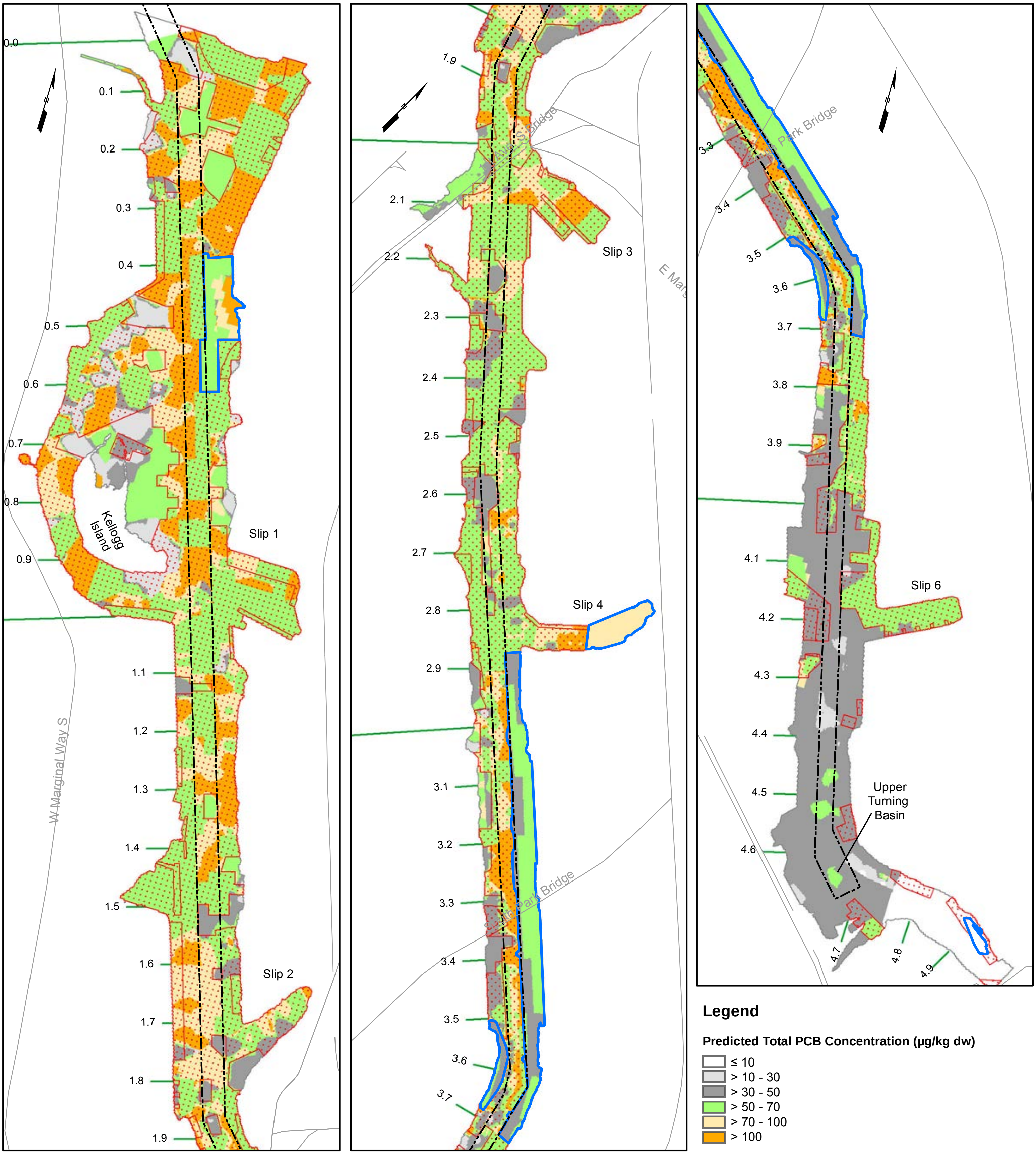
Notes:
1. STM GIS shapefile from 35-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 60 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-4_Y35PCB_3C_BRVM.mxd

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4		**Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 35, BRV = mid**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0
		FIGURE M-4



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

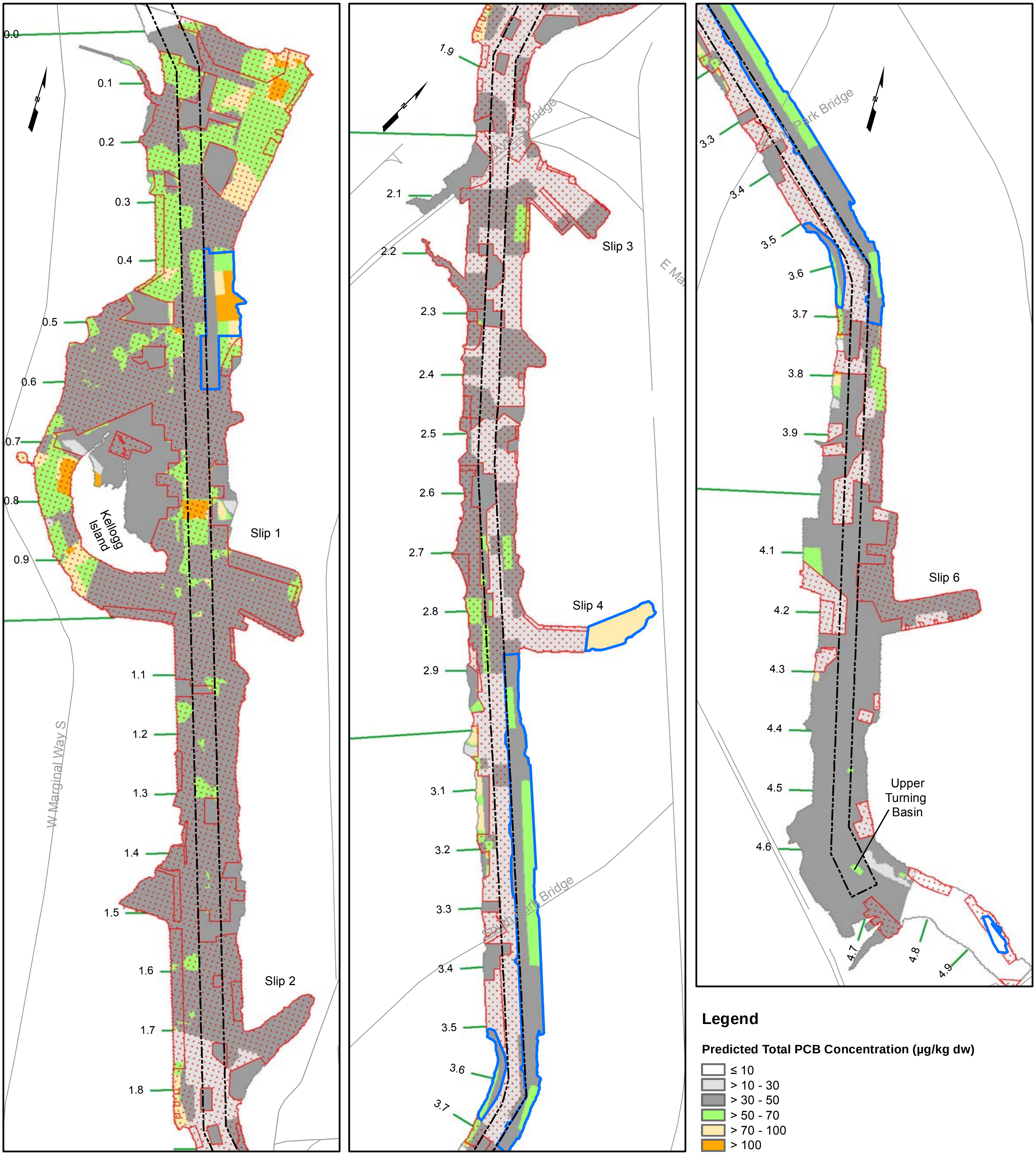
Notes:
1. STM GIS shapefile from 5-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 5, BRV = mid
DATE: 10/31/12 DWRN: MVI/sea Revision: 0	FIGURE M-5



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 15-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

Feet
0 200 400 800

AECOM

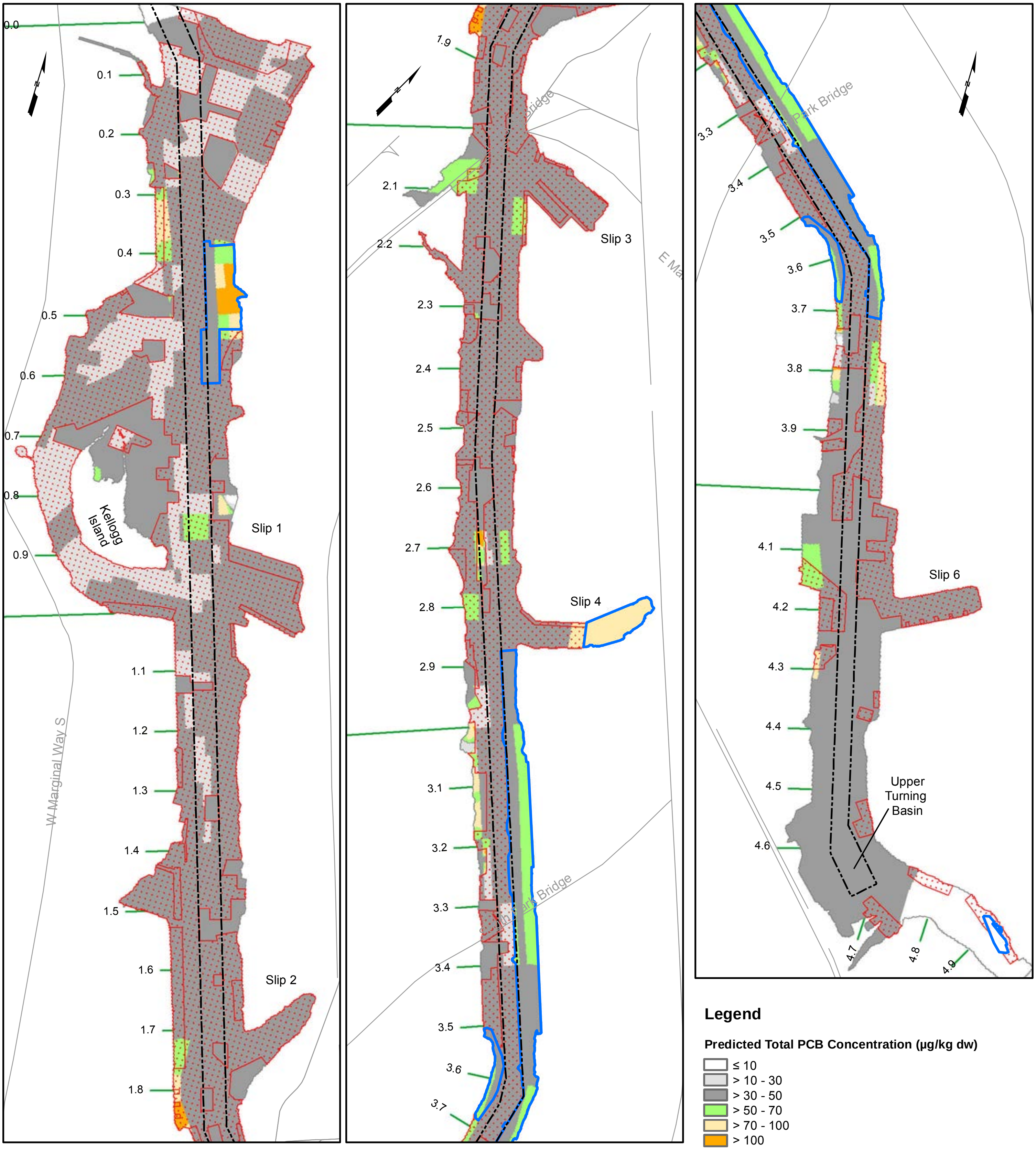
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-8.4

Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 15, BRV = mid

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

FIGURE M-6



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 25-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

M1-59

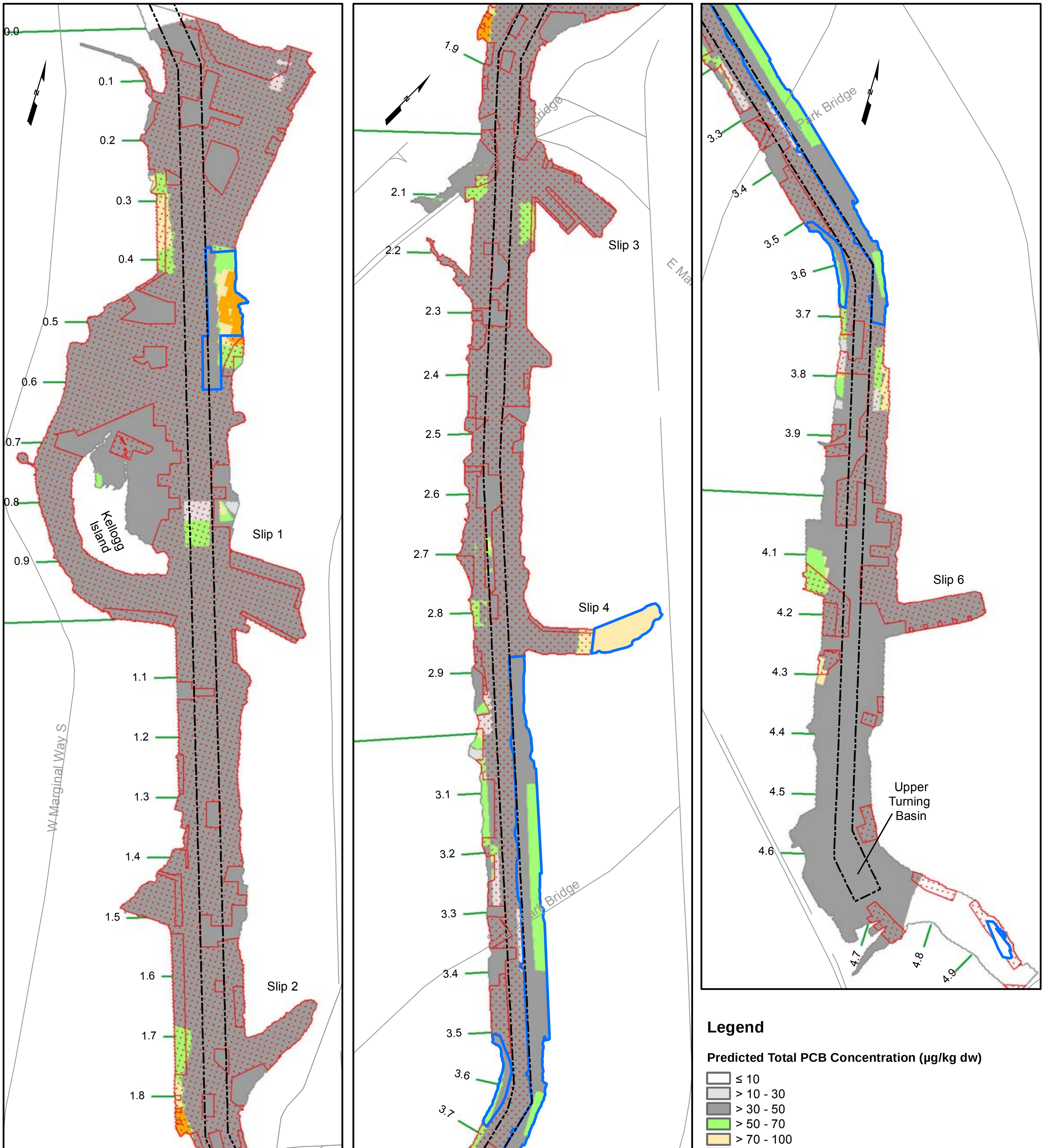
Feet 0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	**Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 25, BRV = mid**
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	**FIGURE M-7**

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix M\M-7_Y25PCB_6C_BRVM.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 35-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

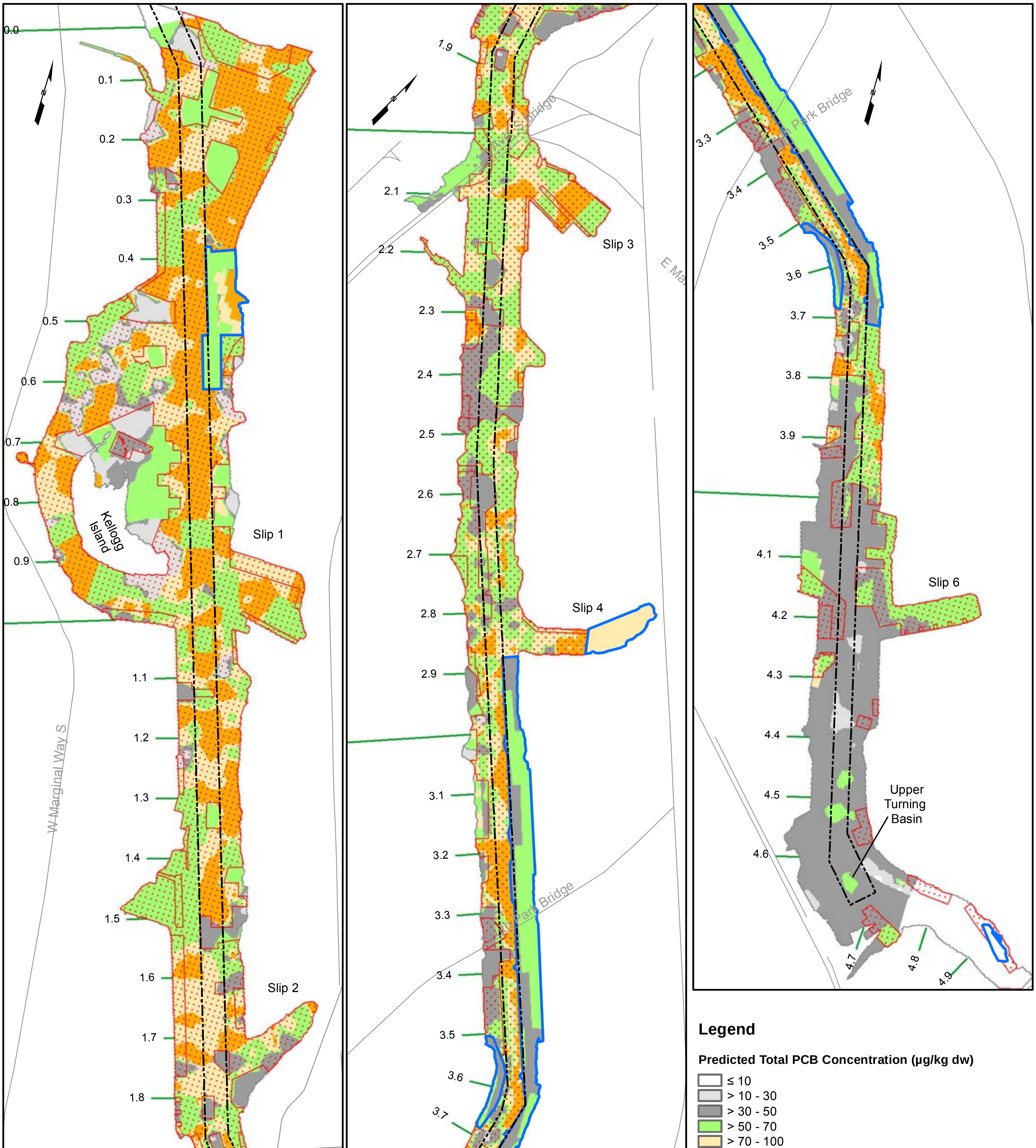
M1-60

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-8_Y35PCB_6C_BRVM.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4			Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 35, BRV = mid
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE M-8



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6R Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 5-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

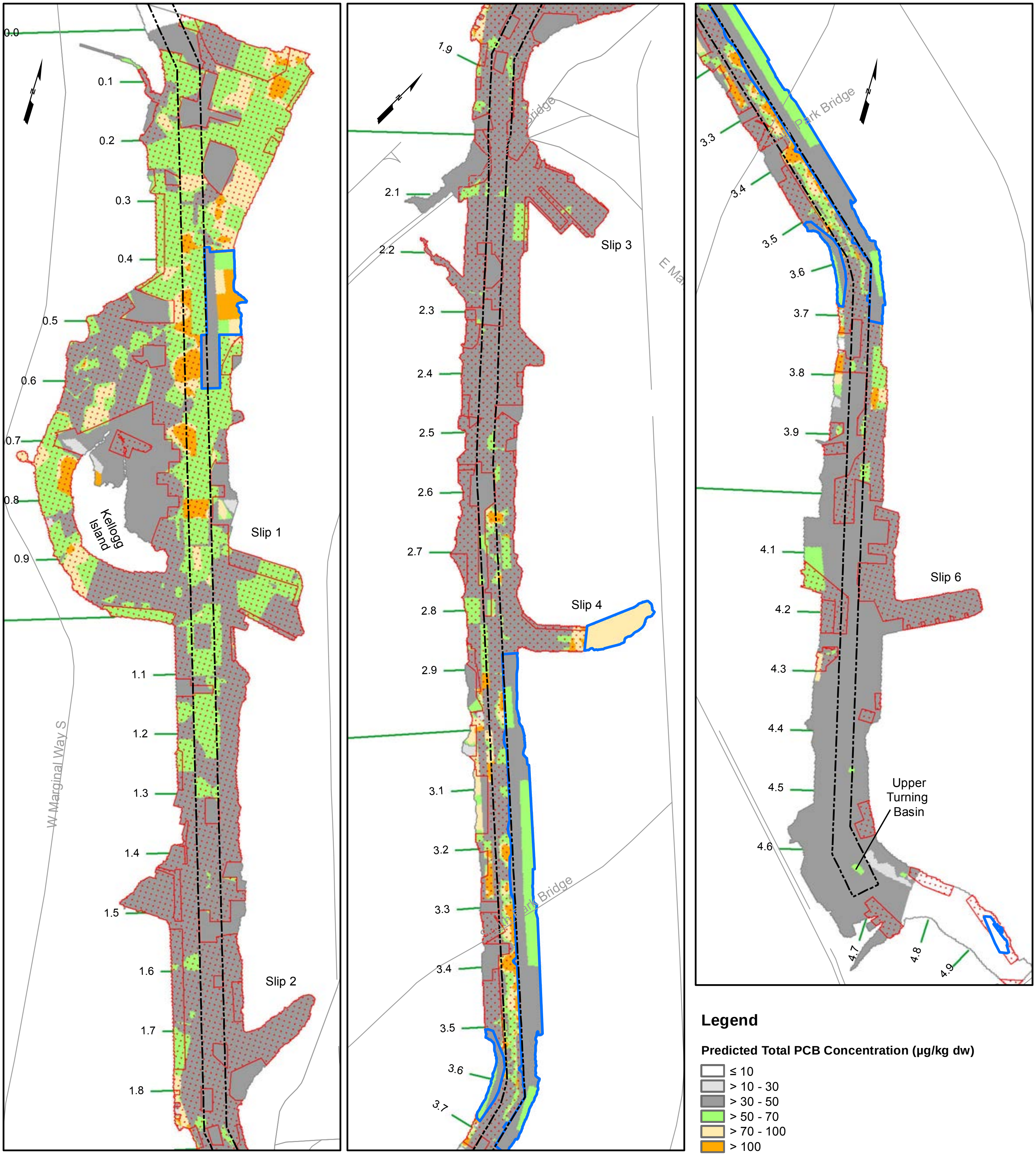
0 200 400 800 Feet

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix MM-9_Y5PCB_6R_BRVM.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4			Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 5, BRV = mid
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE M-9



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6R Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

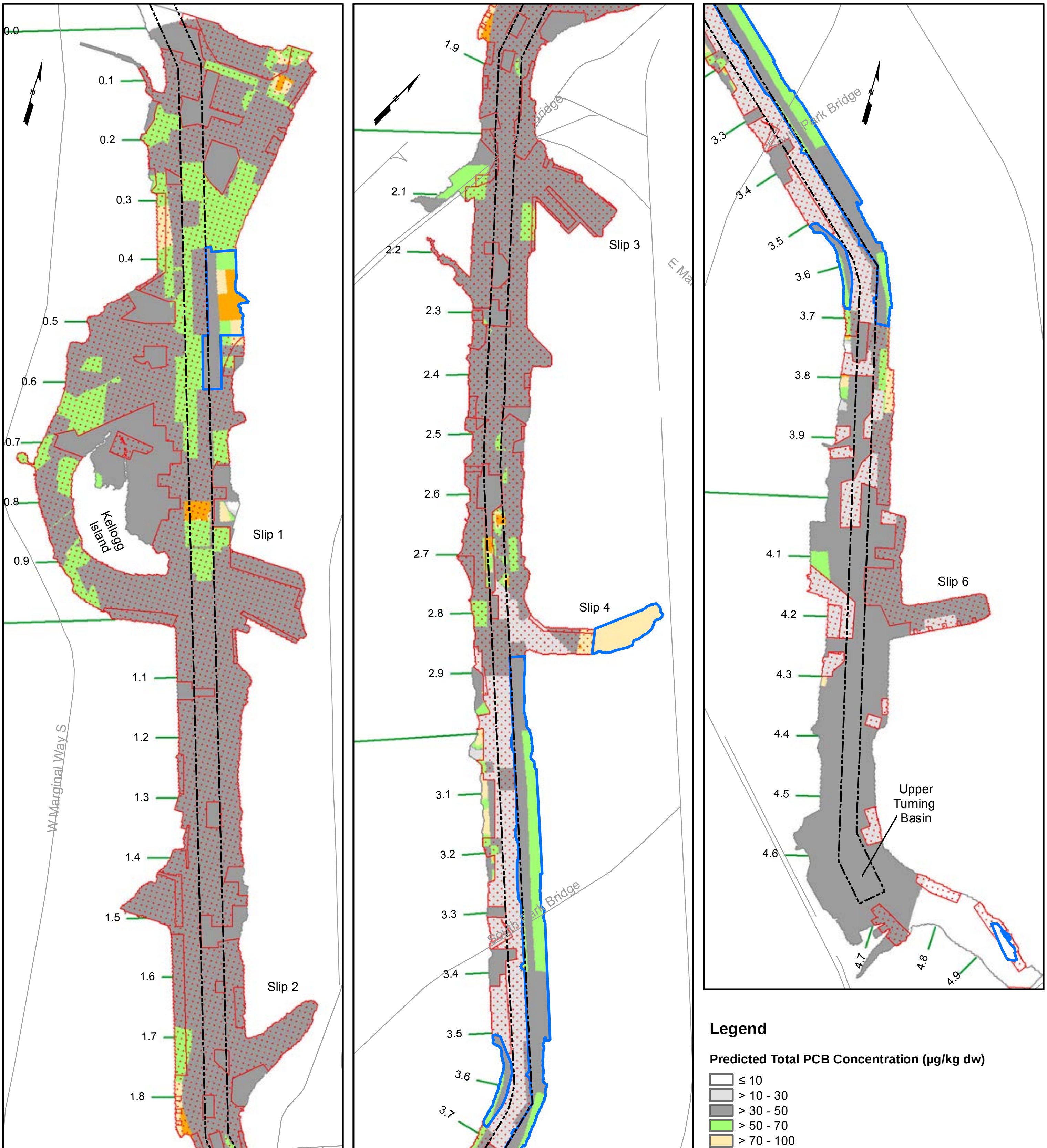
Notes:
1. STM GIS shapefile from 15-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

AECOM | Lower Duwamish Waterway Group — Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	**Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 15, BRV = mid**
DATE: 10/31/12 · DWRN: MVI/sea · Revision: 0	**FIGURE M-10**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-10_Y15PCB_6R_BRVM.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6R Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 25-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

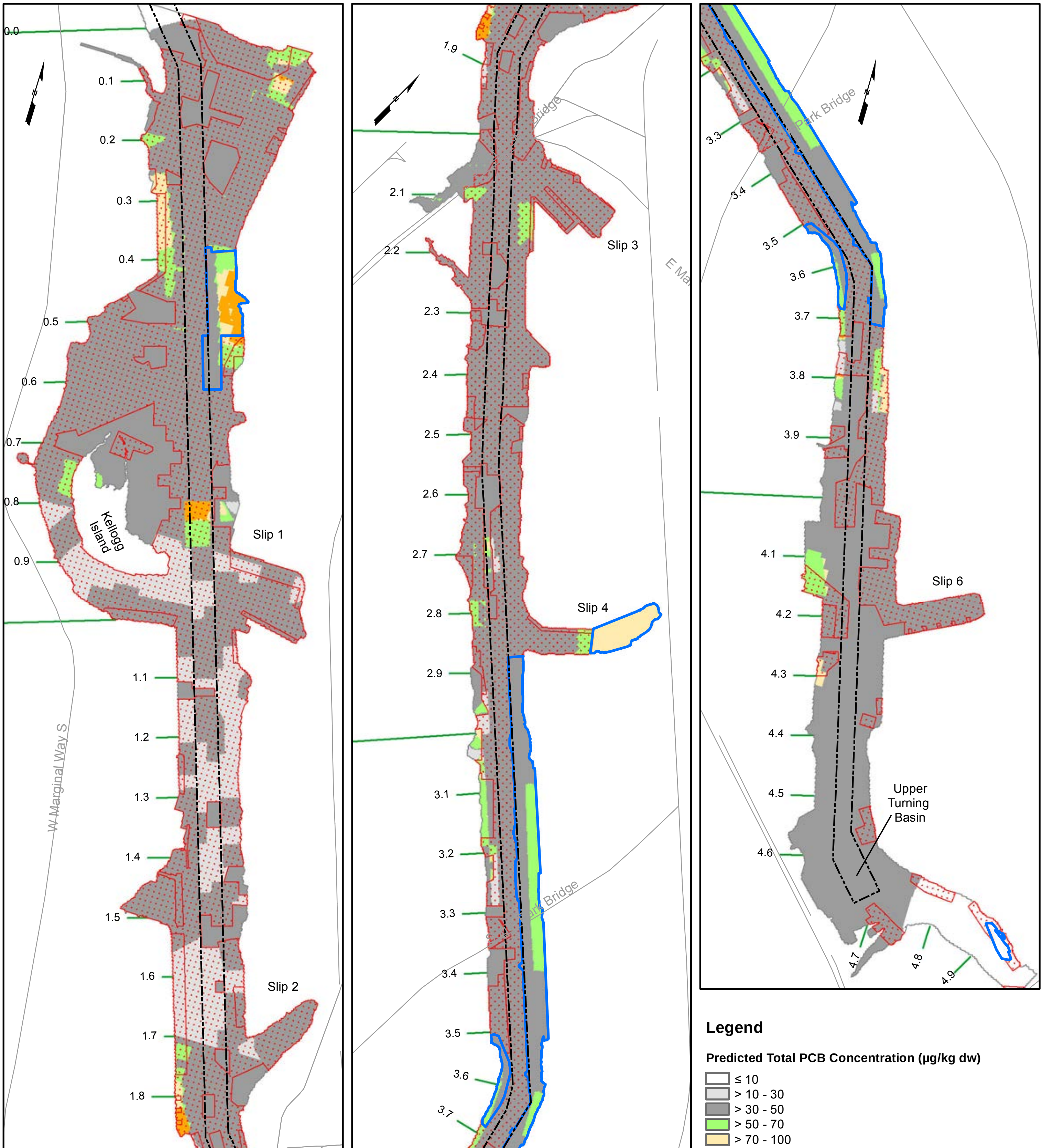
0 200 400 800 Feet

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4		**Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 25, BRV = mid**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0
		FIGURE M-11

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-11_Y25PCB_6R_BRVM.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6R Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 35-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = (AOPC 1=60 µg/kg dw, AOPC 2=20 µg/kg dw)
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

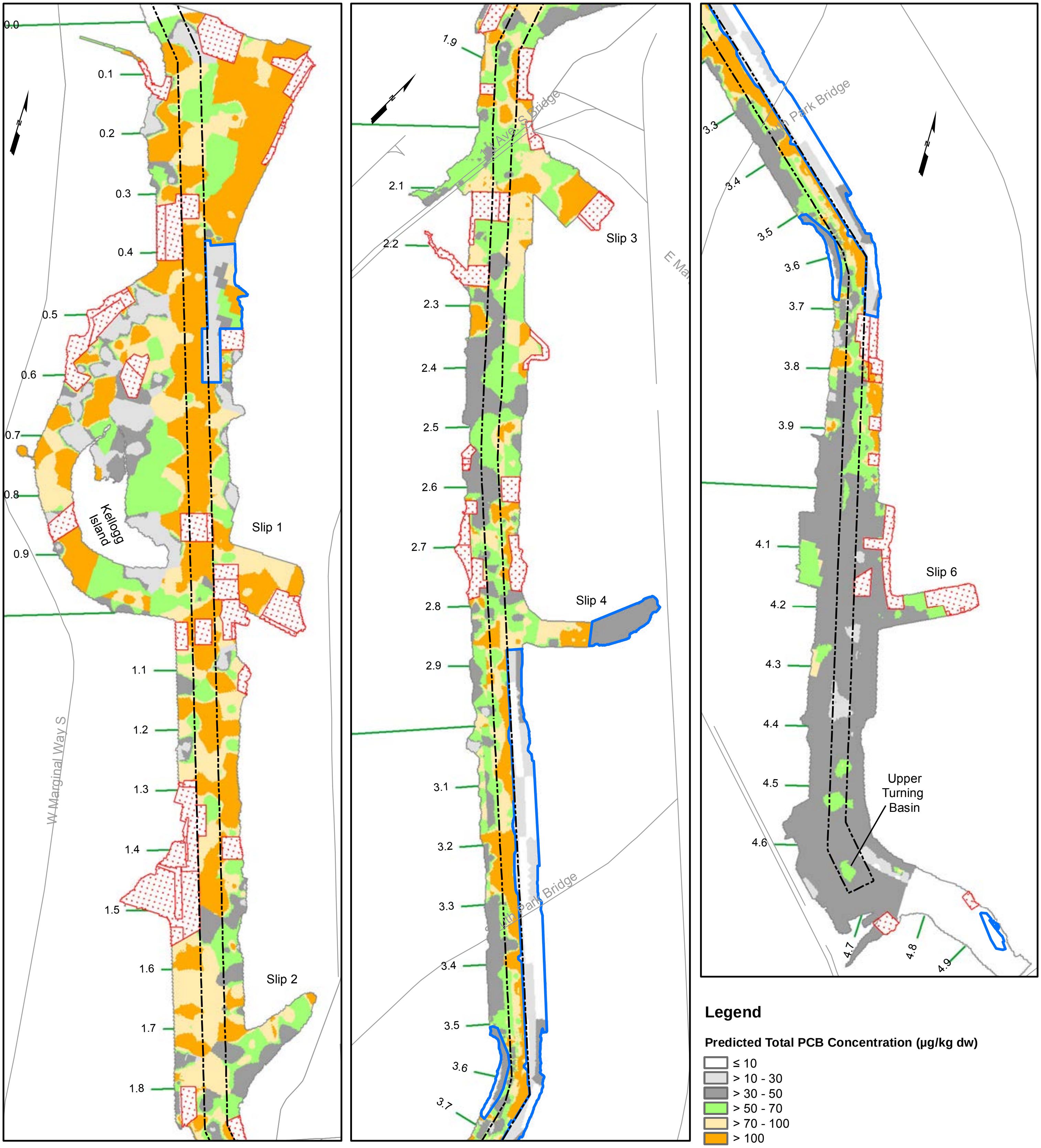
M1-64

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4			Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 35, BRV = mid
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE M-12

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-12_Y35PCB_6R_BRVM.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 3C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 5-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

Feet
0 200 400 800

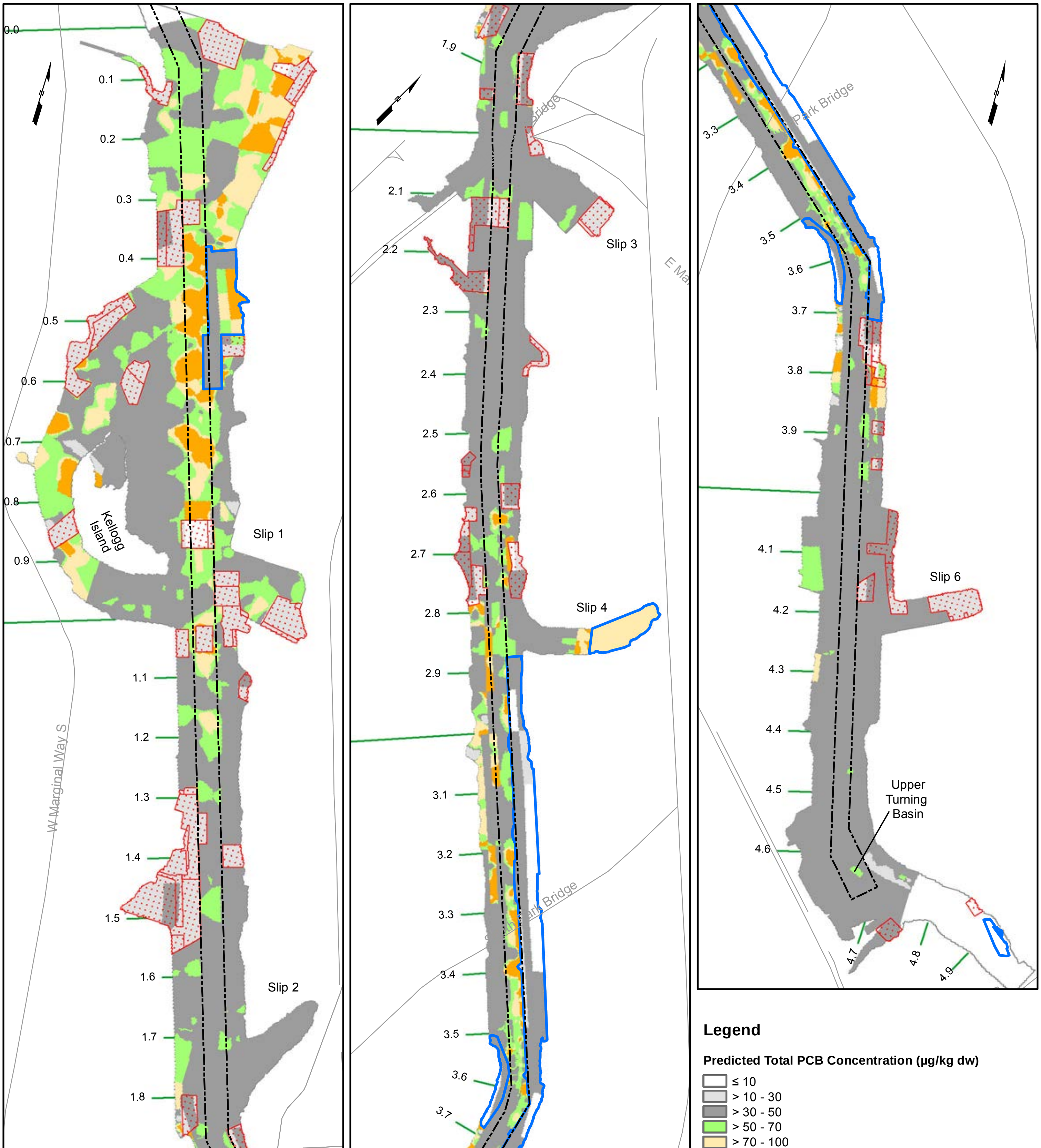
M1-65

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	**Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 5, BRV = 0**
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	**FIGURE M-13**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-13_Y5PCB_3C_BRVM.mxd



Legend

Predicted Total PCB Concentration (μg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

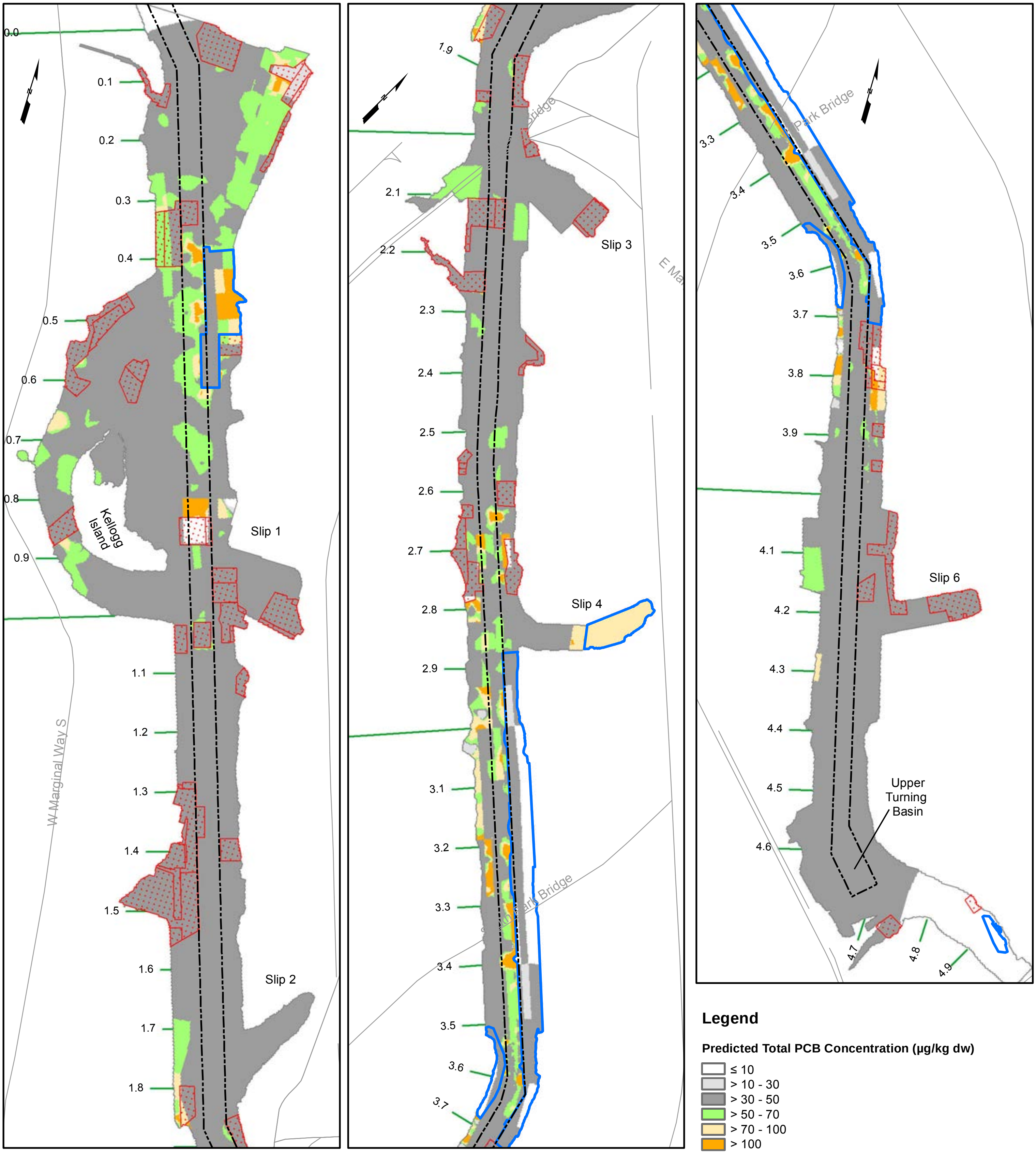
- Active Alternative 3C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 15-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 μg/kg dw
   b. Mid lateral = 300 μg/kg dw
   c. Bed replacement value (BRV) = 0 μg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-14_Y5PCB_3C_BRVM.mxd

AECOM Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 15, BRV = 0
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE M-14



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 3C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 25-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

Feet 0 200 400 800

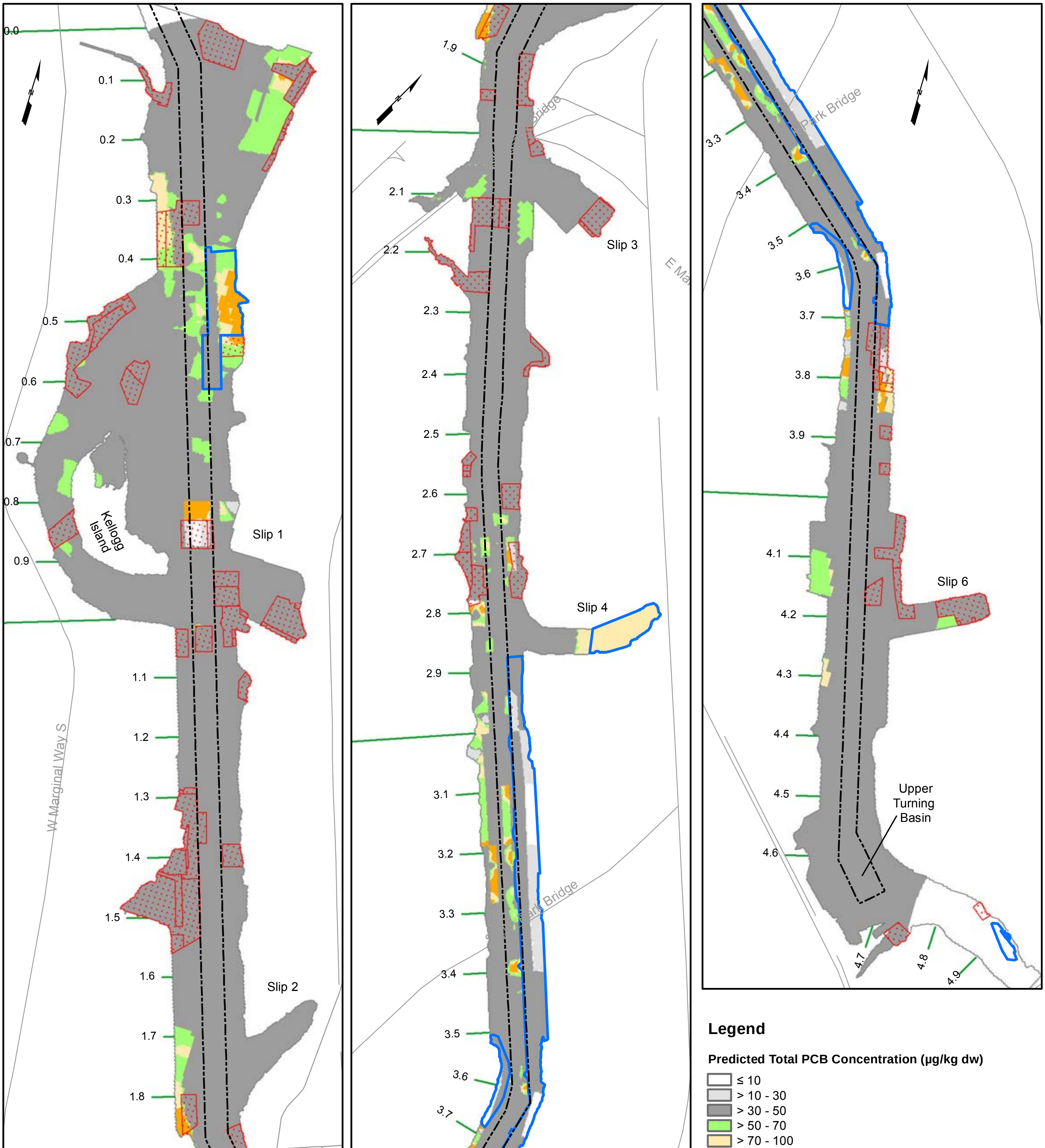
M1-67

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 25, BRV = 0
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE M-15

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-15_Y25PCB_3C_BRV0.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 3C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 35-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

M1-68

0 200 400 800 Feet

AECOM

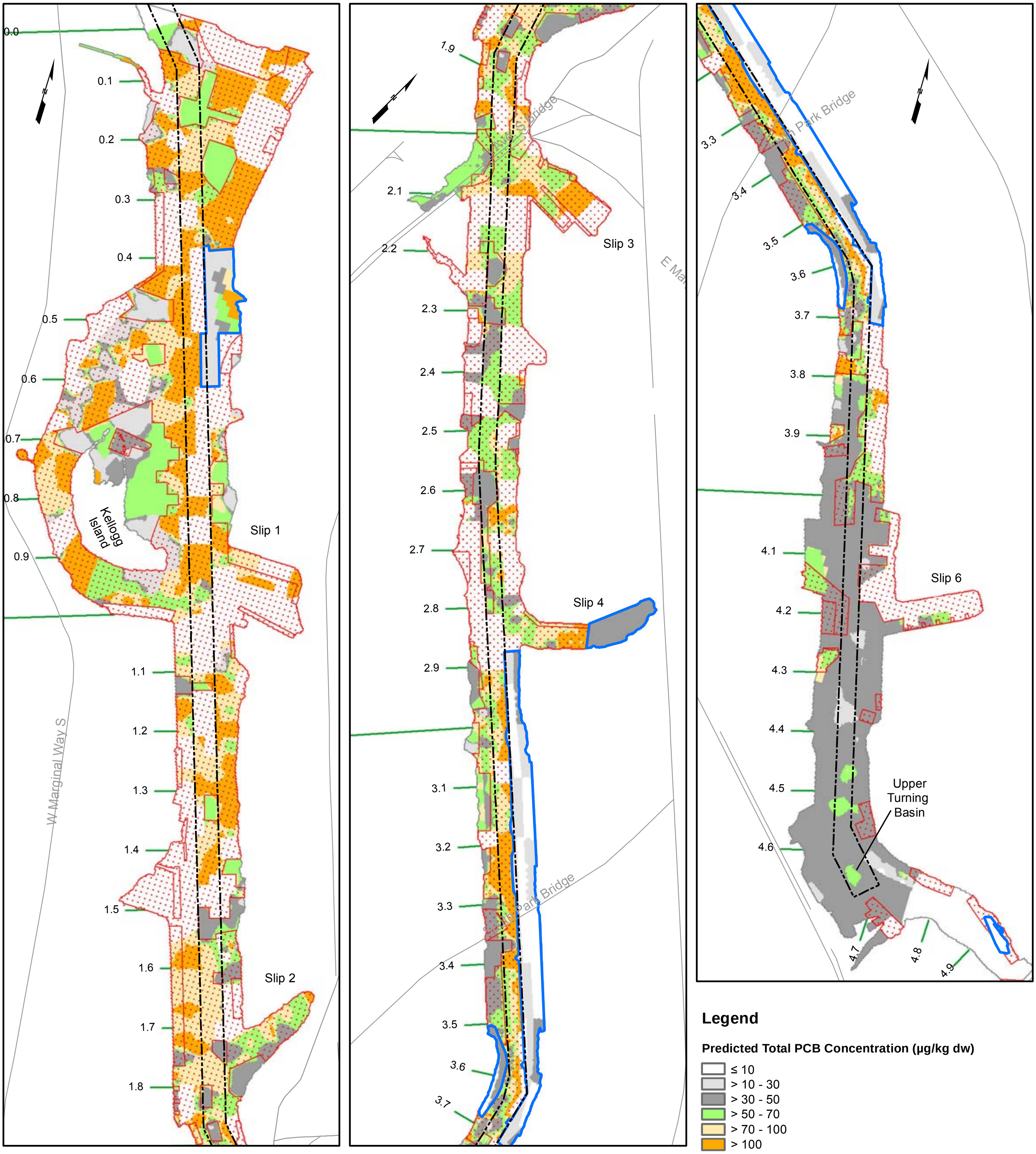
Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-8.4

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0

Predicted Total PCB Distribution in Surface Sediment, Alternative 3C Year 35, BRV = 0

FIGURE M-16



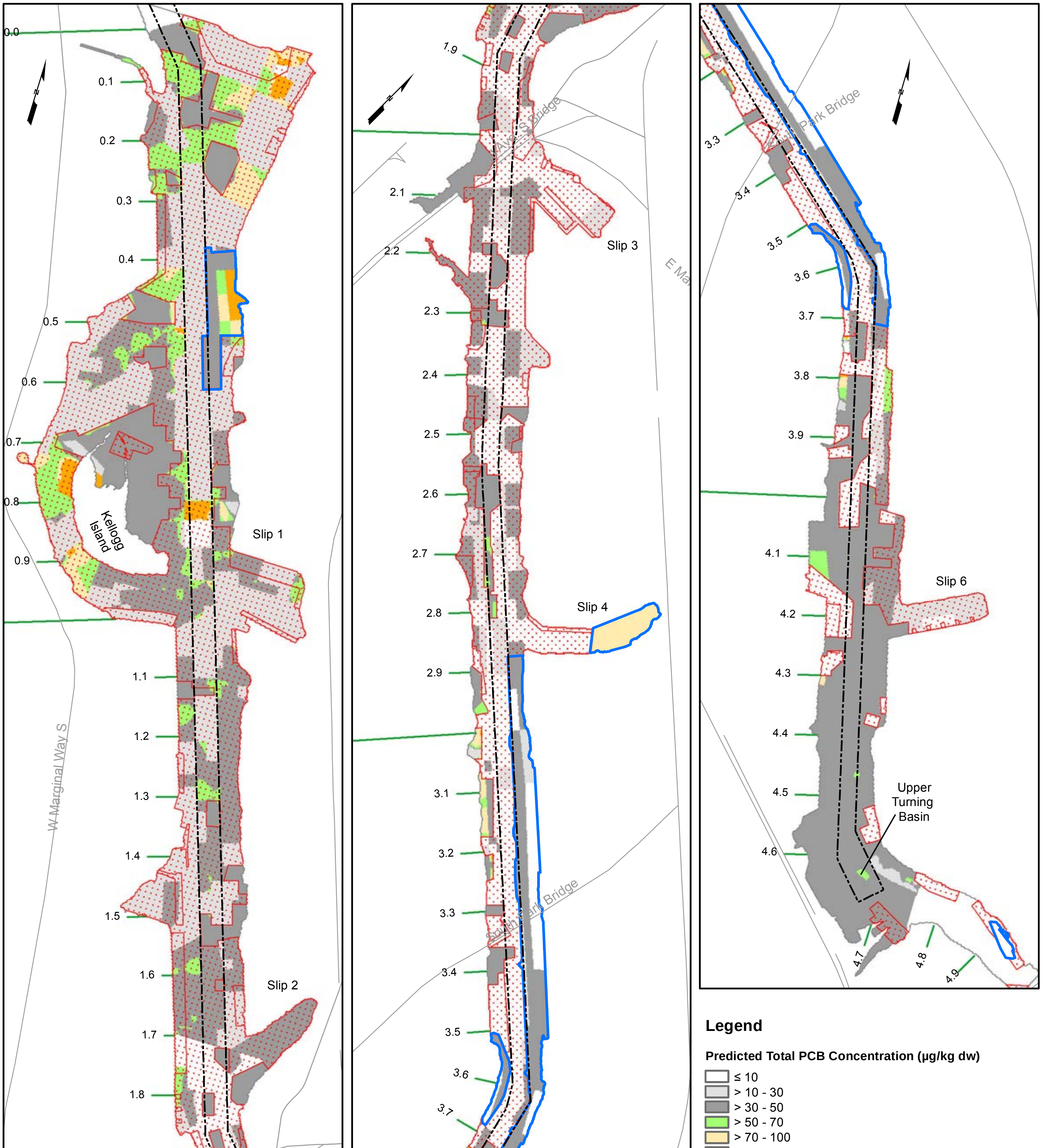
Notes:
1. STM GIS shapefile from 5-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 5, BRV = 0
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE M-17

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-17_Y5PCB_6C_BRV0.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 15-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

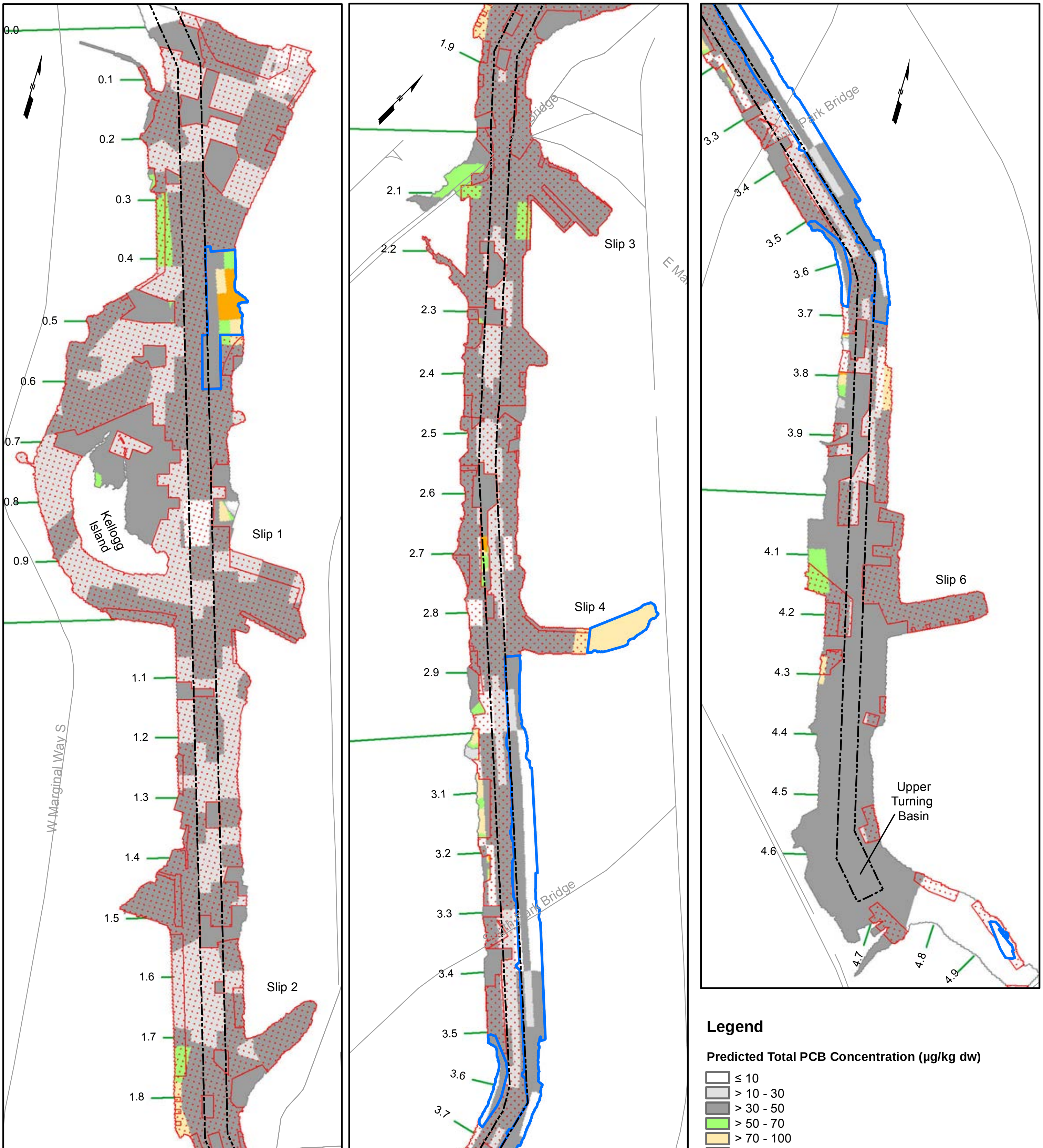
M1-70

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4			**Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 15, BRV = 0**
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	**FIGURE M-18**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-18_Y5PCB_3C_BRVM.mxd



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 25-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

M1-71

Feet
0 200 400 800

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 25, BRV = 0
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE M-19

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-19_Y25PCB_6C_BRV0.mxd

Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6C Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 35-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

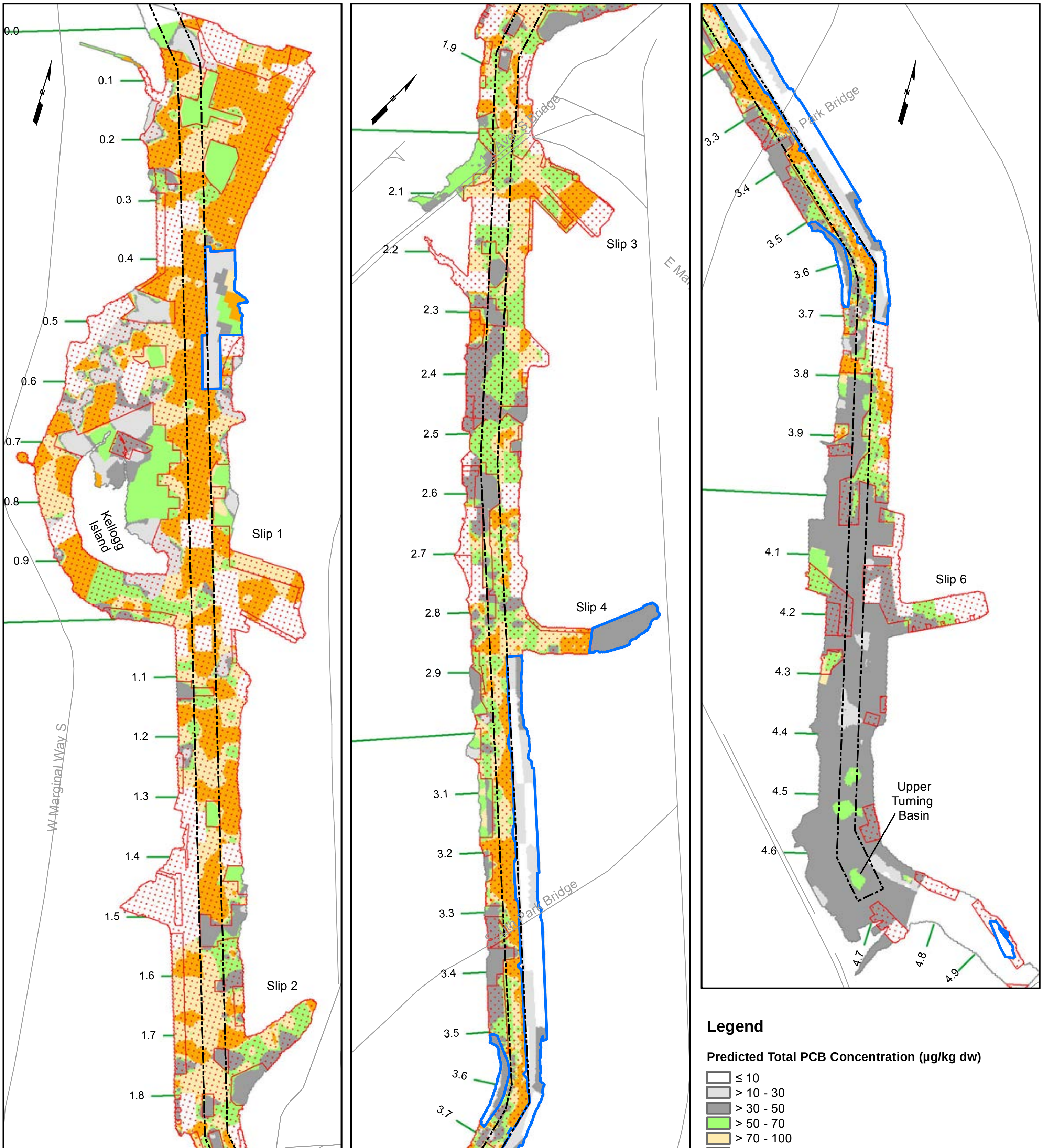
M1-72

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4	Predicted Total PCB Distribution in Surface Sediment, Alternative 6C Year 35, BRV = 0
DATE: 10/31/12 DWRN:MVI/sea Revision: 0	FIGURE M-20

L:\Lower Duwamish FS\FS_Final_GISOct2012\FS_GIS_MXDs_Oct12\Appendix M\M-20_Y35PCB_6C_BRV0.mxd



Notes:
1. STM GIS shapefile from 5-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 μg/kg dw
   b. Mid lateral = 300 μg/kg dw
   c. Bed replacement value (BRV) = 0 μg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

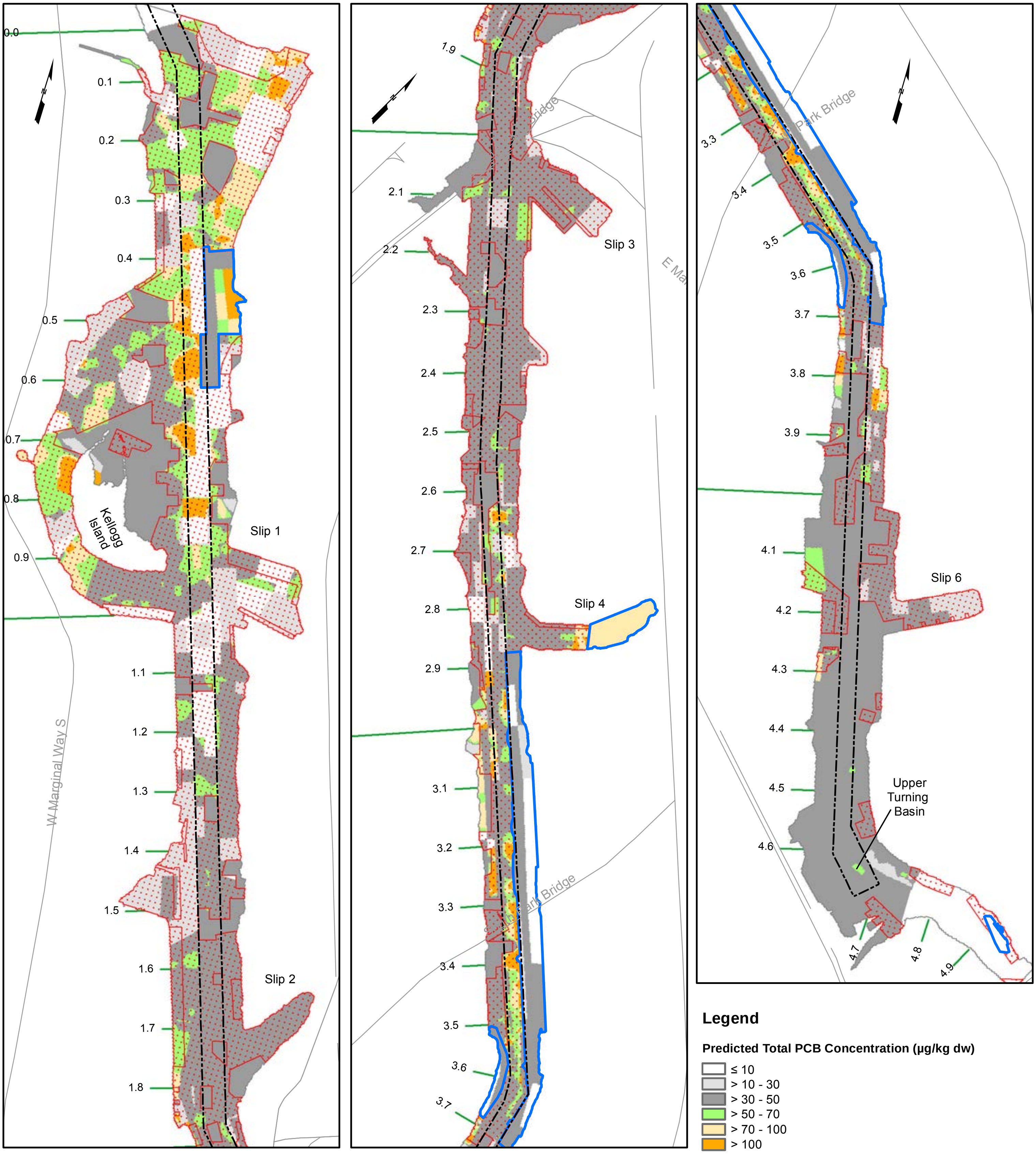
L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-21_Y5PCB_6R_BRV0.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

M1-73

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4			Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 5, BRV = 0
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE M-21



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6R Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 15-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

Feet 0 200 400 800

M1-74

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway
Final Feasibility Study
60150279-8.4

Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 15, BRV = 0

DATE: 10/31/12 | DWRN:MVI/sea | Revision: 0 | **FIGURE M-22**

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix MM-22_Y15PCB_6R_BRV0.mxd

Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6R Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 25-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

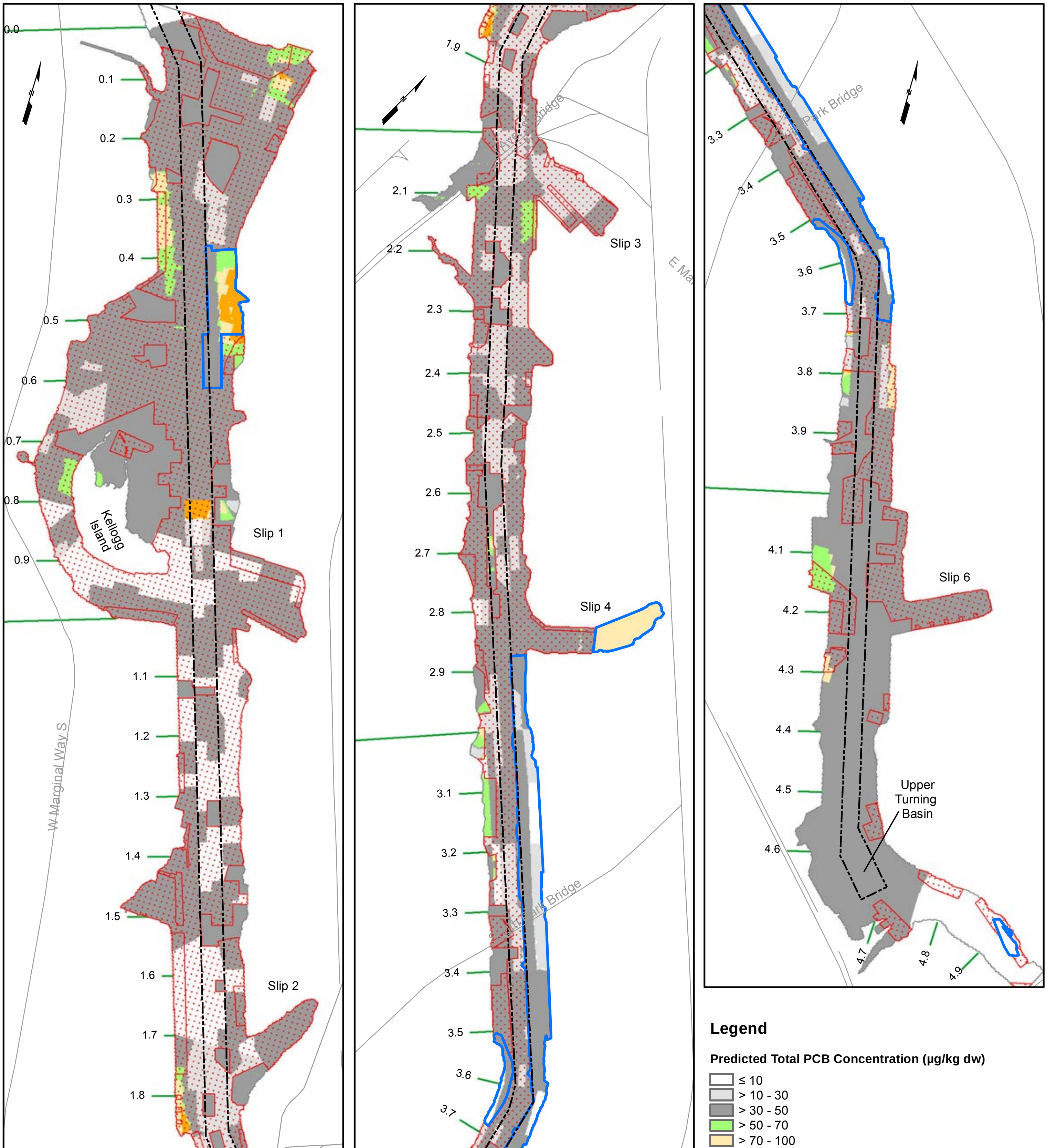
L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix MM-23_Y25PCB_6R_BRV0.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

M1-75

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4			Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 25, BRV = 0
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE M-23



Legend

Predicted Total PCB Concentration (µg/kg dw)

- ≤ 10
- > 10 - 30
- > 30 - 50
- > 50 - 70
- > 70 - 100
- > 100

- Active Alternative 6R Footprint from Draft Final FS
- Early Action Area
- Road
- Navigation Channel
- River Mile Marker

Notes:
1. STM GIS shapefile from 35-year run (QEA Feb. 2009).
2. Total PCBs predicted using the following BCM input parameters:
   a. Mid upstream = 35 µg/kg dw
   b. Mid lateral = 300 µg/kg dw
   c. Bed replacement value (BRV) = 0 µg/kg dw
3. Remedial alternatives are from the Draft Final Feasibility Study (FS; October 2010). This analysis was conducted for FS comment resolution meetings (March 2011) prior to the Final FS remedial alternatives being finalized.

0 200 400 800 Feet

M1-76

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150279-8.4			Predicted Total PCB Distribution in Surface Sediment, Alternative 6R Year 35, BRV = 0
DATE: 10/31/12	DWRN:MVI/sea	Revision: 0	FIGURE M-24

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix M\M-24_Y35PCB_6R_BRV0.mxd

Part 2: Memorandum – Estimate of PCB Export from the Lower Duwamish Waterway

Table of Contents

List of Tables

List of Figures

Memorandum

To: EPA and Ecology

From: AECOM

Subject: Estimate of PCB Export from the Lower Duwamish Waterway

Date: October 15, 2012

On behalf of the Lower Duwamish Waterway Group (LDWG), this memorandum addresses Comment 182 provided by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) in response to the Lower Duwamish Waterway (LDW) Draft Feasibility Study (FS) submitted April 2009:

> ***Comment 182 Quantifying Output from LDW:*** *The FS must include an evaluation of chemical and physical export from the LDW to East and West Waterways and Elliott Bay. This evaluation must be conducted to provide information on the loading of LDW derived sediments to the other waterways. Evaluation of the reduction of this loading from each alternative should also be discussed.*

The Draft Final FS was submitted to EPA and Ecology on October 15, 2010; however, this comment was not specifically addressed in that submittal. This memorandum was first submitted to EPA and Ecology on January 19, 2011 to address Draft FS Comment 182. The contents of this memorandum were discussed with LDWG, EPA, Ecology, and the U.S. Army Corps of Engineers (USACE) in FS comment resolution meetings held on March 21, April 8, and April 26, 2011. The methodology presented herein was revised based on those discussions.

In the FS, sediment discharge from the LDW to the East and West Waterways and Elliott Bay was estimated using the sediment transport model (STM) and reported as a total discharge from the LDW. Separate sediment exports to the East and West Waterways were not computed from model output because data are not available to reliably calibrate the flow divide between the East and West Waterways. Consequently, the model is considered reliable for estimating total sediment discharge from the LDW, but the model cannot reliably quantify the distribution of sediment discharge between the waterways or the transport of those sediments within the East and West Waterways and Elliott Bay.

This memorandum estimates the export of polychlorinated biphenyls (PCBs) from the LDW associated with:

- Suspended solids from upstream of the LDW that pass through the LDW or that temporarily settle in the LDW bed and are later resuspended and exit the LDW, calculated both for baseline conditions (as an initial point of reference) and for the construction periods of each alternative.

- Suspended solids from lateral sources discharging to the LDW (e.g., storm drains, combined sewer overflows, creeks) that pass through the LDW or that temporarily settle in the LDW bed and are later resuspended and exit the LDW, calculated both for baseline conditions (as an initial point of reference) and for the construction periods of each alternative.
- Sediment naturally eroded from the bed (i.e., the bed-source sediment), both for baseline conditions and after each remedial alternative.
- Surface and subsurface sediments that are resuspended by dredging and that exit the LDW, associated with each remedial alternative.

This memorandum focuses on export of bed-source sediments at baseline and changes in these natural erosion exports associated with the various remedial alternatives, as well as their comparison to the exports associated with upstream, lateral, and dredging sources. The upstream- and lateral-source sediments and PCB exports were calculated at baseline conditions as a point of reference to compare with the bed-source exports at baseline. Bed-source sediment export was estimated for each remedial alternative at various time points. To estimate the export, the spatially-weighted average concentrations (SWACs) of total PCBs predicted by the bed composition model (BCM) for each of the three LDW reaches were multiplied by an estimated annual export of bed-source sediment eroded from each reach. The annual export associated with dredging was calculated as an average total PCB concentration associated with sediment expected to be dredged for each remedial alternative, multiplied by an estimated annual dredging rate and an assumed suspended sediment loss. The total PCB export from upstream and lateral sources during construction of the remedial alternatives was calculated based on the annual average PCB export from those sources (assuming an annual average suspended solids load within the LDW and mid PCB input parameters) multiplied by each alternative's specific construction period. These exports were estimated using simplifying assumptions developed in collaboration with EPA, Ecology, and USACE.

Approach

Baseline PCB Export from Upstream- and Lateral-source Sediments

As a point of reference, the estimated sediment and PCB exports from each source (upstream, lateral, and bed) are provided for baseline conditions (Figures 1a and 1b). The sediment export for each sediment source in Figure 1a is the annual average from the first 5 years of the STM hydrograph. The mid BCM input parameters were used to associate PCBs with the exports of upstream- and lateral-source suspended solids (error bars display estimated exports using low and high BCM input parameters; Figure 1b).

Export of PCBs Associated with Resuspended Bed-source Sediments

The estimated bed-source PCB export in Figure 1b uses the baseline surface sediment total PCB SWAC and the average solids export from the first 5 years of the STM hydrograph. Over time and with implementation of the remedial alternatives, sediment and PCB exports from resuspended bed-source sediments within the LDW change in two ways:

- In areas not subject to active remediation, total PCB concentrations in surface sediment generally decrease with time as upstream sediments settle in the LDW. The natural recovery processes associated with sediments originating from upstream are described in Section 5 of the FS and include deposition, mixing, and burial. These processes are modeled in the STM, and the resulting total PCB concentrations in surface sediments are predicted by the BCM.
- In areas that are actively remediated, the surface sediment PCB concentrations change at the time of remediation. Once an area is actively remediated, the total PCB concentration in that footprint is represented by the post-remedy bed sediment replacement value.

For this analysis, the export of resuspended bed-source sediment is assumed to be approximately constant over time because changes in the sediment composition (e.g., different grain sizes) attributable to capping and/or dredging were not incorporated into the STM. This provides a conservative overestimation of sediment export under post-remediation conditions, because capping material is generally coarser than existing bed material and sediments exposed by dredging in uncapped areas are more consolidated and have lower erosion potential than existing surficial sediments.

PCB exports at various times were calculated using the reach-wide PCB SWACs predicted by the BCM, multiplied by an assumed constant bed-source sediment export from each reach (annual export by reach from first 10 years of the STM; Table 1):[2]

- Reach 1 = 32 metric tons (MT)/year
- Reach 2 = 550 MT/year
- Reach 3 = 2 MT/year.

[2] Resuspension and export will vary annually with the hydrograph.

The baseline export rate for eroded bed-source sediments displayed in Figure 1a (732 MT/year) is greater than the annual bed-source sediment export averaged over the first 10 years of the hydrograph (584 MT/year; sum of bullets above) because the annual export of bed-source sediments decreases over time. This occurs as bed-source sediment is buried over time by depositing upstream- and lateral-source sediments, restricting scour and export of these original bed-source sediments.

Table M-1 (found in Part 1 of Appendix M of the Final FS) displays the reach-wide total PCB SWACs predicted by the BCM over time for each remedial alternative, using the mid BCM input parameters. Reach-wide SWACs were also calculated for each BCM period (5-year increments) using the low and high BCM input parameters, and those SWACs were used as inputs for each 5-year period. Reach-wide SWACs are provided for Year 10 in Tables 2a through 2c and for Year 30 in Tables 3a through 3c. The export of PCBs associated with naturally eroded bed-source sediments from each reach of the LDW was calculated as the sediment export rate in MT/year[3] multiplied by the reach-wide SWAC (µg/kg dw) (with unit conversions) to yield a total estimated PCB export rate in kg/year from each reach. The three reach-specific export rates were then summed to estimate the total annual export of PCBs from the LDW associated with erosion of bed-source sediments (Table 4 and Figures 2a and 2b).

Annual exports of PCBs were estimated for each 5-year BCM period, and thus a total export over each 5-year period was calculated (5 years × annual export). PCB export from erosion over the 45-year period for which the BCM was run is the sum of each 5-year export. PCB export rates for years 10 and 30 and the PCB export over the 45-year period are shown in Table 4.

Export of PCBs Associated with Resuspended Sediments Resulting from Remedial Dredging

The actively remediated footprints of the alternatives will be subject to physical disturbances during dredging and, to a lesser extent, from cap and ENR placement. These activities will suspend sediment into the water column during construction. The rate of sediment suspended into the water column and exported out of the LDW during dredging operations was estimated from the annual average dredging production rate (127,000 MT/year, which is equivalent to 140,000 tons/year) and the percent loss of dredged material assumed in the FS. In consultation with EPA and the USACE, it was estimated that the total release of PCBs from dredged sediments would be

3 There are 1,000 kg in 1 MT. A bed-source sediment export rate of 584 MT/year (representing the 10-year annual average) was used in the analysis. The export rate was assumed to be constant, and the bed PCB concentrations (reach-wide PCB SWACs) used to assign the concentration of total PCBs to the exported material varied over time in 5-year time steps.

approximately 2% of the mass of PCBs originally in the dredged sediments. The total release includes:

- Dredge releases: particulate-bound and dissolved PCBs introduced into the water column that reach the end of the mixing zone approximately 100 meters downstream from the dredge.
- Dredge residuals: material containing PCBs that remains within or around the dredge excavation, but moves into the water column due to either desorption of PCBs into the water column or entrainment of the sediment because of the dredge residuals' low density and low critical shear stress for resuspension.
- Debris removal.

Of this 2% PCB release, half is estimated to be in the upper portion of the water column where it can be entrained in the freshwater surface layer and transported downstream. The other half is likely to be in the salt wedge (bottom of water column) and for the purposes of this evaluation is assumed to settle within the LDW. Material suspended in the upper water column is more likely to stay in suspension long enough to exit the LDW, relative to its grain size. Of the material in the upper water column, 50% is estimated to be greater than 100 micrometers (µm) in diameter and would mostly settle before exiting from the LDW. Based on the STM, the trapping efficiency of the finer sediment classes, Class 1A and Class 1B, is approximately 43%. Together, the overall effect of the total loss from the mixing zone, the effect of the salt wedge retaining suspended sediment, and the trapping efficiency of the LDW result in an estimation that 0.3% of the PCB mass in the dredged sediments will be exported from the LDW.

Annual exports of PCBs related to dredging were calculated as an average PCB concentration associated with the sediment to be dredged in each remedial alternative, multiplied by the annual average dredging rate of 127,000 MT/year, multiplied by the portion exported (0.3%; with unit conversions) to yield an estimated annual PCB export in kg/year. The expected concentration of PCBs associated with the dredged sediment was derived by identifying those sediment cores within the dredging and partial dredge and cap footprints for each remedial alternative. The footprints used to identify cores were incremental in that each alternative excluded the previous, smaller remedial alternative footprints (this assumes optimized sequencing of remediation under all alternatives). For example, the sediment cores included in the dredge footprint of Alternative 4R excluded cores in the Alternative 3R dredging footprint because they would have been previously removed during earlier dredging. This approach, which assumes a specific sequencing of remediation, was used to estimate the annual PCB export associated with dredging as the remediation footprints change over time.[4]

For each remedial alternative's dredging (or partial dredge and cap) footprint, the subsurface sediment PCB samples, at depths shallower than the PCB sediment quality standard (SQS) isopach, were vertically averaged.[5] In other words, each sample was weighted by the thickness of the sample interval. The average PCB concentration from the cores was assumed to be the PCB concentration of all the dredged material exported from the LDW during dredging operations from the portion of each remedial alternative footprint beyond the smaller footprint of the previous alternative (used to estimate the PCB exports from dredging that incremental footprint). Cores from areas subject to other active remediation technologies (i.e., ENR/*in situ* or capping) were not included. PCB exports over the entire dredging duration of each remedial alternative were calculated incrementally by multiplying the annual average PCB export rate for each increment by the construction period for that increment. Table 5 lists the estimated in-water construction time frames for active remediation of each remedial alternative. Table 6 lists the incremental time period, the incremental PCB export, and the total PCB export from dredging of each remedial alternative. Table 7 presents an example calculation of PCB exports over the duration of dredging for each removal alternative.

Exports of PCBs from Upstream- and Lateral-source Sediments for Remedial Alternatives

The annual PCB load to the LDW for upstream sources was calculated for each year in the 30 year STM hydrograph. Parameters used to calculate the total PCB load included daily average upstream flow rate, weighted average suspended sediment concentration (as a function of flow rate), and assumed 35 µg/kg dw PCBs in upstream sediments (mid-range BCM upstream input value). PCB load varied for each day of the simulation period. Annual PCB loads calculated using this method ranged from 3.2 to 4.0 kg/yr for the 30 year hydrograph. Average annual PCB upstream load over the 30 year hydrograph was 3.7 kg/yr. The average annual lateral PCB export was estimated at 0.2 kg/yr using the same calculation method.

The exports associated with upstream and lateral sources over the construction periods of the remedial alternatives were calculated for comparison to the export associated

4 For example, remediation of Alternative 3R uses the PCB export rate for EAAs for the first 3 years (years -3 to 0), the Alternative 2R PCB export rate for the following 4 years (years 0 to 4), and the 3R PCB export rate for the following 2 years (years 5 and 6).

5 This was a vertically-weighted average, with no horizontal weighting. Sample intervals with no analytical data were assumed to have the same PCB concentration as the next shallower sample interval. See Appendix E for a description of the SQS isopach layer, representing the estimated vertical extent of contamination.

with natural erosion of the sediment bed and dredging losses over the same time period.

Results

The bed-, lateral-, and upstream-source suspended sediments and PCB exports at baseline conditions are shown in Figures 1a and 1b, respectively, using average annual sediment exports from the first 5 years of the STM hydrograph. These figures illustrate how the majority of sediment and PCB mass export is associated with upstream-source sediments. The error bars on Figure 1b illustrate the uncertainty in the upstream- and lateral-source PCB exports related to the range of the BCM input parameters used in the analysis (5 to 80 µg/kg dw for upstream-source sediments and 100 to 1,000 µg/kg dw for lateral-source sediments). No error bars were estimated on the bed-source PCB export because this calculation used the baseline surface sediment SWAC.

Estimated PCB Export Rates from Natural Sediment Bed Erosion after Completion of Construction

Figures 2a and 2b present the estimated average annual PCB exports from natural erosion of bed-source sediments at model years 10 and 30, respectively, for each remedial alternative using the range of BCM input parameters (all low, all mid, and all high). Results are compared to the estimated PCB export from the sediment bed in the absence of remediation (baseline) of about 0.47 kg/year. Year 10 PCB export rates from bed-source sediments based on the mid BCM input parameters are about 6 to 9% of that for baseline conditions, while Year 30 PCB export rates from bed-source sediments are about 4 to 6% of that for baseline conditions (Table 4). This is largely because of the decrease (from both natural recovery and active remediation) in the PCB concentration of bed-source sediments estimated to be resuspended and transported out of the LDW by natural erosion events (i.e., high-flow scour). Figures 2a and 2b demonstrate that the bed-source PCB exports vary little among the remedial alternatives, because by Year 10, PCB surface sediment concentrations do not vary much among the alternatives. This is largely because PCB hot spots have been actively remediated and because of natural recovery processes in the rest of the LDW that do not vary among remedial alternatives.

The estimated export of PCBs associated with erosion of bed-source sediments for all alternatives ranges from 0.03 to 0.04 kg/year at model year 10 (Figure 2a and Table 4) and from 0.02 to 0.03 kg/year at year 30 (Figure 2b and Table 4). The baseline bed-source annual export is 0.47 kg/year. The estimated annual PCB exports at Year 10 decrease slightly as the actively remediated footprint increases (i.e., with increasing numbered alternatives). However, these incremental differences decrease over time, such that the PCB bed-source exports at Year 30 are similar for all remedial alternatives. This is because the reach-wide SWACs become similar over time, as a result of remediation and BCM-predicted natural recovery processes. The total export of PCBs from naturally eroded bed-source sediments over the 45-year period for which BCM-predicted SWACs are presented is approximately 3 kg regardless of the remedial alternative (Table 4).

Accounting for Losses of PCBs Associated with Dredging

Table 6 presents the estimated PCB exports associated with dredging for each alternative. After the EAAs are remediated, estimated annual average PCB exports associated with dredging decrease from 1.3 kg/year to about 0.3 kg/year, but remain an order of magnitude greater than those for natural erosion of bed-source sediments (0.03 – 0.04 kg/year; Table 4). The estimated PCB exports associated with dredging range from approximately 4 kg for Alternative 1 [EAAs] up to 17.5 kg for Alternative 6R (Table 6 and Figure 3). Table 7 demonstrates the calculation of the cumulative PCB exports from dredging for the removal alternatives. These values represent the fraction of PCBs within the resuspended dredged sediments that are estimated to remain in the water column and leave the LDW. As described above, the remaining fraction of PCBs introduced into the water column from dredging is expected to resettle in the surface sediment bed. These resettled sediments may have elevated PCB concentrations relative to surrounding surface sediment concentrations. Although dredging is another form of disturbance that exposes subsurface contamination, this process was not factored into the STM and BCM calculations, nor was the potential for disturbance due to processes such as vessel scour, as discussed in Appendix M Part 5.

Annual PCB Export under Removal and Combined Alternatives

Figure 4 compares estimates of PCB export from all four sources (upstream, lateral, natural bed erosion, dredging) over the construction periods of each alternative. This figure illustrates the relative contributions from each source; upstream contributes the most and depending on the alternative, either natural bed erosion or lateral contributes the least.

Figures 5a and 5b, respectively, present estimated annual and cumulative PCB exports for the removal alternatives. Figures 6a and 6b present the same type of estimated exports for the combined alternatives.

Figures 5b and 6b are line graphs showing the cumulative PCB export associated with dredging and natural bed erosion for each remedial alternative over the period of active remediation, and the incremental addition of PCBs above the export estimated by the previous (smaller-numbered) alternative. The estimated cumulative PCB export associated with dredging for Alternative 6C is about 9 kg compared to 17.5 kg for Alternative 6R. The removal alternatives have higher cumulative PCB exports associated with dredging compared to the combined alternatives because of longer construction times and greater disturbance of sediments. Figure 4 presents the PCB exports from the LDW originating from natural erosion of bed sediments, lateral sources, dredging losses, and upstream over the construction period for each remedial alternative.

Assumptions

This analysis uses four simplifying assumptions that could influence the estimate of PCBs exported from the LDW. First, the analysis does not include resuspension and export of sediment from ship scour and propeller wash, which would increase the PCB export presented in this memorandum. Second, exports of bed-source sediments are estimated on a reach-wide basis. Reach-wide SWACs (predicted by the BCM) were used to associate PCB concentrations with reach-wide solids export (estimated by the STM). However, there is spatial variability in sediment PCB concentrations and in sediment resuspension and export within each reach of the LDW. More precision (and perhaps greater differences among the remedial alternatives) could be possible by tracking bed-source sediments and PCB exports on a grid-cell basis. The analysis indicates that PCB exports associated with natural erosion of bed-source sediments are similar (3.0 kg to 2.8 kg over 45 years) for Alternatives 2 through 6 as shown in Table 4. Third, the estimated PCB exports associated with dredging were calculated from the average of all subsurface sediment data within the incremental dredging footprints; the data were not spatially interpolated. The average PCB concentrations in the cores within each dredging footprint were based on limited subsurface data and therefore there is uncertainty in the estimated PCB exports associated with dredging. Fourth, the estimate of dredged sediment export to Elliott Bay is based on a simple estimated trapping efficiency (not on using the STM to model transport releases) and estimated dredge loss rates. Therefore, these are only screening level estimates and include a high degree of uncertainty.

Conclusions

In all cases, the estimated export of PCBs out of the LDW from natural erosion of bed-source sediments after completion of remediation under any remedial alternative is substantially less than the PCB export for the baseline condition, because less contamination remains in the sediment bed after remediation. The largest incremental change in PCB export from the baseline condition results from cleanup of the EAAs. Smaller incremental changes are associated with the remedial alternatives based only on natural bed erosion (not accounting for releases from dredging). However, the PCB export associated with the natural resuspension and export of bed-source sediments for any remedial alternative (after completion of the EAAs) is small compared to PCB exports associated with upstream-source sediments over time. The upstream source of

PCB export is also much greater than the exports associated with dredging, natural bed erosion, and lateral sources.

Dredging releases account for a greater proportion of PCB exports from the LDW than does natural erosion of the sediment bed under any of the remedial alternatives. The export estimates presented in this memorandum are based on sediment discharges estimated by the STM and dredged sediment export based on screening level estimated trapping efficiency of the LDW. Similar to lateral source and bed erosion quantities, the dredging operations result in a relatively small amount of PCBs exported from the LDW relative to upstream sources. Therefore, PCBs associated with upstream solids are the largest source of export of PCBs to Elliott Bay and will remain so under all remedial alternatives.

Table 1 STM Estimated Solids Export from Bed-Source Sediment in Each Reach of the LDW

LDW	Bed-Source Sediment Leaving the LDW in 10 Years (MT)	Average Annual Sediment Export Rate from Erosion of the Bed (MT/year)
Reach 1	320	32
Reach 2	5,500	550
Reach 3	20	2
Total Bed-Source Sediments Leaving the LDW	5,840	584

Source: Figure 5-9, Section 5 of the FS.

Notes:

1. The average annual bed-source sediment export in this table (584 MT/year) differs from that in Figure 1a because Figure 1a uses average annual exports over the first 5 years of the hydrograph to represent baseline conditions. The exports in Table 1 are averaged over the first 10 years of the hydrograph and are used to calculate exports of PCBs related to the remedial alternatives.

FS = feasibility study; LDW = Lower Duwamish Waterway; MT = metric ton; PCB = polychlorinated biphenyl; STM = sediment transport model

Table 2 Reach-Wide Year 10 Total PCB SWACs (µg/kg dw) for Each Remedial Alternative

Table 2a Using Low BCM Input Parameters

LDW	No Action – Baseline Reach-Wide SWACs (µg/kg dw)	Year 10 Reach-Wide Total PCB SWACs (µg/kg dw)					
		Alternative 1 (EAAs)	Alternative 2R	Alternative 3C/3R	Alternative 4C/4R	Alternative 5C/5R	Alternative 6C/6R
Reach 1	250	59	51	46/46	36/46	30/46	30/46
Reach 2	660	39	34	33/33	27/30	27/30	27/30
Reach 3	56	10	10	10/10	10/11	11/11	11/11

Table 2b Using Mid BCM Input Parameters

LDW	No Action – Baseline Reach-Wide SWACs (µg/kg dw)	Year 10 Reach-Wide Total PCB SWACs (µg/kg dw)					
		Alternative 1 (EAAs)	Alternative 2R	Alternative 3C/3R	Alternative 4C/4R	Alternative 5C/5R	Alternative 6C/6R
Reach 1	250	84	77	73/73	64/73	58/73	58/73
Reach 2	660	67	63	61/61	57/59	57/59	57/59
Reach 3	56	40	40	40/40	40/41	40/41	40/41

Table 2c Using High BCM Input Parameters

LDW	No Action – Baseline Reach-Wide SWACs (µg/kg dw)	Year 10 Reach-Wide Total PCB SWACs (µg/kg dw)					
		Alternative 1 (EAAs)	Alternative 2R	Alternative 3C/3R	Alternative 4C/4R	Alternative 5C/5R	Alternative 6C/ 6R
Reach 1	250	130	123	119/119	110/118	103/118	103/118
Reach 2	660	115	110	109/109	105/104	104/104	104/104
Reach 3	56	88	88	88/88	88/89	89/89	89/89

Notes:
1. There is no Alternative 2C.
2. Low, mid, and high BCM input parameters are as follows: upstream = 5, 25, and 80 µg/kg dw; lateral = 100, 300, and 1,000 µg/kg dw; RV in AOPC 1 = 30, 60, and 90 µg/kg dw; RV in AOPC 2 = 10, 20, and 40 µg/kg dw.

AOPC = area of potential concern; BCM = bed composition model; C = combined alternative; dw = dry weight; EAA = early action area; kg = kilogram; LDW = Lower Duwamish Waterway; µg = microgram; PCB = polychlorinated biphenyl; R = removal alternative; RV = post-remedy bed sediment replacement value; SWAC = spatially-weighted average concentration

Table 3 Reach-Wide Year 30 Total PCB SWACs (µg/kg dw) for Each Remedial Alternative

Table 3a Using Low BCM Input Parameters

LDW	No Action – Baseline Reach-Wide SWACs (µg/kg dw)	Year 30 Reach-Wide Total PCB SWACs (µg/kg dw)					
		Alternative 1 (EAAs)	Alternative 2R	Alternative 3C/3R	Alternative 4C/4R	Alternative 5C/5R	Alternative 6C/6R
Reach 1	250	15	14	12/12	11/11	10/12	9/12
Reach 2	660	22	20	19/19	17/17	17/17	11/11
Reach 3	56	8	8	7/7	7/7	7/7	7/7

Table 3b Using Mid BCM Input Parameters

LDW	No Action – Baseline Reach-Wide SWACs (µg/kg dw)	Year 30 Reach-Wide Total PCB SWACs (µg/kg dw)					
		Alternative 1 (EAAs)	Alternative 2R	Alternative 3C/3R	Alternative 4C/4R	Alternative 5C/5R	Alternative 6C/6R
Reach 1	250	48	47	45/45	44/45	44/45	41/43
Reach 2	660	52	51	50/50	48/48	48/48	42/38
Reach 3	56	39	39	38/38	38/38	38/38	38/38

Table 3c Using High BCM Input Parameters

LDW	No Action – Baseline Reach-Wide SWACs (µg/kg dw)	Year 30 Reach-Wide Total PCB SWACs (µg/kg dw)					
		Alternative 1 (EAAs)	Alternative 2R	Alternative 3C/3R	Alternative 4C/4R	Alternative 5C/5R	Alternative 6C/6R
Reach 1	250	108	107	105/105	105/105	105/104	98/100
Reach 2	660	104	102	102/102	100/100	100/100	94/84
Reach 3	56	92	90	89/89	89/89	89/89	89/88

Notes:
1. There is no Alternative 2C.
2. Low, mid, and high BCM input parameters are as follows: upstream = 5, 25, and 80 µg/kg dw; lateral = 100, 300, and 1,000 µg/kg dw; RV in AOPC 1 = 30, 60, and 90 µg/kg dw; RV in AOPC 2 = 10, 20, and 40 µg/kg dw.

AOPC = area of potential concern; BCM = bed composition model; C = combined alternative; dw = dry weight; EAA = early action area; kg = kilogram; LDW = Lower Duwamish Waterway; µg = microgram; PCB = polychlorinated biphenyl; R = removal alternative; RV = post-remedy bed sediment replacement value; SWAC = spatially-weighted average concentration

Table 4 Estimated Export of PCBs from Natural Erosion of Bed-Source Sediments for Each Remedial Alternative

PCB Export	No Action – Baseline Conditions (Year 0)	Alternative 1 (EAAs)	Alternative 2R	Alternative 3C/3R	Alternative 4C/4R	Alternative 5C/5R	Alternative 6C/6R
Annual Export of PCBs Using Year 10 BCM SWACs (kg/year)	0.47	0.04	0.04	0.04/0.04	0.03/0.03	0.03/0.03	0.02/0.03
Annual Export of PCBs Using Year 30 BCM SWACs (kg/year)		0.03	0.03	0.03/0.03	0.03/0.03	0.03/0.03	0.02/0.02
Total Export of PCBs (kg) Estimated from Natural Erosion of Bed-Source Sediment over 45 years	n/a	3.1	3.0	3.0/3.0	3.0/3.0	3.0/3.0	2.8/2.9

Notes:

BCM = bed composition model; C = combined alternative; EAA = early action area; kg = kilogram; LDW = Lower Duwamish Waterway; n/a = not applicable; PCB = polychlorinated biphenyl; R = removal alternative; SWAC = spatially-weighted average concentration

Table 5 Construction Time Frames for Each Remedial Alternative

	Alternative 1 (EAAs)	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Estimated In-water Construction Time (years); Not Including EAAs						
Combined Alternative ("C")	0	n/a	3	6	7	16
Removal Alternative ("R")		4	6	11	17	42
Estimated In-water Construction Time (years) Used to Calculate Export from Dredging; Including EAAs						
Combined Alternative ("C")	3	n/a	6	9	10	19
Removal Alternative ("R")		7	9	14	20	45

Notes:

a. For dredging export graphing, EAA construction is assumed to take three years and ends at Year 0. Alternative 2 construction and the BCM begin at Year 0.

BCM = bed composition model; EAA = early action area; LDW = Lower Duwamish Waterway; n/a = not applicable; PCB = polychlorinated biphenyls; SWAC = spatially-weighted average concentration

Table 6 Estimated Export of PCBs from the LDW Associated with Dredging Losses, Upstream-source, and Lateral-source Sediments

Source and Parameter		Remedial Alternative									
		1 (EAAs)	2R	3C	3R	4C	4R	5C	5R	6C	6R
Dredging Losses[a]	Average Total PCB Concentration (µg/kg dw) of Subsurface Sediment Samples in Incremental Dredged Footprint[b]	3,400	1,100	960	750	810	720	780	970	700	720
Dredging Losses[a]	PCB Export Rate (kg/year) from Dredging Losses During Dredging of Incremental Footprint	1.3	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3
Dredging Losses[a]	Construction Time (Total Years including 3 years of EAAs)	3	7	6	9	9	14	10	20	19	45
Dredging Losses[a]	Incremental Construction Years from Previous Alternative (years)	n/a	4	3	2	3	5	1	6	9	25
Dredging Losses[a]	Incremental PCB Export from Previous Alternative (kg)	n/a	1.6	1.2	0.6	0.9	1.5	0.3	2.4	2.7	7.5
Dredging Losses[a]	Total Estimated PCB Export During Active Remediation (kg)[c]	3.9	5.5	5.1[d]	6.1	6.0	7.6	6.3	10.0	9.0	17.5
Upstream	Total Estimated PCB Export Over Construction Period (kg)[e]	11.1	14.8	11.1	22.2	22.2	40.7	25.9	62.9	59.2	155.4
Lateral	Total Estimated PCB Export Over Construction Period (kg)[e]	0.6	0.8	0.6	1.2	1.2	2.2	1.4	3.4	3.2	8.4

Notes:

a. Assuming a 127,000 MT/year dredging production rate and 0.3% of material exported from the LDW.

b. Incremental samples are the samples from dredging footprint of remedial alternative beyond the dredging footprint of the previous, smaller remedial alternative.

c. PCB export is calculated incrementally by multiplying the annual average PCB export rate by the duration of dredging for an incremental remediation footprint. Incremental exports are summed for a total export. For example, the Alternative 3R export is calculated as the Alternative 1 (EAAs) annual export rate multiplied by 3 years, plus the Alternative 2R annual export rate multiplied by 4 years, plus the Alternative 3R annual export rate multiplied by 2 years, for a total PCB export over a 9-year period of dredging.

d. Total export of PCBs for Alternative 3C is sum of Alternative 1 (EAAs) export plus Alternative 3C incremental export. There is no Alternative 2C.

e. PCB exports from upstream and lateral sources are calculated by multiplying the annual average PCB export rates of 3.7 kg/year and 0.2 kg/year, respectively, over the construction period for each alternative (excluding 3 years of EAAs except for Alternative 1).

BCM = bed composition model; C = combined alternative; dw = dry weight; EAA = early action area; kg = kilogram; LDW = Lower Duwamish Waterway; µg = microgram; MT = metric ton; n/a = not applicable; PCB = polychlorinated biphenyls; R = removal alternative

Table 7 Example Calculation of Total PCB Export Associated with Dredging for Each Removal Alternative

Remedial Alternative Dredged	PCB Export (kg) Associated with Dredging of Each Incremental Footprint						Total PCB Export Associated with Dredging (kg)[b]
	EAAs[a]	2R	3R	4R	5R	6R	
Alternative 1 (EAAs)	3.9					*no active remediation*	3.9
Alternative 2R	3.9	1.6				*no active remediation*	5.5
Alternative 3R	3.9	1.6	0.6			*no active remediation*	6.1
Alternative 4R	3.9	1.6	0.6	1.5		*no active remediation*	7.6
Alternative 5R	3.9	1.6	0.6	1.5	2.4	*no active remediation*	10.0
Alternative 6R	3.9	1.6	0.6	1.5	2.4	7.5	17.5

Notes:

a. Estimated exports from dredging of EAAs were included for completeness. Construction of EAAs is assumed to be completed prior to construction within the remedial alternative footprints.

b. Sum of values to the left.

EAA = early action area; kg = kilogram; LDW = Lower Duwamish Waterway; PCB = polychlorinated biphenyls; R = removal alternative

Figure 1a. Estimated Average Annual Sediment Export at Baseline Conditions

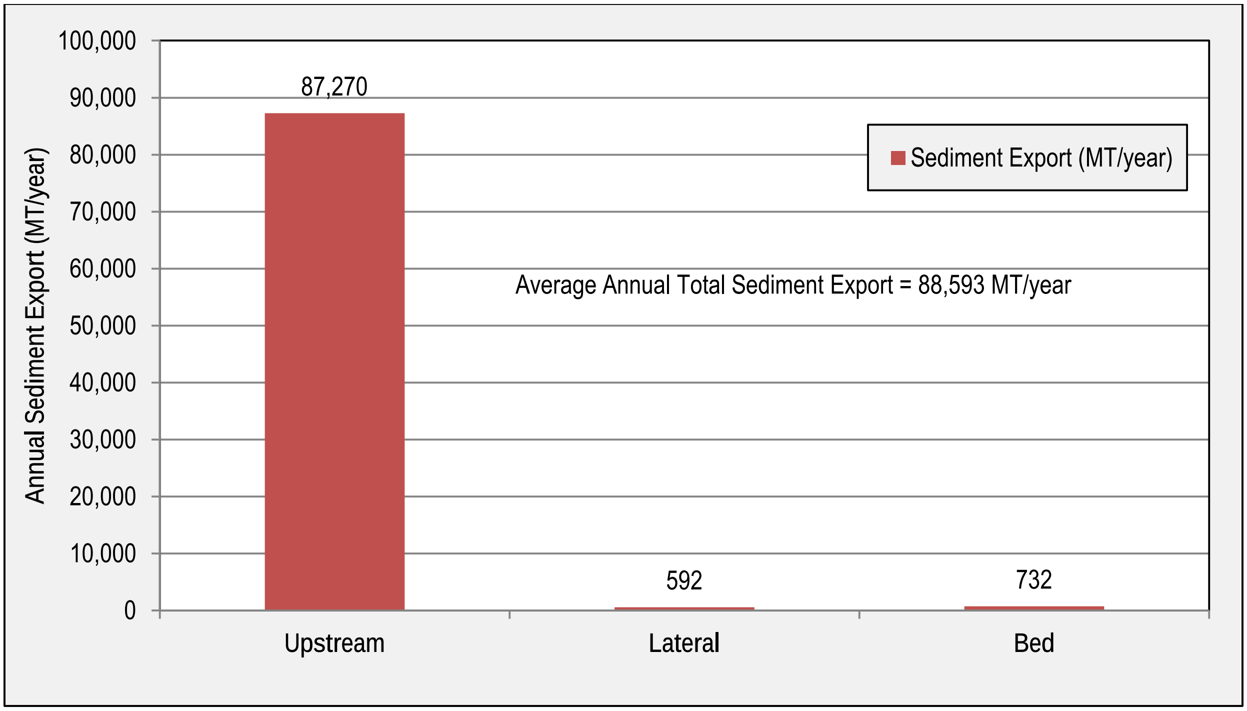


Figure 1b. Estimated Average Annual PCB Export at Baseline Conditions

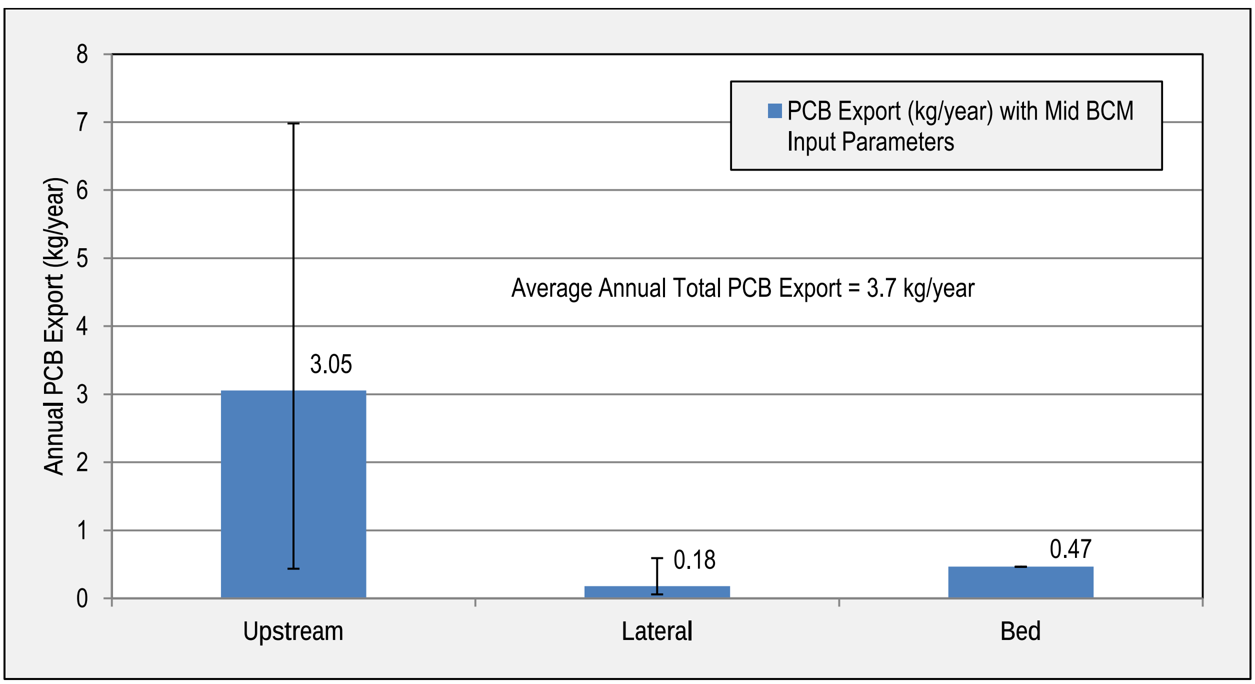


Figure 2a. Estimated Average Annual PCB Export From Year 0 to Year 10

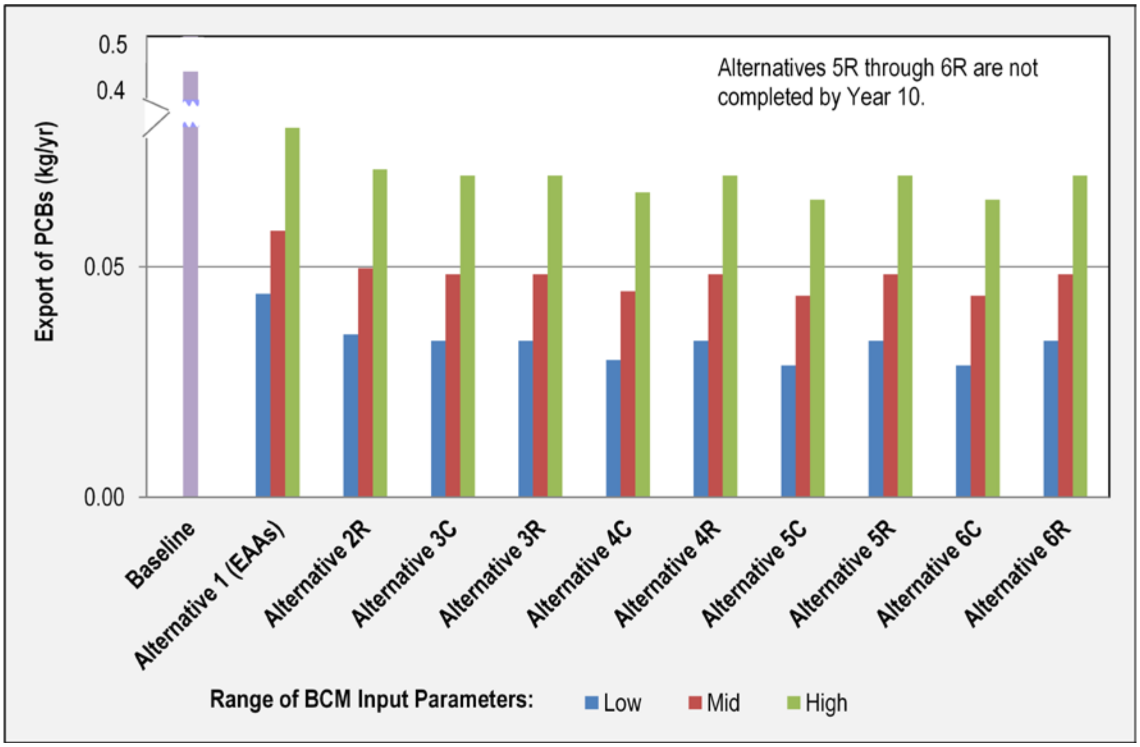
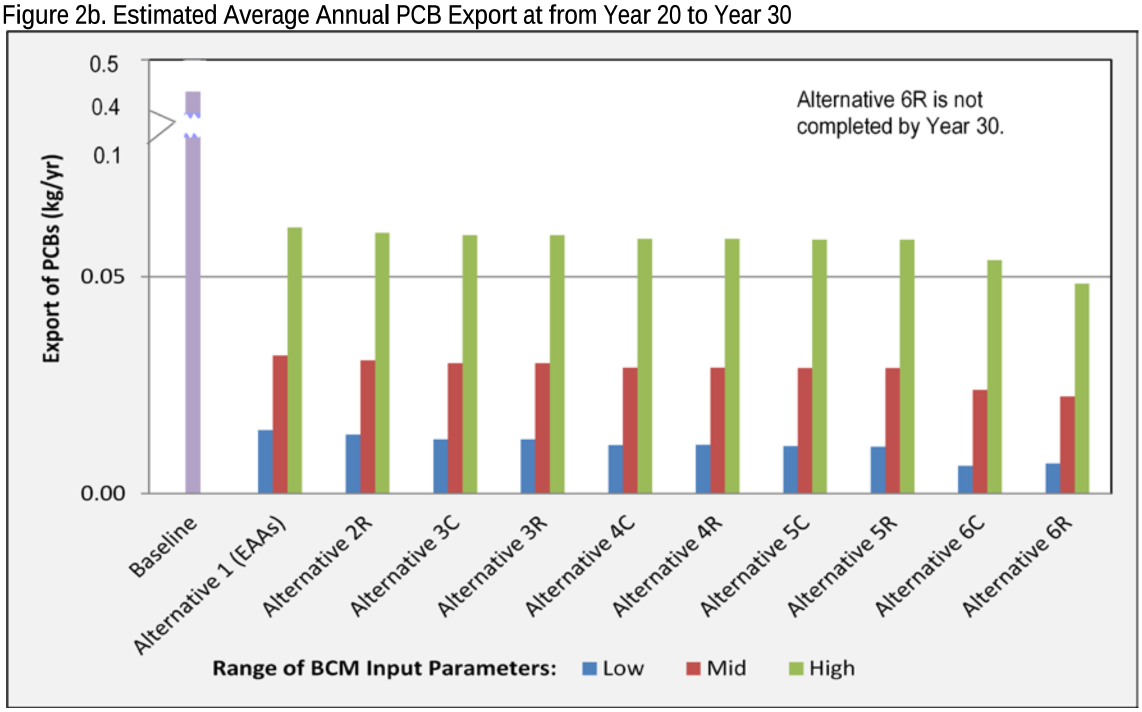


Figure 2b. Estimated Average Annual PCB Export at from Year 20 to Year 30



Notes:

1. Total PCB export is the sum of each reach-wide SWAC from the baseline dataset multiplied by each reach-specific annual average bed sediment export rate over the first 5 years of the STM hydrograph.
2 PCB exports presented in this figure are attributable only to natural erosion of the sediment bed. Additional losses will occur from dredging. Losses associated with dredging are presented in Figures 3 through 6.

Figure 3. Estimated Total Export of PCBs from Dredging Losses

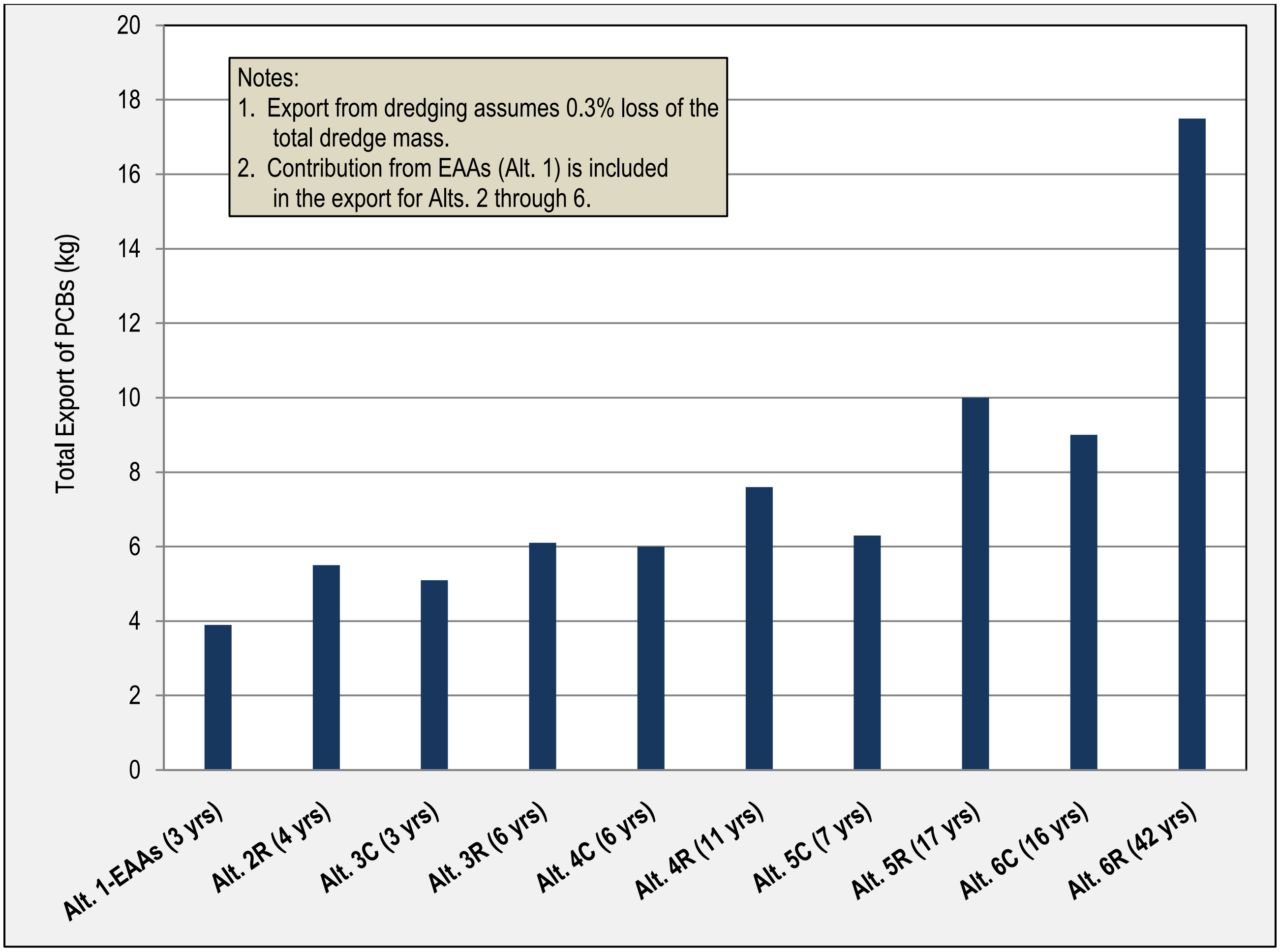
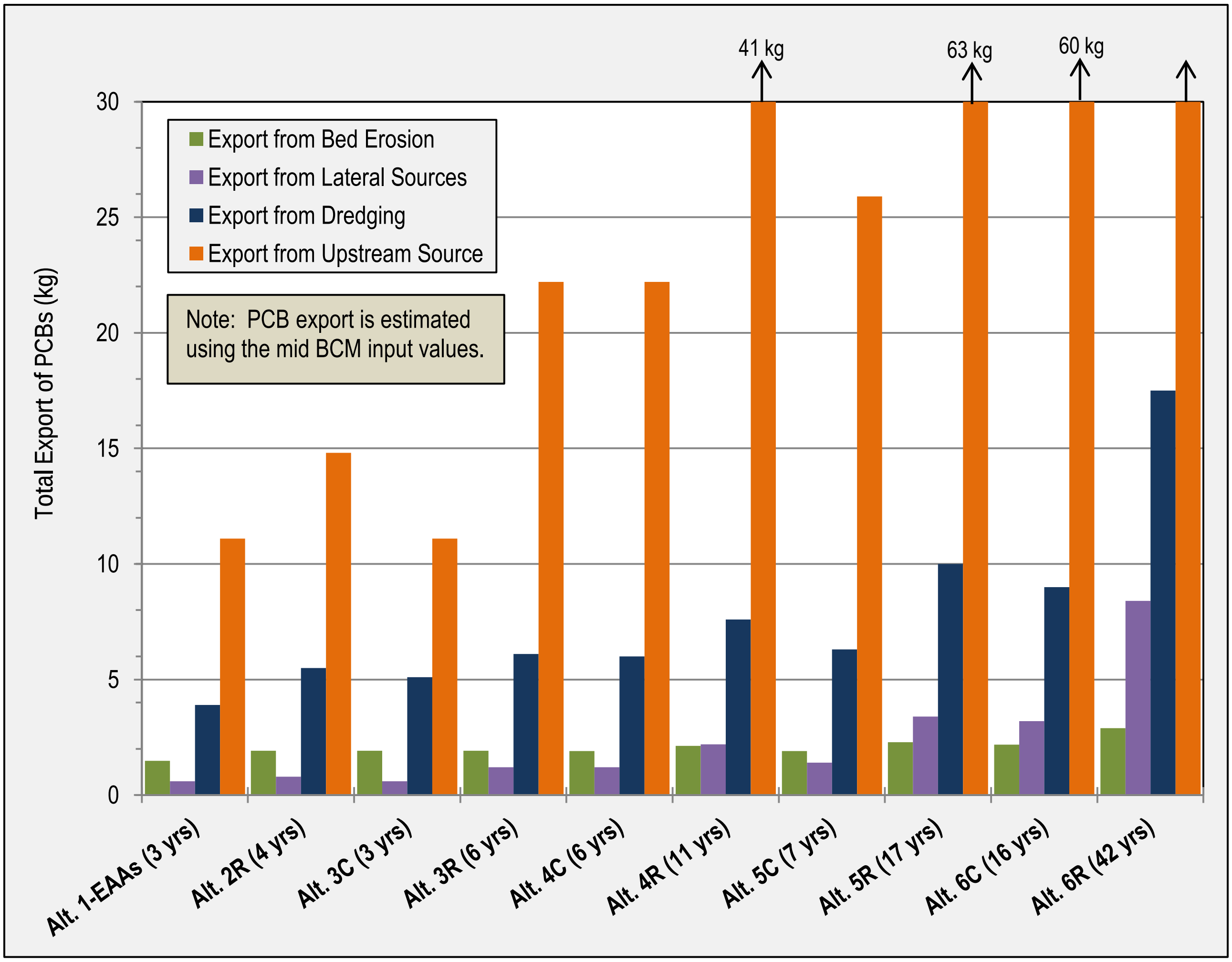


Figure 4. Estimated Total Exports of PCBs from Dredging Losses, Lateral Sources, Natural Bed Erosion, and Upstream Source over Construction Period



Notes:

1. Export from bed erosion was calculated as the sum of the BCM-predicted reach-wide SWACs in 5-year increments for each remedial alternative multiplied by an assumed constant annual bed sediment export rate from each reach.
2. The dredge export rate assumes a 0.3% export of material and an annual dredging production rate of 127,000 MT/year.
3. Contribution from EAAs (Alt. 1) is not included in the export from lateral sources and upstream sources for Alts. 2 through 6. Contribution from EAAs (Alt. 1) is included in the export from dredging and bed erosion for Alts. 2 through 6.
4. The range of PCB export from upstream using the low and high BCM input values ranges from about 2 to 25 kg (Alternative 1, 3 yrs) up to about 20 to 340 kg (Alternative 6R, 42 yrs).
5. The annual PCB export for upstream sources was calculated as a weighted average over a 30-year period from the STM, using 3.2 kg/yr from 0 to 10 years and 4.0 kg/yr from 10 to 30 years. There is year-to-year variability in the hydrograph, but the 10 to 30-year period includes a major storm event. The annual weighted average for the 30-yr period is 3.7 kg/yr for upstream, using the mid BCM input parameter. The same method was used for lateral and the annual PCB export is 0.2 kg/yr.
6. Upstream and lateral source exports for all alternatives were calculated using annual weighted average sediment exports for upstream (3.7 kg/year) and lateral (0.2 kg/year) multiplied by the construction period.

Figure 5a. Estimated Annual PCB Export from Natural Bed Erosion and Dredging Losses for the Removal Alternatives

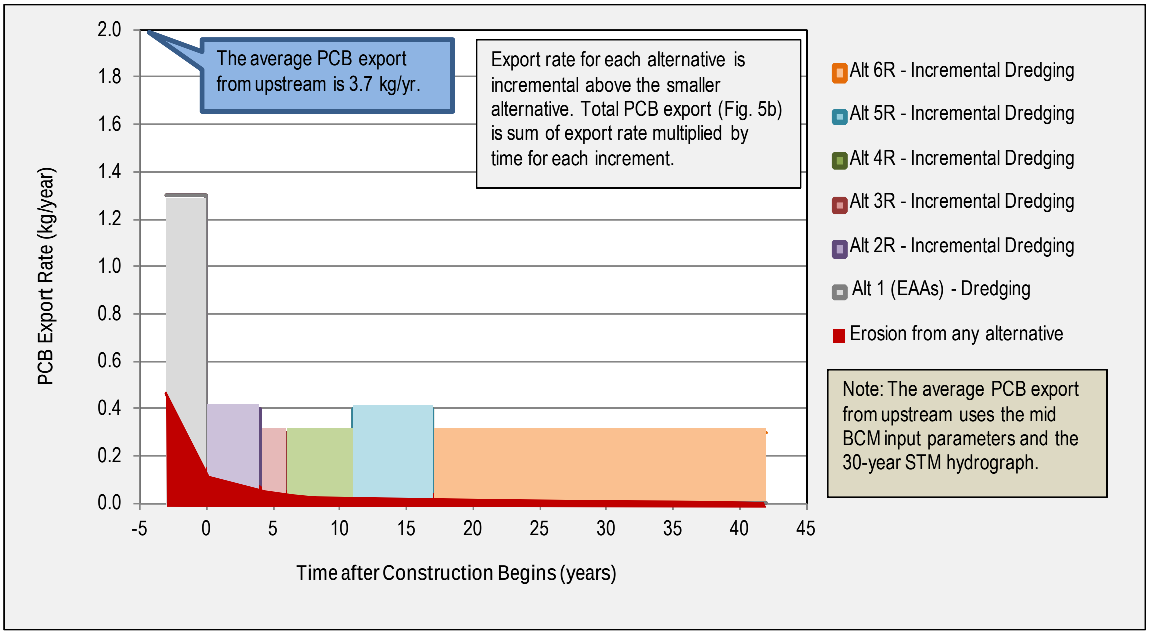
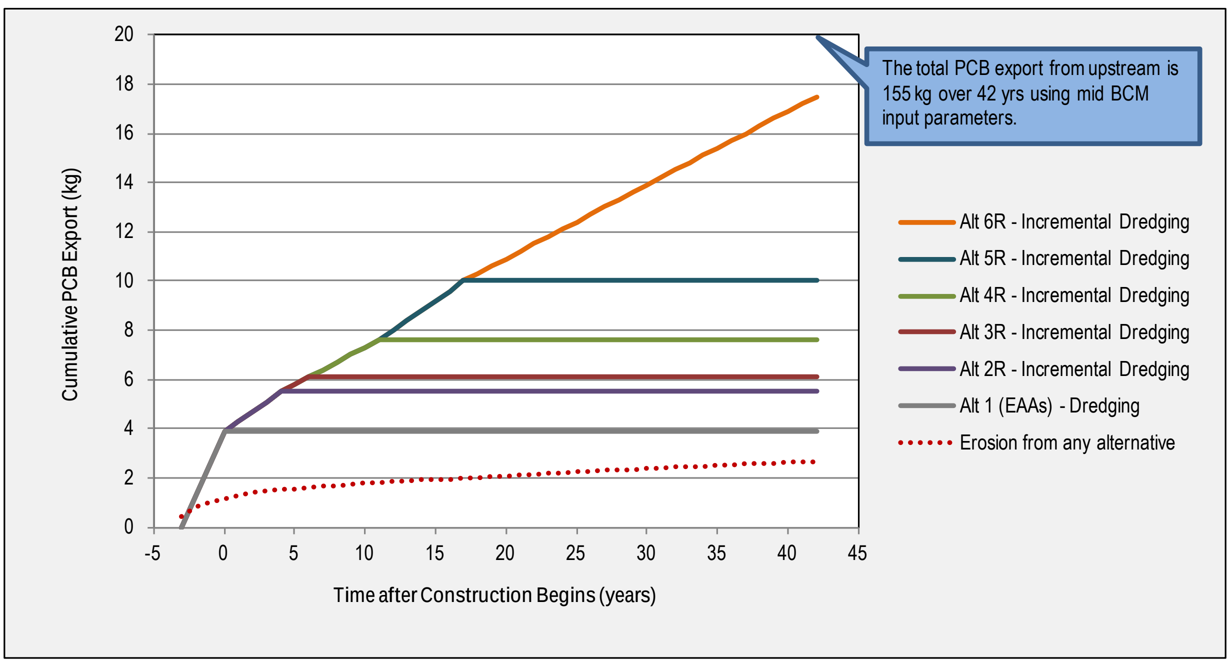


Figure 5b. Estimated Cumulative PCB Export from Natural Bed Erosion and Dredging Losses for the Removal Alternatives



Notes:
1. Dredging export rates were estimated from the average total PCB concentrations in cores (average of all core samples) in incremental dredged footprint beyond smaller alternative's dredged footprint, multiplied by an annual average dredging production rate of 127,000 MT/year, and assuming a 0.3% export of material.
2. Total dredging export is calculated incrementally. For example, total PCB export for Alternative 3R uses the Alternative 1 (EAAs) annual export rate for the first 3 years (years -3 to 0), the Alternative 2R annual export rate for years 0 through 4, and the Alternative 3R annual export rate for years 5 and 6. Construction year 0 is at the beginning of Remedial Alternative 2R.
3. On the scale of these charts, no difference in natural bed erosion is discernible among the alternatives. Therefore, only one line is displayed.
4. Dredging durations are equivalent to the construction periods in Table 5. Alternative 1 is assumed to occur between year -3 and year 0.
5. Average annual export from upstream (3.7 kg/yr shown in Figure 5a) was calculated using the 30-year STM hydrograph. This export does not match the export in Figure 1b (3.05 kg/yr), which was calculated using the first 5 years of the hydrograph.

Figure 6a. Estimated Annual PCB Export from Natural Bed Erosion and Dredging Losses for the Combined Alternatives

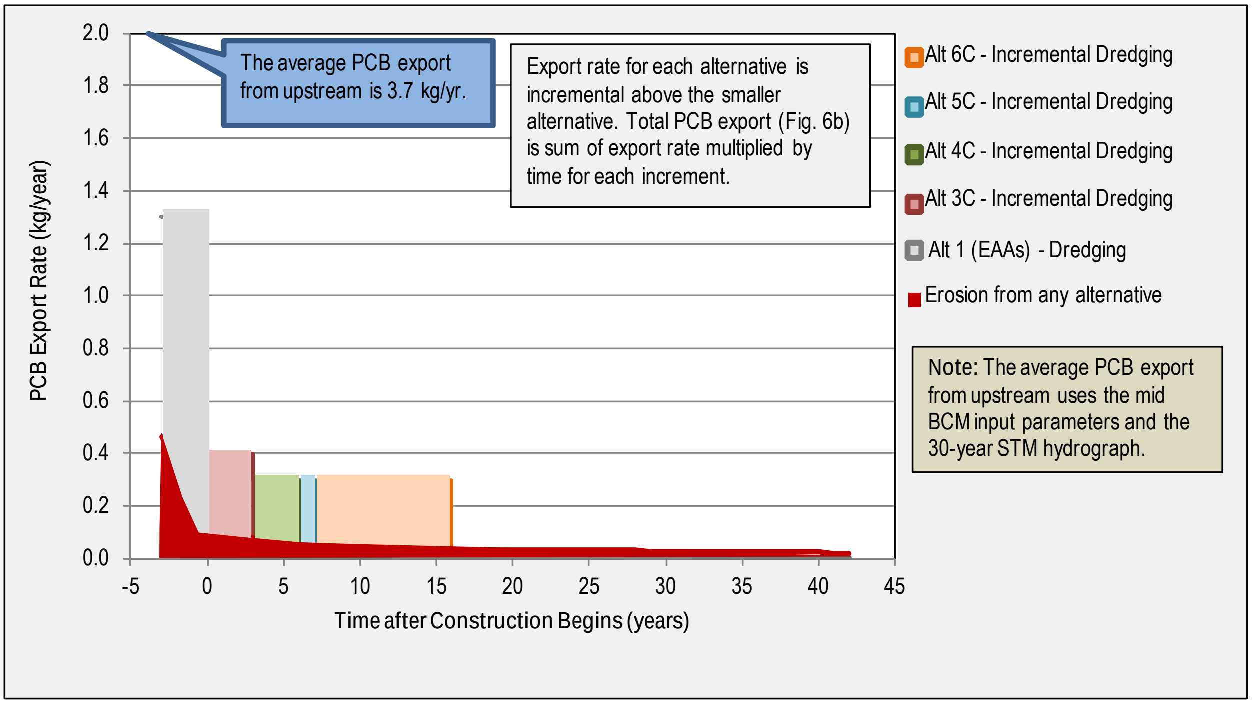
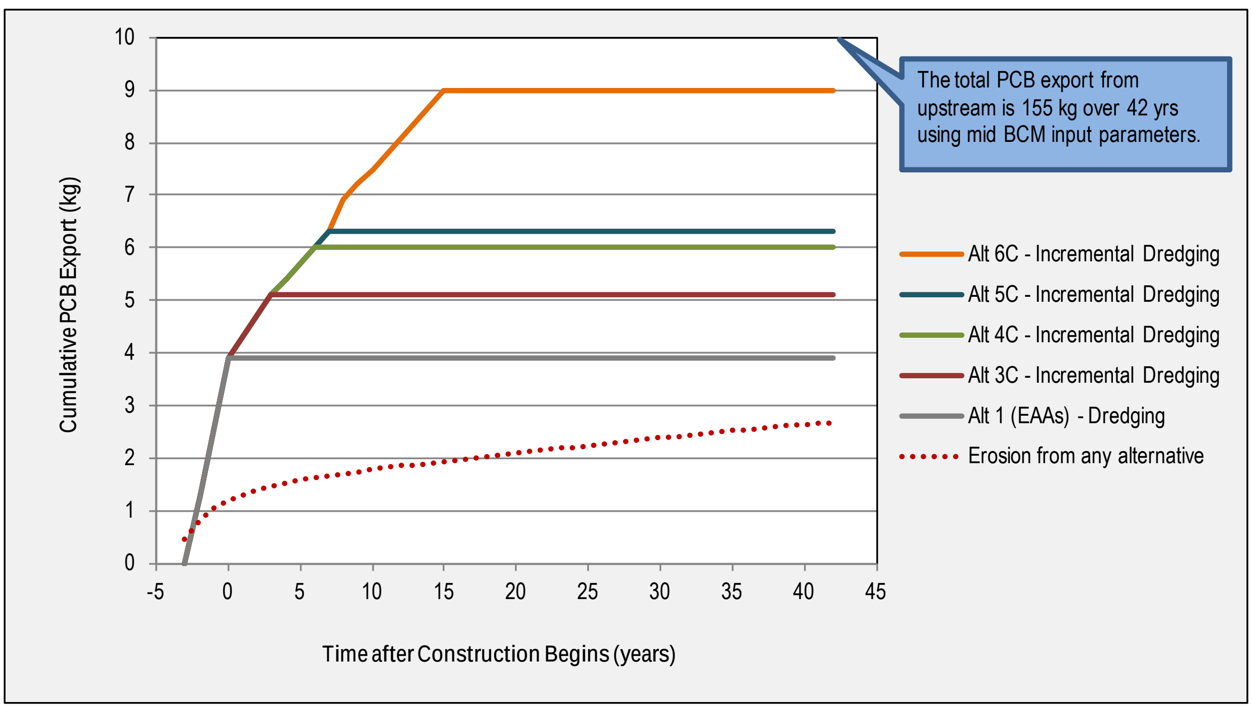


Figure 6b. Estimated Cumulative PCB Export from Natural Bed Erosion and Dredging Losses for the Combined Alternatives



Notes:

1. On the scale of these charts, no difference in natural bed erosion is discernible among the alternatives. Therefore, only one line is displayed.
2. Dredging durations are equivalent to the construction periods in Table 5. Alternative 1 is assumed to occur between year -3 and year 0.
3. Average annual export from upstream (3.7 kg/yr shown in Figure 6a) was calculated using the 30-year STM hydrograph. This export does not match the export in Figure 1b (3.05 kg/yr), which was calculated using the first 5 years of the hydrograph.

Part 3: Memorandum – Change in Total PCB Mass in Surface Sediment for Remedial Alternatives Calculated Using the Bed Composition Model

Table of Contents

List of Tables

Memorandum

To: EPA and Ecology

From: AECOM

Subject: Change in Total PCB Mass in Surface Sediment for Remedial Alternatives Calculated Using the Bed Composition Model

Date: October 15, 2012

On behalf of the Lower Duwamish Waterway Group (LDWG), this memorandum addresses U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) comments (General Comment 1 and Specific Comment 177)[1] on the Draft Final Feasibility Study (FS) and direction from the FS comment resolution meetings held on March 21, April 8, and April 26, 2011 among LDWG, EPA, and the U.S. Army Corps of Engineers (USACE). Calculations were performed in accordance with these discussions and are presented in this memorandum.

For each remedial alternative, this memorandum summarizes the changes in the mass of total polychlorinated biphenyls (PCBs) in surface sediments of the entire LDW both at the completion of construction and following the 45-year period over which natural recovery was modeled in the FS. Within the active footprint for each remedial alternative, the change in PCB mass occurs from dredging, as well as from non-removal actions (capping and enhanced natural recovery/*in situ treatment* [ENR/*in situ*]). The changes in PCB mass that occur as a result of natural recovery processes both within the active footprint after construction and outside of the active footprint are included in this memorandum.

The change in the mass of PCBs does not necessarily represent PCBs removed from the LDW. It represents the mass of PCBs that is predicted to no longer be present in the surface sediment (the primary exposure pathway) either through removal (dredging), burial (capping, ENR/*in situ*), or natural recovery via deposition of upstream-source sediments from the Green/Duwamish River. The change in PCB mass attributed to both the active remediation activities and natural recovery is calculated over the entire 441 acres of the LDW.

---

1 EPA/Ecology comments received February 25, 2011 on the Draft Final Feasibility Study submitted October 15, 2010.

Methods

The change in PCB mass was based on two processes accounted for by the bed composition model (BCM):

- When a remedial alternative footprint is actively remediated, the total PCB concentration in that footprint was changed to an assumed post-remedy bed sediment replacement value (60 or 20 micrograms per kilogram dry weight [µg/kg dw] for grid cells in Areas of Potential Concern 1 and 2, respectively).
- Natural recovery decreases the mass of PCBs in the surface sediment as contaminated sediment is buried (below the biologically active zone) by cleaner upstream-source sediment.

As discussed below, the change in PCB mass was evaluated at two time periods for each remedial alternative: immediately after construction and at the end of the 45-year BCM period.

Immediately After Construction

For each remedial alternative, the change in PCB mass was calculated immediately after construction for:

- **The active footprint:** This represents the change in mass due to active remediation alone. This area includes the EAAs.
- **The entire LDW (441 acres):** This represents the change in mass due to both natural recovery and active remediation. It is assumed that natural recovery processes reduce the surface sediment concentrations of total PCBs in areas beyond the active remedial footprint. In the case of remedial alternatives that take more than 5 years to complete, natural recovery also occurs in the smaller, incremental footprints that are remediated prior to the end of construction for the entire remedial alternative. For example, construction of Alternative 6C takes 15 years, while Alternative 5C is completed by year 5.[2] Therefore, the footprint of Alternative 5C is subject to 10 years of natural recovery while remediation of the incremental footprint of Alternative 6C (the footprint beyond 5C) is under construction. By the same token, the early action areas (EAAs) would be subject to 15 years of natural recovery by the completion of construction of Alternative 6C.

The dry weight mass of surface sediments across the entire LDW was first calculated by multiplying the volume of the surface sediment (441 acres multiplied by a 10-cm depth)

[2] Construction years are rounded to the nearest 5-year interval in the BCM for this analysis.

by a uniform dry bulk density for LDW surface sediments (60.4 pcf)[3], with unit conversions. The mass of total PCBs in surface sediments (at baseline and immediately after construction) was then calculated by multiplying the dry weight mass of surface sediments by the BCM-predicted site-wide SWACs from Table 9-2a.

The mass of total PCBs within each active footprint prior to construction (at baseline) was calculated by multiplying the dry weight mass of the sediments within each active footprint by the average baseline total PCB concentration within the active footprint (the SWAC of the active footprint). Following construction, the mass of total PCBs within each active footprint was calculated by multiplying the dry weight mass of the sediments within each active footprint by the applicable post-remedy bed sediment replacement value.

The equation used to calculate change in PCB mass is:

$$\Delta m_c = c_o m_s - c_f m_s \qquad \text{Equation 1}$$

Where:

- Δm_c is the reduction in mass of PCBs in the upper 10 cm for the given area
- c_o is the baseline PCB SWAC for the given area
- m_s is the dry weight mass of sediment in the upper 10 cm for the given area
- c_f is the final PCB SWAC for the given area (immediately after construction)

For the change in mass in the entire LDW, c_o is the site-wide baseline SWAC, and c_f is the site-wide SWAC at the end of construction (see Table 9-2a). For the change in mass attributable to active remediation, c_o is the baseline SWAC within the active footprint, and c_f is the post-remedy bed sediment replacement value. The reduction in the mass of PCBs attributable to natural recovery alone is the difference between the site-wide change in PCB mass and the change in PCB mass attributable to active remediation:

$$\Delta m_{c(NR)} = \Delta m_{c(site\text{-}wide)} - \Delta m_{c(active)} \qquad \text{Equation 2}$$

Where:

- $\Delta m_{c(NR)}$ is the change in site-wide mass of PCBs in the upper 10 cm attributable to natural recovery
- $\Delta m_{c(site\text{-}wide)}$ is the change in site-wide mass of PCBs (entire LDW) in the upper 10 cm, which is attributable to both active remediation and natural recovery
- $\Delta m_{c(active)}$ is the change in mass of PCBs in the upper 10 cm within the actively remediated footprint

[3] pcf = pounds per cubic foot. *Lower Duwamish Waterway Remedial Investigation, Remedial Investigation Report, Final*. Windward Environmental, LLC. July 9, 2010. p. 30.

Over 45-year Model Period

Additionally, the change in PCB mass for the entire LDW was calculated at the end of the 45-year BCM period by the same method as above, with the exception that c_f is the site-wide PCB SWAC at the end of the 45-year model period (see Table 9-2a). It is assumed that natural recovery processes continue to change the PCB mass in surface sediments from the completion of construction through the end of the 45-year period.

For the smaller remedial alternatives that take 5 or fewer years to complete, natural recovery processes occur over four decades following construction. For remedial alternatives that take more than 5 years to complete, natural recovery processes occur over varying lengths of time within the incremental active remediation footprints, depending on when each was completed.

Results

Table 1 presents the end-of-construction changes in the PCB mass in surface sediments for each remedial alternative. Changes in mass are presented within the active footprint of each remedial alternative (attributable only to active remediation), for the entire LDW (attributable to both construction and natural recovery), and attributable to natural recovery alone.

The "end of construction" varies widely among the remedial alternatives because of the range in construction years (3 to 42 years). Therefore, the predicted change in site-wide PCB mass was also calculated after the 45-year BCM period (Table 2). The change in PCB mass attributable to active remediation is also reported relative to the overall change in PCB mass at the end of the 45-year BCM period (which is due to both active remediation and natural recovery).

Active remediation of the EAAs, prior to the start of any remedial alternative, is estimated to result in the largest change in PCB mass. It accounts for approximately 50% of the overall change in PCB mass over the 45-year BCM period. The progressions from Alternatives 2R through 5R and from Alternatives 3C through 5C result in relatively small incremental reductions in the PCB mass attributable to active remediation (i.e., each step up through the progression removes only an additional 1 to 4 kg of PCBs). However, because Alternatives 6R and 6C actively remediate a fairly large surface area (145 acres beyond that actively remediated by Alternatives 5R and 5C), they achieve a larger incremental reduction in PCB mass (i.e., 12 kg), even though total PCB surface concentrations within the footprint of Alternative 6 are lower (< 240 µg/kg dw). After 45 years, all of the remedial alternatives achieve a nearly identical site-wide reduction in PCB mass (approximately 53 kg relative to a baseline PCB mass of 60 kg). As the remedial alternatives get larger, the PCB mass reduction attributable to active remediation increases while the mass reduction attributable to natural recovery decreases.

Table 3 presents the same summary information as Table 1, but illustrates the incremental contribution from sequential active remediation from Alternative 1 through Alternative 6. In addition, this table helps explain the change in PCB mass calculation attributable to natural recovery over time.

Table 1 Change in PCB Mass in the Top 10 cm of Sediment at the End of Construction

Remedial Alternative	Construction Completion (BCM years)[a]	Site-wide PCB Mass (kg)			Cumulative Area Actively Remediated (acres with EAAs)	Cumulative Change in PCB Mass (kg) at the End of Construction	
		Baseline[b]	At End of Construction[c]	Change		Attributable to Active Remediation[d]	Attributable to Natural Recovery[e]
Alternative 1 (EAAs)	Before year 0	60	35	25	29	25	0
Alternative 3C	5	60	18	42	87	33	9
Alternative 4C	5	60	14	46	136	36	10
Alternative 5C	5	60	12	48	186	39	9
Alternative 6C	15	60	10	50	331	48	2
Alternative 2R	5	60	19	41	61	31	10
Alternative 3R	5	60	18	42	87	33	9
Alternative 4R	10	60	14	46	136	36	10
Alternative 5R	15	60	12	48	186	39	9
Alternative 6R	40	60	10	50	331	48	2

Notes:
a. Construction periods rounded to the nearest 5 years, corresponding to output of the BCM.
b. PCB mass was calculated from the site-wide SWAC at baseline (Year 0).
c. PCB mass was calculated from the site-wide SWAC predicted at the completion of construction, using mid BCM input parameters; see Table 9-2a.
d. See text for explanation of the calculation of these values.
e. Change in PCB mass attributable to natural recovery was calculated for each remedial alternative as the site-wide (entire LDW) change in PCB mass at the end of construction minus the change in PCB mass attributable to active remediation.

BCM = bed composition model; EAAs = early action areas; C = combined technology emphasis; alternative; cm = centimeters; kg = kilogram; PCB = polychlorinated biphenyl; R = removal emphasis; SWAC = spatially weighted average concentration.

Table 2 Change in PCB Mass in the Top 10 cm of Sediment at the End of 45-Year BCM Period

Remedial Alternative	Site-wide PCB Mass (kg)			Cumulative Change in PCB Mass (kg) at the End of 45-Year BCM Period	
	Baseline[a]	At End of 45-Year BCM Period[b]	Change	Change in PCB Mass (kg) Attributable to Active Remediation[c] (Percent of Total Change)	Change in PCB Mass (kg) Attributable to Natural Recovery[d] (Percent of Total Change)
Alternative 1 (EAAs)	60	7.4	52.6	25 (48%)	27.6 (52%)
Alternative 3C	60	7.2	52.8	33 (63%)	19.8 (37%)
Alternative 4C	60	7.1	52.9	36 (68%)	16.9 (32%)
Alternative 5C	60	7.1	52.9	39 (74%)	13.9 (26%)
Alternative 6C	60	6.9	53.1	48 (90%)	5.1 (10%)
Alternative 2R	60	7.4	52.6	31 (59%)	21.6 (41%)
Alternative 3R	60	7.2	52.8	33 (63%)	19.8 (37%)
Alternative 4R	60	7.1	52.9	36 (68%)	16.9 (32%)
Alternative 5R	60	7.1	52.9	39 (74%)	13.9 (26%)
Alternative 6R	60	6.7	53.3	48 (90%)	5.3 (10%)

Notes:

a. PCB mass was calculated from the site-wide SWAC at baseline (Year 0).

b. PCB mass was calculated from the site-wide SWAC predicted at the end of the 45-year BCM period, using mid BCM input parameters; see Table 9-2a.

c. Values from Table 1.

d. Change in PCB mass attributable to natural recovery was calculated for each remedial alternative as the site-wide (entire LDW) change in PCB mass at the end of the 45-year BCM period minus the change in PCB mass attributable to active remediation.

BCM = bed composition model; EAAs = early action areas; C = combined-technology emphasis; cm = centimeters; kg = kilogram; LDW = Lower Duwamish Waterway; PCB = polychlorinated biphenyl; R = removal-emphasis; SWAC = spatially-weighted average concentration.

Table 3 Example Calculation of Incremental Change in Mass Attributable to Active Remediation and Natural Recovery – at End of Construction

Remedial Alternative Dredged	Change in PCB Mass Associated with Active Remediation of Each Incremental Footprint (kg)							Cumulative Change in PCB Mass Attributable to Active Remediation (kg)[a]	Cumulative Change in PCB Mass Attributable to Active Remediation and Natural Recovery (kg)[b]
	EAAs	2R	3R	4R	5R	6R	Rest of LDW		
Alternative 1 (EAAs)	25	*No NR*						25	25
Alternative 2R	25	6	*5 years of NR in EAAs and rest of LDW*					31	41
Alternative 3R	25	6	2	*5 years of NR in EAAs and rest of LDW*				33	42
Alternative 4R	25	6	2	3	*5 years of NR in Alts 2R and 3R; 10 years of NR in EAAs and rest of LDW*			36	46
Alternative 5R	25	6	2	3	3	*5 years of NR in Alt 4R; 10 years of NR in Alts 2R and 3R; 15 years of NR in EAAs and rest of LDW*		39	48
Alternative 6R	25	6	2	3	3	9	*25 years of NR in Alt 5R; 30 years of NR in Alt 4R; 35 years of NR in Alts 2R and 3R; 40 years of NR in EAAs and rest of LDW*	48	50

Notes:

a. Sum of unshaded cells in row and values from Table 1.

b. Values from Table 1.

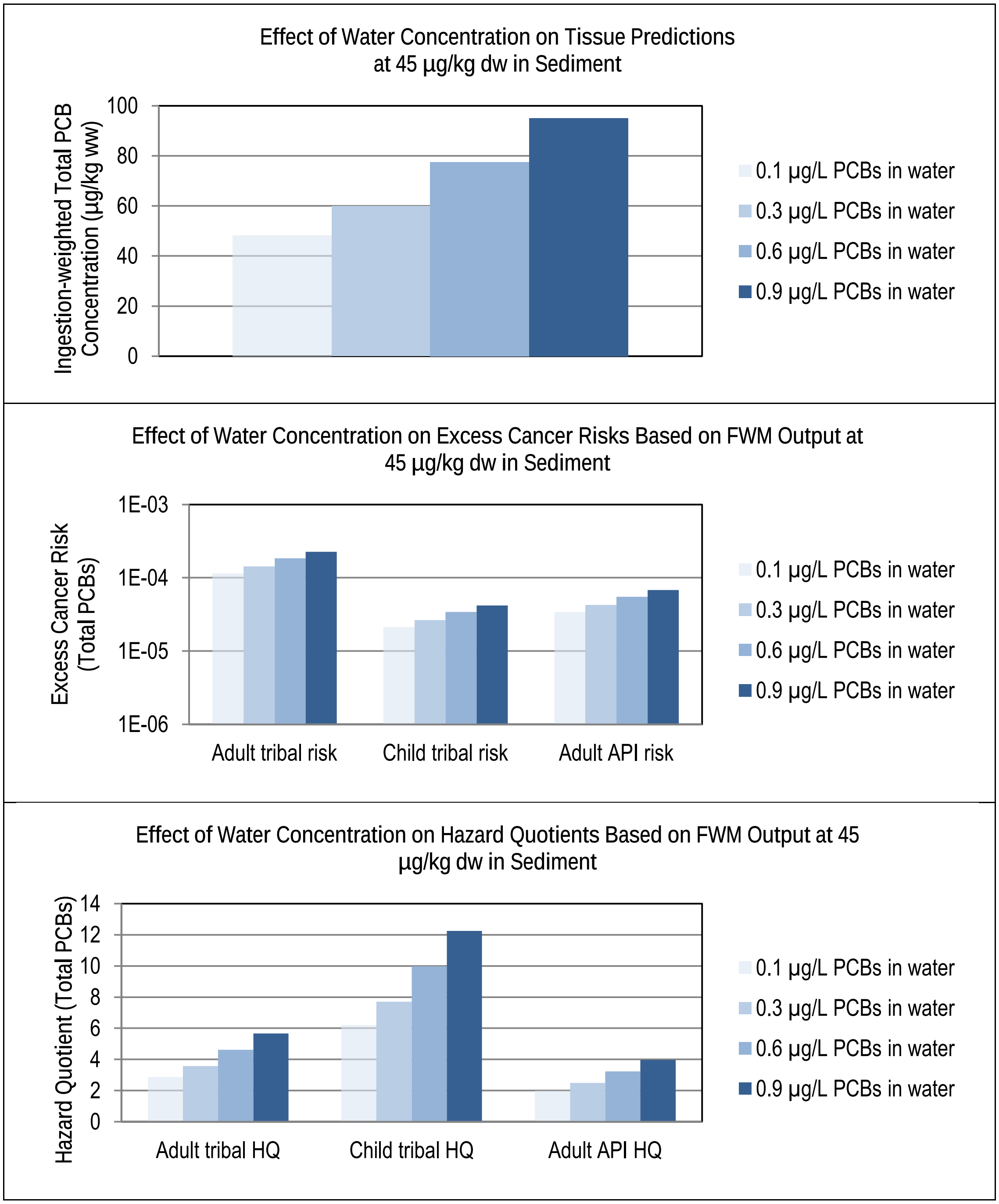
EAA = early action area; kg = kilogram; LDW = Lower Duwamish Waterway; NR = natural recovery; PCB = polychlorinated biphenyls; R = removal alternative

Part 4: Food Web Model Sensitivity

Prepared by Windward Environmental, LLC

List of Figures

Figure 1 PCB FWM Output and Related Human Health Risk Based on Different Assumptions of Total PCB Concentrations in Water



Notes:

1. A total PCB concentration in sediment of 45 µg/kg dw was selected for the sensitivity analysis because this is the approximate long-term average sediment concentration for the various alternatives.
2. Although a total PCB concentration of 0.1 µg/L was evaluated for the sensitivity analysis, the existing data for the Green River upstream of the LDW suggest this concentration was be unrealistically low for the LDW.

API = Asian Pacific Islander; dw = dry weight; FWM = food web model; HQ = hazard quotient; kg = kilograms; L = liters; µg = micrograms; PCB = polychlorinated biphenyl; ww = wet weight

Figure 2 PCB FWM Output and Related Human Health Risk Based on Alternate BCM Scenarios

Alternative	Ingestion-weighted Total PCB Tissue Concentration (µg/kg ww)	Excess Cancer Risk (Adult Tribal)	Hazard Quotient (Child Tribal)

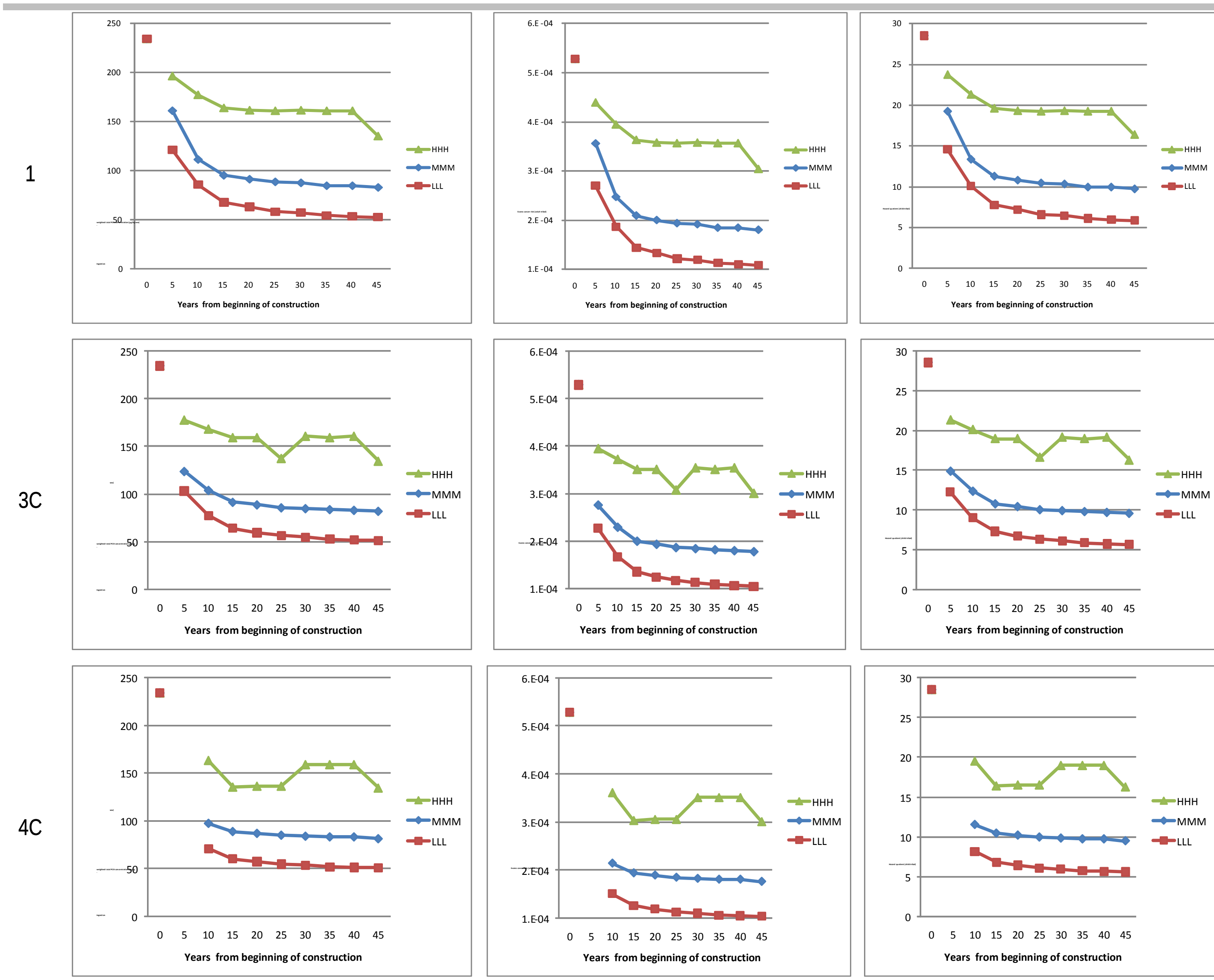


Figure 2 PCB FWM Output and Related Human Health Risk Based on Alternate BCM Scenarios (continued)

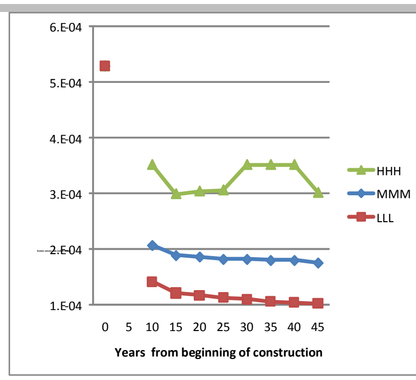
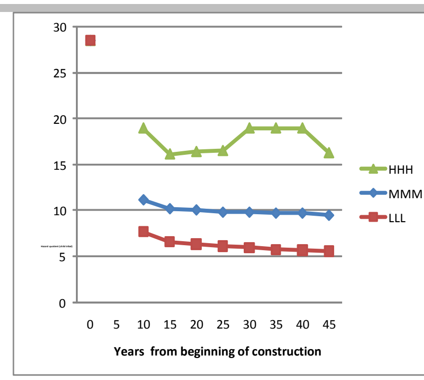
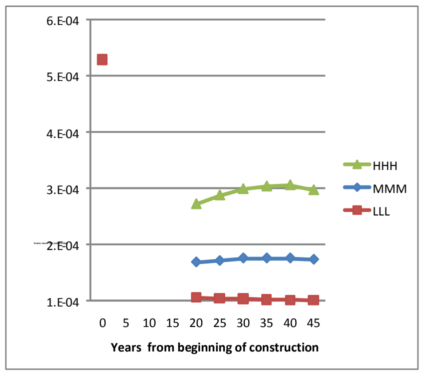
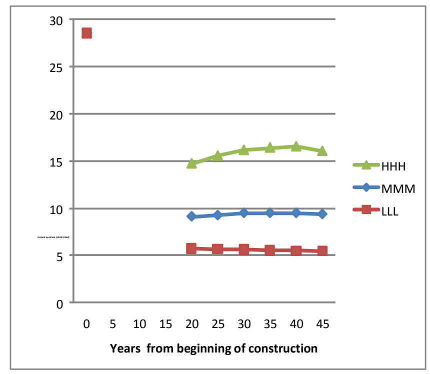
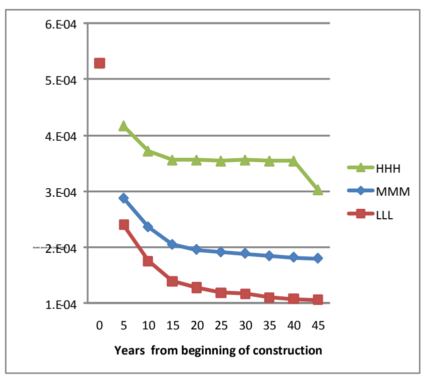
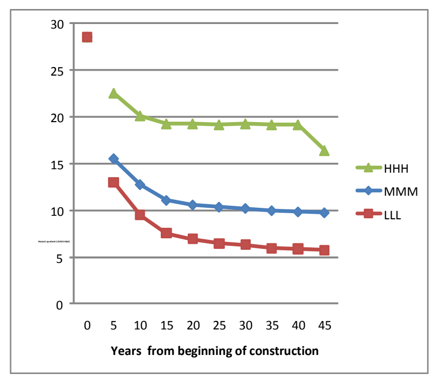
Alternative	Ingestion-weighted Total PCB Tissue Concentration (µg/kg ww)	Excess Cancer Risk (Adult Tribal)	Hazard Quotient (Child Tribal)
5C			
6C			
2R			

Figure 2 PCB FWM Output and Related Human Health Risk Based on Alternate BCM Scenarios (continued)

Alternative	Ingestion-weighted Total PCB Tissue Concentration (µg/kg ww)	Excess Cancer Risk (Adult Tribal)	Hazard Quotient (Child Tribal)

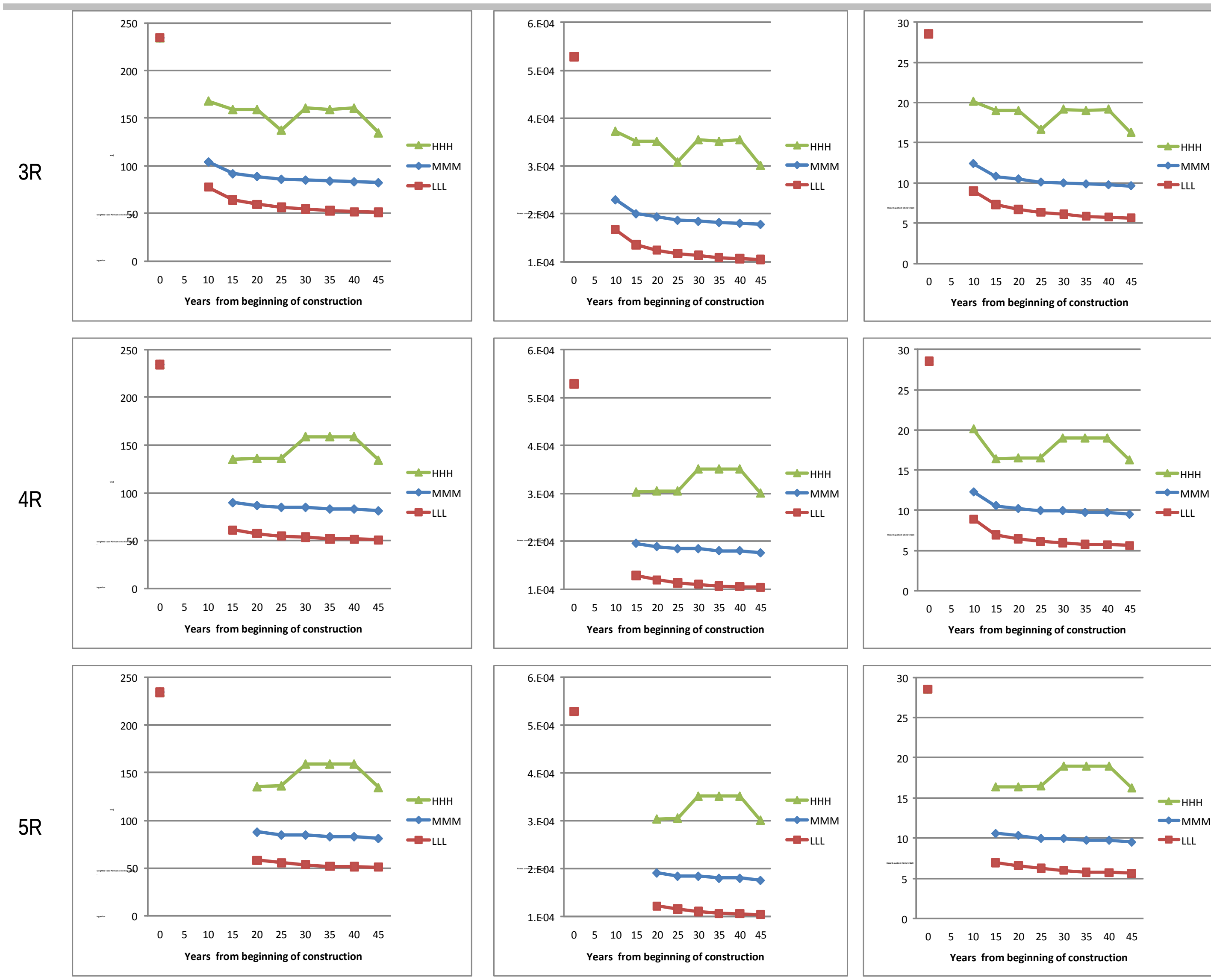
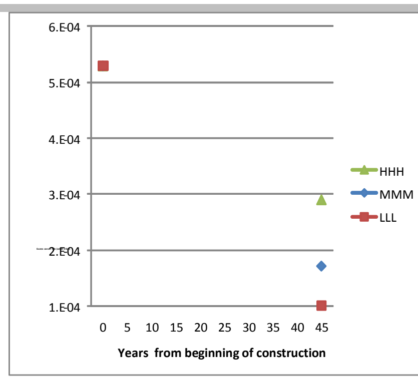
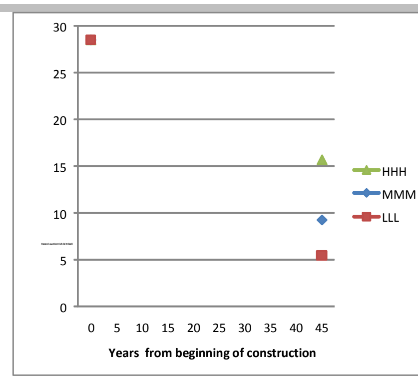


Figure 2 PCB FWM Output and Related Human Health Risk Based on Alternate BCM Scenarios (continued)

Alternative	Ingestion-weighted Total PCB Tissue Concentration (µg/kg ww)	Excess Cancer Risk (Adult Tribal)	Hazard Quotient (Child Tribal)
6R			

Notes:

1. Model output is not shown for construction years, given the high uncertainty of model predictions under those conditions.
2. The exposure scenarios shown for excess cancer risk and hazard quotient are the highest among the reasonable maximum exposure scenarios. The shape of the curves would be identical for the other exposure scenarios.
3. The BCM input parameters for total PCBs (in µg/kg dw) used in the three scenarios are: 1) Low-Low-Low (LLL): upstream = 5; lateral = 100; bed sediment replacement value = 30 (AOPC 1), 10 (AOPC 2); 2) Mid-Mid-Mid (MMM): upstream = 35; lateral = 300; bed sediment replacement value = 60 (AOPC 1), 20 (AOPC 2), and 3) High-High-High (HHH): upstream = 80; lateral = 1,000; bed sediment replacement value = 90 (AOPC 1), 40 (AOPC 2).
4. Excess cancer risks estimated using the FWM, alternative-specific total PCB SWACs in surface sediment (Section 9, Table 9-2a of the FS), and assumed surface water dissolved total PCB concentrations of 0.6 ng/L, except 0.9 ng/L for Year 0 for all alternatives and Year 5 for Alternative 1.

AOPC = area of potential concern; BCM = bed composition model; FWM = food web model; kg = kilograms; L = liters; µg = micrograms; ng = nanograms; PCB = polychlorinated biphenyl; ww = wet weight

Part 5: Potential Increase in Surface Sediment Concentrations Due to Disturbance of Subsurface Sediments

Table of Contents

List of Tables and Figures

Memorandum

To: EPA and Ecology

From: Lower Duwamish Waterway Group

Subject: **Potential Increase in Surface Sediment Concentrations Due to Disturbance of Subsurface Sediments**

Date: October 15, 2012

The potential for remaining subsurface sediment contamination to be exposed following active remediation of the Lower Duwamish Waterway (LDW) is evaluated as one component of long-term effectiveness of the remedial alternatives presented in this feasibility study (FS). This memorandum presents a method for estimating the potential effect of disturbance events on surface sediment concentrations along with results of the evaluation. The method was developed based on discussions among the Lower Duwamish Waterway Group (LDWG), the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and the U.S. Army Corps of Engineers (USACE) on October 25, 2011, March 6, 2012, and April 12, 2012 and comments received from EPA on April 23, 2012 and July 12, 2012. It provides a tool for evaluating the potential impact of these deep disturbance events, without attempting to determine the cause or estimate the spatial extent of these disturbances.

Introduction

The potential effects of vessel propeller wash from routine operations in the navigation channel and maneuvering in/out of berthing areas, and from high-flow scour on LDW sediment stability were identified in the FS by analyzing several lines of evidence, including bathymetric contours, vessel traffic patterns, and model predictions. Recently, concern has been raised by EPA and Ecology regarding the potential effect of other types of deep disturbance events, such as vessels traveling outside of frequent lanes of operation, vessels operating with excessive propeller power in berthing areas or elsewhere, barge groundings, emergency maneuverings, changes in the patterns of site use, maintenance of overwater structures, and earthquakes on predicted future surface sediment contaminant concentrations. There is some indication, based on contaminant profiles in some cores and geochronological data, that deep disturbance events may hinder recovery at localized areas. However, the frequency and magnitude of these events is unknown.

The STM and bed composition model (BCM), which were used to predict future surface sediment contaminant concentrations for the remedial alternatives (e.g., see FS Sections 5 and 9), did not incorporate these disturbance events into the long-term model-predicted surface sediment contaminant concentrations in the LDW. Although the frequency, magnitude, and impact of individual disturbance events is not known, methods were sought to estimate bounds on their cumulative impacts.

This memorandum presents a method for estimating the potential effect of the disturbance events mentioned above. Such events could cause erosion or scour that would expose humans or organisms to contaminated subsurface sediments. The potential magnitude of these effects was estimated using the site-wide spatially-weighted average concentration (SWAC) for total polychlorinated biphenyls (PCBs). This method takes into account: 1) potential sediment disturbance in any area of the waterway, and 2) subsurface sediment contaminant concentrations. Results are presented for all remedial alternatives. [1]

Methods and Assumptions

An equation was developed to estimate the long-term site-wide SWAC based on a hypothetical area of disturbance, a fraction of the disturbance area that results in exposure, and a concentration in the exposure area:

$$C' = C_{lt} + \frac{A_d F_e (C_e - C_{lt})}{A_t}$$

Where:

C′ = site-wide total PCB SWAC

C_{lt} = long-term BCM-predicted total PCB SWAC (assumed to be 40 micrograms per kilogram dry weight [µg/kg dw] for all remedial alternatives)

A_d = total area (acres) disturbed in areas of potential concern (AOPCs) 1+2

F_e = fraction of the total disturbance area that has the potential to expose subsurface contaminants (assumed to equal the area of ENR+MNR+VM+AOPC 2[2] for each alternative divided by the total area of AOPCs 1+2; this is equivalent to the total area within AOPCs 1+2 that is outside the EAAs and capped or dredged areas)

---

1 In addition, in FS Section 5.3.2.7, a first-order sensitivity evaluation was developed to estimate the potential impact of vessels operating under normal operations to create potential scour and alter the STM/BCM predictions. That evaluation assumed that areas of the LDW with evidence of vessel scour (i.e., Recovery Category 1 areas) do not undergo natural recovery because continual disturbance from normal vessel operations could reduce accumulation of layers of cleaner upstream sediments, thereby hindering recovery. Results were presented for Alternatives 3C and 3R.

2 ENR = enhanced natural recovery, MNR = monitored natural recovery, VM = verification monitoring.

C_e = total PCB SWAC in the exposure area, assumed to be equal to the average sediment concentration in the 0- to 2-ft interval of cores outside of the EAAs and dredged and capped areas (i.e., cores inside of ENR+MNR+VM+AOPC 2 areas for each alternative)

A_t = total area of the site (441 acres)

Figure 1 presents a schematic of the variables, and Table 1 presents the input values. The equation shown above calculates a site-wide SWAC (C′) for each alternative, assuming a sediment concentration (C_e) in exposure areas (A_dF_e) and the long-term BCM-predicted concentration of 40 µg/kg dw (C_{lt}) in non-exposure areas. The area calculated to have subsurface exposure (A_dF_e) is assumed to have a total PCB concentration equal to the average total PCB concentration (C_e) in the upper 2 ft of sediment cores. The disturbance is assumed to be limited to the upper 2 ft of the sediment core. The average total PCB concentration was determined for sediment cores located in ENR, MNR, VM, and AOPC 2 footprints after active remediation. The area that does not result in exposure includes all areas outside of the disturbance area, and areas within that disturbance area that would not result in exposure (i.e., areas that have been dredged or capped). In those areas, the surface sediment concentration is assumed to equal the long-term BCM-predicted concentration (C_{lt}).

This simplified model of disturbance effects on the SWAC is sufficient for the purpose of this analysis, but contains some simplifying assumptions:

- The long-term total PCB SWAC without disturbance effects (C_{lt}) is assumed to be 40 µg/kg dw for all remedial alternatives. BCM sensitivity runs indicate that the long-term SWAC is likely to fall within the range of 5 µg/kg dw to 80 µg/kg dw.
- The area of disturbance within AOPCs 1+2 (A_d) is expressed as a range from 0 to 45 acres, with 45 acres representing 10% of the total waterway. The most likely area that may be disturbed is not defined for this analysis, nor is the location-specific disturbance mechanism. Disturbance is assumed to have an equal chance of occurring anywhere in AOPCs 1+2 without accounting for factors such as proximity to berthing areas, bathymetric evidence of scour, water depth, or contaminant evidence of vessel scour.
- Areas with empirical evidence of disturbance were classified as Recovery Category 1 areas (not likely to recover) and were assigned technologies such as dredging or armored capping when concentrations of contaminants of concern (COC) in the top 2 ft of sediments exceeded the RALs. This mitigates the impacts of disturbance in all remedial alternatives to varying degrees, with more of the Category 1 areas addressed through dredging or capping in higher-numbered alternatives (see FS Section 8). However, the empirical evidence used to delineate Recovery Category 1 such as the sun-illuminated

interpretations of sediment elevation are unlikely to detect disturbed areas that have filled in. This memorandum addresses disturbances that could occur anywhere in the waterway.

- The recurring fraction of the area disturbed (i.e., that would be continuously exposed over time) that could result in exposure (F_e) is assumed to be equal to the total area remediated by ENR or passively remediated (MNR+VM+AOPC 2) divided by the total area of AOPCs 1+2. As discussed above, this calculation assumes that exposure of subsurface contamination has an equal chance of occurring anywhere in AOPCs 1+2, without considering location-specific conditions.
- The total PCB SWAC in the exposure area is assumed to be equal to the average subsurface total PCB concentration (C_e) in the upper 2 ft of cores in that area (ENR+MNR+VM+AOPC 2).[3,4] The estimation of C_e does not factor in: 1) new sedimentation over the long term, 2) the addition of sand material in ENR/*in situ* areas, 3) repeated disturbance events in localized areas, 4) adaptive management measures to mitigate these disturbances, and 5) that actual subsurface concentrations may differ from those used in this analysis because of the potentially unrepresentative distribution of cores. These conditions, which would effectively lower the average concentration in the 0- to 2-ft depth range, were not factored into the analysis. Factoring these conditions in might mitigate some of the increases in predicted SWACs in this analysis. In addition to change in the SWAC, time is also a factor because ongoing deep disturbances could result in longer recovery times needed to achieve the cleanup objectives.

---

[3] The average concentration of core data in the upper 2 ft is considered reasonable for this analysis because sediment is resuspended/mixed after disturbance then homogenized into average concentrations from the disturbed interval. It represents the net effect of disturbance events. It also represents the average concentration exposed from a range of scour events between 0 and 2 feet deep. Upper bound values, such as the 95% upper confidence limit on the mean or maximum concentrations were not used because of the skewed distribution of core sampling locations and the preponderance of cores collected in hotspot areas.

[4] The vertically-weighted average total PCB concentration for each core was calculated following these steps: 1) identify all samples in a core overlapping the 0- to 2-ft depth interval; 2) calculate the thickness of overlap between the samples and the 0- to 2-ft interval (e.g., a sample collected from the 1- to 3-ft depth interval has a 1-ft thick overlap with the desired 0- to 2-ft interval); 3) multiply the sample concentration by the thickness of overlap for each sample (concentration*thickness); 4) sum all the concentration*thicknesses for samples that overlap the 0- to 2-ft interval; and 5) divide the result of step #4 by the sum of all the thicknesses for samples that overlap the 0- to 2-ft interval. This calculation effectively weights thicker intervals more than thinner intervals (within the 0- to 2-ft interval) and ignores intervals that do not have data (intervals that were not analyzed). After a vertically-weighted average concentration was calculated for each core, the average concentration of all cores of interest was calculated without weighting (i.e., each core in an area of interest was weighted equivalently).

- One factor that can influence the extent of scour effects from maneuvering vessels is water depth. The energy generated by a propeller decreases exponentially away from the source with water depth. Deeper water depths could limit the areas available for potential deep disturbance but were not factored into this analysis.

Results

The results are presented in Figure 2 for disturbance areas ranging from 0 acres to 45 acres, representing up to 10% of the total waterway, or 15% of AOPCs 1+2. This data range provides a first-order estimate on the bounds of reasonable minimum acreage (0 acres) to maximum acreage (45 acres) of continuously exposed subsurface contamination from repetitive disturbance events. These acreages are used to bound the possible effects on the predicted total PCB SWAC since the frequency and magnitude of these events is unknown. At 45 acres, the site-wide SWACs range from 40 µg/kg dw (Alternative 6R) (i.e., no change from the long-term model-predicted SWAC) to 80 µg/kg dw (Alternative 1), with the other alternatives in between, generally proportional to the acres of dredging and capping for each.

References

U.S. Environmental Protection Agency (EPA) 2012. *Memorandum: Agency Review of Evaluation of Disturbance Events* Provided on April 12, 2012. April 23, 2012.

Table 1 Input Parameters for Estimating Potential Change in the Site-wide SWAC Resulting from Disturbance of Subsurface Sediments

Parameter			Remedial Alternative									
Row #	Variable	Description	1	2R	3R	4R	5R	6R	3C	4C	5C	6C
Input - Areas of Interest (acres)												
1		Area that could have a disturbance (AOPCs 1+2)	302	302	302	302	302	302	302	302	302	302
2		Area that could result in an exposure due to disturbance (AOPC 1+2 excluding EAAs, dredged and capped areas; equivalent to the total ENR+MNR+VM+AOPC 2 area)	302	270	245	195	146	0	254	212	199	101
3	F_e	Fraction of potential disturbance area that could result in exposure of subsurface contamination (Row 2 divided by Row 1)	1.00	0.89	0.81	0.65	0.48	0.00	0.84	0.70	0.66	0.33
4	A_t	Total FS study area	441	441	441	441	441	441	441	441	441	441
Input - Total PCBs Concentrations of Interest (µg /kg dw)												
5	C_{lt}	Long-term SWAC in non-exposure areas	40	40	40	40	40	40	40	40	40	40
6	C_e	Long-term SWAC in exposure areas (assumed to equal the mean concentration in the upper 2 ft of cores in FS baseline dataset in areas that could result in exposure, i.e., areas in Row 2)[a]	431	394	300	332	253	n/a	356	409	343	352

Notes:

a. The long-term SWAC in exposure areas (C_e) is assumed to equal the mean concentration in the upper 2 ft of cores in the baseline dataset in potential exposure areas (i.e., the areas in Row 2). Therefore, the calculation does not account for natural recovery in shallow subsurface sediment, mixing with surface sediment, or mixing with ENR/*in situ* material. Note that some counter-intuitive trends occur in subsurface concentrations between alternatives (e.g., Alternatives 3C and Alternative 4C). These are not considered to be significant and are attributable to the small numbers of cores used to calculate averages for the larger alternatives.

AOPC = area of potential concern; C = combined; EAA = early action area; ENR = enhanced natural recovery; FS = feasibility study; MNR = monitored natural recovery; R = removal; SWAC = spatially-weighted average concentration; VM = verification monitoring

Figure 1 Representation of Site, Disturbance Area, and Exposure Area

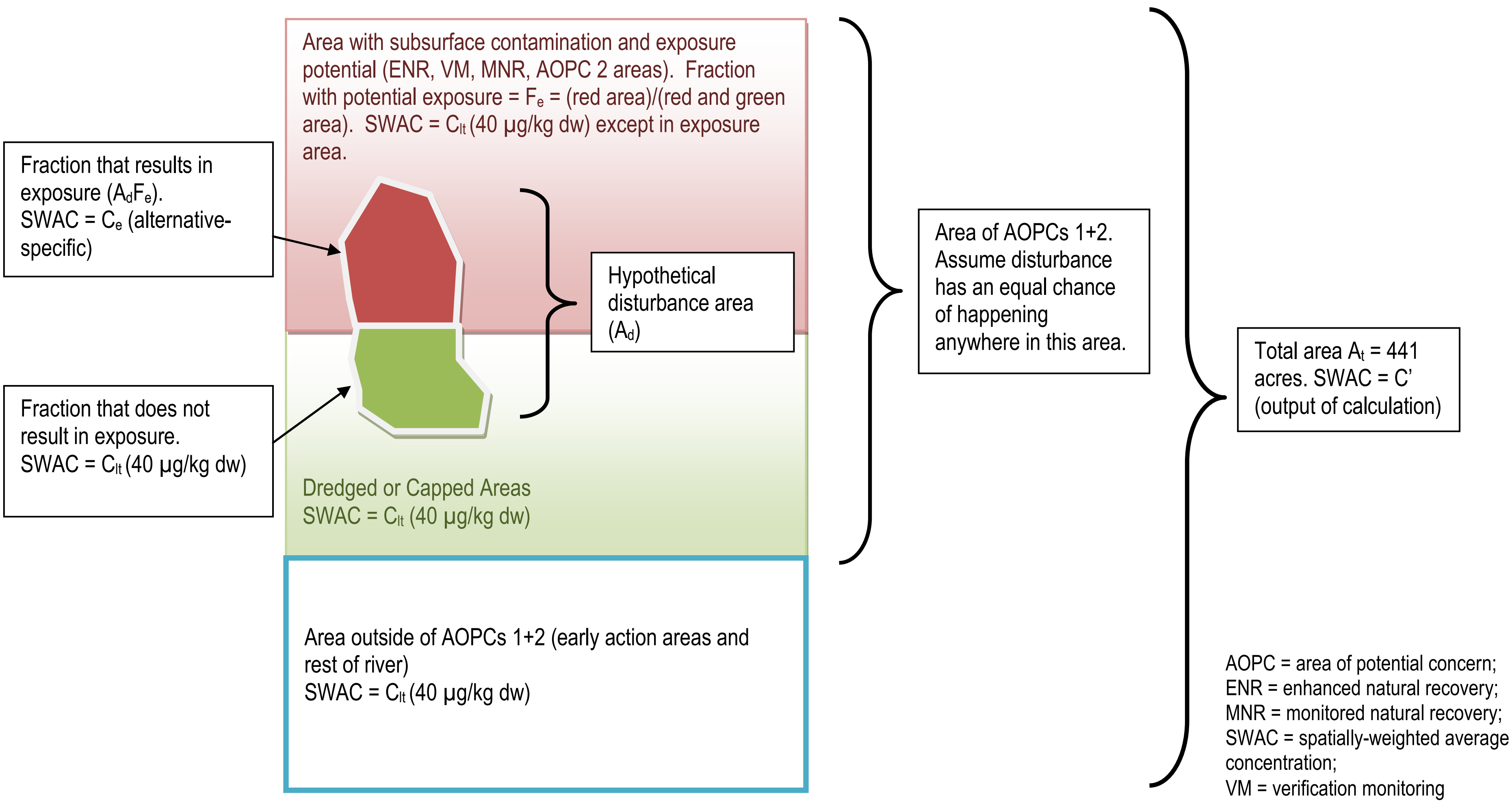
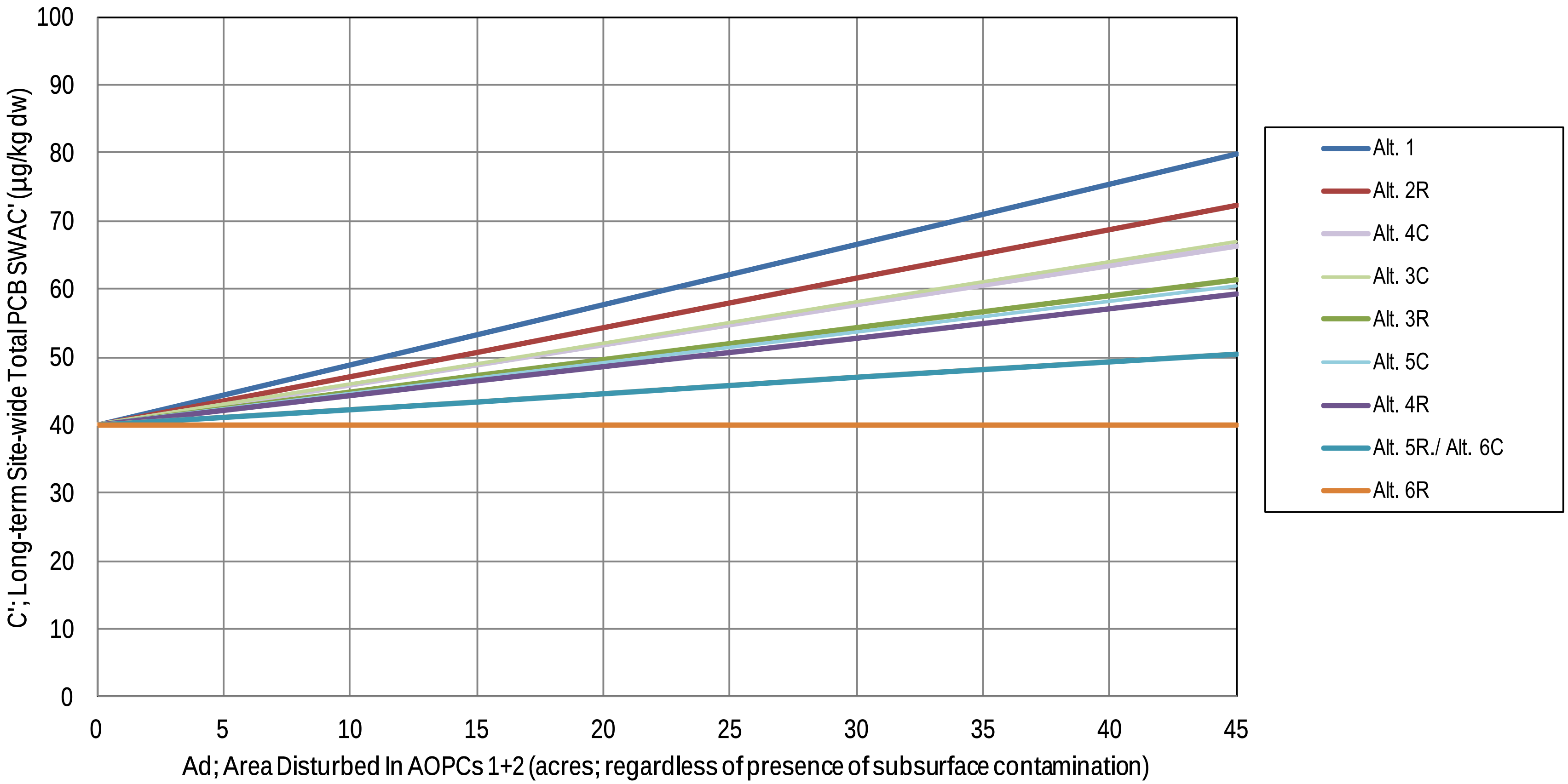


Figure 2 Estimates of Potential Change in the Site-wide SWAC Resulting from Disturbance of Subsurface Sediments



Notes:
1) For comparison, all alternatives are assumed to have the same long-term SWAC without any disturbance (40 µg/kg dw).

AOPC = area of potential concern; C = combined; PCB = polychlorinated biphenyl; R = removal; SWAC = spatially-weighted average concentration

Lower Duwamish Waterway Group

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

Appendix N
Description of FS Baseline Dataset

Final Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

FOR SUBMITTAL TO:

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

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

October 31, 2012

Prepared by: AECOM

710 Second Avenue, Suite 1000 ♦ Seattle, Washington ♦ 98104

Windward environmental LLC

200 W Mercer St # 401 ♦ Seattle, Washington ♦ 98119

Table of Contents

Part 1: FS Baseline Dataset Tables – Revised from RI Appendix E (Data Selection for the Baseline Surface Sediment Dataset and Data Quality Review Summaries)

Introduction

The baseline surface sediment data used in the feasibility study (FS) was based on a similar dataset used in the Lower Duwamish Waterway Remedial Investigation (LDW RI; Windward 2007), which is documented in Appendix E of the RI. The baseline dataset used in the FS was updated with data collected after the RI baseline dataset was finalized in 2006. This appendix contains tables that provide supplemental information about the baseline surface sediment dataset.

Surface sediment data that were collected within dredged area boundaries prior to dredging were excluded from the FS baseline surface sediment dataset because they are not representative of present conditions (Tables N-1 and N-2).

Dredging and capping occurred at the Duwamish/Diagonal early action area during the 2003/2004 dredging season. The predredging data within the removal area and the enhanced natural recovery area were used to characterize baseline conditions. Additional details on the inclusion or exclusion of surface sediment data from this area in the FS baseline dataset are provided in Table N-3 and Part 2 of this appendix.

The FS baseline dataset also includes data from resampled surface sediment locations. Newer data from resampled locations (Table N-4) replaced the older data from those locations (Table N-5).

The quality of the data in the sampling events included in the FS baseline dataset (and those that were excluded) was extensively reviewed, as summarized in Tables N-6 and N-7 and a series of data quality memoranda prepared by Windward Environmental (*Technical Memorandum: Summary of Chemistry Datasets to be used in the Phase 2 RI/FS – Addendum 3*, 2012; the other memoranda are cited in the sources for Table N-5).

List of Tables

Table N-1 Dredging Events Outside of Navigation Channel (1990 to 2009)

Project/Site Name	Dredging Year	River Mile	Volume Dredged (cy)
Lone Star Northwest – Slip 2	1990	RM 1.70 – RM 1.76 east	1,600
Lone Star Northwest – Slip 2	1991	RM 1.70 – RM 1.76 east	1,100
Morton	1992	RM 2.86 – RM 2.97 west	7,980
South Park Marina	1993	RM 3.36 – RM 3.44 west	15,500
Lone Star Northwest – West Terminal	1993	RM 1.43 – RM 1.52 west	3,900
Terminal 115	1993	RM 1.78 – RM 1.95 west	3,000
Lone Star Northwest – Slip 2	1994	RM 1.70 – RM 1.76 east	3,000
Lone Star Northwest – Slip 2	1994	RM 1.70 – RM 1.76 east	2,000
Lone Star – Hardie/Kaiser	1996	RM 1.55 – RM 1.75 east	18,000
Crowley	1996	RM 2.8 – RM 2.85 east	13,000
Boyer	1998	RM 2.39 – RM 2.49 west	8,000
Hurlen	1998	RM 2.64 – RM 2.77 west	15,000
James Hardie Gypsum	1999	RM 1.56 – RM 1.75 east	10,000
Duwamish Yacht Club	1999	RM 4.03 – RM 4.15 west	24,000
Norfolk	1999	RM 4.85 – RM 4.95 east	5,190
Glacier Ready-mix Facility	2001	RM 1.7 east	4,900
Boeing Developmental Center south storm drain outfall	2003	RM 4.9 east	60
Duwamish/Diagonal	2003/2004	RM 0.4 – RM 0.6 east	68,250
Delta Marine	2004	RM 4.17 – RM 4.24 west	7,000
Lehigh Northwest	2004	RM 1.02 – RM 1.09 east	9,000
Terminal 103	2005	RM 0.46 – RM 0.56 west	1,350
Glacier NW	2005	RM 1.42 – RM 1.54 west	9,920
Delta Marine	2008	RM 4.17 – RM 4.24 west	11,905
Lafarge	2009	RM 1.07 – RM 1.08 west	1,000
Terminal 115	2009	RM 1.5 – RM 1.9 west	3,000

Notes:

cy = cubic yards; RM = river mile.

Table N-2 Navigation Channel Dredging Events Conducted by the USACE (1990 to 2010)

Dates	River Miles	Volume Dredged (cy)
2/28/90 – 3/30/90	RM 3.97 – RM 4.65	127,619
2/6/92 – 3/21/92	RM 3.34 – RM 4.65	177,076
3/7/94 – 3/28/94	RM 4.33 – RM 4.65	57,243
2/22/96 – 3/30/96	RM 4.02 – RM 4.48	90,057
2/5/97 – 3/31/97	RM 4.26 – RM 4.65	89,011
3/11/99 – 6/29/99	RM 3.43 – RM 4.65	165,116
1/14/02 – 2/9/02	RM 4.27 – RM 4.65	96,523
1/15/04 – 2/16/04	RM 4.33 – RM 4.65	75,770
12/11/07 – 1/10/08	RM 4.27 – RM 4.65	140,608
2/19/10 – 3/30/10	RM 4.18 – RM 4.65	60,371

Notes:

cy = cubic yards; RM = river mile; USACE = U.S. Army Corps of Engineers.

Table N-3 Duwamish/Diagonal Sampling Events

Event Name	Description	Date	Included in Baseline?
Duw/Diag-1	Phase 1 site assessment	Aug 1994	Yes
Duw/Diag-1.5	Phase 1.5 site assessment	Nov 1995	Yes
Duw/Diag-2	Phase 2 site assessment	May-Sep 1996	Yes
DuwDiag-October2003	Perimeter monitoring – predredge	Oct 2003	Yes
DuwDiagonal-March2004	Perimeter monitoring – post-dredge	Mar 2004	Yes (subset)[a]
DuwDiag-June2004	Baseline cap monitoring – year 0	Jun 2004	No
DuwDiag-Jan2005	Perimeter monitoring – 1 year post-dredge before thin-layer cap placement	Jan-Feb 2005	Yes (subset)[a,b]
LDWRI-SurfaceSediment	Phase 2 RI sampling conducted by LDWG	Jan-Feb 2005	No[c]
DuwDiag-Mar2005	Perimeter monitoring – 1 year post-dredge after thin-layer cap placement	Mar 2005	No
DuwDiag-April2005	Cap monitoring – year 1	Apr 2005	No
DuwDiagonal-August 2005	Cap monitoring – year 1	Aug 2005	No
DuwDiag-Mar2006	Cap monitoring – year 2	Mar 2006	Yes (subset)[a]
DuwDiagonal-April 2007	Cap, perimeter, and thin-layer placement area monitoring – year 3	Apr 2007	Yes (subset)[a]
DuwDiagonal-March2008	Cap, perimeter, and thin-layer placement area monitoring – year 4	Mar 2008	No
DuwDiagonal-April2009	Cap, perimeter, and thin-layer placement area monitoring – year 5	Apr 2009	Yes[d]

Notes:

a. If data were available from these sampling events for contaminants not included in the most recent dataset (i.e., April 2009), these data were included in the baseline dataset.

b. While only the most recent samples (i.e., April 2009) from annually monitored perimeter stations were included in the FS baseline dataset, five perimeter stations were sampled only one time (during the January-February 2005 event) and were not resampled in any other subsequent events. These results were therefore included in the baseline dataset because they are the most recent available data at these stations.

c. Samples from five locations within 200 ft of the dredging boundary (SS18, SS20, SS21, SS22, and SS25) were excluded from the FS baseline surface sediment dataset because these locations may be have been unduly influenced by the 2003/2004 dredging activity. The other samples collected by LDWG in Jan-Feb 2005 were included in the FS baseline surface sediment dataset.

d. Because the Duwamish/Diagonal data included in the FS baseline surface sediment dataset are intended to represent surface sediment conditions prior to the 2003 to 2004 remediation or outside the 2003-2004 remediation area for this event, only data from sampling locations on the perimeter of the remediation area were included in the FS baseline surface sediment dataset.

FS = feasibility study; LDWG = Lower Duwamish Waterway Group; RI = remedial investigation.

Table N-4 Newer Surface Sediment Samples that Superseded Older Surface Sediment Samples if the Sample Locations Were Less Than 10 ft Apart

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
LDW-SS1-010	LDWRI-SurfSedRound1	LDW-SS1	1/17/05	0.0	K-11[a]	Harbor Island RI	K-11	9/30/91	0.6
LDW-SS4-010	LDWRI-SurfSedRound1	LDW-SS4	1/17/05	0.0	K-07	Harbor Island RI	K-07	9/30/91	1.4
LDW-SS5-010	LDWRI-SurfSedRound1	LDW-SS5	1/17/05	0.0	SD-DR076-0000[a]	EPA SI	DR076	8/24/98	1.5
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-1[a]	Harbor Island RI	K-05	10/14/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-1-B[a]	Harbor Island RI	K-05	10/14/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-1-D1[a]	Harbor Island RI	K-05	9/27/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-1-D2	Harbor Island RI	K-05	10/14/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-2[a]	Harbor Island RI	K-05	10/14/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-2-D1[a]	Harbor Island RI	K-05	9/27/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-2-D2	Harbor Island RI	K-05	10/14/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-3[a]	Harbor Island RI	K-05	10/14/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-3-D1[a]	Harbor Island RI	K-05	9/27/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	K-05-3-D2	Harbor Island RI	K-05	10/14/91	10.4[b]
6324233	Ecology SPI	TRI-010	8/8/06	0.2	LDW-SS10-010[a]	LDWRI-SurfSedRound1	LDW-SS10	1/17/05	9.2
LDW-SS12-010	LDWRI-SurfSedRound1	LDW-SS12	1/17/05	0.2	SD-DR035-0000[a]	EPA SI	DR035	8/11/98	2.1
LDW-SS15-010	LDWRI-SurfSedRound1	LDW-SS15	1/17/05	0.3	SD-DR079-0000[a]	EPA SI	DR079	8/24/98	1.7
6324235	Ecology SPI	TRI-016	8/8/06	0.3	LDW-SS16-010[a]	LDWRI-SurfSedRound2	LDW-SS16	3/8/05	5.0
LDW-SS17-010	LDWRI-SurfSedRound1	LDW-SS17	1/24/05	0.3	L7279-11[a]	Duw/Diag-1.5	DUD042	11/11/95	3.3
L7279-3	Duw/Diag-1.5	DUD032	11/9/95	0.4	L4288-27[a]	Duw/Diag-1	DUD032	8/12/94	0.0
L12059-1	KC WQA	DD-1	9/24/97	0.4	L4288-30[a]	Duw/Diag-1	DUD001	8/17/94	4.5
L12666-1	KC WQA	DD-1	9/24/97	0.4	L4288-30[a]	Duw/Diag-1	DUD001	8/17/94	4.5
L12666-2	KC WQA	DD-2	9/24/97	0.4	L4288-5[a]	Duw/Diag-1	DUD006	8/10/94	4.2
L12666-3	KC WQA	DD-2	9/24/97	0.4	L4288-5[a]	Duw/Diag-1	DUD006	8/10/94	4.2

Table N-4 Newer Surface Sediment Samples that Superseded Older Surface Sediment Samples if the Sample Locations Were Less Than 10 ft Apart (continued)

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
L12059-3	KC WQA	DD-3	9/24/97	0.5	L4288-21[a]	Duw/Diag-1	DUD022	8/10/94	4.3
L12666-4	KC WQA	DD-3	9/24/97	0.5	L4288-21[a]	Duw/Diag-1	DUD022	8/10/94	4.3
L12666-5	KC WQA	DD-4	9/24/97	0.5	L4288-28[a]	Duw/Diag-1	DUD034	8/12/94	4.5
L12666-6	KC WQA	DD-4	9/24/97	0.5	L4288-28[a]	Duw/Diag-1	DUD034	8/12/94	4.5
L12059-5	KC WQA	DD-5	9/24/97	0.5	L7279-8[a]	Duw/Diag-1.5	DUD039	11/9/95	4.2
L12666-7	KC WQA	DD-5	9/24/97	0.5	L7279-8[a]	Duw/Diag-1.5	DUD039	11/9/95	4.2
L29990-4	DuwDiagOct2003	DUD_4C	10/23/03	0.6	L7279-4[a]	Duw/Diag-1.5	DUD036	11/11/95	6.0
L29990-5	DuwDiagOct2003	DUD_4C	10/23/03	0.6	L7279-4[a]	Duw/Diag-1.5	DUD036	11/11/95	6.0
LDW-SS200-010	LDWRI-SurfSedRound1	LDW-SS27	1/18/05	0.8	EST21-03[a]	NOAA SiteChar	EST219	9/17/97	4.5
LDW-SS27-010	LDWRI-SurfSedRound1	LDW-SS27	1/18/05	0.8	EST21-03[a]	NOAA SiteChar	EST219	9/17/97	4.5
LDW-SSB2b-010	LDWRI-SurfSedRound2	LDW-SSB2b	3/11/05	0.8	SD-DR085-0000[a]	EPA SI	DR085	8/31/98	5.6
SD-DR048-0000	EPA SI	DR048	8/12/98	0.9	WST20-02[a]	NOAA SiteChar	WST367	9/19/97	6.3
LDW-SS32-010	LDWRI-SurfSedRound1	LDW-SS32	1/18/05	0.9	SD-DR019-0000[a]	EPA SI	DR019	8/17/98	0.6
LDW-SS31-010	LDWRI-SurfSedRound1	LDW-SS31	1/21/05	0.9	SD-DR020-0000[a]	EPA SI	DR020	8/17/98	1.0
LDW-SS319-010	LDWRI-SurfaceSedimentRound3	LDW-SS319	10/4/06	0.9	SD-DR021-0000[a]	EPA SI	DR021	8/17/98	6.7
LDW-SS37-010	LDWRI-SurfSedRound1	LDW-SS37	1/18/05	1.0	SD-DR087-0000[a]	EPA SI	DR087	8/12/98	2.5
LDW-SS40-010	LDWRI-SurfSedRound1	LDW-SS40	1/18/05	1.1	SD-DR088-0000[a]	EPA SI	DR088	8/31/98	1.1
LDW-SS44-010	LDWRI-SurfSedRound1	LDW-SS44	1/21/05	1.2	SD-DR053-0000-CC[a]	EPA SI	DR053	8/31/98	1.6
6324258	Ecology SPI	B4B	8/11/06	1.3	LDW-B4b-S[a]	LDWRI-Benthic	B4b	8/28/04	4.2
6324258	Ecology SPI	B4B	8/11/06	1.3	SD-DR028-0000[a]	EPA SI	DR028	8/17/98	3.2
6324239	Ecology SPI	TRI-045	8/9/06	1.3	LDW-SS45-010[a]	LDWRI-SurfSedRound2	LDW-SS45	3/10/05	6.7
LDW-SS48-010	LDWRI-SurfSedRound1	LDW-SS48	1/18/05	1.3	SS-2[a]	Duwamish Shipyard	SS-2	8/17/93	1.5
LDW-SS202-010	LDWRI-SurfSedRound1	LDW-SS50	1/24/05	1.3	SD-DR030-0000[a]	EPA SI	DR030	8/17/98	1.9

Table N-4 Newer Surface Sediment Samples that Superseded Older Surface Sediment Samples if the Sample Locations Were Less Than 10 ft Apart (continued)

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
LDW-SS50-010	LDWRI-SurfSedRound1	LDW-SS50	1/24/05	1.3	SD-DR030-0000[a]	EPA SI	DR030	8/17/98	1.9
6324243	Ecology SPI	TRI-051	8/9/06	1.3	SD-DR160-0000[a]	EPA SI	DR160	8/12/98	5.0
6324243	Ecology SPI	TRI-051	8/9/06	1.3	LDW-SS51-010[a]	LDWRI-SurfSedRound1	LDW-SS51	1/18/05	6.3
LDW-SS49-010	LDWRI-SurfSedRound1	LDW-SS49	1/26/05	1.4	SS-6[a]	Duwamish Shipyard	SS-3	8/17/93	8.0
LDW-SS49-010	LDWRI-SurfSedRound1	LDW-SS49	1/26/05	1.4	SS-3[a]	Duwamish Shipyard	SS-3	8/17/93	8.0
LDW-SS55-010	LDWRI-SurfSedRound1	LDW-SS55	1/24/05	1.4	SS-4[a]	Duwamish Shipyard	SS-4	8/17/93	3.0
LDW-SS57-010	LDWRI-SurfSedRound1	LDW-SS57	1/24/05	1.4	SD-DR123-0000[a]	EPA SI	DR123	9/14/98	6.7
LDW-SS52-010	LDWRI-SurfSedRound1	LDW-SS52	1/25/05	1.4	SD-DR065-0000[a]	EPA SI	DR065	8/17/98	1.2
LDW-SS63-010	LDWRI-SurfSedRound1	LDW-SS63	1/21/05	1.7	SD-DR097-0000[a]	EPA SI	DR097	8/20/98	9.7
LDW-SS70-010	LDWRI-SurfSedRound1	LDW-SS70	1/21/05	1.8	SD-DR131-0000-CC[a]	EPA SI	DR131	8/13/98	1.3
LDW-SS75-010	LDWRI-SurfSedRound1	LDW-SS75	1/21/05	1.9	SD0056	Boeing SiteChar	R7	10/15/97	5.7
LDW-SS76-010	LDWRI-SurfSedRound1	LDW-SS76	1/20/05	2.0	SD-DR106-0000[a]	EPA SI	DR106	8/19/98	2.3
LDW-SS79-010	LDWRI-SurfSedRound1	LDW-SS79	1/24/05	2.0	CH07-01[a]	NOAA SiteChar	CH0023	10/16/97	1.7
LDW-SS81-010	LDWRI-SurfSedRound2	LDW-SS81	3/8/05	2.1	SD-DR113-0000-CC[a]	EPA SI	DR113	8/19/98	1.1
6324256	Ecology SPI	DR-111	8/11/06	2.1	SD-DR111-0000-CC[a]	EPA SI	DR111	8/19/98	5.0
LDW-B5a-S2	LDWRI-Benthic	B5a-2	9/24/04	2.2	WIT11-01[a]	NOAA SiteChar	WIT280	10/3/97	9.8
SD-DR141-0000-CC	EPA SI	DR141	8/20/98	2.3	WST14-01[a]	NOAA SiteChar	WST342	10/23/97	3.9
LDW-SS88-010	LDWRI-SurfSedRound1	LDW-SS88	1/25/05	2.5	EIT09-01[a]	NOAA SiteChar	EIT074	11/3/97	7.2
LDW-SS92-010	LDWRI-SurfSedRound1	LDW-SS92	1/25/05	2.7	EST13-05[a]	NOAA SiteChar	EST180	10/6/97	2.4
LDW-SS94-010	LDWRI-SurfSedRound1	LDW-SS94	1/21/05	2.7	SD-DR175-0000[a]	EPA SI	DR175	8/20/98	0.7
6324248	Ecology SPI	TRI-096	8/10/06	2.8	LDW-SS96-010[a]	LDWRI-SurfSedRound1	LDW-SS96	1/21/05	6.7

Table N-4 Newer Surface Sediment Samples that Superseded Older Surface Sediment Samples if the Sample Locations Were Less Than 10 ft Apart (continued)

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
6324249	Ecology SPI	DR-181	8/10/06	2.9	SD-DR181-0000[a]	EPA SI	DR181	9/1/98	2.2
LDW-SS102-010	LDWRI-SurfSedRound1	LDW-SS102	1/24/05	3.0	SD-DR198-0000[a]	EPA SI	DR198	8/20/98	2.8
LDW-SS104-010	LDWRI-SurfSedRound1	LDW-SS104	1/25/05	3.1	SD-DR202-0000[a]	EPA SI	DR202	8/27/98	1.5
T117-SE10-SG	T117BoundaryDefinition	T117-SE-10-G	12/8/03	3.5	WST09-02[a]	NOAA SiteChar	WST323	10/21/97	1.2
T117-107-SG	T117 Sed Boundary	T117-SE107-G	8/29/08	3.6	T117-SE19-SG	T117BoundaryDefinition	T117-SE-19-G	12/5/03	1.7
SD-309-0000	JorgensenAugust2004	SD-309-S	8/16/04	3.6	EST11-03[a]	NOAA SiteChar	EST152	9/24/97	3.5
SD-320-0000	JorgensenAugust2004	SD-320-S	8/16/04	3.6	SD2B-DUW92-0000[a]	Plant 2 RFI-2b	SD-DUW92	4/2/96	4.8
SD-334-0000	JorgensenAugust2004	SD-334-S	8/26/04	3.6	EST11-04[a]	NOAA SiteChar	EST154	9/24/97	9.1
SD-343-0000	JorgensenAugust2004	SD-343-S	8/27/04	3.6	SD2B-DUW90-0000[a]	Plant 2 RFI-2b	SD-DUW90	4/4/96	6.1
SWY17	Plant2-TransformPhase1	SD-SWY17	9/9/03	3.6	SD-SWY07-0000[a]	Plant 2 RFI-1	SD-SWY07	6/13/95	7.0
LDW-SS110-010	LDWRI-SurfSedRound1	LDW-SS110	1/25/05	3.6	SD-323-0000	Jorgensen August 2004	SD-323-S	8/17/04	3.4
LDW-SS111-010	LDWRI-SurfSedRound1	LDW-SS111	1/19/05	3.6	SD-DR186-0000[a]	EPA SI	DR186	8/27/98	1.0
T117-113-SG	T117 Sed Boundary	T117-SE113-G	8/29/08	3.7	SD0019[a]	Boeing SiteChar	R19	10/11/97	5.7
T117-114-SG	T117 Sed Boundary	T117-SE114-G	8/29/08	3.7	SD0018[a]	Boeing SiteChar	R18	10/11/97	1.9
T117-117-SG	T117 Sed Boundary	T117-SE117-G	8/29/08	3.7	T117-SE46-SG[a]	T117BoundaryDefinition	T117-SE-46-G	12/9/03	5.1
LDW-SS113b-010	LDWRI-SurfSedRound1	LDW-SS113b	1/20/05	3.7	SD0009	Boeing SiteChar	R21	10/9/97	1.4
LDW-SS115-010	LDWRI-SurfSedRound1	LDW-SS115	1/25/05	3.7	SD-DR187-0000[a]	EPA SI	DR187	8/27/98	3.0
LDW-SS117-010	LDWRI-SurfSedRound1	LDW-SS117	1/20/05	3.8	SD0013	Boeing SiteChar	R24	10/10/97	1.2
LDW-SS119-010	LDWRI-SurfSedRound1	LDW-SS119	1/19/05	3.8	SD0021	Boeing SiteChar	R30	10/11/97	2.3
LDW-SS121-010	LDWRI-SurfSedRound1	LDW-SS121	1/25/05	3.9	EIT06-02[a]	NOAA SiteChar	EIT061	9/29/97	4.0
AN019-SS-061024	8801 E Marginal (formerly KenworthPACCAR)	AN-019	10/24/06	3.9	EST09-04[a]	NOAA SiteChar	EST144	9/25/97	9.2

Table N-4 Newer Surface Sediment Samples that Superseded Older Surface Sediment Samples if the Sample Locations Were Less Than 10 ft Apart (continued)

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
AN019-SS-061024	8801 E Marginal (formerly KenworthPACCAR)	AN-019	10/24/06	3.9	LDW-SS123-010[a]	LDWRI-SurfSedRound1	LDW-SS123	1/24/05	8.2
AN019-SS-061024	8801 E Marginal (formerly KenworthPACCAR)	AN-019	10/24/06	3.9	LDW-SS203-010[a]	LDWRI-SurfSedRound1	LDW-SS123	1/24/05	8.2
LDW-SS125-010	LDWRI-SurfSedRound1	LDW-SS125	1/20/05	4.0	SD-DR238-0000[a]	EPA SI	DR238	8/27/98	1.1
LDW-B8b-S	LDWRI-Benthic	B8b	8/19/04	4.1	EST07-07[a]	NOAA SiteChar	EST135	11/12/97	2.7
LDW-SS126-010	LDWRI-SurfSedRound1	LDW-SS126	1/20/05	4.1	RPL-A11-05-02[a]	Rhône-Poulenc RFI-2	A11-05	8/18/94	2.1
LDW-SS126-010	LDWRI-SurfSedRound1	LDW-SS126	1/20/05	4.1	RPL-A11-10-02[a]	Rhône-Poulenc RFI-2	A11-05	8/18/94	2.1
Upper SB-01	RhônePoulenc2004	SB-1	8/25/04	4.2	SD-DR242-0000-CC[a]	EPA SI	DR242	8/24/98	9.5
Upper SB-15	RhônePoulenc2004	SB-1	8/25/04	4.2	SD-DR242-0000-CC[a]	EPA SI	DR242	8/24/98	9.5
LDW-SS127-010	LDWRI-SurfSedRound1	LDW-SS127	1/20/05	4.2	SD0032	Boeing SiteChar	R40	10/13/97	1.0
LDW-SS129-010	LDWRI-SurfSedRound1	LDW-SS129	1/20/05	4.2	SD0033	Boeing SiteChar	R42	10/13/97	8.4
LDW-SS130-010	LDWRI-SurfSedRound1	LDW-SS130	1/20/05	4.2	SD0070	Boeing SiteChar	R45	10/16/97	0.5
Upper SH-04	RhônePoulenc2004	SH-04	8/24/04	4.3	06-intsed-2[a]	Rhône-Poulenc RFI-3	06-intsed-2	7/1/96	8.6
Upper SH-02	RhônePoulenc2004	SH-02	8/25/04	4.3	07-intsed-1[a]	Rhône-Poulenc RFI-3	07-intsed-1	7/1/96	9.7
LDW-B10b-S	LDWRI-Benthic	B10b	8/19/04	4.3	SD-DR286-0000-CC[a]	EPA SI	DR286	8/26/98	3.2
LDW-SS148-010	LDWRI-SurfSedRound2	LDW-SS148	3/9/05	4.7	SD-DR271-0000[a]	EPA SI	DR271	9/15/98	2.0
L20703-2	Norfolk-monit4	NFK501	4/24/01	4.9	L15421-1[a]	Norfolk-monit1	NFK501	4/23/99	8.7
L23995-6	Norfolk-monit5	NFK503	4/30/02	4.9	L16628-6[a]	Norfolk-monit2a	NFK503	10/8/99	4.2
L23995-6	Norfolk-monit5	NFK503	4/30/02	4.9	L17647-6[a]	Norfolk-monit3	NFK503	4/6/00	3.3
L23995-6	Norfolk-monit5	NFK503	4/30/02	4.9	L20703-6	Norfolk-monit4	NFK503	4/24/01	4.0
288131	Ecology-Norfolk	2	7/9/02	4.9	L4321-2[a]	Norfolk-cleanup1	NFK002	8/18/94	8.5

Table N-4 Newer Surface Sediment Samples that Superseded Older Surface Sediment Samples if the Sample Locations Were Less Than 10 ft Apart (continued)

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
288132	Ecology-Norfolk	3	7/9/02	4.9	L4321-2[a]	Norfolk-cleanup1	NFK002	8/18/94	9.5
288133	Ecology-Norfolk	4	7/9/02	4.9	L4321-2[a]	Norfolk-cleanup1	NFK002	8/18/94	8.7
288134	Ecology-Norfolk	5	7/9/02	4.9	SD0079[a]	Boeing SiteChar	R87	10/18/97	5.3
288134	Ecology-Norfolk	5	7/9/02	4.9	L17311-1	Norfolk-monit2b	NFK506	2/10/00	6.3
288136	Ecology-Norfolk	7	7/9/02	4.9	SD0079[a]	Boeing SiteChar	R87	10/18/97	6.4
288136	Ecology-Norfolk	7	7/9/02	4.9	L17311-1	Norfolk-monit2b	NFK506	2/10/00	6.3
288148	Ecology-Norfolk	7	7/9/02	4.9	SD0079[a]	Boeing SiteChar	R87	10/18/97	6.4
288148	Ecology-Norfolk	7	7/9/02	4.9	L17311-1	Norfolk-monit2b	NFK506	2/10/00	5.4
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/06	4.9	288139	Ecology-Norfolk	10	7/9/02	8.9
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/06	4.9	L17315-3	Norfolk-monit2b	NFK503	2/8/00	7.6
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/06	4.9	L28052-6[a]	Norfolk-monit6	NFK503	4/23/03	4.3
LDW-SS341-010	LDWRI-SurfaceSedimentRound3	LDW-SS341	10/3/06	4.9	L31635-6[a]	Norfolk-monit7	NFK503	4/5/04	1.8
NFK502VV12	LDW Upstream Sed	NFK502	4/30/08	4.9	L16628-4[a]	Norfolk-monit2a	NFK502	10/8/99	4.5
NFK502VV12	LDW Upstream Sed	NFK502	4/30/08	4.9	L17647-4[a]	Norfolk-monit3	NFK502	4/6/00	6.4
NFK502VV12	LDW Upstream Sed	NFK502	4/30/08	4.9	L20703-4[a]	Norfolk-monit4	NFK502	4/24/01	3.6
NFK502VV12	LDW Upstream Sed	NFK502	4/30/08	4.9	L23995-4[a]	Norfolk-monit5	NFK502	4/30/02	3.2
NFK502VV12	LDW Upstream Sed	NFK502	4/30/08	4.9	L28052-4[a]	Norfolk-monit6	NFK502	4/23/03	4.2
NFK502VV12	LDW Upstream Sed	NFK502	4/30/08	4.9	L31635-4[a]	Norfolk-monit7	NFK502	4/5/04	3.0
NFK502VV12	LDW Upstream Sed	NFK502	4/30/08	4.9	LDW-SS342-010[a]	LDWRI-SurfaceSedimentRound3	LDW-SS342	10/3/06	2.8
NFK-501VV16	LDW Upstream Sed	NFK501	5/1/08	4.9	288146	Ecology-Norfolk	17	7/9/02	8.4
NFK-501VV16	LDW Upstream Sed	NFK501	5/1/08	4.9	L17315-1	Norfolk-monit2b	NFK501	2/8/00	10.8[b]
NFK-501VV16	LDW Upstream Sed	NFK501	5/1/08	4.9	L23995-2[a]	Norfolk-monit5	NFK501	4/30/02	8.4
NFK-501VV16	LDW Upstream Sed	NFK501	5/1/08	4.9	L28052-2[a]	Norfolk-monit6	NFK501	4/23/03	4.2
NFK-501VV16	LDW Upstream Sed	NFK501	5/1/08	4.9	L31635-2[a]	Norfolk-monit7	NFK501	4/5/04	6.2

Table N-4 Newer Surface Sediment Samples that Superseded Older Surface Sediment Samples if the Sample Locations Were Less Than 10 ft Apart (continued)

Newer Sample				River Mile	Older Sample				Nominal Distance Between New and Old Coordinates (ft)
Sample	Event	Location	Sampling Date		Sample	Event	Location	Sampling Date	
NFK-501VV16	LDW Upstream Sed	NFK501	5/1/08	4.9	LDW-SS343-010[a]	LDWRI-SurfaceSedimentRound3	LDW-SS343	10/3/06	7.4
NFK-501VV16	LDW Upstream Sed	NFK501	5/1/08	4.9	288142	Ecology-Norfolk	13	7/9/02	6.2
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L15421-4[a]	Norfolk-monit1	NFK504	4/23/99	1.1
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L17647-8[a]	Norfolk-monit3	NFK504	4/6/00	6.6
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L20703-8[a]	Norfolk-monit4	NFK504	4/24/01	6.8
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L23995-8[a]	Norfolk-monit5	NFK504	4/30/02	8.9
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L28052-8[a]	Norfolk-monit6	NFK504	4/23/03	7.2
LDW-SS344-010	LDWRI-SurfaceSedimentRound3	LDW-SS344	10/3/06	4.9	L31635-8[a]	Norfolk-monit7	NFK504	4/5/04	3.0

Notes:

1. Sampling location coordinates are Washington State Plane North, U.S. survey ft, North American Vertical Datum 1983 (NAD83).
2. The FS surface sediment baseline dataset consists of 1,718 samples, including the 99 newer samples that superseded the 125 older samples shown in this table.

a. Newer results have replaced older results in the FS baseline dataset (see Table N-5), but for chemicals not analyzed in the newer samples, older results have been preserved in the FS baseline dataset. In most cases, only a small number of chemical results from the older samples are used.

b. Nominal distance between oldest and newest location is slightly greater than the 10-ft threshold. Results from an older sample were originally superseded in the RI by a sample that has been subsequently superseded by a third (newer) sample shown in this table. The distances between this intermediate-date sample and the newest and oldest samples were both less than 10 ft.

Ecology = Washington State Department of Ecology; EPA = U.S. Environmental Protection Agency; FS = feasibility study; ft = feet; KC = King County; LDW = Lower Duwamish Waterway; NOAA = National Oceanic and Atmospheric Administration; RCRA = Resource Conservation and Recovery Act; RFI = RCRA facility investigation; RI = remedial investigation; SI = site investigation; SPI = sediment profile imaging; WQA = water quality assessment.

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
Boeing SiteChar	R18	195175	1275682	10/11/97	SD0018[a]		10	superseded by T117-SE114-G, 2 ft away
Boeing SiteChar	R19	195178	1275727	10/11/97	SD0019[a]		10	superseded by T117-SE113-G, 6 ft away
Boeing SiteChar	R21	194955	1275772	10/9/97	SD0009		10	superseded by LDW-SS113b, 1 ft away
Boeing SiteChar	R24	194553	1275818	10/10/97	SD0013		10	superseded by LDW-SS117, 1 ft away
Boeing SiteChar	R30	194391	1276226	10/11/97	SD0021		10	superseded by LDW-SS119, 2 ft away
Boeing SiteChar	R40	193044	1277453	10/13/97	SD0032		10	superseded by LDW-SS127, 1 ft away
Boeing SiteChar	R42	192917	1277567	10/13/97	SD0033		10	superseded by LDW-SS129, 8 ft away
Boeing SiteChar	R45	192810	1277407	10/16/97	SD0070		10	superseded by LDW-SS130, less than 1 ft away
Boeing SiteChar	R7	201578	1269271	10/15/97	SD0056		10	superseded by LDW-SS75, 6 ft away
Boeing SiteChar	R86	190215	1278519	10/19/97	SD0091		10	sample falls inside 1999 Norfolk dredge area
Boeing SiteChar	R87	190257	1278543	10/18/97	SD0079[a]		10	superseded by Ecology-Norfolk 5 and 7
Duw/Diag-1	DUD001	209120	1267153	8/17/94	L4288-30[a]		10	superseded by KC WQA loc. DD-1
Duw/Diag-1	DUD006	209059	1267092	8/10/94	L4288-5[a]		10	superseded by KC WQA loc. DD-2
Duw/Diag-1	DUD022	208929	1267040	8/10/94	L4288-21[a]		10	superseded by KC WQA loc. DD-3
Duw/Diag-1	DUD032	208978	1266889	8/12/94	L4288-27[a]		10	superseded by 1995 location DUD032, samp L7279-3
Duw/Diag-1	DUD034	208785	1266933	8/12/94	L4288-28[a]		10	superseded by KC WQA loc. DD-4
Duw/Diag-1.5	DUD036	208245	1267118	11/11/95	L7279-4[a]		10	superseded by DUD_4C
Duw/Diag-1.5	DUD039	208606	1266844	11/9/95	L7279-8[a]		10	superseded by KC WQA loc. DD-5
Duw/Diag-1.5	DUD042	209785	1266880	11/11/95	L7279-11[a]		10	superseded by LDW-SS17, 3 ft away
Duwamish Shipyard	SS-2	204599	1268050	8/17/93	SS-2[a]		7.5	superseded by LDW-SS48
Duwamish Shipyard	SS-3	204476	1268107	8/17/93	SS-3[a]		7.5	superseded by LDW-SS49
Duwamish Shipyard	SS-3	204476	1268107	8/17/93	SS-6[a]	duplicate	7.5	superseded by LDW-SS49
Duwamish Shipyard	SS-4	204181	1268184	8/17/93	SS-4[a]		7.5	superseded by LDW-SS55
Duwamish Shipyard	SS-5	203667	1268323	8/17/93	SS-5		7.5	inside 2005 Glacier NW dredge area
DuwDiagApril2005	DUD_1A	209089	1267047	4/27/05	L35394-1		8	on top of dredged area cap
DuwDiagApril2005	DUD_1B	208484	1267060	4/27/05	L35394-7		10	on top of dredged area cap
DuwDiagApril2005	DUD_2A	208902	1267139	4/27/05	L35394-2		5	on top of dredged area cap
DuwDiagApril2005	DUD_3A	208973	1266951	4/27/05	L35394-3		6	on top of dredged area cap
DuwDiagApril2005	DUD_4A	209354	1266888	4/27/05	L35394-4		10	on top of dredged area cap
DuwDiagApril2005	DUD_5A	209410	1266805	4/27/05	L35394-5		8	on top of dredged area cap
DuwDiagApril2005	DUD_5A	209410	1266805	4/27/05	L35394-6		7	on top of dredged area cap
DuwDiagJan2005	DUD_1C	208754	1267168	2/1/05	L34524-1		6	only most recent data (April 2009) included
DuwDiagJan2005	DUD_2C	208651	1267175	1/31/05	L34524-2		9	only most recent data (April 2009) included

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
DuwDiagJan2005	DUD_3C	208144	1267146	1/31/05	L34524-3		10	within thin-layer placement area
DuwDiagJan2005	DUD_4C	208239	1267116	1/31/05	L34524-4		7	within thin-layer placement area
DuwDiagJan2005	DUD_4C	208239	1267116	1/31/05	L34524-5	replicate	7	within thin-layer placement area
DuwDiagJan2005	DUD_5C	208263	1267025	1/31/05	L34524-6		10	within thin-layer placement area
DuwDiagJan2005	DUD_6C	208501	1266950	1/31/05	L34524-7		9	within thin-layer placement area
DuwDiagJan2005	DUD_7C	208486	1266902	1/31/05	L34524-8		9	within thin-layer placement area
DuwDiagJan2005	DUD_8C	208920	1266864	2/1/05	L34524-10	replicate	7	only most recent data (April 2009) included
DuwDiagJan2005	DUD_8C	208920	1266864	2/1/05	L34524-9		6	only most recent data (April 2009) included
DuwDiagJan2005	DUD_9C	209157	1266784	1/31/05	L34524-11		7	only most recent data (April 2009) included
DuwDiagJan2005	DUD_10C	209517	1266663	2/1/05	L34524-12		8	only most recent data (April 2009) included
DuwDiagJan2005	DUD_11C	209535	1266844	2/1/05	L34524-13		7	only most recent data (April 2009) included
DuwDiagJan2005	DUD_12C	209630	1266813	2/2/05	L34524-14		9	only most recent data (April 2009) included
DuwDiagJan2005	DUD_13C	207853	1267236	2/2/05	L34524-15		10	approximately 120 ft from thin-layer placement area and possibly influenced by thin-layer placement
DuwDiagJan2005	DUD_14C	208000	1267196	2/2/05	L34524-16		10	within thin-layer placement area
DuwDiagJan2005	DUD_15C	207970	1267059	2/2/05	L34524-17		10	within thin-layer placement area
DuwDiagJune2004	DUD_1A	209089	1267047	6/1/04	L32085-1		6	on top of dredged area cap
DuwDiagJune2004	DUD_1B	208484	1267060	6/1/04	L32085-7		6	on top of dredged area cap
DuwDiagJune2004	DUD_2A	208902	1267139	6/1/04	L32085-2		5	on top of dredged area cap
DuwDiagJune2004	DUD_2B	208621	1267079	6/1/04	L32085-8		5	on top of dredged area cap
DuwDiagJune2004	DUD_3B	208716	1267049	6/1/04	L32085-9		6	on top of dredged area cap
DuwDiagJune2004	DUD_4A	209354	1266888	6/1/04	L32085-4		10	on top of dredged area cap
DuwDiagJune2004	DUD_5A	209410	1266805	6/1/04	L32085-5		10	on top of dredged area cap
DuwDiagJune2004	DUD_5A	209410	1266805	6/1/04	L32085-6		10	on top of dredged area cap
DuwDiagMarch2005	DUD_3C	208144	1267146	3/16/05	L34971-3		10	within thin-layer placement area
DuwDiagMarch2005	DUD_4C	208239	1267116	3/16/05	L34971-4		9	within thin-layer placement area
DuwDiagMarch2005	DUD_4C	208239	1267116	3/16/05	L34971-5		9	within thin-layer placement area
DuwDiagMarch2005	DUD_5C	208263	1267025	3/24/05	L34971-6		10	within thin-layer placement area
DuwDiagMarch2005	DUD_6C	208501	1266950	3/24/05	L34971-7		10	within thin-layer placement area
DuwDiagMarch2005	DUD_7C	208486	1266902	3/24/05	L34971-8		10	within thin-layer placement area
DuwDiagMarch2005	DUD_14C	208000	1267196	3/16/05	L34971-16		10	within thin-layer placement area
DuwDiagMarch2005	DUD_15C	207970	1267059	3/16/05	L34971-17		10	within thin-layer placement area
DuwDiagonal-March2004	DUD_1C	208754	1267168	3/29/04	L31520-1		10	only most recent data (April 2009) included
DuwDiagonal-March2004	DUD_2C	208651	1267175	3/29/04	L31520-2		10	only most recent data (April 2009) included

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
DuwDiagonal-March2004	DUD_3C	208144	1267146	3/29/04	L31520-3		10	within thin-layer placement area
DuwDiagonal-March2004	DUD_4C	208239	1267116	3/29/04	L31520-4		10	within thin-layer placement area
DuwDiagonal-March2004	DUD_4C	208239	1267116	3/29/04	L31520-5	replicate	10	within thin-layer placement area
DuwDiagonal-March2004	DUD_5C	208263	1267025	3/29/04	L31520-6		10	within thin-layer placement area
DuwDiagonal-March2004	DUD_6C	208501	1266950	3/30/04	L31520-15	replicate	10	within thin-layer placement area
DuwDiagonal-March2004	DUD_6C	208501	1266950	3/30/04	L31520-7		10	within thin-layer placement area
DuwDiagonal-March2004	DUD_7C	208486	1266902	3/30/04	L31520-8		10	within thin-layer placement area
DuwDiagonal-March2004	DUD_8C	208920	1266864	3/30/04	L31520-10	replicate	10	only most recent data (April 2009) included
DuwDiagonal-March2004	DUD_8C	208920	1266864	3/30/04	L31520-9		10	only most recent data (April 2009) included
DuwDiagonal-March2004	DUD_9C	209157	1266784	3/30/04	L31520-11		10	only most recent data (April 2009) included
DuwDiagonal-March2004	DUD_10C	209517	1266663	3/30/04	L31520-12		10	only most recent data (April 2009) included
DuwDiagonal-March2004	DUD_11C	209535	1266844	3/30/04	L31520-13		10	only most recent data (April 2009) included
DuwDiagonal-March2004	DUD_12C	209630	1266813	3/30/04	L31520-14		10	only most recent data (April 2009) included
DuwDiagonal August 2005	DUD_2B	208621	1267079	8/17/05	L36565-3		3	on top of dredged area cap
DuwDiagonal August 2005	DUD_30C	208888	1267269	8/17/05	L36565-1		3	bank-soil station likely influenced by cap
DuwDiagonal August 2005	DUD_31C	209000	1267237	8/17/05	L36565-2		3	bank-soil station likely influenced by cap
DuwDiagMarch2006	DUD_1A	209089	1267047	3/7/06	L38325-1		8	on top of dredged area cap
DuwDiagMarch2006	DUD_1B	208484	1267060	3/7/06	L38325-7		7	on top of dredged area cap
DuwDiagMarch2006	DUD_1C	208754	1267168	3/8/06	L38326-1		10	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_2A	208902	1267139	3/7/06	L38325-2		9	on top of dredged area cap
DuwDiagMarch2006	DUD_2B	208621	1267079	3/7/06	L38325-8		4	on top of dredged area cap
DuwDiagMarch2006	DUD_2C	208651	1267175	3/8/06	L38326-2		7	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_3A	208973	1266951	3/7/06	L38325-3		7	on top of dredged area cap
DuwDiagMarch2006	DUD_3B	208716	1267049	3/7/06	L38325-9		5	on top of dredged area cap
DuwDiagMarch2006	DUD_3C	208144	1267146	3/10/06	L38327-1		10	within thin-layer placement area
DuwDiagMarch2006	DUD_4A	209354	1266888	3/7/06	L38325-4		9	on top of dredged area cap
DuwDiagMarch2006	DUD_4C	208239	1267116	3/10/06	L38327-2		10	within thin-layer placement area
DuwDiagMarch2006	DUD_4C	208239	1267116	3/10/06	L38327-3	replicate	10	within thin-layer placement area
DuwDiagMarch2006	DUD_5A	209410	1266805	3/7/06	L38325-5		6	on top of dredged area cap
DuwDiagMarch2006	DUD_5A	209410	1266805	3/7/06	L38325-6	replicate	6	on top of dredged area cap
DuwDiagMarch2006	DUD_5C	208263	1267025	3/10/06	L38327-4		10	within thin-layer placement area
DuwDiagMarch2006	DUD_6C	208501	1266950	3/10/06	L38327-5		10	within thin-layer placement area
DuwDiagMarch2006	DUD_7C	208486	1266902	3/10/06	L38327-6		10	within thin-layer placement area

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
DuwDiagMarch2006	DUD_8C	208920	1266864	3/8/06	L38326-9		5	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_8C	208920	1266864	3/8/06	L38326-10	replicate	5	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_9C	209157	1266784	3/8/06	L38326-11		5	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_10C	209517	1266663	3/8/06	L38326-12		6	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_11C	209535	1266844	3/9/06	L38326-13		6	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_12C	209630	1266813	3/9/06	L38326-14		8	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_13C	207853	1267236	3/9/06	L38326-15		10	approximately 120 ft from thin-layer placement area and possibly influenced by thin-layer placement
DuwDiagMarch2006	DUD_14C	208000	1267196	3/10/06	L38327-7		10	only most recent data (April 2009) included
DuwDiagMarch2006	DUD_15C	207970	1267059	3/10/06	L38327-8		10	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_1A	209089	1267047	4/3/07	L42276-1		6	on top of dredged area cap
DuwDiagonal April 2007	DUD_1B	208484	1267060	4/3/07	L42276-7		10	on top of dredged area cap
DuwDiagonal April 2007	DUD_1C	208754	1267168	4/2/07	L42275-1[a]		10	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_2A	208902	1267139	4/3/07	L42276-2		10	on top of dredged area cap
DuwDiagonal April 2007	DUD_2B	208621	1267079	4/3/07	L42276-8		7	on top of dredged area cap
DuwDiagonal April 2007	DUD_2C	208651	1267175	4/2/07	L42275-2[a]		10	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_3A	208973	1266951	4/3/07	L42276-3		9	on top of dredged area cap
DuwDiagonal April 2007	DUD_3B	208716	1267049	4/3/07	L42276-9		10	on top of dredged area cap
DuwDiagonal April 2007	DUD_3C	208144	1267146	4/3/07	L42274-1		10	within thin-layer placement area
DuwDiagonal April 2007	DUD_4A	209354	1266888	4/3/07	L42276-4		7	on top of dredged area cap
DuwDiagonal April 2007	DUD_4C	208239	1267116	4/3/07	L42274-2		10	within thin-layer placement area
DuwDiagonal April 2007	DUD_4C	208239	1267116	4/3/07	L42274-3		10	within thin-layer placement area
DuwDiagonal April 2007	DUD_5A	209410	1266805	4/3/07	L42276-5		4	on top of dredged area cap
DuwDiagonal April 2007	DUD_5A	209410	1266805	4/3/07	L42276-6	replicate	4	on top of dredged area cap
DuwDiagonal April 2007	DUD_5C	208263	1267025	4/3/07	L42274-3		7	within thin-layer placement area
DuwDiagonal April 2007	DUD_6C	208501	1266950	4/3/07	L42274-4		6	within thin-layer placement area
DuwDiagonal April 2007	DUD_7C	208486	1266902	4/4/07	L42274-5		9	within thin-layer placement area
DuwDiagonal April 2007	DUD_8C	208920	1266864	4/2/07	L42275-3[a]		5	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_8C	208920	1266864	4/2/07	L42275-4[a]	replicate	5	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_9C	209157	1266784	4/2/07	L42275-5[a]		5	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_10C	209517	1266663	4/2/07	L42275-6[a]		8	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_11C	209535	1266844	4/2/07	L42275-7[a]		8	only most recent data (April 2009) included
DuwDiagonal April 2007	DUD_12C	209630	1266813	4/2/07	L42275-8[a]		6	only most recent data (April 2009) included

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
DuwDiagonal April 2007	DUD_13C	207853	1267236	4/4/07	L42275-9		10	approximately 120 ft from thin-layer placement area and possibly influenced by thin-layer placement
DuwDiagonal April 2007	DUD_14C	208000	1267196	4/4/07	L42274-7		10	within thin-layer placement area
DuwDiagonal April 2007	DUD_15C	207970	1267059	4/4/07	L42274-8		9	within thin-layer placement area
DuwDiagonalMarch2008	DUD_1A	209093	1267050	3/24/08	L45304-1		5	on top of dredged area cap
DuwDiagonalMarch2008	DUD_1B	208488	1267058	3/24/08	L45304-7		9	on top of dredged area cap
DuwDiagonalMarch2008	DUD_1C	208757	1267167	3/24/08	L45302-1		5	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_2A	208905	1267140	3/24/08	L45304-2		7	on top of dredged area cap
DuwDiagonalMarch2008	DUD_2B	208625	1267076	3/24/08	L45304-8		7	on top of dredged area cap
DuwDiagonalMarch2008	DUD_2C	208653	1267168	3/24/08	L45302-2		5	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_3A	208973	1266952	3/24/08	L45304-3		9	on top of dredged area cap
DuwDiagonalMarch2008	DUD_3B	208717	1267049	3/24/08	L45304-9		6	on top of dredged area cap
DuwDiagonalMarch2008	DUD_3C	208145	1267145	3/25/08	L45303-1		10	within thin-layer placement area
DuwDiagonalMarch2008	DUD_4A	209357	1266886	3/24/08	L45304-4		7	on top of dredged area cap
DuwDiagonalMarch2008	DUD_4C	208237	1267115	3/25/08	L45303-2		9	within thin-layer placement area
DuwDiagonalMarch2008	DUD_4C	208237	1267115	3/25/08	L45303-3	replicate	9	within thin-layer placement area
DuwDiagonalMarch2008	DUD_5A	209409	1266798	3/24/08	L45304-5		9	on top of dredged area cap
DuwDiagonalMarch2008	DUD_5A	209409	1266798	3/24/08	L45304-6	replicate	9	on top of dredged area cap
DuwDiagonalMarch2008	DUD_5C	208265	1267024	3/25/08	L45303-4		8	within thin-layer placement area
DuwDiagonalMarch2008	DUD_6C	208505	1266948	3/25/08	L45303-5		8	within thin-layer placement area
DuwDiagonalMarch2008	DUD_7C	208486	1266900	3/25/08	L45303-6		9	within thin-layer placement area
DuwDiagonalMarch2008	DUD_8C	208917	1266866	3/24/08	L45302-3		6	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_8C	208917	1266866	3/24/08	L45302-4	replicate	6	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_9C	209159	1266785	3/24/08	L45302-5		6	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_10C	209515	1266662	3/24/08	L45302-6		7	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_11C	209538	1266843	3/25/08	L45302-7		7	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_12C	209630	1266812	3/25/08	L45302-8		8	only most recent data (April 2009) included
DuwDiagonalMarch2008	DUD_13C	207860	1267238	3/25/08	L45302-9		10	approximately 120 ft from thin-layer placement area and possibly influenced by thin-layer placement
DuwDiagonalMarch2008	DUD_14C	208001	1267195	3/25/08	L45303-7		9	within thin-layer placement area
DuwDiagonalMarch2008	DUD_15C	207969	1267057	3/25/08	L45303-8		9	within thin-layer placement area
DuwDiagonalApril2009	DUD_1A	209093	1267050	4/28/09	L47890-1		6	on top of dredged area cap
DuwDiagonalApril2009	DUD_1B	208488	1267058	4/27/09	L47890-7		8	on top of dredged area cap
DuwDiagonalApril2009	DUD_2A	208905	1267140	4/28/09	L47890-2		7	on top of dredged area cap

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
DuwDiagonalApril2009	DUD_2B	208625	1267076	4/27/09	L47890-8		5	on top of dredged area cap
DuwDiagonalApril2009	DUD_3A	208973	1266952	4/28/09	L47890-3		10	on top of dredged area cap
DuwDiagonalApril2009	DUD_3B	208717	1267049	4/27/09	L47890-9		5	on top of dredged area cap
DuwDiagonalApril2009	DUD_3C	208145	1267145	4/28/09	L47893-1		10	within thin-layer placement area
DuwDiagonalApril2009	DUD_4A	209357	1266886	4/28/09	L47890-4		7	on top of dredged area cap
DuwDiagonalApril2009	DUD_4C	208237	1267115	4/28/09	L47893-2		10	within thin-layer placement area
DuwDiagonalApril2009	DUD_4C	208237	1267115	4/28/09	L47893-3	replicate	10	within thin-layer placement area
DuwDiagonalApril2009	DUD_5A	209409	1266798	4/28/09	L47890-5		9	on top of dredged area cap
DuwDiagonalApril2009	DUD_5A	209409	1266798	4/28/09	L47890-6	replicate	9	on top of dredged area cap
DuwDiagonalApril2009	DUD_5C	208265	1267024	4/28/09	L47893-4		10	within thin-layer placement area
DuwDiagonalApril2009	DUD_6C	208505	1266948	4/28/09	L47893-5		10	within thin-layer placement area
DuwDiagonalApril2009	DUD_7C	208486	1266900	4/28/09	L47893-6		10	within thin-layer placement area
DuwDiagonalApril2009	DUD_13C	207860	1267238	4/29/09	L47888-9		10	approximately 120 ft from thin-layer placement area and possibly influenced by thin-layer placement
DuwDiagonalApril2009	DUD_14C	208001	1267195	4/28/09	L47893-7		8	within thin-layer placement area
DuwDiagonalApril2009	DUD_15C	207969	1267057	4/28/09	L47893-8		8	within thin-layer placement area
Ecology-Norfolk	10	190201	1278537	7/9/02	288139		10	superseded by LDW-SS341, 9 ft away
Ecology-Norfolk	13	190172	1278577	7/9/02	288142		10	superseded by NFK501, 6 ft away
Ecology-Norfolk	17	190168	1278591	7/9/02	288146		10	superseded by LDW-SS343, 1 ft away
EPA SI	DR019	206530	1268204	8/17/98	SD-DR019-0000[a]		10	superseded by LDW-SS32, less than 1 ft away
EPA SI	DR020	206549	1268450	8/17/98	SD-DR020-0000[a]		10	superseded by LDW-SS31, 1 ft away
EPA SI	DR021	206718	1267822	8/17/98	SD-DR021-0000[a]		10	superseded by LDW-SS319, 7 ft away
EPA SI	DR022	206228	1267936	8/17/98	SD-DR022-0000-CC		10	sample falls within 2004 Lehigh NW dredge area
EPA SI	DR028	204607	1268471	8/17/98	SD-DR028-0000[a]		10	superseded by LDWB4b, 2 ft away
EPA SI	DR030	204436	1268521	8/17/98	SD-DR030-0000[a]		10	superseded by LDW-SS50, 2 ft away
EPA SI	DR031	211452	1265523	8/11/98	SD-DR031-0000		10	north of RM 0, therefore outside of study area
EPA SI	DR035	210194	1266104	8/11/98	SD-DR035-0000[a]		10	superseded by LDW-SS12, 2 ft away
EPA SI	DR053	204908	1267941	8/31/98	SD-DR053-0000-CC[a]		10	superseded by LDW-SS44, 2 ft away
EPA SI	DR065	204315	1268452	8/17/98	SD-DR065-0000[a]		10	superseded by LDW-SS52, 1 ft away
EPA SI	DR076	211210	1265996	8/24/98	SD-DR076-0000[a]		10	superseded by LDW-SS5, 2 ft away
EPA SI	DR079	209860	1266467	8/24/98	SD-DR079-0000[a]		10	superseded by LDW-SS15, 2 ft away
EPA SI	DR085	207054	1267392	8/31/98	SD-DR085-0000[a]		10	superseded by LDW-SSB2b, 6 ft away
EPA SI	DR087	206171	1267735	8/12/98	SD-DR087-0000[a]		10	superseded by LDW-SS37, 3 ft away
EPA SI	DR088	205507	1267960	8/31/98	SD-DR088-0000[a]		10	superseded by LDW-SS40, 1 ft away

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
EPA SI	DR093	203278	1268849	8/17/98	SD-DR093-0000		10	sample inside 1999 James Hardie dredge area
EPA SI	DR096	203090	1269369	9/2/98	SD-DR096-0000		10	sample inside 1999 Glacier Ready Mix dredge area
EPA SI	DR097	203284	1269528	8/20/98	SD-DR097-0000[a]		10	superseded by LDW-SS63, 10 ft away
EPA SI	DR106	201545	1270217	8/19/98	SD-DR106-0000[a]		10	superseded by LDW-SS76, 1 ft away
EPA SI	DR111	201460	1269985	8/19/98	SD-DR111-0000-CC[a]		10	superseded by DR-111, 5 ft away
EPA SI	DR113	200851	1270429	8/19/98	SD-DR113-0000-CC[a]		10	superseded by LDW-SS81, 1 ft away
EPA SI	DR123	203890	1267968	9/14/98	SD-DR123-0000[a]		10	superseded by LDW-SS57, 7 ft away
EPA SI	DR125	204137	1268161	8/31/98	SD-DR125-0000		10	sample inside Glacier NW 2005 dredge area
EPA SI	DR131	201998	1268809	8/13/98	SD-DR131-0000-CC[a]		10	superseded by LDW-SS70, 1 ft away
EPA SI	DR142	199659	1271055	8/20/98	SD-DR142-0000		10	sample inside 1998 Hurlen-Boyer dredge area
EPA SI	DR143	199472	1271243	8/31/98	SD-DR143-0000		10	sample inside 1998 Hurlen-Boyer dredge area
EPA SI	DR145	203146	1268825	8/17/98	SD-DR145-0000		10	inside 1999 James Hardie dredge area
EPA SI	DR160	204365	1268236	8/12/98	SD-DR160-0000[a]		10	superseded by LDW-SS51, 2 ft away
EPA SI	DR163	203131	1268774	8/27/98	SD-DR163-0000		10	inside 1999 James Hardie dredge area
EPA SI	DR175	198641	1272581	8/20/98	SD-DR175-0000[a]		10	superseded by LDW-SS94, 1 ft away
EPA SI	DR181	198868	1273272	9/1/98	SD-DR-181-0000[a]		10	superseded by DR-181, 2 ft away
EPA SI	DR186	195288	1275958	8/27/98	SD-DR186-0000[a]		10	superseded by LDW-SS111, 1 ft away
EPA SI	DR187	194730	1276134	8/27/98	SD-DR187-0000[a]		10	superseded by LDW-SS115, 3 ft away
EPA SI	DR191	198744	1271964	8/13/98	SD-DR191-0000		10	sample falls within 1998 Hurlen-Boyer dredge area
EPA SI	DR192	198507	1272251	8/13/98	SD-DR192-0000		10	sample falls within 1998 Hurlen-Boyer dredge area
EPA SI	DR198	197314	1273506	8/20/98	SD-DR198-0000[a]		10	superseded by LDW-SS102, 3 ft away
EPA SI	DR202	197040	1273815	8/27/98	SD-DR202-0000[a]		10	superseded by LDW-SS104, 2 ft away
EPA SI	DR228	196122	1275015	9/1/98	SD-DR228-0000		10	sample inside 1999 USACE dredge area
EPA SI	DR229	195739	1275490	8/27/98	SD-DR229-0000		10	sample inside 1999 USACE dredge area
EPA SI	DR230	194778	1275907	8/25/98	SD-DR230-0000		10	sample inside 1999 USACE dredge area
EPA SI	DR234	196363	1274835	8/19/98	SD-DR234-0000		10	sample inside 1999 USACE dredge area
EPA SI	DR235	195030	1275851	8/26/98	SD-DR235-0000		10	sample inside 1999 USACE dredge area
EPA SI	DR238	193348	1276577	8/27/98	SD-DR238-0000[a]		10	superseded by LDW-SS125, 1 ft away
EPA SI	DR242	192929	1277477	8/24/98	SD-DR242-0000-CC[a]		10	superseded by RhônePoulenc2004 loc. SB-1
EPA SI	DR255	190300	1278369	9/15/98	SD-DR255-0000		10	Inside 1999 Norfolk dredge area
EPA SI	DR256	190118	1278608	9/15/98	SD-DR256-0000		10	Inside 1999 Norfolk dredge area
EPA SI	DR260	193122	1276042	9/2/98	SD-DR260-0000		10	Inside Duwamish YC 1999 dredge area
EPA SI	DR261	192860	1276181	8/25/98	SD-DR261-0000		10	Inside Duwamish YC 1999 dredge area

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
EPA SI	DR271	189995	1277573	9/15/98	SD-DR271-0000[a]		10	superseded by LDW-SS148, 2 ft away
EPA SI	DR282	194054	1276089	8/25/98	SD-DR282-0000		10	sample inside 1999 USACE dredge area
EPA SI	DR283	193104	1276196	8/25/98	SD-DR283-0000		10	Inside Duwamish YC 1999 dredge area
EPA SI	DR286	191854	1276508	8/26/98	SD-DR286-0000-CC[a]		10	superseded by LDW-B10b, 3 ft away
EPA SI	DR288	193668	1276259	8/25/98	SD-DR288-0000		10	sample inside 1999 USACE dredge area
Harbor Island RI	K-05	210286	1266258	9/27/91	K-05-1-D1[a]		2	superseded by TRI-10, 10 ft away
Harbor Island RI	K-05	210286	1266258	9/27/91	K-05-2-D1[a]	field duplicate	2	superseded by TRI-10, 10 ft away
Harbor Island RI	K-05	210286	1266258	9/27/91	K-05-3-D1[a]	field duplicate	2	superseded by TRI-10, 10 ft away
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-1[a]		2	superseded by TRI-10, 10 ft away
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-1-B[a]		2	superseded by TRI-10, 10 ft away
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-2[a]		2	superseded by TRI-10, 10 ft away
Harbor Island RI	K-05	210286	1266258	10/14/91	K-05-3[a]		2	superseded by TRI-10, 10 ft away
Harbor Island RI	K-07	211229	1266883	9/30/91	K-07		2	superseded by LDW-SS4,1 ft away
Harbor Island RI	K-08	211686	1267033	9/30/91	K-08		2	north of RM 0, therefore outside of study area
Harbor Island RI	K-11	211372	1266032	9/30/91	K-11[a]		2	superseded by LDW-SS1, less than 1 ft away
Harbor Island RI	K-12	211610	1265764	9/30/91	K-12		2	north of RM 0, therefore outside of study area
Harbor Island RI	K-13	211863	1265485	9/30/91	K-13		2	north of RM 0, therefore outside of study area
JorgensenAugust2004	SD-323-S	195348	1275946	8/17/04	SD-323-0000		10	superseded by LDW-SS10, 3 ft away
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-1		10	Coordinates uncertain and do not meet project DQOs
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-2		10	Coordinates uncertain and do not meet project DQOs
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-3		10	Coordinates uncertain and do not meet project DQOs
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-4		10	Coordinates uncertain and do not meet project DQOs
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-5		10	Coordinates uncertain and do not meet project DQOs
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-6		10	Coordinates uncertain and do not meet project DQOs
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-7		10	Coordinates uncertain and do not meet project DQOs

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-8		10	Coordinates uncertain and do not meet project DQOs
KC WQA	Kellogg Island - Amphipods	207202	1266150	7/14/98	L13812-9		10	Coordinates uncertain and do not meet project DQOs
KC WQA	West Marginal Way - Amphipods	207348	1266548	7/23/98	L13898-1		10	Coordinates uncertain and do not meet project DQOs
KC WQA	West Marginal Way - Amphipods	207348	1266548	7/23/98	L13898-2		10	Coordinates uncertain and do not meet project DQOs
KC WQA	West Marginal Way - Amphipods	207348	1266548	7/23/98	L13898-3		10	Coordinates uncertain and do not meet project DQOs
LDWRI-Benthic	B4b	204605	1268471	8/28/04	LDW-B4b-S[a]		10	superseded by B4B, 4 ft away
LDWRI-SurfaceSedimentRound1	LDW-SS10	210287	1266257	1/17/05	LDW-SS10-010[a]		10	superseded by TRI-010, 9 ft away
LDWRI-SurfaceSedimentRound1	LDW-SS18	209531	1266844	2/1/05	LDW-SS18-010		10	Collected within 200 ft of Duwamish/Diagonal dredging, thereby reflecting post-remediation conditions in this area
LDWRI-SurfaceSedimentRound1	LDW-SS20	209158	1266779	2/2/05	LDW-SS20-010		10	Collected within 200 ft of Duwamish/Diagonal dredging, thereby reflecting post
LDWRI-SurfaceSedimentRound1	LDW-SS22	208754	1267170	1/17/05	LDW-SS22-010		10	Collected within 200 ft of Duwamish/Diagonal dredging, thereby reflecting post
LDWRI-SurfaceSedimentRound1	LDW-SS51	204366	1268234	1/18/05	LDW-SS51-010[a]		10	superseded by TRI-051, 6 ft away
LDWRI-SurfaceSedimentRound1	LDW-SS96	198348	1272753	1/21/05	LDW-SS96-010[a]		10	superseded by TRI-096, 7 ft away
LDWRI-SurfaceSedimentRound1	LDW-SS123	193932	1276329	1/24/05	LDW-SS123-010[a]		10	superseded by AN-019, 8 ft away
LDWRI-SurfaceSedimentRound1	LDW-SS123	193932	1276329	1/24/05	LDW-SS203-010[a]	field duplicate	10	superseded by AN-019, 8 ft away
LDWRI-SurfaceSedimentRound2	LDW-SS16	209832	1266290	3/8/05	LDW-SS16-010[a]		10	superseded by TRI-016, 5 ft away
LDWRI-SurfaceSedimentRound2	LDW-SS21	209139	1266686	3/8/05	LDW-SS21-010		10	Collected within 200 ft of Duwamish/Diagonal dredging, thereby reflecting post
LDWRI-SurfaceSedimentRound2	LDW-SS25	208202	1267285	3/10/05	LDW-SS25-010		10	Collected within 200 ft of Duwamish/Diagonal dredging, thereby reflecting post
LDWRI-SurfaceSedimentRound2	LDW-SS-45	204843	1268062	3/10/05	LDW-SS45-010[a]		10	superseded by TRI-045, 7 ft away
LDWRI-SurfaceSedimentRound2	LDW- SS-151	189733	1279105	3/15/05	LDW-SS151-010[a]		10	superseded by DR-02, 8 ft away
NOAA SiteChar	CH0005	194120	1276106	10/9/97	CH02-01		10	sample inside 1999 USACE dredge area
NOAA SiteChar	CH0009	195697	1275667	10/15/97	CH03-01		10	sample inside 1999 USACE dredge area
NOAA SiteChar	CH0010	195402	1275830	10/15/97	CH03-02		10	sample inside 1999 USACE dredge area
NOAA SiteChar	CH0011	195146	1275866	10/15/97	CH03-03		10	sample inside 1999 USACE dredge area
NOAA SiteChar	CH0012	194742	1275998	10/15/97	CH03-04		10	sample inside 1999 USACE dredge area
NOAA SiteChar	CH0017	196259	1274916	11/13/97	CH04-04		10	sample inside 1999 USACE dredge area

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
NOAA SiteChar	CH0023	201244	1269902	10/16/97	CH07-01[a]		10	superseded by LDW-SS79, 2 ft away
NOAA SiteChar	EIT061	194079	1276332	9/29/97	EIT06-02[a]		10	superseded by LDW-SS121, 4 ft away
NOAA SiteChar	EIT074	199309	1271869	11/3/97	EIT09-01[a]		10	superseded by LDW-SS88, 7 ft away
NOAA SiteChar	EST135	192760	1276632	11/12/97	EST07-07[a]		10	superseded by LDW-B8b, 3 ft away
NOAA SiteChar	EST144	193933	1276329	9/25/97	EST09-04[a]		10	superseded by AN-019, 9 ft away
NOAA SiteChar	EST152	195584	1275858	9/24/97	EST11-03[a]		10	superseded by Jorgenson 2004 location SD-309-S
NOAA SiteChar	EST154	195474	1275881	9/24/97	EST11-04[a]		10	superseded by Jorgenson 2004 location SD-334-S
NOAA SiteChar	EST180	198751	1272435	10/6/97	EST13-05[a]		10	superseded by LDW-SS92, 2 ft away
NOAA SiteChar	EST202	205988	1267994	9/17/97	EST19-01		10	sample inside Lehigh NW 2004 dredge area
NOAA SiteChar	EST219	207310	1267542	9/17/97	EST21-03[a]		10	superseded by LDW-SS27, 5 ft away
NOAA SiteChar	WIT280	200290	1270188	10/3/97	WIT11-01[a]		10	superseded by LDW-B5a, 10 ft away
NOAA SiteChar	WST313	192989	1276092	10/20/97	WST06-01		10	sample inside 1999 Duwamish YC dredge area
NOAA SiteChar	WST316	193828	1276100	10/1/97	WST07-02		10	sample inside 1999 USACE dredge area
NOAA SiteChar	WST317	193461	1276205	10/15/97	WST07-03		10	sample inside 1999 USACE dredge area
NOAA SiteChar	WST318	195552	1275619	10/2/97	WST08-01		10	sample inside 1999 USACE dredge area
NOAA SiteChar	WST319	195294	1275737	10/2/97	WST08-02		10	sample inside 1999 USACE dredge area
NOAA SiteChar	WST320	195074	1275811	10/2/97	WST08-03		10	sample inside 1999 USACE dredge area
NOAA SiteChar	WST321	194891	1275832	10/2/97	WST08-04		10	sample inside 1999 USACE dredge area
NOAA SiteChar	WST323	195779	1275215	10/21/97	WST09-02[a]		10	superseded by T117-SE-10-G
NOAA SiteChar	WST341	198722	1272031	10/21/97	WST13-03		10	inside Hurlen-Boyer 1998 dredge area
NOAA SiteChar	WST342	199913	1270839	10/23/97	WST14-01[a]		10	superseded by EPA SI location DR141
NOAA SiteChar	WST344	199541	1271195	10/10/97	WST14-02		10	inside Hurlen-Boyer 1998 dredge area
NOAA SiteChar	WST367	206409	1266994	9/19/97	WST20-02[a]		10	superseded by EPA SI location DR048
Norfolk-cleanup1	NFK001	190277	1278459	8/18/94	L4321-1		10	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK002	190237	1278506	8/18/94	L4321-2[a]		10	superseded by Ecology - Norfolk locations 2,3 and 4
Norfolk-cleanup1	NFK004	190165	1278594	8/18/94	L4321-4		10	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK007	190249	1278415	8/22/94	L4321-7		10	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK008	190203	1278497	8/17/94	L4321-8		10	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK009	190154	1278564	8/17/94	L4321-9		10	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK009	190154	1278564	8/31/94	L4321-25		15	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK012	190158	1278480	8/18/94	L4321-13		10	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK013	190089	1278542	8/19/94	L4321-14		10	inside 1999 Norfolk dredge area
Norfolk-cleanup1	NFK014	190015	1278609	8/19/94	L4321-16	field duplicate	10	inside 1999 Norfolk dredge area

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
Norfolk-cleanup2	NFK201	190294	1278424	8/23/95	L6725-1		10	inside 1999 Norfolk dredge area
Norfolk-cleanup2	NFK202	190219	1278524	8/23/95	L6725-2		10	inside 1999 Norfolk dredge area
Norfolk-cleanup2	NFK203	190129	1278619	8/23/95	L6725-3		10	inside 1999 Norfolk dredge area
Norfolk-cleanup2	NFK205	190234	1278457	8/28/95	L6725-5		10	inside 1999 Norfolk dredge area
Norfolk-cleanup3	NFK201	190294	1278424	12/5/95	L7462-16		10	inside 1999 Norfolk dredge area
Norfolk-cleanup3	NFK312	190314	1278384	12/5/95	L7462-12		10	inside 1999 Norfolk dredge area
Norfolk-cleanup3	NFK314	190257	1278407	12/6/95	L7462-14		10	inside 1999 Norfolk dredge area
Norfolk-cleanup3	NFK315	190186	1278524	12/5/95	L7462-15		10	inside 1999 Norfolk dredge area
Norfolk-monit1	NFK501	190150	1278591	4/23/99	L15421-1[a]		10	superseded by April-01 sample from this location
Norfolk-monit1	NFK504	190083	1278626	4/23/99	L15421-4[a]		10	superseded by LDW-SS344, 1 ft away
Norfolk-monit2a	NFK501	190160	1278569	10/8/99	L16628-1		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit2a	NFK502	190164	1278512	10/8/99	L16628-3		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit2a	NFK502	190164	1278512	10/8/99	L16628-4[a]		10	superseded by NFK502, 5 ft away
Norfolk-monit2a	NFK503	190181	1278543	10/8/99	L16628-5[a]		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit2a	NFK503	190181	1278543	10/8/99	L16628-6		10	superseded by April-02 sample from this location
Norfolk-monit2a	NFK504	190086	1278619	10/8/99	L16628-7		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit2b	NFK501	190166	1278593	2/8/00	L17315-1		2	superseded by NFK501, 11 ft away[b]
Norfolk-monit2b	NFK503	190197	1278548	2/8/00	L17315-3		2	superseded by LDW-SS341, 2 ft away
Norfolk-monit2b	NFK506	190257	1278543	2/10/00	L17311-1		10	superseded by Ecology, Norfolk locations 5 and 7
Norfolk-monit3	NFK501	190142	1278573	4/6/00	L17647-1		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit3	NFK502	190165	1278511	4/6/00	L17647-3		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit3	NFK502	190165	1278511	4/6/00	L17647-4[a]		10	superseded by LDW-SS342, 9 ft away
Norfolk-monit3	NFK503	190179	1278543	4/6/00	L17647-5		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit3	NFK503	190179	1278543	4/6/00	L17647-6[a]		10	superseded by April-02 sample from this location
Norfolk-monit3	NFK504	190076	1278628	4/6/00	L17647-7		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit3	NFK504	190076	1278628	4/6/00	L17647-8[a]		10	superseded by LDW-SS344, 7 ft away
Norfolk-monit4	NFK501	190153	1278583	4/24/01	L20703-1		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit4	NFK502	190156	1278512	4/24/01	L20703-3		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit4	NFK502	190156	1278512	4/24/01	L20703-4[a]		10	superseded by NFK502, 4 ft away
Norfolk-monit4	NFK503	190177	1278549	4/24/01	L20703-5		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit4	NFK503	190177	1278549	4/24/01	L20703-6		10	superseded by April-02 sample from this location
Norfolk-monit4	NFK504	190075	1278625	4/24/01	L20703-7		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit4	NFK504	190075	1278625	4/24/01	L20703-8[a]		10	superseded by LDW-SS344, 7 ft away

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
Norfolk-monit5	NFK501	190165	1278589	4/30/02	L23995-1		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit5	NFK501	190165	1278589	4/30/02	L23995-2[a]		10	superseded by LDW-SS343, 4 ft away
Norfolk-monit5	NFK502	190156	1278513	4/30/02	L23995-3		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit5	NFK502	190156	1278513	4/30/02	L23995-4[a]		10	superseded by LDW-SS342, 3 ft away
Norfolk-monit5	NFK503	190177	1278545	4/30/02	L23995-5		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit5	NFK504	190074	1278622	4/30/02	L23995-7		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit5	NFK504	190074	1278622	4/30/02	L23995-8[a]		10	superseded by LDW-SS344, 9 ft away
Norfolk-monit6	NFK501	190167	1278586	4/23/03	L28052-1		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit6	NFK501	190167	1278586	4/23/03	L28052-2[a]		10	superseded by NFK501, 4 ft away
Norfolk-monit6	NFK502	190156	1278511	4/23/03	L28052-3		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit6	NFK502	190156	1278511	4/23/03	L28052-4[a]		10	superseded by NFK502, 4 ft away
Norfolk-monit6	NFK503	190197	1278543	4/23/03	L28052-5		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit6	NFK503	190197	1278543	4/23/03	L28052-6[a]		10	superseded by LDW-SS341, 4 ft away
Norfolk-monit6	NFK504	190076	1278622	4/23/03	L28052-7		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit6	NFK504	190076	1278622	4/23/03	L28052-8[a]		10	superseded by LDW-SS344, 7 ft away
Norfolk-monit7	NFK501	190169	1278589	4/5/04	L31635-1		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit7	NFK501	190169	1278589	4/5/04	L31635-2[a]		10	superseded by LDW-SS343, 1 ft away
Norfolk-monit7	NFK502	190156	1278515	4/5/04	L31635-3		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit7	NFK502	190156	1278515	4/5/04	L31635-4[a]		10	superseded by LDW-SS342, 2 ft away
Norfolk-monit7	NFK503	190194	1278543	4/5/04	L31635-5		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit7	NFK503	190194	1278543	4/5/04	L31635-6[a]		10	superseded by LDW-SS341, 2 ft away
Norfolk-monit7	NFK504	190079	1278627	4/5/04	L31635-7		2	only 0-2 cm depth, 10 cm depth preferred
Norfolk-monit7	NFK504	190079	1278627	4/5/04	L31635-8[a]		10	superseded by LDW-SS344, 3 ft away
Plant 2 RFI-1	SD-SWY07	195628	1275855	6/13/95	SD-SWY07-0000[a]		9	superseded by Plant2-Transformer Phase1 loc. SD-SWY17
Plant 2 RFI-2b	SD-DUW83	195679	1275624	4/3/96	SD2B-DUW83-0000		9	sample inside 1999 USACE dredge area
Plant 2 RFI-2b	SD-DUW90	195533	1275877	4/4/96	SD2B-DUW90-0000[a]		9	superseded by Jorgenson August 2004 loc SD-343-S
Plant 2 RFI-2b	SD-DUW92	195387	1275932	4/2/96	SD2B-DUW92-0000[a]		9	superseded by Jorgenson August 2004 loc SD-320-S
PSAMP/NOAA98	203	208455	1266636	6/22/98	203		2	not acceptable for all phase 2 uses, insufficient QA/QC available
PSAMP/NOAA98	204	208272	1267209	6/22/98	204		2	not acceptable for all phase 2 uses, insufficient QA/QC available
PSAMP/NOAA98	205	202467	1269112	6/23/98	205		2	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-1	A11-01	192748	1276772	3/3/94	RPL-A11-01-01		15	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-1	A11-02	192817	1276678	3/3/94	RPL-A11-02-01		15	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-1	A11-03	192906	1276719	3/3/94	RPL-A11-03-01		15	not acceptable for all phase 2 uses, insufficient QA/QC available

Table N-5 LDW Surface Sediment Samples Collected Since 1990 Excluded from the FS Baseline Dataset (continued)

Event Name	Location Name	Northing[a]	Easting[a]	Sampling Date	Sample ID	Field QC	Lower Depth (cm)	Rationale for Exclusion
Rhône-Poulenc RFI-1	A11-03	192906	1276719	3/3/94	RPL-A11-08-01	duplicate	15	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-1	A11-04	193038	1276583	3/3/94	RPL-A11-04-01		15	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-1	A11-05	193145	1276637	3/3/94	RPL-A11-05-01		15	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-1	A11-06	193383	1276536	3/3/94	RPL-A11-06-01		15	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-1	A11-07	193521	1276514	3/3/94	RPL-A11-07-01		15	not acceptable for all phase 2 uses, insufficient QA/QC available
Rhône-Poulenc RFI-2	A11-05	193145	1276637	8/18/94	RPL-A11-05-02[a]		2	superseded by LDW-SS126, 2 ft away
Rhône-Poulenc RFI-2	A11-05	193145	1276637	8/18/94	RPL-A11-10-02[a]	field duplicate	2	superseded by LDW-SS126, 2 ft away
Rhône-Poulenc RFI-3	06-intsed-2	193293	1276681	7/1/96	06-intsed-2[a]		10	superseded by RhônePoulenc2004 loc. SH-04
Rhône-Poulenc RFI-3	07-intsed-1	193466	1276645	7/1/96	07-intsed-1[a]		10	superseded by RhônePoulenc2004 loc. SH-02
T117BoundaryDefinition	T117-SE-19-G	195677	1275494	12/5/03	T117-SE19-SG		10	superseded by T117-SE107-G, 2 ft away
T117BoundaryDefinition	T117-SE-46-G	195148	1275660	12/9/03	T117-SE46-SG[a]		10	superseded by T117-SE117-G, 5 ft away

Notes:

1. Sampling location coordinates are Washington State Plane North, U.S. survey ft, NAD83.
2. Although these data were excluded from the FS baseline dataset and were not used for mapping the extent of contamination, some of these data were used for time trend analyses (see Section 2.2.3 for details).

a. Newer results have replaced older results in the FS baseline dataset, but for chemicals not analyzed in the newer samples, older results have been preserved in the FS baseline dataset. In most cases, only a small number of chemical results from the older sample are used.

b. Nominal distance between oldest and newest location is slightly greater than the 10-ft threshold. Results from older sample were originally superseded in the RI by sample that has been subsequently superseded by a third (newer) sample shown in this table. The distances between this intermediate-date sample and the newest and oldest samples were both less than 10 ft.

cm = centimeter; DQO = data quality objective; Ecology = Washington State Department of Ecology; EPA = U.S. Environmental Protection Agency; FS = feasibility study; ID = identification; KC = King County; LDW = Lower Duwamish Waterway; NOAA = National Oceanic and Atmospheric Administration; QA = quality assurance; QC = quality control; RI = remedial investigation; RFI = RCRA facility investigation; SI = site investigation; RCRA = Resource Conservation and Recovery Act; USACE = U.S. Army Corps of Engineers; WQA = water quality assessment; YC = yacht club.

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Sediment Chemistry							
Duwamish/Diagonal Apr 2009 (surface sediment)	Duw Diagonal April 2009	2009	RM 0.3 – 0.7 east and navigation channel	PCBs (as Aroclors), metals, SVOCs, pesticides, dioxins/furans, conventionals	23 surface sediment samples (0-10 cm) and 3 field replicates from 23 locations collected using multiple casts of a 0.1-m^2 van Veen grab sampler; 3 composites and 1 field replicate were analyzed for dioxins/furans	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2003a, 2010) King County (2005a) included in Anchor (2007a), Appendix A
Boeing Developmental Center 2009 (surface sediment)	Boeing DC 2009	2009	RM 4.9 – 5.0 east	PCBs (as Aroclors), TOC, total solids	3 surface sediment samples (0-5 cm) and one field duplicate collected using disposable plastic spoons	data validation consistent with EPA guidelines	Project Performance Corporation (2004) CALIBRE (2009a)
Boeing Plant 2-2009 (subsurface sediment)	Boeing P2 2009 DSOA	2009	RM 2.9 – 3.7 east and navigation channel	TOC, total solids, PCB Aroclors, VOCs	226 subsurface sediment samples and 23 field duplicates from 33 locations collected using the MudMole™ impact corer with the exception of one sample, which was collected using freeze coring methods. Samples were collected at 1-ft intervals down to a depth of 12 to 13 ft below mudline	data validation consistent with EPA guidelines; validation qualifiers added to database	AMEC Geomatrix (2010)
Turning basin maintenance dredging – 2009 (subsurface sediment)	LDW Turning Basin 09	2009	RM 4.1-4.3 navigation channel	PCBs (as Aroclors), pesticides, SVOCs, VOCs, metals, conventionals	11 subsurface sediment samples (up to 13 ft in depth) from 13 locations collected using a vibracorer	data review consistent with EPA guidelines; validation qualifiers added to database	SAIC (2008a, b, 2009a, b)
Terminal 115 (surface and subsurface sediment)	T115 Intertidal 2009 (surface) T115 (subsurface)	2009 (surf.) 2008 (subsurf.)	RM 1.7 – 1.9 west	PCBs (as Aroclors), SVOCs, pesticides, dioxin/furans, conventionals	5 surface sediment samples (0-10 cm) and 1 field duplicate from 5 locations 11 subsurface sediment samples (2 samples from 0 to 3 ft, 9 1-ft z-layer samples down to 6 ft) from 4 locations using a vibracorer	data validation consistent with EPA guidelines; validation qualifiers added to database	Anchor (2007b, 2008) Anchor QEA (2009a, c)
Boeing Developmental Center 2008 (surface sediment)	Boeing DC 2008	2009	RM 4.9 – 5.0 east	PCBs (as Aroclors), TOC, total solids	3 surface sediment samples (0-5 cm) and one field duplicate collected using disposable plastic spoons	data validation consistent with EPA guidelines	Project Performance Corporation (2004) CALIBRE (2009b)
Ecology upstream sampling (surface sediment)	LDW Upstream Sed	2008	RM 4.9 – 7.4	PCBs (as Aroclors), SVOCs, metals, conventionals	86 surface sediment samples (1-10 cm) and 2 field duplicates collected using a van Veen sampler or by manual methods	data review consistent with EPA guidelines; validation qualifiers added to database	Ecology (2008) Ecology and Environment (2009)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Turning basin maintenance dredging – 2008 (surface and subsurface sediment)	LDW Turning Basin 08	2008	RM 4.1-4.7 navigation channel	PCBs (as Aroclors), dioxins/ furans, pesticides, SVOCs, VOCs, metals, conventionals	32 subsurface sediment samples (up to 6 ft in depth) from 32 locations collected using a vibracorer and modified Young van Veen grab sampler	data review consistent with EPA guidelines; validation qualifiers added to database	SAIC (2008a, b, 2009a, b)
Terminal 117 boundary delineation (surface sediment)	T117 Sed Boundary	2008	RM 3.4 – 3.7 west and navigation channel	PCBs (as Aroclors), SVOCs, pesticides, metals, conventionals	17 surface sediment samples (0-10 cm) and 1 field duplicate collected using an Eckman grab sampler or by hand using a stainless steel spoon; 1 sample composited from 3 grabs (2-3 cm) because of insufficient penetration	data validation consistent with EPA guidelines; validation qualifiers added to database	Windward et al. (2003) Windward (2008) Windward and Integral (2009)
Duwamish/Diagonal Mar 2008 (surface sediment)	DuwDiagonal March 2008	2008	RM 0.3 – 0.8 east and navigation channel	PCBs (as Aroclors), metals, SVOCs, pesticides, conventionals	23 surface sediment samples (0 to10 cm) and 3 field replicates from 23 locations collected using multiple casts of a 0.1-m^2 van Veen grab sampler	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2003a, 2010) King County (2005a) included in Anchor (2007a), Appendix A
Slip 4 investigation of PCB sources (subsurface sediment)	Slip 4-Landau 2008	2008	Slip 4 (RM 2.8 – 2.9 east)	PCBs (as Aroclors)	13 subsurface sediment samples (up to 24 in. depth) from 4 locations collected by hand using divers	data validation consistent with EPA guidelines; no validation qualifiers needed	Landau (2008)
Boeing Plant 2-2008 (subsurface sediment)	Boeing P2 2008 DSOA	2008	RM 3.1 – 3.7east	PCBs (as Aroclors), TOC, total solids	37 subsurface sediment samples and 2 field duplicates collected at 1-ft intervals from 3 to 15 ft below mudline from 10 locations using a MudMole™ sampler	data validation consistent with EPA guidelines; validation qualifiers added to database	Geomatrix (2007) AMEC Geomatrix (2009b)
Boeing Plant 2-under building (subsurface sediment)	Boeing P2 Under Bldg	2008	RM 3.3 – 3.6 east	PCBs (as Aroclors), metals, SVOCs, conventionals	61 samples and 6 field duplicates from 18 locations were collected using a hollow-stem auger drill rig with a split-spoon sampler. Samples were collected at 1- to 1.5-ft intervals down to depths of 5 to 9 ft below mudline	data validation consistent with EPA guidelines; validation qualifiers added to database	Geomatrix and Floyd|Snider (2008) AMEC Geomatrix (2009a)
Industrial Container Services (surface sediment)	Industrial Container Services	2007	RM 2.1 – 2.3 west	PCBs (as Aroclors), pesticides, SVOCs, TPH, metals, conventionals	5 surface sediment samples (0 to 10 cm) and 1 field duplicate collected by hand using stainless steel scoops	data validation consistent with EPA guidelines; validation qualifiers added to database	SAIC (2007, 2009c)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
8801 E. Marginal (surface and subsurface sediment)	8801 E Marginal (formerly Kenworth PACCAR)	2008, 2006	RM 3.8 – 4.1 east	PCBs (as Aroclors), SVOCs, pesticides, metals, conventionals	29 surface sediment samples (0 to 10 cm) and 3 field duplicates collected using a van Veen sampler except where soft sediment or low tide events necessitated the use of an Eckman sampler or manual sample collection using a stainless steel trowel. 24 subsurface sediment samples and 1 field duplicate from 4 locations collected using a vibracorer. Samples were collected at 1-ft intervals to a depth of 6 ft below mudline	data validation consistent with EPA guidelines; validation qualifiers added to database	Anchor (2006) Anchor QEA (2009b)
Boeing Plant 2-DSOA west boundary (surface and subsurface sediment)	Plant 2-DSOA West Boundary and Nav Channel	2007	RM 3.1 – 3.6 navigation channel	PCBs (as Aroclors), TOC, total solids	11 surface sediment samples (0-10 cm) and 1 field duplicate collected using 0.1-m^2 modified van Veen grab sampler. 48 subsurface sediment samples (1-9 ft) and 1 field duplicate from 12 locations were collected using a MudMole™ sampler	data validation consistent with EPA guidelines; validation qualifiers added to database	Geomatrix (2007, 2008)
Boeing Developmental Center 2007 (surface sediment)	Boeing Developmental Center-2007	2007	RM 4.9 – 5.0 east	PCBs (as Aroclors), TOC, total solids	3 surface sediment samples (0-5 cm) and one field duplicate collected using disposable plastic spoons	data validation consistent with EPA guidelines	Project Performance Corporation (2004) CALIBRE (2008)
Duwamish/Diagonal Apr 2007 (surface sediment)	DuwDiagonal April 2007	2007	RM 0.3 – 0.8 east and navigation channel	PCBs (as Aroclors), SVOCs, pesticides, metals, conventionals	23 surface sediment samples (0-10 cm) and 3 field replicates from 23 locations collected using multiple casts of a 0.1-m^2 van Veen grab sampler	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2003a, 2005a) included in Anchor (2007a), Appendix A King County and Anchor (2008)
Slip 4 boundary definition (surface and subsurface sediment)	Slip 4 EAA 2008	2006	Slip 4 (RM 2.8 – 2.9 east)	PCBs (as Aroclors), SVOCs, TPH, pesticides, metals, geotechnical parameters, conventionals	4 surface sediment samples (0-10 cm) and 1 field replicate collected by hand, using stainless steel spoons. 26 subsurface sediment samples including one composite representing the total lengths of 3 cores were collected from 11 locations using either split spoon (max core tube length of 18 or 24 in.) or Shelby tube (max 30 in.) samplers	data validation consistent with EPA guidelines; validation qualifiers added to database	Integral (2006, 2007)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Ecology SPI (surface sediment)	Ecology SPI	2006	RM 0.0 – 2.9 east, west, and navigation channel (including Slip 4)	PCBs (as Aroclors), SVOCs, metals, organotins, conventionals	30 surface sediment samples (0-10 cm) and 1 field duplicate collected using a 0.1-m^2 double van Veen grab sampler	data validation consistent with EPA guidelines; validation qualifiers added to database	Germano & Associates (2006) Ecology (2007)
Duwamish Diagonal March 2006 cap monitoring – year 2, perimeter sediment characterization, and ENR cap sediment characterization – year 1	DuwDiag March 2006	2006	RM 0.4-0.6 east	Grain size, TOC, metals, SVOCs, PCB Aroclors, organochlorine pesticides	23 samples and 3 field duplicate samples; 8 grab samples collected with 6" coring device; 18 samples composited using equal aliquots of 3-10 grab samples collected using a van Veen grab sampler (0-10 cm)	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers will be added to database	King County (2006a, b, 2007)
Duwamish/Diagonal Aug 2005 (surface sediment)	DuwDiagonal August 2005	2005	RM 0.5 – 0.6 east	PCBs (as Aroclors), metals, SVOCs, pesticides, conventionals	1 surface sediment sample (0-10 cm) collected using multiple casts of a 0.1-m^2 modified, stainless steel van Veen grab sampler; 2 bank samples were collected by hand on the same day	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2003a, 2005a) included in Anchor (2007a), Appendix A
Boeing Developmental Center 2005 Annual Sampling of South Storm Drain System – Year 2	Boeing Developmental Center-2005	2005	RM 4.9 east	PCB Aroclors, TOC, total solids	3 surface (0-2 cm) sediment grab samples (1 field duplicate sample) collected using disposable plastic spoons	QC consistent with EPA guidelines; no validation qualifiers needed	CALIBRE (2006)
Duwamish Diagonal Jan-Feb 2005 post-dredge perimeter - before thin-layer cap placement	DuwDiag Jan 2005	2005	RM 0.4-0.6 east	Grain size, TOC, metals, SVOCs, PCB Aroclors, organochlorine pesticides	22 grab surface (0-10 cm) sediment samples (2 field replicates) using van Veen grab sampler	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2005f)
Duwamish Diagonal Mar 2005 post-dredge perimeter - after thin-layer cap placement	DuwDiag March 2005	2005	RM 0.4-0.6 east	Grain size, TOC, metals, SVOCs, PCB Aroclors, organochlorine pesticides	8 surface sediment samples (1 replicate) using a diver-actuated coring device from the top 10 cm of sediment	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2005e)
Duwamish Diagonal April 2005 baseline cap monitoring - year 1	DuwDiag April 2005	2005	RM 0.4-0.6 east	TOC, grain size, metals, SVOCs, PCB Aroclors, organochlorine pesticides	7 surface sediment grab samples (1 replicate) using van Veen grab samplers from the top 10 cm of sediment	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2005d)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Boeing Developmental Center 2004 Annual Sampling of South Storm Drain System – year 1	Boeing Developmental Center-2004	2004	RM 4.9 east	PCB Aroclors, TOC, total solids	3 surface (0-2 cm) sediment grab samples (1 field duplicate sample) collected using disposable plastic spoons	QC consistent with EPA guidelines; no validation qualifiers needed	CALIBRE (2005)
Triad approach (immunoassay as a real-time measure) to characterize PCB in a Washington riverine sediment site	Jorgensen August 2004	2004	RM 3.5-3.7 east	TOC, SVOCs, grain size, mercury, lead	18 surface sediment samples (2 duplicate samples) using the van Veen sampler (<10 cm) and 50 subsurface sediment samples from 17 locations collected by vibracorer (1-6 ft, samples generally at 1-ft intervals)	data validation consistent with EPA guidelines; validation qualifiers for all fixed laboratory analyses added to database; field screening data may be used for informational purposes only	Herrera (2005) EPA (2005a, 2004)
Upriver (Area 1) sediment characterization	Jorgensen April 2004	2004	RM 3.6-3.7 east	metals, PCB Aroclors, TOC, grain size	75 subsurface sediment samples from 22 sediment cores (2 duplicate cores) from 20 locations using the MudMole (6.8 to 10.6-ft cores; samples generally at 1-ft intervals)	data validation consistent with EPA guidelines; validation qualifiers added to database	MCS (2004c)
Rhône-Poulenc surface/subsurface sediment	RhônePoulenc 2004	2004	RM 4.0-4.3 east	VOCs, metals, pesticides, PCB Aroclors	50 sediment samples (8 duplicate samples) from 21 locations using a clam gun; cores were divided into upper (0-10 cm) and lower (> 10 cm) samples	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	EPA (2005b)
Duwamish Diagonal June 2004 baseline cap monitoring - year 0 (post-cap placement)	DuwDiagJune 2004	2004	RM 0.4-0.6 east	TOC, grain size, metals, PCB Aroclors, SVOCs	8 surface sediment grab samples from the top 10 cm of sediment using the van Veen grab sampler	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2005g)
Boeing Plant 2 DSOA additional vertical characterization - Phase 2	DSOAvertchar2	2004	RM 2.9-3.2 east	PCB Aroclors, TOC	28 subsurface samples from 15 sediment cores (2 duplicate samples) from 15 locations using the MudMole (3.7 to 10.6-ft cores; samples generally at 1-ft intervals)	data validation consistent with EPA guidelines; validation qualifiers added to database	MCS (2004a)
Boeing Plant 2 DSOA additional vertical characterization - Phase 3	DSOAvertchar3	2004	RM 3.0-3.4 east	PCB Aroclors, TOC	5 sediment cores from 4 new locations and one reoccupied location using the MudMole (5.4 to 9.9-ft cores; samples generally at 1-ft intervals)	data validation consistent with EPA guidelines; all data, as reported are acceptable for use	MCS (2004b)
Boyer Towing dock replacement	Boyer Towing	2004	RM 2.4 west	metals, SVOCs, PCB Aroclors, conventionals	4 surface (0-10 cm) and 4 subsurface (30-60 cm) sediment samples collected with push core	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	WR Consulting (2004)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
PSDDA characterization at the Lehigh Northwest Duwamish Waterway Facility	Lehigh NW	2004	RM 1.1 east	metals, SVOCs, PCB Aroclors, organochlorine pesticides, conventionals	3 sediment core samples (2 from 0-120 cm, 1 from 120-150 cm) collected with impact corer	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	MCS (2004d)
Slip 4 early action area site characterization	Slip4-EarlyAction	2004	Slip 4 (RM 2.8-2.9 east)	PCB Aroclors, mercury	29 grab samples (van Veen) from 0-10 cm; 58 core samples (vibracorer) taken from 11 locations; 4-6 samples taken at each location to a depth of 360 cm	data validation and data quality review consistent with EPA guidelines; data collected under existing LDW RI AOC, so no data quality review is needed in this memorandum	Integral (2004)
Additional vertical characterization, Duwamish Sediment Other Area	DSOAvert char2	2004	RM 2.8-3.7 east	PCB Aroclors	28 core samples (vibracorer) taken from 15 locations; 1-3 samples from each location from 60-144 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	MCS (2004a)
Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 5, April 2004	Norfolk-monit7	2004	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2005c)
Duwamish/Diagonal pre- and post-cleanup monitoring data	DuwDiag-Dredge Monitoring	2003-2004	RM 0.4-0.6 east	metals, PCB Aroclors, organochlorine pesticides, SVOCs	24 composite samples from 10 grab samples (van Veen) from 0-10 cm at 12 locations, sampled both before dredging and after dredging	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County et al. (2005)
Terminal 117 early action area site characterization	T117 Boundary Definition	2003-2004	RM 3.6-3.7 west	PCB Aroclors; metals, SVOCs on selected samples	46 grab samples (power grab or by hand from intertidal) from 0-10 cm; 101 core samples (vibracorer) from 18 locations, 3-6 samples collected at each core location to a depth of 300 cm [c]	data validation and data quality review consistent with EPA guidelines; data collected under existing LDW RI AOC, so no data quality review is needed in this memorandum	Windward et al. (2004a, b)
Final preliminary site investigation report for the South Park Bridge project	South Park Bridge	2003	RM 3.3-3.4	metals, TBT, VOCs, SVOCs, organochlorine pesticides, PCB Aroclors, TOC	11 subsurface sediment samples from 2 locations (rotary drill unit) from depths up to 100 ft (samples collected at 2.5 ft intervals in top 10 ft, and at several deeper 2.5 ft intervals to 100 ft)	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers as reported are acceptable for use	Wilbur Consulting (2004)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 4, April 2003	Norfolk-monit6	2003	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2003b)
Sediment characterization results for the Duwamish River navigational channel turning basin	Turning Basin	2003	RM 4.2-4.7	metals, PCB Aroclors, organochlorine pesticides, SVOCs	5 core samples (vibracorer) taken down to depths of 144 to 390 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Anchor (2003)
Boeing Plant 2 transformer investigation – Phase 1	Plant 2-Transformer Phase1	2003	RM 3.6 east	PCB Aroclors	5 surface grab samples (by hand) taken from 0-5 cm; 46 core samples (vibracorer) taken from 13 locations; 3-5 samples at each location from 0-240 cm [b]	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Floyd Snider McCarthy (2004)
PSDDA dredged sediment characterization for Glacier NW	Glacier NW	2002	RM 1.5 west	metals, PCB Aroclors, organochlorine pesticides, SVOCs	4 composite sediment samples from eleven cores collected by vibracorer from 0-172 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	PIE (2002)
Norfolk combined sewer overflow (Duwamish River) sediment cap recontamination. Phase I investigation	Ecology-Norfolk	2002	RM 4.9-5.0 east	PCB Aroclors	20 grab samples (van Veen) from 0-10 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Ecology (2003)
Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 3, April 2002	Norfolk-monit5	2002	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2002)
Data report, DSOA vertical characterization and outfall 12 data collection. Duwamish sediment other area, Boeing Plant 2	DSOAvert char	2001	RM 2.8-3.7 east	PCB Aroclors	125 core samples (vibracorer) from 37 locations; 2-6 samples at each location, most locations starting at 60 cm down to depths of 150-280 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Pentec (2001)
Norfolk CSO five-year monitoring program, Year Two, April 2001	Norfolk-monit4	2001	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	validation qualifiers added to database	King County (2001b)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Norfolk CSO five-year monitoring program – Twelve-month post construction	Norfolk-monit3	2000	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	validation qualifiers added to database	King County (2000c)
Norfolk CSO five-year monitoring program – Supplemental nearshore sampling	Norfolk-monit2b	2000	RM 4.9-5.0 east	PCB Aroclors	Composites of 3 grab samples (van Veen) at each of 3 locations; 3 samples from 0-2 cm; 3 samples from 0-10 cm	validation qualifiers added to database	King County (2000b)
Outfall and nearshore sediment sampling report, Duwamish Facility	James Hardie	2000	RM 1.5 east	metals, PCB Aroclors, SVOCs	9 grab samples (van Veen or by hand in intertidal) from 0-10 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Weston (2000)
PSDDA sediment characterization of Duwamish River navigation channel: FY2000 operations and maintenance dredging data report	PSDDA99	1999	RM 1.9-3.4	metals, PCB Aroclors, organochlorine pesticides, SVOCs	20 composite core samples (vibracorer) taken from 18 locations; three borings made at each location; 18 samples from 0 to 120 cm; 2 samples from 120 to 240 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	SEA (2000a, b)
Norfolk CSO five-year monitoring program – Six-month post construction	Norfolk-monit2a	1999	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-2 cm; 4 samples from 0-10 cm	validation qualifiers added to database	King County (2000d)
Norfolk CSO five-year monitoring program – Post backfill	Norfolk-monit1	1999	RM 4.9-5.0 east	metals, PCB Aroclors, SVOCs	Composites of 3 grab samples (van Veen) at each of 4 locations; 4 samples from 0-10 cm	validation qualifiers added to database	King County (1999b)
PSDDA sediment characterization of Duwamish River navigation channel: FY99 operations and maintenance dredging data report	PSDDA98	1998	RM 3.5-4.6	metals, PCB Aroclors, organochlorine pesticides, SVOCs	10 core samples (vibracorer) taken from 12 locations; 7 samples taken from 0 to 60-90 cm, each from single location; 3 samples taken from 2 or 3 locations (0-60 cm, 0-120 cm, and 120-360 cm)	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	SEA (1998)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
EPA Site Inspection: Lower Duwamish River	EPA SI	1998	entire LDW study area	metals, organochlorine pesticides, PCB Aroclors & selected congeners, dioxins & furans, TBT, SVOCs, VOCs	300 grab samples from 0-10 cm (van Veen); 33 core samples (vibracorer) from 0-60 and 60-120 cm from 17 locations	data collected by EPA for Superfund program; acceptable for all uses	Weston (1999)
King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay	KC WQA	1997	Duwamish/Diagonal (RM 0.5-0.6 east); Kellogg Island (RM 0.7 west); Brandon CSO (RM 1.1 east); 8th Ave CSO (RM 2.8 west); South Park (RM 3.3 east); Hamm Creek (RM 4.4 west)	metals, PCB Aroclors, SVOCs, TBT	0-10 cm grab samples (van Veen) from 14 locations; single samples from 5 Duwamish/Diagonal locations and 4 Kellogg Island locations; weekly samples from Kellogg Island (9 samples), Brandon (13 samples), 8th Ave (9 samples), South Park (4 samples), Hamm Creek (4 samples)	validation qualifiers added to database	King County (1999a)
Duwamish Waterway Phase 1 site characterization	Boeing SiteChar	1997	RM 1.8-2.0 west; Slip 4 (RM 2.8-2.9 east); RM 3.6-4.0; RM 4.2-5.0 east	metals, PCB Aroclors, SVOCs	88[b] grab samples (van Veen) from 0-10 cm	accepted by EPA for all uses	Exponent (1998)
Duwamish Waterway sediment characterization study	NOAA SiteChar	1997	entire LDW study area	total PCBs, selected PCB congeners, total PCTs	328 grab samples (van Veen) from 0-10 cm	validation qualifiers added to database; congener data not appropriate for use in Phase 2 risk assessments	NOAA (1997, 1998)
1996 USACE Duwamish O&M	USACE 1996	1996	RM 4.2-4.6 navigation channel	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs,	4 core samples (vibracorer) collected to a depth of 120 cm	validation qualifiers added to database	SEA (1996)
Seaboard Lumber site, Phase 2 site investigation	Seaboard-Ph2	1996	RM 0.4-0.7 west	metals, PCB Aroclors, SVOCs	20 grab samples (van Veen) from 0-10 cm	accepted by EPA for all uses	Herrera (1997)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2b	Plant 2 RFI-2b	1996	RM 2.8-3.7 east	metals, PCB Aroclors, SVOCs	39 grab samples (van Veen) from 0-10 cm; 44 core samples (vibracorer) from 15 locations – 2 to 4 samples per core, up to 480 cm below mudline	validation qualifiers J+/J- changed to JH/JL; accepted by EPA for all uses	Weston (1998)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Duwamish/Diagonal cleanup Study – Phase 2	Duw/Diag-2	1996	RM 0.4-0.6 east	metals, PCB Aroclors, SVOCs, TPH	36 grab samples (van Veen) from 0-10 cm; 53 core samples (vibracorer) from 15 locations – 1 to 6 samples per core, up to 270 cm below mudline	validation qualifiers added to database	King County (2000a)
Duwamish/Diagonal cleanup Study – Phase 1.5	Duw/Diag-1.5	1995	RM 0.4-0.6 east	metals, PCB Aroclors, SVOCs, TBT	12 grab samples (van Veen) from 0-10 cm	validation qualifiers added to database	King County (2000a)
Norfolk CSO sediment cleanup study – Phase 3	Norfolk-cleanup3	1995	RM 4.9-5.0 east	PCB Aroclors	16 grab samples (van Veen) from 0-10 cm	validation qualifiers added to database	King County (1996)
Norfolk CSO sediment cleanup study – Phase 2	Norfolk-cleanup2	1995	RM 4.9-5.0 east	metals, organochlorine pesticides, PCB Aroclors and selected congeners, SVOCs, VOCs, TPH	12 grab samples (van Veen) from 0-10 cm; 27 core samples (vibracorer) from 3 locations at 30 or 60 cm intervals up to 180 cm below mudline	validation qualifiers added to database	King County (1996)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 2a	Plant 2 RFI-2a	1995	RM 2.8-3.7 east	metals, PCB Aroclors SVOCs	54 grab samples (van Veen) from 0-10 cm	validation qualifiers J+/J- changed to JH/JL; accepted by EPA for all uses	Weston (1998)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 1	Plant 2 RFI-1	1995	RM 2.8-3.7 east	metals, PCB Aroclors, TPH, SVOCs, VOCs	65 grab samples (van Veen) from 0-10 cm; 22 core samples (vibracorer) from 12 locations at 15-45 cm intervals down to 135 cm below mudline	validation qualifiers J+/J- changed to JH/JL; accepted by EPA for all uses	Weston (1998)
Duwamish/Diagonal cleanup Study – Phase 1	Duw/Diag-1	1994	RM 0.4-0.6 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, TBT	38 grab samples (van Veen) from 0-10 cm; 2 grab samples (van Veen) from 0-15 cm; 12 core samples (vibracorer) from 2 locations at 15-30 cm intervals down to 150 cm below mudline	validation qualifiers added to database	King County (2001a)
Norfolk CSO sediment cleanup study – Phase 1	Norfolk-cleanup1	1994	RM 2.8-3.7 east	metals, organochlorine pesticides, SVOCs, PCB Aroclors, VOCs	21 grab samples (van Veen) from 0-10 cm; 3 core samples from 1 location – 15-30, 30-45, and 45-60 cm	validation qualifiers added to database	King County (1996)
Rhône-Poulenc RCRA Facility Investigation for the Marginal Way facility – Round 2	Rhône-RFI-2	1994	Slip 6 (RM 4.2 east)	metals, SVOCs, PCB Aroclors 1254 and 1260, organochlorine pesticides	7 grab samples (van Veen) from 0-2 cm	accepted by EPA for all uses	Rhône-Poulenc (1995)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Results of sampling and analysis, sediment monitoring plan, Duwamish Shipyard, Inc.	Duwamish Shipyard	1993	RM 1.4-1.5 west	metals, SVOCs, TBT	5 grab samples (van Veen) from 0-10 cm	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Hart Crowser (1993)
Harbor Island Remedial Investigation	Harbor Island RI	1991	RM 0.0-0.4	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs, TPH, TBT	34 grab samples (van Veen) from 0-10 cm	data collected by EPA for Superfund program; acceptable for all uses	Weston (1993)
1991 USACE Duwamish O&M	USACE 1991	1991	RM 2.9-3.6 navigation channel	metals, SVOCs, PCB Aroclors, organochlorine pesticides	20 composite samples (vibracorer), each made from single core samples, including 19 samples from 0 to 90-150 cm, and 1 sample from 120 to 420 cm	validation qualifiers added to database	SAIC (1991)
1990 USACE Duwamish O&M	USACE 1990	1990	RM 3.4-4.5 navigation channel	metals, SVOCs, PCB Aroclors, organochlorine pesticides	8 composite samples (vibracorer), each made from single core samples collected from 0 to 150-210 cm	validation qualifiers added to database	PTI (1990)
Tissue Chemistry							
King County tissue 2006	KC 2006 fish tissue	2006	RM 0.2 –1.0, 1.6 – 2.4, 2.9– 3.7, and 4.2– 5.2	PCBs (as Aroclors), phthalates, total solids, lipids	6 English sole whole-body tissue composite samples, 9 English sole individual whole-body tissue, and 6 shiner surfperch whole-body tissue composites and one field replicate collected using a high-rise otter trawl	QC consistent with previous ARI analytical tissue analyses and LDC data validation; validation qualifiers added to database	Anchor and King County (2006, 2007)
East Waterway, Harbor Island Superfund site: Technical memorandum: Tissue chemistry results for juvenile chinook salmon collected from Kellogg Island and East Waterway	EW-Salmon	2002	Kellogg Island (RM 0.8-0.9 west)	PCB Aroclors, mercury	12 composite samples of whole-body juvenile chinook salmon (6 from LDW, 6 from East Waterway) collected by beach seine; each sample consisted of 6-7 fish	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	Windward (2002)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
NMFS Duwamish injury assessment project	NOAA-salmon2	2000	Kellogg Island (RM 0.8-0.9 west), Slip 4 (RM 2.8 east)	PCB congeners, organochlorine pesticides (salmon); PCB Aroclors (shiner perch)	29 samples of whole-body juvenile chinook salmon collected by beach seine (9 were composites of 3-10 fish, 20 were individual fish); 6 composite samples of chinook salmon stomach contents; 2 composite samples of whole-body shiner perch	neither EPA nor LDWG plan to conduct a review of the salmon portion of this dataset because LDWG's 2003 juvenile chinook salmon sampling results make the effort required for such a review unwarranted, as documented by Windward (2005); therefore, these data were not used in the final RI. The shiner perch portion of the dataset has been previously approved for all uses by EPA (2003)	NMFS (2002)
Waterway Sediment Operable Unit Harbor Island Superfund Site	WSOU	1998	RM 0.4-0.9 (crab), RM 2.0-4.4 (English sole), RM 0.0-0.2 (striped perch)	Hg, TBT, PCB Aroclors	3 English sole skinless fillet composite samples (5 fish/composite caught by trawl); 3 red rock crab edible meat composite samples (5 crab/composite caught by crab trap); 1 Dungeness crab edible meat sample (1 individual caught by crab trap); 3 striped perch skinless fillet samples (5 fish/composite for 2 samples, 1 individual fish for 1 sample; caught by diver)	collected under EPA oversight for a previously conducted Superfund risk assessment; previously approved for all uses by EPA (2003)	ESG (1999)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay	KC WQA	1996- 1997	RM 0.5-0.9	metals, TBT, SVOCs, PCB Aroclors	3 English sole skinless fillet composite samples (20 fish/composite caught by trawl); 3 English sole whole-body composite samples[d] (20 fish/ composite caught by trawl); 2 Dungeness crab edible meat composite samples (3 crabs/sample caught by crab trap); 1 Dungeness crab hepatopancreas composite sample (3 crabs caught by crab trap); 4 amphipod composite samples (caught by benthic sledge); 3 shiner surfperch whole-body composite samples (10 fish/sample caught by trawl); 22 mussels edible meat composite samples (20 mussels/ sample collected by hand) [e]	add validation qualifiers; English sole whole-body composite samples not acceptable for all uses because they don't truly represent whole bodies	King County (1999a)
Puget Sound Ambient Monitoring Program – annual sampling	PSAMP-fish	1992	RM 0.4-1.3	organochlorine pesticides, SVOCs, PCB Aroclors, As, Cu, Pb, Hg	3 English sole skinless fillet (10-20 fish/ sample collected by trawl)	acceptable for all uses	West et al. (2001)
		1995	RM 0.4-1.3	organochlorine pesticides, PCB Aroclors, As, Cu, Pb, Hg	3 English sole skinless fillet composite samples (10-20 fish/sample collected by trawl)	acceptable for all uses	
		1997	RM 0.4-1.3	Hg, organochlorine pesticides	3 English sole skinless fillet composite samples (10-20 fish/sample collected by trawl)	acceptable for all uses	
Elliott Bay/Duwamish River Fish Tissue Investigation	EVS 95	1995	RM 1.1-1.4	PCB Aroclors, Hg, MeHg, TBT	3 English sole skinless fillet composite samples (6 fish/sample collected by trawl)	collected under EPA oversight for a previously conducted Superfund risk assessment; previously approved for all uses by EPA (2003)	Battelle (1996); EVS (unpublished); Frontier Geosciences (1996)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Contaminant exposure and associated biochemical effects in outmigrant juvenile chinook salmon from urban and non-urban estuaries of Puget Sound	NOAA-salmon	1989- 1990	RM 0.7	organochlorine pesticides, PCB Aroclors, PAHs	14 composite samples of whole-body juvenile chinook salmon collected by beach seine (2-10 fish/sample); 6 composite samples of stomach contents (10 fish/sample) [f]	neither EPA nor LDWG plan to conduct a review of this dataset because LDWG's 2003 juvenile chinook salmon sampling results make the effort required for such a review unwarranted; therefore, these data were not used in final RI	Varanasi et al. (1993)
Other Chemistry							
King County surface water quality sampling – 2001 to 2008 (surface water)	KC Arsenic SW KC 2007 SW KC_Fall2007 KC 2008 SW	2001 – 2008	RM 0, 3.3, 6.3, and 12.4	PCB congeners, dioxin/furans, PAHs, metals, conventionals	All surface water samples 2001 – 13 samples collected on 13 dates and analyzed for arsenic and TSS 2002 – 71 samples collected on 35 dates and analyzed for arsenic and TSS 2003 – 58 samples collected on 34 dates and analyzed for arsenic and TSS 2004 – 13 samples collected on 13 dates and analyzed for arsenic and TSS 2005 – 2 samples collected on 2 dates and analyzed for arsenic and TSS 2006 – 15 samples collected on 14 dates and analyzed for arsenic and TSS 2007 – 12 samples collected on 5 dates from upstream of the LDW and analyzed for PCB congeners and conventionals; 2 samples collected on 2 dates and analyzed for metals 2008 – 4 samples collected on 2 dates and analyzed for PCB congeners; 28 samples collected on 10 dates and analyzed for PAHs and conventionals	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (2005b) LDC (2007a, b, 2008a, b, c, d, e, f)
Duwamish River/Elliott Bay/Green River Water Column PCB Congener Survey	KC 2005 Water Sampling	2005	RM 0 and 3.3	PCB congeners, conventional parameters	28 water samples collected over 4 months at 4 locations; 2 locations in the Duwamish River were sampled at both surface and bottom depths of the water column; all samples analyzed for PCB congeners and conventional field parameters	QC consistent with previous King County events approved for all uses; validation qualifiers added to database; Windward evaluated field and laboratory replicate samples for method blank contamination	Mickelson and Williston (2006)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Rhône-Poulenc porewater	RhônePoulenc 2004	2004	RM 4.0-4.3 east	VOCs, metals, pesticides, PCB Aroclors	16 porewater samples for chemistry parameters (1 duplicate sample, and 1 additional sample analyzed only for field parameters) collected using a piezometer or a seepage meter	data validation consistent with EPA guidelines; laboratory Form 1s present in data report; validation qualifiers added to database	EPA (2005b)
RCRA Facility Investigation Duwamish Waterway sediment investigation, Plant 2 – Phase 1	Plant 2 RFI-1	1995	RM 2.8 – 3.7 east	metals, PCB Aroclors, TPH, SVOCs, VOCs	22 seep water	comprehensive data quality review not warranted because EPA has previously approved these data for all uses in the RCRA program	Weston (1998)
Rhône-Poulenc RCRA Facility Investigation for the Marginal Way facility – Round 3	RhônePoulenc-RFI-3	1995	Slip 6 (RM 4.2 east)	VOCs	7 seep water	comprehensive data quality review not warranted because EPA has previously approved these data for all uses in the RCRA program	Rhône-Poulenc (1996)
Supplemental remedial investigation and feasibility study. Great Western International	Great Western Apr-94	1994	RM 2.2 east	VOCs	6 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1994a)
	Great Western Jul-94	1994		VOCs	9 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1994b)
	Great Western Nov-94	1994		VOCs	7 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1996)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
Supplemental remedial investigation and feasibility study. Great Western International (cont.)	Great Western May-95	1995	RM 2.2 east	VOCs	7 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1996)
	Great Western-1995 Annual	1995		VOCs	7 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1996)
	Great Western-1996 Annual	1996		VOCs	5 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Hart Crowser (1997)
	Great Western-1997 Annual	1997		VOCs	4 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)
	Great Western-1998 Annual	1998		VOCs	9 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)
	Great Western-Embayment Study	1998		VOCs	10 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)
	Great Western-1999 Annual	1999		VOCs, SVOCs	5 seep water	comprehensive data quality review not warranted because Ecology has previously approved these data for all uses in the MTCA program	Terra Vac, Floyd & Snider (2000)

Table N-6 Chemistry Datasets Acceptable for All Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Actions/Conclusions [a]	Reference
King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay [g]	KC WQA	1996-1997	Duwamish/ Diagonal CSO (RM 0.5 east), Brandon CSO (RM 1.1 east), SW Michigan CSO (RM 2.0 east), Norfolk CSO (RM 4.9 east) [h]	metals, SVOCs, conventionals, PCB Aroclors	1,249 surface water samples collected using Niskin and van Dorn samplers. Samples were collected from multiple depths (near-surface and near-bottom) and up to 3 locations horizontally across the waterway. Samples were collected weekly and also during storm events [h]	QC consistent with previous King County events approved for all uses by EPA; validation qualifiers added to database	King County (1999a)

Notes:

a. All events listed on this table are: 1) considered acceptable for all uses in Phase 2, even if not specifically mentioned, 2) acceptable for some uses, but not others, as noted, or 3) undergoing additional review by EPA; acceptability determination is still pending.

b. Sample total does not include three reference samples that were collected upstream of the study area.

c. Does not include soil, groundwater, and seep data collected concurrently during this investigation.

d. Samples are of remnant tissues following the subsampling of fillet tissue. In addition, livers were removed from some fish in the composite samples.

e. Sample counts do not include data from cooked crab and English sole samples or data from caged mussel deployments. These data were not used in the final RI.

f. Six composite samples of juvenile chinook salmon livers were also analyzed, but these data were not used in the Final RI.

g. Only water chemistry data. Sediment and tissue chemistry data from this sampling event were previously reviewed in Windward (2005b).

h. Samples collected outside the LDW study area were also included in this sampling event.

AOC = administrative order on consent; As = arsenic; CSO = combined sewer overflow; Cu = copper; DC = developmental center; ENR = enhanced natural remediation; EPA = U.S. Environmental Protection Agency; EW = East Waterway; FS = feasibility study; FY = fiscal year; Hg = mercury; LDC = Laboratory Data Consulting; MeHg = methylmercury; MTCA = Model Toxics Control Act; NMFS = National Marine Fisheries Service; NOAA = National Oceanic and Atmospheric Administration; PAH = polycyclic aromatic hydrocarbon; Pb = lead; PCB = polychlorinated biphenyl; PCT = polychlorinated terphenyl; PSAMP = Puget Sound Ambient Monitoring Program; PSDDA = Puget Sound Dredged Disposal Analysis Program; QC = quality control; RCRA = Resource Conservation and Recovery Act; RM = river mile; SVOC = semivolatile organic compound; TBT = tributyltin; TOC = total organic carbon; TPH = total petroleum hydrocarbons; TSS = total suspended solids; USACE = U.S. Army Corps of Engineers; VOC = volatile organic compound; WSOU = Waterway Sediment Operable Unit.

Sources for Table N-6:

AMEC Geomatrix 2009a. Building 2-41 complex under-building investigation data report, Boeing Plant 2 Duwamish Sediment Other Area and Southwest Bank Interim Measure, Tukwila, Washington. AMEC Geomatrix, Lynnwood, WA.

AMEC Geomatrix 2009b. DSOA additional characterization data report, Boeing Plant 2 Duwamish Sediment Other Area, Tukwila, Washington. AMEC Geomatrix, Lynnwood, WA.

AMEC Geomatrix 2010. 2009 DSOA additional characterization data report, Boeing Plant 2 Duwamish Sediment Other Area, Seattle/Tukwila, Washington. Submitted to The Boeing Company. AMEC Geomatrix, Lynnwood, WA.

Anchor 2003. Data report: sediment characterization results for the Duwamish River navigational channel turning basin. Prepared for Dredged Material Management Office, U.S. Army Corps of Engineers. Anchor Environmental L.L.C, Seattle, WA.

Anchor 2006. Sediment evaluation work plan, 8801 E Marginal Way South property. Prepared for PACCAR, Inc. Anchor Environmental, L.L.C., Seattle, WA.

Sources for Table N-6 (continued):

Anchor 2007a. Duwamish/Diagonal sediment remediation project 2005 monitoring report: Elliott Bay/Duwamish restoration program panel. Panel publication 40. Prepared for King County Department of Natural Resources and Parks Elliot Bay/Duwamish restoration program. Anchor Environmental, L.L.C., Seattle, WA.

Anchor 2007b. Sampling and analysis plan for Port of Seattle Terminal 115 sediment characterization. Prepared for Port of Seattle. Anchor Environmental, L.L.C., Seattle, WA.

Anchor 2008. Port of Seattle Terminal 115 sediment characterization report. Prepared for the Port of Seattle. Anchor Environmental, L.L.C., Seattle, WA.

Anchor and King County 2006. Quality assurance project plan: Fish tissue sampling and chemical analysis in the Lower Duwamish Waterway. Anchor Environmental, L.L.C. and King County Department of Natural Resources and Parks, Seattle, WA.

Anchor and King County 2007. Data report: fish tissue sampling and chemical analysis in the Lower Duwamish Waterway. Anchor Environmental, L.L.C. and King County Department of Natural Resources and Parks, Seattle, WA.

Anchor QEA 2009a. Port of Seattle Terminal 115 slope area surface sediment characterization report. Anchor QEA, LLC, Seattle, WA.

Anchor QEA 2009b. Sediment evaluation data report, 8801 E Marginal Way South property. Prepared for PACCAR Inc. Anchor QEA, LLC, Seattle, WA.

Anchor QEA 2009c. Sediment evaluation work plan, Terminal 115, slope area surface sediment characterization. Prepared for Port of Seattle. Anchor QEA, LLC, Seattle, WA.

Battelle 1996. Final report for the PCB Aroclor and congener analyses on fish tissue samples from the Elliott Bay/Duwamish River project. Pacific Northwest Division, Battelle Marine Research Laboratory, Sequim, WA.

CALIBRE 2005. 2004 annual sampling report, south storm drain system, Boeing Developmental Center. Prepared for the Boeing Group. CALIBRE Systems, Bellevue, WA.

CALIBRE 2006. 2005 annual sampling report, south storm drain system, Boeing Developmental Center. Prepared for the Boeing Group. CALIBRE Systems, Bellevue, WA.

CALIBRE 2008. 2007 annual sampling report, south storm drain system, Boeing Developmental Center. Prepared for the Boeing Group. CALIBRE Systems, Bellevue, WA.

CALIBRE 2009a. 2009 annual sampling report, south storm drain system, Boeing Developmental Center. Prepared for the Boeing Company. CALIBRE Systems, Bellevue, WA.

CALIBRE 2009b. Summary of storm drain line cleanout work and 2008 annual sampling report, south storm drain system, Boeing Developmental Center. Prepared for The Boeing Company, Engineering Operations and Technology, EHS Remediation. CALIBRE Systems, Bellevue, WA.

Ecology 2003. Norfolk combined sewer overflow (Duwamish River) sediment cap recontamination. Phase I investigation. Publ. no. 03-03-004. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA.

Ecology 2007. Using sediment profile imaging (SPI) to evaluate sediment quality at two cleanup sites in Puget Sound. Part I - Lower Duwamish Waterway. Publ. no. 07-03-025. Washington State Department of Ecology, Olympia, WA.

Ecology 2008. Duwamish River sediment sampling and analysis plan. Final. Toxics Cleanup Program, Washington State Department of Ecology, Bellevue, WA.

Ecology and Environment 2009. Final report, Duwamish River sediment sampling and analysis. Technical memorandum dated June 30, 2009, prepared for B. Helland, Washington State Department of Ecology. Ecology and Environment, Inc., Seattle, WA.

EPA 2003. Review of the analytical data used for the scoping Phase 1 Remedial Investigation report for Lower Duwamish Waterway for use in the Phase 2 baseline risk assessments. Memorandum to the Lower Duwamish Waterway Group, February 10, 2003. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA 2004. Memorandum: Peer review of the total metals analysis for Lower Duwamish Triad sampling event samples. November 22, 2004. U.S. Environmental Protection Agency Region 10 Laboratory, Port Orchard, WA.

EPA 2005a. Memorandum: Data review for the PCB Aroclor analysis of sediment and water samples from the Lower Duwamish Triad Project. January 12, 2005. U.S. Environmental Protection Agency Region 10 Laboratory, Port Orchard, WA.

EPA 2005b. Rhône-Poulenc (Rhodia) sediment & porewater investigation Aug/Sept 2004. Data report: volatile organic compounds, metals, and pesticides/PCBs detected in sediment and porewater. Draft. U.S. Environmental Protection Agency Region 10, Seattle, WA.

ESG 1999. Waterway sediment operable unit, Harbor Island Superfund site. Assessing human health risks from the consumption of seafood: human health risk assessment report. Prepared for Port of Seattle, Todd Shipyards, and Lockheed-Martin for submittal to U.S. Environmental Protection Agency, Region 10, Seattle, WA. Environmental Solutions Group, Inc., Seattle, WA.

Sources for Table N-6 (continued):

EVS unpublished. Elliott Bay/Duwamish River fish tissue investigation, 1995. Fish collection field log. EVS Environment Consultants, Inc., Seattle, WA.

Exponent 1998. Duwamish Waterway phase I site characterization report. Prepared for The Boeing Company. Exponent, Bellevue, WA.

Floyd Snider McCarthy 2004. Boeing Plant 2, Seattle/Tukwila, Washington: Phase 1 transformer PCB investigation report. Floyd Snider McCarthy, Inc., Seattle, WA.

Frontier Geosciences 1996. Mercury results in 18 fish samples for the Elliott Bay/Duwamish River project. Frontier Geosciences, Seattle, WA.

Geomatrix 2007. Quality assurance project plan, Boeing Plant 2 Duwamish Sediment Other Area, western boundary and navigation channel sample collection, Tukwila, Washington. Prepared for The Boeing Company. Geomatrix Consultants, Inc., Mountlake Terrace, WA.

Geomatrix 2008. Data report: Boeing Plant 2 Duwamish sediment other area western boundary and navigation channel sample collection, Tukwila, Washington. Geomatrix Consultants, Inc., Lynnwood, WA.

Geomatrix and Floyd|Snider 2008. Building 2-41 complex under-building investigation quality assurance project plan. Boeing Plant 2 Duwamish Sediment Other Area and Southwest Bank Interim Measure, Tukwila, Washington. Prepared for the Boeing Company. Geomatrix Consultants, Inc., Lynnwood, WA, and Floyd|Snider, Seattle, WA.

Germano & Associates 2006. Quality assurance project plan: Feasibility of using sediment profile imaging technology to evaluate sediment quality and impacts to benthic communities found at two contaminated sediment cleanup sites in the Puget Sound. Germano & Associates, Inc., Bellevue, WA.

Hart Crowser 1993. Results of sampling and analysis, sediment monitoring plan, Duwamish Shipyard, Inc., Seattle, Washington. Hart Crowser, Inc., Seattle, WA.

Hart Crowser 1994a. Technical memorandum no. 9 - Duwamish Waterway seep and shellfish sampling, Great Western Chemical Company Remedial Investigation. Hart Crowser, Inc., Seattle, WA.

Hart Crowser 1994b. Technical memorandum no. 10 - Second quarter Duwamish Waterway seep and shellfish sampling, Great Western Chemical Company Remedial Investigation. Hart Crowser, Inc., Seattle, WA.

Hart Crowser 1996. Technical memorandum No. 11- off-site GeoProbe study and baseline sampling and analysis results, Great Western Chemical Company facility, Seattle, Washington. Hart Crowser, Inc., Seattle, WA.

Hart Crowser 1997. Technical memorandum No. 13 - RI/FS annual monitoring, December 1996. Hart Crowser, Inc., Seattle, WA.

Herrera 1997. Seaboard Lumber Site. Phase 2 site investigation. Draft. Prepared for Seattle Department of Parks and Recreation. Herrera Environmental Consultants, Inc., Seattle, WA.

Herrera 2005. Memorandums to J. Wakeman, USACE, Seattle District, regarding grain size distribution, TCLP lead, mercury, SVOC, and total organic carbon data validation for Lower Duwamish Triad sampling event. January 21, 2005. Herrera Environmental Consultants, Inc., Seattle, WA.

Integral 2004. Lower Duwamish Waterway Slip 4 early action area: cruise and data report. Prepared for City of Seattle and King County. Integral Consulting, Inc., Mercer Island, WA.

Integral 2006. Lower Duwamish Waterway Slip 4 early action area: Sampling and analysis plan for boundary definition. Addendum: pre-design investigation sampling Prepared for City of Seattle and King County. Integral Consulting, Inc., Mercer Island, WA.

Integral 2007. Lower Duwamish Waterway Slip 4 early action area: 100% design submittal, Appendix A: pre-design investigation data summary report. Prepared for City of Seattle and King County. Integral Consulting, Inc., Mercer Island, WA.

King County 1996. Norfolk CSO sediment cleanup study. Prepared for Elliott Bay/Duwamish Restoration Program. King County Department of Natural Resources, Seattle, WA.

King County 1999a. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1: Overview and interpretation, plus appendices. King County Department of Natural Resources, Seattle, WA.

King County 1999b. Norfolk CSO sediment remediation project five-year monitoring program: April 1999 monitoring report. Prepared for Elliott Bay/Duwamish Restoration Program. King County Department of Natural Resources, Seattle, WA.

King County 2000a. Duwamish/Diagonal CSO/SD site assessment report. Draft. Prepared for Elliott Bay/Duwamish Restoration Program. King County Department of Natural Resources, Seattle, WA.

King County 2000b. King County environmental laboratory quality assurance review for estuarine sediment analytical data. Norfolk CSO sediment remediation project five-year monitoring program. February 2000 sampling event. Environmental Laboratory, King County Department of Natural Resources, Seattle, WA.

Sources for Table N-6 (continued):

King County 2000c. Norfolk CSO sediment remediation project five-year monitoring program. Annual monitoring report-year one, April 2000. Prepared for Elliott Bay/Duwamish Restoration Program. King County Department of Natural Resources, Seattle, WA.

King County 2000d. Norfolk CSO sediment remediation project five-year monitoring program. Six-month post-construction monitoring report, October 1999. Prepared for Elliott Bay/Duwamish Restoration Program. King County Department of Natural Resources, Seattle, WA.

King County 2001a. Duwamish/Diagonal CSO/SD cleanup study report. Draft. Prepared for Elliott Bay/Duwamish Restoration Program panel. King County Department of Natural Resources, Seattle, WA.

King County 2001b. Norfolk CSO sediment remediation project five-year monitoring program. Annual monitoring report-year two, April 2001. Prepared for Elliott Bay/Duwamish Restoration Program. King County Department of Natural Resources, Seattle, WA.

King County 2002. Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 3, April 2002. Prepared for the Elliott Bay/Duwamish Restoration Panel. King County Department of Natural Resources and Parks, Seattle, WA.

King County 2003a. Duwamish/Diagonal sediment remediation project dredging and capping operations: Sediment monitoring sampling and analysis plan. King County Department of Natural Resources and Parks, Seattle, WA.

King County 2003b. Norfolk CSO sediment remediation project five-year monitoring program: Annual monitoring report - year 4, April 2003. Prepared for the Elliott Bay/Duwamish Restoration Panel. Panel publication 33. King County Department of Natural Resources and Parks, Seattle, WA.

King County 2005a. Duwamish Diagonal interim action residual remedy proposal: memorandum dated January 21, 2005 to Washington Department of Ecology. King County, Seattle, WA.

King County 2005b. Duwamish River, Elliott Bay, and Green River water column PCB congener survey: sampling and analysis plan. King County Department of Natural Resources and Parks, Seattle, WA.

King County 2005c. Norfolk CSO sediment remediation project five-year monitoring program: Final monitoring report - year 5, April 2004. Prepared for the Elliott Bay/Duwamish Restoration Panel. King County Department of Natural Resources and Parks, Seattle, WA.

King County 2005d. Quality assurance review for estuarine sediment analytical data, Duwamish/Diagonal sediment remediation project year zero, ENR cap sediment characterization, April 2005 monitoring event. King County Environmental Laboratory, Seattle, WA.

King County 2005e. Quality assurance review for estuarine sediment analytical data, Duwamish/Diagonal sediment remediation project year zero, ENR cap sediment characterization, March 2005 monitoring event. King County Environmental Laboratory, Seattle, WA.

King County 2005f. Quality assurance review for estuarine sediment analytical data, Duwamish/Diagonal sediment remediation project, perimeter sediment characterization, February 2005 monitoring event. King County Environmental Laboratory, Seattle, WA.

King County 2005g. Quality assurance review for estuarine sediment analytical data, Duwamish/Diagonal sediment remediation project. Year zero, cap sediment characterization, June 2004 monitoring event. King County Environmental Laboratory, Seattle, WA.

King County 2006a. Quality assurance review for estuarine sediment analytical data, Duwamish/Diagonal sediment remediation project, year one, ENR cap sediment characterization, March 2006 sampling event. King County Environmental Laboratory, Seattle, WA.

King County 2006b. Quality assurance review for estuarine sediment analytical data, Duwamish/Diagonal sediment remediation project, year two, cap sediment characterization, March 2006 sampling event. King County Environmental Laboratory, Seattle, WA.

King County 2007. Quality assurance review for estuarine sediment analytical data, Duwamish/Diagonal sediment remediation project, perimeter sediment characterization, March 2006 sampling event. King County Environmental Laboratory, Seattle, WA.

King County 2010. Duwamish/Diagonal sediment remediation project: 2008/2009 monitoring report. Water and Land Resources Division, King County Department of Natural Resources and Parks, Seattle, WA.

King County and Anchor 2008. Duwamish/Diagonal sediment remediation project 2006/2007 monitoring report. Prepared for the Elliott Bay Duwamish Restoration Program Panel. King County Department of Natural Resources and Anchor Environmental LLC, Seattle, WA.

King County, Anchor, and EcoChem 2005. Duwamish/Diagonal CSO/SD sediment remediation project closure report. Prepared for the Elliott Bay Duwamish Restoration Program Panel. King County Department of Natural Resources, Anchor Environmental LLC, and EcoChem, Inc., Seattle, WA.

Sources for Table N-6 (continued):

Landau 2008. Report: Investigation of potential polychlorinated biphenyls (PCBs) sources to Slip 4, Seattle, Washington. Prepared for The Boeing Company. Landau Associates, Edmonds, WA.

LDC 2007a. Lower Duwamish Group data validation for samples collected May 2007. SDG# DPWG22504/WB22085: polychlorinated biphenyls as congeners. Laboratory Data Consultants, Inc., Carlsbad, CA.

LDC 2007b. Lower Duwamish Group revised data validation for samples collected March 2007. SDG# DPWG21879/WB21623; DPWG22263/WG21936; DPWT22449/SG22167; DPWG22504/WG22085; DPWG22684/WB22356: polychlorinated biphenyls as congeners. Laboratory Data Consultants, Inc., Carlsbad, CA.

LDC 2008a. Lower Duwamish Group data validation for samples collected August 2008. SDG# DPWG26867/WG26535: polychlorinated biphenyls as congeners. Laboratory Data Consultants, Inc., Carlsbad, CA.

LDC 2008b. Lower Duwamish Group data validation for samples collected December 2007. SDG# DPWG24566/WG24297: polychlorinated biphenyls as congeners. Laboratory Data Consultants, Inc., Carlsbad, CA.

LDC 2008c. Lower Duwamish Group data validation for samples collected June 2008. SDG# DPWG26117/WG25565: polychlorinated biphenyls as congeners. Laboratory Data Consultants, Inc., Carlsbad, CA.

LDC 2008d. Lower Duwamish Group, data validation for samples collected December 2007, SDG# DPWG24448/WB24067: dioxins/dibenzofurans. Laboratory Data Consultants, Inc., Carlsbad, CA.

LDC 2008e. Lower Duwamish Group, data validation for samples collected November 2007. SDG# DPWG24536/WG24262: polychlorinated biphenyls as congeners. Laboratory Data Consultants, Inc., Carlsbad, CA.

LDC 2008f. Lower Duwamish Group, data validation for samples collected October 2007. SDG# DPWG23923/WB23640: polychlorinated biphenyls as congeners. Laboratory Data Consultants, Inc., Carlsbad, CA.

MCS 2004a. Additional vertical characterization, Duwamish sediment other area, Seattle, Washington. Data report, February 2004. Prepared for The Boeing Company. MCS Environmental, Inc., Mountlake Terrace, WA.

MCS 2004b. Additional vertical characterization, Duwamish sediment other area, Seattle, Washington. Data report, October 2004. Prepared for The Boeing Company. MCS Environmental, Inc., Mountlake Terrace, WA.

MCS 2004c. Boeing Plant 2 Duwamish sediment other area upriver (area 1) sediment characterization, Seattle, Washington. Prepared for The Boeing Company. MCS Environmental, Inc., Mountlake Terrace, WA.

MCS 2004d. Puget Sound dredged disposal analysis for the Lehigh Northwest Duwamish Waterway Facility, Seattle, Washington. Full PSDDA characterization. Prepared for Lehigh Northwest, Inc. MCS Environmental, Inc., Mountlake Terrace, WA.

Mickelson, S. and D. Williston 2006. Technical memorandum: Duwamish River/Elliott Bay/Green River water column PCB congener survey: transmittal of data and quality assurance documentation. King County Department of Natural Resources, Seattle, WA.

NMFS 2002. Unpublished data on PCB concentrations in juvenile chinook salmon captured in the Lower Duwamish Waterway during 1993 and 2000. Environmental Conservation Division, National Marine Fisheries Service, Seattle, WA.

NOAA 1997. Duwamish River sediment study: sampling and analysis plan, quality assurance plan. Environmental Conservation Division, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA.

NOAA 1998. Duwamish Waterway sediment characterization study report. Damage Assessment Center, National Oceanic and Atmospheric Administration, Seattle, WA.

Pentec 2001. Data report, DSOA vertical characterization and Outfall 12 data collection. Duwamish sediment other area, Boeing Plant 2, Seattle/Tukwila, Washington. Pentec Environmental, Edmonds, WA.

PIE 2002. Puget Sound Dredged Disposal Analysis (PSDDA) dredged sediment characterization report, Glacier Northwest Seattle Cement Terminal. Prepared for Glacier Northwest, Inc. Pacific International Engineering, PLLC, Edmonds, WA.

Project Performance Corporation 2004. Sampling and analysis plan for south storm drain outfall and nearby sediments, Boeing Developmental Center. Prepared for The Boeing Company. Project Performance Corporation, Bellevue, WA.

PTI 1990. Duwamish River sediment analyses. Prepared for U.S. Army Corps of Engineers, Seattle District. PTI Environmental Services, Bellevue, WA.

Rhône-Poulenc. 1995. RCRA facility investigation (RFI) report for the Marginal Way facility. Vol 1: RFI results and conclusions. Prepared for U.S. Environmental Protection Agency, Region 10. Rhône-Poulenc, Tukwila, WA.

Sources for Table N-6 (continued):

Rhône-Poulenc. 1996. RCRA facility investigation (RFI) report for the Marginal Way facility. Round 3 data and sewer sediment technical memorandum. Prepared for U.S. Environmental Protection Agency, Region 10. Rhône-Poulenc, Tukwila, WA.

SAIC 1991. Letter report: Sediment chemistry and conventional analyses results for Duwamish Channel sediments collected in August, 1991. Prepared for U.S. Army Corps of Engineers, Seattle District. Science Applications International Corporation, Bothell, WA.

SAIC 2007. Lower Duwamish Waterway early action area 2: sampling and analysis plan for additional site characterization activities. Prepared for Toxics Cleanup Program, Washington State Department of Ecology. Science Applications International Corporation, Bothell, WA.

SAIC 2008a. Duwamish River federal navigation channel dredged material characterization, Seattle, Washington: sampling and analysis plan addendum. Final. Prepared for U.S. Army Corps of Engineers, Seattle District. Science Applications International Corporation, Bothell, WA.

SAIC 2008b. Duwamish River federal navigation channel dredged material characterization: sampling and analysis plan. Final. Prepared for U.S. Army Corps of Engineers, Seattle District. Science Applications International Corporation, Bothell, WA.

SAIC 2009a. Dredged material characterization for Duwamish River navigation channel: data report. Final. Prepared for U.S. Army Corps of Engineers, Seattle District. Science Applications International Corporation, Bothell, WA.

SAIC 2009b. Duwamish River federal navigation channel dredged material characterization: data report addendum. Final. Prepared for U.S. Army Corps of Engineers, Seattle District. Science Applications International Corporation, Bothell, WA.

SAIC 2009c. Lower Duwamish Waterway, early action area 2. Summary of additional site characterization activities: Trotsky and Douglas Management Company properties. Prepared for Toxics Cleanup Program, Washington State Department of Ecology. Science Applications International Corporation, Bothell, WA.

SEA 1996. PSDDA chemical characterization of Duwamish Waterway and upper turning basin. FY97 operations and maintenance dredging. Prepared for U.S. Army Corps of Engineers, Seattle District. Striplin Environmental Associates, Inc., Olympia, WA.

SEA 1998. PSDDA sediment characterization of Duwamish River navigation channel: FY99 operations and maintenance dredging data report. Prepared for U.S. Army Corps of Engineers, Seattle District. Striplin Environmental Associates, Inc., Olympia, WA.

SEA 2000a. PCB congener analysis of three sediment samples collected from the Duwamish River navigation channel. Prepared for U.S. Army Corps of Engineers, Seattle District. Striplin Environmental Associates, Inc., Olympia, WA.

SEA 2000b. PSDDA sediment characterization of Duwamish River navigation channel: FY2000 operations and maintenance dredging data report. Prepared for U.S. Army Corps of Engineers, Seattle District. Striplin Environmental Associates, Inc., Olympia, WA.

Terra Vac and Floyd & Snider 2000. Supplemental remedial investigation and feasibility study. Agency review draft. Volume 1. Prepared for GW International. Terra Vac, Edmonds, WA, and Floyd & Snider Inc., Seattle, WA.

Varanasi, U., E. Casillas, M. Arkoosh, T. Hom, D. Misitano, D.W. Brown, S-L Chan, T.K. Collier, B.B. McCain, J.E. Stein 1993. Contaminant exposure and associated biochemical effects in outmigrant juvenile chinook salmon (*Onchorynchus tschawytscha*) from urban and nonurban estuaries of Puget Sound, Washington. NOAA technical memorandum NMFS-FWFSC-8. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA.

West, J.E., S.M. O'Neill, G. Lippert, and S. Quinnell 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound ambient monitoring program fish component 1989-1999. Washington Department of Fish and Wildlife, Olympia, WA.

Weston 1993. Harbor Island remedial investigation report (part 2-sediment). Vol 1-report. Prepared for U.S. Environmental Protection Agency, Region 10. Roy F. Weston, Inc., Seattle, WA.

Weston 1998. Comprehensive RCRA facility investigation report, Boeing Plant 2, Seattle/Tukwila, Washington. Roy F. Weston, Inc., Seattle, WA.

Weston 1999. Site inspection report, Lower Duwamish River (RK 2.5-11.5), Seattle, Washington. Vol 1-Report and appendices. Prepared for U.S. Environmental Protection Agency, Region 10. Roy F. Weston, Inc., Seattle, WA.

Weston 2000. Outfall and nearshore sediment sampling report, Duwamish facility. Prepared for James Hardie Gypsum, Seattle, Washington. Roy F. Weston, Inc., Seattle, WA.

Sources for Table N-6 (continued):

Wilbur Consulting 2004. Final preliminary site investigation report for the South Park Bridge project. Prepared for King County Department of Transportation. Wilbur Consulting, Inc., Seattle, WA.

Windward 2002. East Waterway, Harbor Island Superfund site: Technical memorandum: Tissue chemistry results for juvenile chinook salmon collected from Kellogg Island and East Waterway. Prepared for the Port of Seattle. Windward Environmental LLC, Seattle, WA.

Windward 2005. Lower Duwamish Waterway remedial investigation. NOAA juvenile chinook salmon tissue data. Memorandum to EPA prepared on behalf of the Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward 2008. T-117 quality assurance project plan addendum—sediment sampling for PCB sediment removal boundary delineation in the revised EE/CA. Prepared for the Port of Seattle and the City of Seattle. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Windward Environmental LLC, Seattle, WA.

Windward and Integral 2009. Dioxin investigation and PCB sediment removal boundary delineation data report. Prepared for the Port of Seattle and the City of Seattle. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Windward Environmental LLC, Seattle, WA; Integral Consulting, Inc., Mercer Island, WA.

Windward, DOF, and Onsite 2003. Quality assurance project plan. Prepared for the Port of Seattle. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, and Onsite 2004a. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Sediment field sampling, cruise and data report. Draft. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, and Onsite 2004b. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 sediment and soil supplemental data report. Draft. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmstead & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

WR Consulting 2004. Final sediment characterization report, Boyer Towing, Inc. dock replacement, Seattle, Washington. WR Consulting, Inc., Seattle, WA.

Table N-7 Chemistry Datasets Not Acceptable for all Uses in the FS, Including Data Quality Review Summaries

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Action/ Conclusions	Reference
Sediment Chemistry							
Delta Marine dredged material characterization (subsurface sediment)	Delta Marine	2007	RM 4.2 west	PCBs (as Aroclors), SVOCs, VOCs, dioxin/furans, metals, conventionals	7 cores were collected using a vibracore sampler and homogenized to represent 3 DMMUs. One Z sample was also analyzed	not reviewed by Windward; sediment characterized has been dredged	AMEC (2007a,b) USACE et al. (2008)
Dredge material characterization Duwamish Yacht Club	Duwam Yacht Club	1999	RM 4.1 west	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs, TBT	6 core samples (vibracorer), each made from 2 separate cores collected to 50-65 cm	not reviewed by Windward; sediment characterized has been dredged	Hart Crowser (1999)
Sediment sampling and analysis James Hardie Gypsum Inc. – Round 1	Hardie Gypsum-1	1999	RM 1.6-1.7 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	5 core samples (vibracorer) made from single cores down to 120 cm	not reviewed by Windward; sediment characterized has been dredged	Spearman (1999)
Sediment sampling and analysis James Hardie Gypsum Inc. – Round 2	Hardie Gypsum-2	1999	RM 1.6-1.7 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	9 core samples (vibracorer) made from single cores down to 90 cm	not reviewed by Windward; sediment characterized has been dredged	Spearman (1999)
Dredge material characterization Hurlen Construction Company & Boyer Alaska Barge Lines berthing areas	Hurlen-Boyer	1998	RM 2.4-2.7 west	metals, organochlorine pesticides, PCB Aroclors, SVOCs, TBT, TPH	6 core samples (vibracorer), 2 from Boyer, 4 from Hurlen, each made from 2 separate cores collected to 60-120 cm	not reviewed by Windward; sediment characterized has been dredged	Hart Crowser (1998)
Sediment quality in Puget Sound. Year 2 – Central Puget Sound	PSAMP/ NOAA98	1998	RM 0.5, 0.6, 1.8	metals, PCB Aroclors, organochlorine pesticides, SVOCs, TBT	3 grab samples (van Veen) collected from 0-2 cm	Windward did not conduct a review of this dataset because the QA/QC information was not readily available. The effort that would have been required to obtain this QA/QC information was not justified for the purposes of the RI and risk assessments	NOAA and Ecology (2000)
RCRA facility investigation (RFI) report for the Marginal Way facility. Round 3 data and sewer sediment technical memorandum	RhônePoulenc RFI3	1996	RM 4.2 east	metals, phenols (4 samples)	16 grab samples collected by hand from 0-10 cm	data validation consistent with EPA guidelines, but laboratory Form 1s not present in data report; Phase 2 RI DQOs not met, so not acceptable for all uses	Rhône-Poulenc (1996)
Proposed dredging of Slip No. 4, Duwamish River, Seattle, WA	Slip4-Crowley	1996	RM 2.8 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs, TBT	4 core samples (vibracorer) composited from sediment at 9 locations collected to a depth of 70-130 cm	not reviewed by Windward; sediment characterized has been dredged	PTI (1996)
Lone Star Northwest and James Hardie Gypsum – Kaiser dock upgrade	Lone Star-Hardie Gypsum	1995	RM 1.6 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	5 core samples (vibracorer); 4 collected to a depth of 120-150 cm, 1 at 120-360 cm	not reviewed by Windward; sediment characterized has been dredged	Hartman (1995)

Table N-7 Chemistry Datasets Not Acceptable for all Uses in the FS, Including Data Quality Review Summaries (continued)

Sampling Event	Event Code	Year	Location	Chemicals	Sample Summary	Data Quality Review Action/ Conclusions	Reference
Rhône-Poulenc RCRA Facility Investigation for the Marginal Way facility – Round 1	RhônePoulenc RFI-1	1994	RM 4.2 east	metals, SVOCs, PCB Aroclors, organochlorine pesticides	7 grab samples (van Veen) collected from 0-15 cm	data validation consistent with EPA guidelines, but laboratory Form 1s not present in data report; Phase 2 RI DQOs not met, so not acceptable for all uses	Rhône-Poulenc (1995)
Lone Star Northwest – West Terminal US ACOE – Seattle	Lone Star 92	1992	RM 1.5 east	metals, organochlorine pesticides, PCB Aroclors, SVOCs, VOCs	1 core sample (vibracorer), made from 2 separate cores collected to 120 cm	not reviewed by Windward; sediment characterized has been dredged	Hartman (1992)
Sediment sampling and analysis, South Park Marina, Duwamish Waterway, Seattle, Washington	South Park Marina	1991	RM 3.5 west	metals, SVOCs, PCB Aroclors, organochlorine pesticides	2 core samples (vibracorer), each made from 2 separate cores collected to 120 cm	data not reviewed because of age of data; sediment characterized has been dredged	Spearman (1991)
Tissue Chemistry							
Preliminary exposure assessment of dioxin-like chlorobiphenyls in great blue herons of the lower Duwamish River	Heron USFWS	1998	heron colony west of RM 0.5 west	PCB congeners	6 samples taken from 5 great blue heron eggs collected by hand from nest (5 egg samples, 1 egg yolk sample)	no formal data validation conducted, laboratory Form 1s not present in data report; EPA determined QA/QC data were not readily available	Krausmann (2002)
Puget Sound Ambient Monitoring Program – annual sampling	PSAMP- fish	1992	RM 0.7	SVOCs, organochlorine pesticides, PCB Aroclors, As, Cu, Pb, Hg	6 coho salmon and 6 chinook salmon composite fillet samples (5 fish/composite caught by gill net)	Adult salmon; data were summarized in the Phase 1 RI, but were not used in the risk assessments because almost all the chemicals in these fish are associated with exposure outside the LDW	West et al. (2001)
		1993 – 1996	RM 0.7	organochlorine pesticides, PCB Aroclors, As, Cu, Pb, Hg	1993: 5 coho salmon and 6 chinook salmon composite fillet samples (5 fish/composite caught by gill net); 1994: 5 coho salmon composite fillet samples and 6 chinook salmon filet samples (5 composite, 1 individual) (5 fish/composite caught by gill net); 1995: 7 coho salmon (6 composite, 1 individual) and 15 chinook salmon filet samples (13 composite, 2 individual) (5 fish/composite caught by gill net); 1996: 19 coho salmon (5 composite, 14 individual) and 49 chinook salmon fillet samples (all individual) (5 fish/composite caught by gill net)		
		1998	RM 0.7	Hg, organochlorine pesticides	13 coho salmon composite fillet samples (5 fish/composite caught by gill net)		

Notes:

Ag = silver; Cu = copper; DMMU = Dredged Material Management Unit; DQO = data quality objective; EPA = U.S. Environmental Protection Agency; FS = feasibility study; Hg = mercury; NOAA = National Oceanic and Atmospheric Administration; O&M = operations and maintenance; Pb = lead; PCB = polychlorinated biphenyl; PSAMP = Puget Sound Ambient Monitoring Program; QA/QC = quality assurance/quality control; RCRA = Resource Conservation and Recovery Act; RI = remedial investigation; RM = river mile; SVOC = semivolatile organic compound; TBT = tributyltin; TPH = total petroleum hydrocarbons; VOC = volatile organic compound.

Sources for Table N-7:

AMEC 2007a. Draft sampling and analysis plan, Delta Marine PSDDA sediment sampling, Seattle, Washington. AMEC Earth & Environmental, Inc., Kirkland, WA.

AMEC 2007b. Sediment characterization investigation, Delta Marine PSDDA sediment sampling, Seattle, Washington. AMEC Earth & Environmental, Inc., Kirkland, WA.

Hart Crowser 1998. Dredge material characterization, Hurlen Construction Company and Boyer Alaska Barge Lines Berthing Areas, Duwamish Waterway, Seattle, Washington. Prepared for Peratrovich, Nottingham & Drage. Hart Crowser, Inc., Seattle, WA.

Hart Crowser 1999. Dredge material characterization, Duwamish Yacht Club, Duwamish Waterway, Seattle, Washington. Prepared for Peratrovich, Nottingham & Drage. Hart Crowser, Inc., Seattle, WA.

Hartman 1992. Lone Star Northwest west terminal, Duwamish River PSDDA sampling and analysis results. Hartman Associates, Inc., Seattle, WA.

Hartman 1995. Lone Star Northwest and James Hardie Gypsum, Kaiser Dock Upgrade, Duwamish Waterway PSDDA sampling and analysis results. Hartman Associates, Inc., Seattle, WA.

Krausmann, J.D. 2002. Preliminary exposure assessment of dioxin-like chlorobiphenyls in great blue herons of the lower Duwamish River in Seattle, Washington. U.S. Fish and Wildlife Service, Lacey, WA.

NOAA and Ecology 2000. Sediment quality in Puget Sound. Year 2 - central Puget Sound. Ecology publication no. 00-03-055. National Oceanic and Atmospheric Administration, Silver Spring, MD and Washington Department of Ecology, Olympia, WA.

PTI 1996. Proposed dredging of slip no. 4, Duwamish River, Seattle, Washington: data report. Prepared for Puget Sound Dredged Disposal Analysis Program. PTI Environmental Services, Bellevue, WA.

Rhône-Poulenc 1995. RCRA facility investigation (RFI) report for the Marginal Way facility. Vol 1: RFI results and conclusions. Prepared for U.S. Environmental Protection Agency, Region 10. Rhône-Poulenc, Tukwila, WA.

Rhône-Poulenc 1996. RCRA facility investigation (RFI) report for the Marginal Way facility. Round 3 data and sewer sediment technical memorandum. Prepared for U.S. Environmental Protection Agency, Region 10. Rhône-Poulenc, Tukwila, WA.

Spearman, J.W. 1991. Sediment sampling and analysis, South Park Marina, Duwamish Waterway, Seattle, Washington. Jay W. Spearman, Consulting Engineer, PS, Kirkland, WA.

Spearman, J.W. 1999. Sediment sampling and analysis, James Hardie Gypsum Inc., Duwamish Waterway, Seattle, Washington. Jay W. Spearman Engineering, PS, Kirkland, WA.

USACE, EPA, Ecology, and DNR 2008. Supplemental determination regarding the suitability, with respect to dioxin, of proposed dredged material from Delta Marine Industries, Duwamish River, Seattle, King County, for unconfined open-water disposal at the Elliott Bay nondispersive site. CENWS-OD_TS-DMMO. September 9, 2008. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, Washington State Department of Ecology, and Washington State Department of Natural Resources, for the Dredged Material Management Program, Seattle, WA.

West, J.E., S.M. O'Neill, G. Lippert, and S. Quinnell 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound ambient monitoring program fish component 1989-1999. Washington Department of Fish and Wildlife, Olympia, WA.

Part 2: Memorandum on Use of Duwamish/Diagonal Early Action Area Surface Sediment Data

MEMORANDUM

To:	EPA, Ecology	**Date:**	May 27, 2010[1]
From:	Lower Duwamish Waterway Group	**Project:**	Lower Duwamish Waterway FS
Re:	**Use of Duwamish/Diagonal Early Action Area Surface Sediment Data in Final Feasibility Study**		

The RI baseline dataset contained surface sediment data collected between 1991 and 2006. The RI baseline dataset was "locked down" following receipt of the Round 3 surface sediment data collected in 2006. Since establishment of the Remedial Investigation (RI) baseline dataset that was used to conduct the characterizations and analyses in the RI and in the Draft FS, additional data have been collected in the Lower Duwamish Waterway (LDW). Therefore, a new feasibility study (FS) "baseline dataset" has been established for the Final FS. The purpose of the FS baseline dataset is to: 1) establish conditions within the LDW prior to any proposed remedies,[2] and 2) use these baseline conditions in the comparative analysis of remedial alternatives in the Final FS. This memo discusses the use of data collected by King County in and around the Duwamish/Diagonal Early Action Area (EAA) in the Final FS. The FS baseline dataset adheres to the same general data rules as those for the RI baseline dataset (Windward 2003; LDWG 2010).

Duwamish/Diagonal Post-Action Data

In November 2003, King County dredged a 7-acre area of the Duwamish/Diagonal EAA (Figure 1). Next, an armored sand cap was placed over the dredged area in February and March 2004. Based on post-construction monitoring data collected in 2004, a 6-inch layer of sand (enhanced natural recovery [ENR]) was placed over an adjacent 4-acre area (Figure 1) during the following construction window in February 2005.

Following completion of these actions, cap, ENR, and perimeter monitoring stations were sampled annually for five years (2005 through 2009). These monitoring data were not used in the RI baseline dataset because the dataset was "locked down" in 2006 and because only preremedy data from the cap, ENR, and perimeter monitoring stations

[1] Revised to reflect that the work was done for the Final FS. No new analysis was performed.

[2] Including baseline conditions prior to the now-completed Duwamish/Diagonal EAA and Boeing Developmental Center south storm drain actions.

were used (per the definition of "baseline" for the RI). Both the RI and the Draft FS presented the 2005–2007 data from these monitoring locations in a time trends analysis.[3]

Use of Duwamish/Diagonal Data in the Draft Final FS

Under the general "10-foot" rule for reoccupied stations, the most recently available data were used for the FS baseline dataset, which had a "lock down" date of April 2010. The Duwamish/Diagonal data are an exception to this rule. The Duwamish/Diagonal data collected from the cap, ENR, and perimeter monitoring stations were used in the Final FS as listed below and as described in Tables 1 and 2:

- Only the dredge/cap footprint was used to define the boundary of the EAA. Because thin-layer placement within the ENR area was in response to dredge residuals rather than a final remedy, it was considered like the rest of the LDW for inclusion within the Areas of Potential Concern for development and evaluation of remedial alternatives (i.e., rather than part of the EAA footprint for Alternative 1).
- The preremedy data from the cap[4] and ENR monitoring stations were used in the FS baseline dataset. The exception is that the 2009 dioxin/furan composite sample[5] from the ENR area (referred to as Composite C) was used in the FS baseline dataset because of the limited dataset and because there were no dioxin/furan data there prior to thin-layer placement. The 2009 dioxin/furan composite data from the cap area (Composites A and B) were not used in the FS baseline dataset because they reflect remediated, post-EAA conditions.
- The most recent data from the 2005-2009 perimeter monitoring events, conducted since completion of the EAA actions, was included in the FS baseline dataset. Following the data rules, the most recent data (2009) were presented (data from the four previous years were trumped because the same nominal locations were sampled each year). Any data that were trumped (e.g., preremedy or post-remedy monitoring data) were retained for use in the Final FS for time trend analyses, similar to any other area of the LDW with data collected in multiple years.
- Data from the 2005-2009 monitoring of the ENR area were used to inform the assignment of remedial technologies for the remedial alternatives. They were

[3] The 2005 to 2007 monitoring data were evaluated in the Draft FS; the 2008 and 2009 results were not yet available.

[4] The monitoring data from the dredge/cap footprint are described as cap monitoring data.

[5] Three composite samples were made from the 2009 cap and ENR samples collected by King County: one each from Cap Area A, Cap Area B, and the ENR Area. These three composite samples were analyzed for dioxins/furans.

also used, along with the preremedy data collected in the ENR area, to demonstrate the efficacy of this technology (ENR) in the LDW.

- Preremedy data and data from the 2005-2009 post-remedy monitoring of the cap were used to demonstrate the efficacy of this technology (capping) in the LDW.

The time trends data (preremedy and 2005-2009 post-remedy monitoring data) were valuable for providing site-specific information about the performance of three technologies in the LDW: cap, ENR, and monitored natural recovery (MNR).

The FS baseline data were used in a strictly objective sense to evaluate remedial action level exceedances and to set the footprint for active remediation (dredging, capping, ENR) in areas outside the EAAs for each remedial alternative. Figure 1 displays the locations of the surface sediment data discussed in this memo that were included in the FS baseline dataset and were used for other FS analyses.

Table 1. Comparison of Duwamish/Diagonal Data and Use of Data Types

<table>
<tr><th rowspan="2">Monitoring Data</th><th colspan="3">Document/ Dataset and How Used</th></tr>
<tr><th>Draft FS:
RI Baseline</th><th>Final FS:
FS Baseline</th><th>Final FS:
Time Trends and Technology Assignments</th></tr>
<tr><td>Cap</td><td rowspan="3">Preremedy</td><td>Pre-remedy</td><td rowspan="3">All data up through 2009 for time trends; Most recent data in ENR and perimeter areas for technology assignments (2009)</td></tr>
<tr><td>ENR</td><td>Preremedy plus 2009 dioxin/furan composite “C” sample</td></tr>
<tr><td>Perimeter</td><td>Most recent (up through 2009)</td></tr>
</table>

Note: See Figure 1 for locations of the monitoring stations.

Table 2. Use of Duwamish/Diagonal Data in the Draft Final FS

FS Section	Pre-Remedy Data			Post-Remedy Data		
	Dredge/Cap	ENR	Perimeter	Cap	ENR	Perimeter
Section 2 – nature/extent mapping; re-interpolation (FS baseline dataset)	X	X	X	—	—	Most recent (up through 2009)[c]
Section 6 – establish the area of potential concern (AOPC)	—[a]	X[b]	X	—	—	
Section 7 – time trends and evaluation of dredging/capping, ENR, and MNR technologies	Compare preremedy to post-remedy conditions			Compare 2005 through 2009 trends		
Section 8 – assign technologies and develop remedial alternatives	—	—	—	—	X (2009)	X (2009)

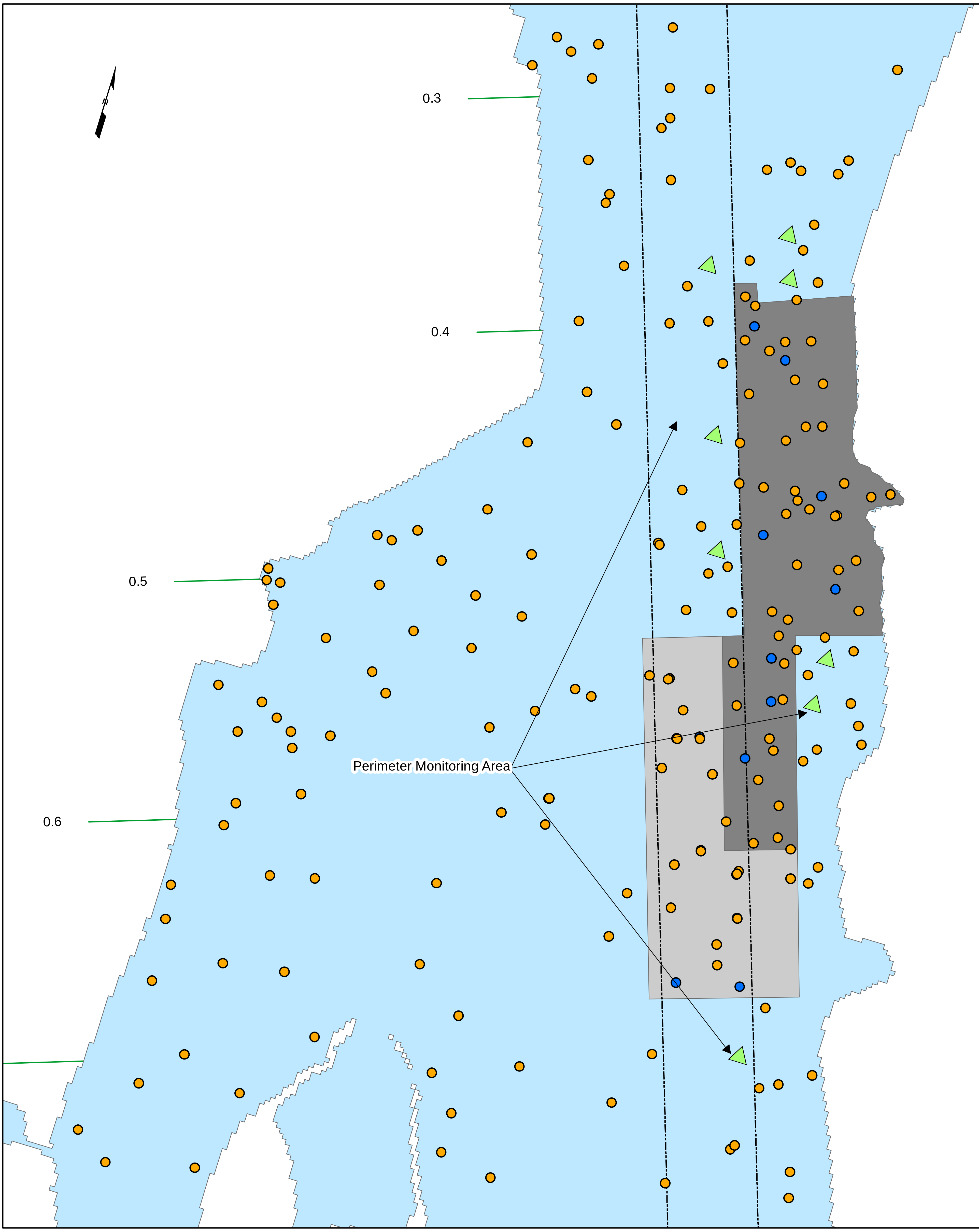
Notes:
X Data used for purpose indicated.
— Data not used for purpose indicated.
[a] The dredge/cap footprint, as an EAA, is included in the Alternative 1 footprint as a completed action.
[b] Includes 2009 dioxin/furan composite sample C from the ENR area.
[c] Perimeter monitoring data follow 10-ft trumping rule established in RI. During each year of the monitoring, the samples were collected nominally from the same locations, so only the most recent data are used in the FS baseline dataset.

References

LDWG 2010. *Additional sediment chemistry data needed for the LDW FS.* Memorandum to U.S. Environmental Protection Agency and Washington Department of Ecology. Prepared for the Lower Duwamish Waterway Group. Prepared by AECOM and Windward Environmental LLC, Seattle, WA. February 24, 2010.

Windward 2003. *Lower Duwamish Waterway Remedial Investigation. Task 5: Identification of candidate sites for early action, Technical Memorandum: Data analysis and candidate site identification.* Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward 2006. *Technical Memorandum: Criteria for Defining the Baseline Surface Sediment Dataset for Use in the Lower Duwamish Waterway Phase 2 RI/FS.* Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.



Notes:
1. Five years of post remedy data (2005-2009) for the cap, ENR area, and perimeter monitoring stations will be considered for the time trend analysis and technology assignments.
2. FS Baseline data from database provided by Windward on April 2, 2010, with the exception of the baseline ENR area data, which is from the RI baseline dataset.

Legend

Duwamish/Diagonal Cap, ENR, Perimeter, and Vicinity Sampling Locations

- Post-remedy Monitoring Location (2005-2009)
- FS Baseline Location
- Perimeter Monitoring Station (2009 in FS baseline; 2005-2009 for time trends/technology assignment).
- Duwamish/Diagonal Dredge and Capping Area
- Duwamish/Diagonal ENR Area
- Study Area
- Navigation Channel
- River Mile Marker

Feet
0 125 250 500

L:\Lower Duwamish FS\FS_Final_GIS\Oct2012\FS_GIS_MXDs_Oct12\Appendix N\FigureN-1_DD_ENRSamplocsV2.mxd

AECOM

Lower Duwamish Waterway Group
Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Final Feasibility Study 60150270-14.33			**Duwamish/Diagonal Cap, ENR, Perimeter, and Vicinity Sampling Locations**
DATE: 10/31/12	DWRN:mvi/SEA	Revision: 1	**FIGURE 1**