Lower Duwamish Waterway Group

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

Appendix D – Supporting Analysis for SMAs and RALs

Draft 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 Field Office
Bellevue, WA

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Appendix D: Supporting Analysis for SMAs and RALs

To support the identification of Sediment Management Areas (SMAs) and the selection of Remedial Action Levels (RALs), several exploratory analyses were conducted. These analyses were summarized in Section 6 of the FS. This appendix provides additional supporting information for these analyses for defining SMAs (Section D.1), exploring the relationship between point concentrations and SWACs (Section D.2) and identifying RALs (Section D.3).

D.1 Lines of Evidence for Sediment Management Areas

Section 6 describes the process for mapping and delineating Sediment Management Areas. It also presents the 49 SMAs and 79 subSMAs. Table D-1 summarizes the chemical and physical data evaluated for each SMA. Table D-2 summarizes the lines of evidence used to evaluate natural recovery potential for each SMA. The types of data evaluated within each SMA included:

- Highest surface sediment chemical concentration detected in an SMA (as interpolated data or sample point data)
- Number and magnitude of chemical exceedances
- Physical features such as berthing areas, shoreline access, recent dredging events, beach play or potential tribal clamming area
- Other historical details (e.g., land use, debris, chemical spills, etc.)
- Maximum depth of SQS and CSL exceedances in subsurface cores, and interval with highest concentrations
- Highest concentration detected in the core, and in the upper interval (0 to 2 ft) of the core
- Chemical results for surface sediment samples collected from re-occupied stations, compared to older results
- BCM recovery predictions
- Presence/absence of scour from high-flow events
- Empirical evidence of scour from vessel operations
- Estimated net sedimentation rates from model or empirical evidence.

D.2 Relationship between Point Values and Average Concentrations

The SMA footprint was initially mapped as individual point concentrations that exceed the PRGs. However, a direct comparison of chemical point concentrations (at specific sample locations) to PRGs is not appropriate for all PRGs. This is because the PRGs associated with RAO 1 (seafood consumption), RAO 2 (direct contact), and RAO 4 (consumption of prey) are area-based averages. Therefore, each area-based average concentration needs to be "converted" to not-to-exceed point concentration to draw the AOPC footprint.

To accomplish this "conversion," chemical concentrations were evaluated in an iterative fashion by individual chemical. The chemical concentrations were ranked from highest to lowest (point data for dioxins/furans or interpolated grid cells for the other chemicals), and the highest values were sequentially replaced with a post-remedy bed sediment replacement value (in Excel worksheets) until a risk-based target concentration, or site-wide SWAC, was achieved. For example, if areas with total PCB concentrations of greater than 250 micrograms per kilogram dry weight (µg/kg dw) are actively managed on a point-basis, then a SWAC of 100 µg/kg dw would be achieved site-wide immediately following active remediation. The conversion also considered the relative distribution of the risk drivers in each SMA to prioritize the PRGs selected for evaluation (i.e., the evaluation focused on hot spots first, then increasing footprints). The resulting point-based values were used to define the AOPC footprint[1], which in turn was used to map the SMAs in Section 6.

Figures D-1a through D-1d show the maximum point concentrations remaining as the footprint increases, and incrementally larger areas are "remediated," moving from the highest to lowest concentration. This figure series illustrates that the rate of change in point concentrations rapidly diminishes as the footprint increases in size. The rate of change in the SWAC in surface sediments also diminishes as the footprint size increases. These curves were used to select surrogate point concentrations for the comparison to PRGs and for mapping the SMAs.

D.3 Exploratory RAL Analysis

In order to define RALs for the FS, several methods (or metrics) were evaluated to determine the RALs or to verify the selection and effectiveness of the RALs identified. This analysis was presented in Section 6 of the FS; this Appendix provides additional detail regarding these approaches.

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[1] The AOPC footprint is about 210 acres, but when mapped as SMAs is only 193 acres. The SMAs consolidated the AOPC footprint into manageable acres based on co-location of chemicals, physical conditions, and sediment toxicity passes, which resulted in a slightly smaller footprint.

As stated in Section 6, three different methods (exploratory analyses) were used to evaluate the RALs for each risk driver. These methods included:

1) Using the BCM model-predicted concentrations to identify RALs that achieve set criteria within 10 years following completion of active remediation.

2) Evaluating maximum remaining point concentrations versus percent change in SWAC (effectiveness index).

3) Evaluating the maximum remaining point concentrations versus SMAs managed to confirm the findings of the first two methods by considering the co-occurrence of chemicals and prioritization of SMA footprints.

For all three analyses, the metric of primary interest was the SWAC in the biologically active zone (top 10 centimeters [cm]) as a surrogate measure of the effectiveness in reducing risk. The results of these analyses are summarized in Section 6, with details provided below. Overall, all of the exploratory methods yielded similar results.

D.3.1 Metric 1: BCM-predicted Year 10 Concentrations

The first metric explored in selecting RALs for the FS used BCM-predicted concentrations to identify RALs that achieve set criteria within 10 years following completion of active remediation. This analysis uses the BCM to back-calculate an acceptable year 0 concentration needed to achieve site-wide goals within 10 years following active remediation.

The STM output can be used to look at the time it takes for Green/Duwamish River sediments to dominate the bed composition within a model grid cell. Areas with a lot of sediment input from upstream can be expected to approach the upstream concentration in a reasonable time frame.

The concept can also be applied as a method of screening for RALs. The BCM model (Equation 1) is used in the analysis. The fixed variables are time (i.e., ten years) and the concentration desired at Year 10 (e.g., the SQS), the BCM equation can then be solved for an acceptable Year 0 concentration (point-based) that is predicted to be below the CSL or SQS within ten years.

This is calculated by re-arranging equation 1 to solve for C_{bed} (at year 0) as follows:

$$\text{Year 10 } C_{(time/bed)} = \text{Year 0 } C_{bed} * f_{bed} + C_{lateral} * f_{lateral} + C_{upstream} * f_{upstream} \quad \text{(Eq 1)}$$

Then solve for C_{bed}:

$$\text{Year 0 } C_{bed} = \text{Year 10 } C_{(bed)} - (C_{lateral}*f_{lateral} + C_{upstream}*f_{upstream}) / f_{bed} \qquad \text{(Eq 2)}$$

Where:

- f_{bed}, $f_{lateral}$, and $f_{upstream}$ are, respectively, the fractions of surface sediment sourced from existing bed sediment, from lateral source sediment, and from upstream Green/Duwamish River sediment in each grid cell at a specific point in time. For this analysis, these fractions are derived from a 10-year run of STM.
- $C_{lateral}$ and $C_{upstream}$ are the concentrations of a COC associated with each sediment source. These concentrations (input values) are described in Section 5.
- $C_{(time/bed)}$ is the desired concentration, or cleanup level, at a particular year in the future. For this analysis, Year 10 concentration goals for surface sediment were the CSL, SQS, and background PRGs.

The STM output provides the bed composition sourced from lateral, upstream inflows, and bedded sediment (expressed as fractions). The STM output for Year 10 indicates that the site-wide average bed composition is expected to be about 23% original bed, 75% upstream source, and 2% lateral source (Table D-3, upper part). The average composition (source fractions) for Reaches 1, 2, and 3 are also shown in Table D-3 for comparison. Using the recommended BCM input values for lateral and upstream source sediment (see Section 5 or Table D-3, middle part) and various 10-year risk-driver goals, the BCM equation is solved for Year 0 concentrations (or RALs).

The lower portion of Table D-3 presents the model-predicted Year 0 concentrations required to meet the various Year 10 goals. This analysis shows:

- For PCBs, a point concentration of about 830 µg/kg dw is expected to yield the most point values below 240 µg/kg dw (approximate SQS value based on 2% TOC) within 10 years following active remediation. The total PCB RAL should be lowered to about 700 µg/kg dw to account for the slightly longer recovery time needed for Reach 1. A point concentration of about 5,410 µg/kg dw, or about four times the CSL, is expected to yield the most points below the CSL within 10 years.
- For arsenic, the analysis shows that all existing point values between the CSL (93 mg/kg dw) and the SQS are predicted to recover to below the SQS within 10 years following active remediation (there are not many data points above the CSL). A site-wide RAL for arsenic is not needed for the FS beyond the existing

SQS and CSL criteria, because remediation of the areas with concentrations above the CSL and SQS accounts for most of the predicted incremental change in either the point data or averaged concentrations. To meet the SQS within 10 years, a RAL of 180 mg/kg dw for arsenic would be needed; therefore, the CSL is simply used as the SQS Year 10 RAL.

- For cPAHs, if the metric is to ensure that every cPAH point value is below 1,500 µg TEQ/kg dw (the net-fishing 10^{-6} PRG) within 10 years, then a RAL of 5,720 µg TEQ/kg dw is needed. If the metric is for every point to be below 900 µg TEQ/kg dw within 10 years, then a RAL of about 3,000 is needed, and could be lowered to about 2,650 to account for the slightly longer recovery time needed for Reach 1.

  For cPAHs, the site-wide baseline SWAC (or "current conditions") is about 390 µg TEQ/kg dw. The site-wide SWAC (using the BCM) is predicted to be below a background value of 300 µg TEQ/kg dw (the PRG for RAO 1) within 10 years following the removal actions within the sponsored EAAs; therefore, a site-wide RAL for cPAHs is not needed for the FS. However, as shown in the point-value analysis in Section 6, an area-wide RAL for cPAHs in beach and clamming areas is needed to address direct contact risks in the individual beach play and tribal clamming areas.

Reaches 2 and 3 are expected to have higher percentages of material sourced from upstream in 10 years (>76%) compared to Reach 1 or the LDW-wide average. RALs applied to the entire LDW will likely be conservative for these areas.

Dioxins/furans and other SMS chemicals were not evaluated using this method of site-wide average BCM model predictions because limited data are available for interpolating the bed surface needed to run the BCM model.

D.3.2 Metric 2: Effectiveness Index

The second metric evaluated in the RAL analysis focused on the relationship between the relative changes in SWAC reduction (effectiveness index) to remediated acres. In this analysis, GIS was used to sort interpolated grid cells (every 50^{th} 10-ft by 10-ft cell) in ranked columns from the highest concentration to the lowest for each risk driver chemical. The highest grid cell values were sequentially replaced one-by-one with post-remedy bed sediment replacement values (in Excel worksheets) as each grid cell was "remediated" and the site-wide SWAC was recalculated. The supporting Excel data file includes the number of acres remediated, the unique grid-cell identification (ID) expressed as a rank, the point concentration in that cell, the incremental change in SWAC, and the incremental change in acres.

Estimates were made of the relative risk reduction (percent change in SWAC) associated with progressively greater volumes of actively managed LDW sediment (i.e., dredging, capping, or ENR). This measure is called the "relative effectiveness index" (REI). For this analysis, the REI is defined as the incremental reduction in the site-wide SWAC following active remediation (relative risk reduction) divided by the incremental number of acres of sediment dredging/capping/ENR required to achieve the change. The change in SWAC is normalized to the biggest reduction in SWAC after the highest concentrations are managed (Figures D-2a through D-2d).

As shown on these figures, the points on the curve relate the percent change in SWAC (biggest SWAC reduction) to the increasing number of actively managed areas. The analysis shows a continuum of decreasing SWAC reduction per unit area, and the "knee-in-the-curve" where the effectiveness index reaches a low and fairly constant value as the remedial footprint (acres) increases. This definition assumes that risk is directly proportional to the SWAC. In general, the rate of change decreases below the SMS point-based criteria or 1 x 10^{-5} RBTCs for direct contact. Table D-4 lists the maximum remaining point concentrations (or RALs) depending upon which point in the curve is selected–the top, middle ("knee"), or the bottom of the curve. The top of the curve represents hotspot areas that can be managed with a small number of acres for the largest SWAC reductions (similar to the AOPC 2 footprint). The middle of the curve represents areas with medium concentrations/exceedances that can be managed with a larger number of acres and still see some SWAC reductions. The bottom of the curve represents the limit of reasonably effective RALs. The effectiveness index curves are presented in Figures D-2a through D-2d for PCBs, arsenic, cPAHs, and dioxins/furans, respectively[2]. The results and maximum remaining point based on these curves (and recommended RAL) are summarized in Table D-4.

In summary, these percent change in SWAC (effectiveness index) graphs show:

- The knee-in-the-curve for total PCBs is about 2,200 µg/kg dw (Figure D-2a). The bottom of curve is about 700 µg/kg dw, which is similar to the model-derived RAL for PCBs.
- The knee-in-the-curve for arsenic is about 80 to 90 mg/kg dw (Figure D-2b). This value is similar to the CSL of 93. The model does not provide a well-defined bottom of the curve for arsenic

[2] Some of these figures are "zoomed in" so the knee-in-curve is more apparent; however, this prevents the top of the curve from being shown.

because equilibrium is reached within a fairly small number of acres remediated.

- The knee-in-the-curve for cPAHs is about 2,000 µg TEQ/kg dw (Figure D-2c). The bottom of the curve is about 900 µg TEQ/kg dw which is similar to the model-derived RAL needed to manage direct contact risks for beach play, clamming, and netfishing scenarios.

- The model for dioxins/furans is limited by the smaller sample size, but the knee-in-the-curve of data points (N=51) is about 49 ng TEQ/kg dw (Figure D-2d). The bottom of the curve is about 28 ng TEQ/kg dw.

These curves show that the greatest net benefits are gained by managing hotspots. There is incrementally less benefit (less change in the SWAC) by managing larger areas. Other metrics, such as managing SQS and CSL point exceedances or direct contact exposure areas, may be the driving force for selecting larger areas to actively remediate, and not the SWAC.

D.3.3 Metric 3: Evaluation of RALs by SMA Ranking

The RALs identified in the two methods described above were limited to individual chemicals; the co-occurrence of chemicals and SMAs was not considered. The SMAs defined in Section 6.2 consider the spatial proximity of chemicals to each other, levels of toxicity and concentration, and chemical gradients. Therefore, it is possible that fewer RALs are needed among the array of RALs because fewer thresholds exist as SMAs are actively remediated (e.g., by design, the SMA boundaries extend to the limits of chemical exceedances of the SQS).

To explore the relationship between exceedances and spatial areas, RALs were evaluated by ranking the SMAs from highest to lowest concentrations using two different criteria: (1) by total PCB concentration, and (2) by summing the concentrations of risk-driver chemicals. The next step was determining the maximum/second maximum point remaining concentration outside of the SMA footprint, assuming the SMA with the highest chemical concentration was managed first, followed by the next highest ranking SMA. This was accomplished as follows:

- The SMAs were sorted by non-parametric ranking, based on ranking the risk driver chemicals (total PCBs, arsenic, and cPAHs) and SQS exceedances individually, then summing the ranks into a fourth analysis.[3]

- The SMAs were re-ordered into a final rank based on the lowest cumulative rank to highest.
- The SMA with the lowest cumulative rank (after the EAAs) was replaced first using the BCM chemical input values and so on.[4]

The resulting final ranks are presented in Table D-5. The cumulative rank was explored with and without dioxins/furans, results showed little difference between the two methods. The analysis used the highest exceedance factor (EF) for any SMS chemical of concern above the SQS criteria, regardless of the chemical. The ranks were converted to percentiles and summed. The lowest percentile rank was ranked first. The recommended RALs based on this SMA ranking analysis are summarized in Table D-6.

In general, the Category 1 SMAs (higher concentrations not expected to recover) were ranked first, and the Category 2 SMAs (moderate concentrations expected to recover) were ranked after that. The Category 3 SMAs (lower concentrations, recovery already expected) were generally in the last group. These SMA ranking results were used to help guide the assembly of remedial alternatives in Section 8. This third analysis considers the co-occurrence of chemicals within an SMA, whereas the previous RAL analyses do not. The previous analyses only explored individual chemicals without consideration of proximity to other chemicals or location in the LDW. The SMA ranking metric more realistically represents how areas may be managed during implementation by simulating entire SMAs that may be actively remediated and how these affect the site-wide average results.

Figures D-3a through D-3c present the cumulative SMA ranks expressed in acres, and the resulting average concentrations for total PCBs, arsenic, and cPAHs, respectively (each symbol on the map is an SMA)[5]. This figure shows a step-wise reduction in the average concentrations; three "steps" are evident on the figure, roughly matching SMA Categories 1, 2, and 3 (SMA categories are described in Section 6.4 of the FS).

The slope of the line on these figures represents the incremental SWAC reduction per acre remediated:

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3 First, the SMAs were ranked from highest to lowest concentration for total PCBs, arsenic, and cPAHs individually (three columns), then summing the ranks into a fourth column. The summed and ranked SMAs were then sorted from highest to lowest.

4 While other means of ranking SMAs could be developed, this method is considered useful for the exploratory analysis discussed in this subsection.

5 An MS Excel reference table was used to determine the maximum remaining concentration outside of the SMA footprint.

- For arsenic and total PCBs, the largest change in slope occurs after managing EAAs and the Category 1 SMAs, a moderate slope change occurs after managing the next group of SMAs, and a very small slope change is observed for the remaining SMAs (above about 150 acres).
- For cPAHs, there is a roughly constant but gradual decreasing slope, which is indicative of the fewer cPAH hotspots and widely distributed low levels of cPAH concentrations. This pattern may indicate that cPAHs will be difficult to remediate in the short-term because of non-point source contributions of cPAHs typical of urban settings such as the LDW.

Table D-6 presents the recommended RALs associated with these ranked SMAs and changes in slope (breakpoints). A second ranking was also completed using total PCB concentrations only (SMAs were ranked in order from the highest detected PCB concentration to the lowest), with similar results. The analysis was not conducted on dioxins/furans. Figure D-4 shows the SMA ranking based on total PCB concentrations, and not cumulative ranks.

In particular, this PCB-only analysis shows:

- The maximum remaining point concentration after managing the first group of SMAs of about 5 to 10 SMAs with the highest concentrations (50 to 60 acres) was 1,700 µg/kg dw for total PCBs. This value is similar to the RALs derived from the bed composition model (SQS Year 10 values).
- The maximum remaining point concentration after managing the second group of about 15 SMAs with moderate concentrations (100 to 130 acres) is 660 µg/kg dw for total PCBs. This value is similar to the RALs derived from the effectiveness index evaluation.
- The maximum remaining point concentration after managing the third group of SMAs with moderate to low concentration (about 160 acres) (and expected to recover naturally) was about 460 µg/kg dw for total PCBs. This value is similar to the RALs derived from the effectiveness index evaluation.

The SMA-derived RALs consider the co-occurrence of chemicals and incremental management of SMA footprints. By doing so, the effective change in SWAC is realized with higher RALs for individual chemicals. Active remediation of SMAs with the highest chemical concentrations will have the greatest change in SWACs.

Table D-1 Chemical and Physical Considerations for Mapping Sediment Management Areas (Category 1 and 2 SubSMAs)

				CHEMICAL DATA							
				Interpolated Data			# of SMS Stations		# of Chemicals	Magnitude of Concentrations	
Proposed SMA	River Mile	Location/ Description	Size (acres)	cPAH (µg TEQ/kg)	PCB (µg/kg)	As (mg/kg)	Chemical Exceedances	Toxicity Exceedances	Chemicals > SQS?	CSL EF > 2.0	Dioxin TEQ >37 (ng TEQ/kg)
SMA 1	0	Harbor Island Marina	4.9	>900	Low	Low	4 SQS	1 CSL	Hg, PCB, PAH	No CSL	—
SMA 2	0.1 E	Ash Grove Cement	1.3	380-900	>CSL due to 1 station	>CSL due to 1 station	2 CSL; 1 SQS	1 CSL	Pb, BEHP, PCB, As (all >CSL); zinc (>SQS)	PCBs SQS EF 15	No, 1 station at 7
SMA 3	0.2 E	Ash Grove Cement	2.2	>900	Low	Low	1 SQS	—	PCB only	No CSL, SQS EF 1.1	—
SMA 4	0.1 - 0.2 W	T103 Park/ Ferguson	3.3	>900	Low	Low	3 SQS	—	Phenol, PCB, PAH	Most around 1, 2.3 for fluoranthene (of SQS)	No, 1 station at 6
SMA 5	0.25 mid channel - 0.4 W	General Recycling and Herring's House	6.2	Hot spot >900, most >380	Some parts >240	<16	3 CSL; 5 SQS	2 SQS	Hg (CSL); PAH, PCB (SQS)	Hg CSL 1.5 - 4.4	—
SMA 6A-E	0.3 E - 0.55 navigation channel	Adjacent to D/D EAA	15.7	Hot spots >900, most >380	Hot spots > 1300, most >240	Most > 20	17 CSL; 17 SQS (included stations on d/d border)	2 CSL; 1 SQS; 1pass	Hg, silver, BEHP, PCB, methylphenol	PCBs, BEHP	—
SMA 7A-D	0.5-0.7 W	NW of Kellogg Island	10.0	Hot spots >900, remainder below 90	Small spots >720, mix	1 station > 20, rest low	4 CSL; 8 SQS	1 CSL	PAHs, PCB, mercury	PAHs, PCB at 7.8	No, 1 station at 16
SMA 8A	RM 0.85W	West side Kellogg Island	1.6	1 hot spot >900, remainder mix	1 spot >480, remainder low	Low	3 SQS	—	PCB, phenol, fluoranthene	No CSL	No, 1 station at 9
SMA 9	0.8-0.9 navigation channel	east of Kellogg Island	5.8	150-380	Low	Low	4 SQS	1 CSL	PCB, fluoranthene, total HPAHs	No CSL	No, 1 station at 10
SMA 10	Slip 1	Slip 1, almost whole slip	7.5	2 hot spots >900, remainder mix	1 station at 720, remainder is low mix	1 hot spot >93, rest is low mix	3 CSL; 4 SQS	1 CSL; 1 SQS	As, PCB, mercury, zinc	As, Zn, Hg >2	—
SMA 11	1.0-1.1 W	LaFarge berth and dioxin navigation channel	8.4	>380	1 station > 1300; remainder mix	Low	2 CSL; 3 SQS	1 CSL	PAHs, PCB, Hg, phthalates	PCBs, PAHs	124 bounded by 4 stations below 20
SMA 12	1.1 E	Lehigh NW	0.4	>380	Low	>20	1 CSL	1 CSL	Hg	No	—
SMA 13	1.1-1.2 navigation channel	Navigation channel (RM 1.1-1.2)	2.7	Low	Low	Low	2 SQS	1 CSL	PCB, BEHP	No CSL	—
SMA 14	1.25 - 1.45 W	Duwamish Shipyard	3.7	Hot spots >900	Low	Hot spots > 93	4 CSL, 2 SQS	1 CSL	Metals, PAHs, phthalates	As, Cu, Zn	No, 1 station at 18 at downstream end

	PHYSICAL DATA /LAND USE				
		Use			
Proposed SMA	Other Details (Historic Land Use, Observations)	Recent Dredging?[a]	Active Berthing Area?[a]	In Beach Area?	In Clamming Area?
SMA 1	Historic Harbor Island sources?	No recent dredging	Harbor Island Marina, no permited water depth reported	No	No
SMA 2	Rock flour in core, part of larger TTA Ash Grove Cement; historic water tank mnfg, historic and current cement plant	No recent dredging	Ash Grove Cement: 2 piers/wharfs permitted to -25'	No	No
SMA 3	Cement plant and T106, barge broke and spilled gravel	No recent dredging		No	No
SMA 4	Habitat restoration area, old piling field	No recent dredging	No - T103 Pilegroup (Glacier NW South Wharf) permitted to -10'	Yes	Yes
SMA 5	Downstream of Seaboard Lumber restoration; historic steel foundry and rock processing	No recent dredging	2 Birmingham Steel Wharfs maintained to -40' and -15', underwater and overhead cables	No	No
SMA 6A-E	Terminal and historic wastewater treatment plant and sludge lagoons	No recent dredging outside of EAA	Wharf, no maintained depth published, not dredged	Yes	Yes
SMA 7A-D	Historic lumber and brick company	No recent dredging	Pilings and dolphins, part of Birmingham Steel Wharf, maintained to -15	Yes	Yes
SMA 8A	Port of Seattle property, no historic sources identified	No recent dredging	No	Yes	Yes
SMA 9	Scour area east of Kellogg Island	No recent dredging	Authorized nav channel	No	No
SMA 10	Historical PCB spill, Lehigh NW DMMU 2 not suitable for open water disposal (2004)	Lehigh NW dredged in 2004 outside of Slip 1 to -20': 1 of 3 DMMUs was unsuitable for open water disposal	Manson Const and US Govt, maintained depth range -15' to -26'	No	No
SMA 11	R3 samples taken to bound dioxin and PCB hot spot	No recent dredging	Wharf to -32'; nav channel to -30'	No	Yes, in part of SMA
SMA 12	Current properties are Cadman / Lehigh NW and ICONCO/LVI Demolition	upstream of Lehigh NW dredging to -20'	No, pile group	No	No
SMA 13	Historic chemical mfg to west	No recent dredging	Navigation channel maintained to -30'	No	No
SMA 14	Sand blast debris in core, historic ship building, current ship maintenance	No recent dredging	Graving dock to -20' (filled in); wharf to -25'	No	No

Table D-1 Chemical and Physical Considerations for Mapping Sediment Management Areas (Category 1 and 2 SubSMAs)

				CHEMICAL DATA								PHYSICAL DATA /LAND USE				
				Interpolated Data			# of SMS Stations		# of Chemicals	Magnitude of Concentrations			Use			
Proposed SMA	River Mile	Location/ Description	Size (acres)	cPAH (µg TEQ/kg)	PCB (µg/kg)	As (mg/kg)	Chemical Exceedances	Toxicity Exceedances	Chemicals > SQS?	CSL EF > 2.0	Dioxin TEQ >37 (ng TEQ/kg)	Other Details (Historic Land Use, Observations)	Recent Dredging?[a]	Active Berthing Area?[a]	In Beach Area?	In Clamming Area?
SMA 15	1.3 - 1.4 E	Saint Gobain	2.4	>380	1 station >480, remainder below	Low	3 SQS	1 CSL	PCB and benzyl alcohol only	No CSL	—	TTAD, Glacier NW to St. Gobian, one pass in cluster; historic gravel company to north	No recent dredging	General construction mooring permitted to -17', offshore timbers	No	Yes, in part of SMA
SMA 16	1.4-1.5 W	Glacier Bay	6.9	2 hot spots >900, remainder mix	2 stations > 720	1 hot spot >93, rest > 20	1 CSL, 4 SQS	2 CSL, 1 SQS	PCBs, PAHs, As, Zn	No, CSL at 1.8 for As	Yes, 4 stations > 50	Area outside dock was dredged and required cap; 2 DMMUs not suitable for open water disposal	Glacier NW dredged to -35', and utilized thin-layer placement	Permitted water depth -35' to -40'	No	Yes
SMA 18A	1.55 - 1.7 E	Downstream of Slip 2	1.7	1 spot >380, remainder low	1 spot >240, remainder low	1 spot >20, remainder low	2 CSL; 2 SQS (1 chem SQS at tox pass not counted)	1 pass	PCB, Zn, chrysene	No	No, 1 stations at 10	Historic cement manufacturing	near or partial overlap with James Hardie Gypsum in 1995 and 1999	James Hardie Gypsum to -32'	No	Yes, in part of SMA
SMA 19	Slip 2	Slip 2	3.1	>150	Low	Low	1 SQS	1 pass	only sampled for PCB	No CSL	—	Historic cement manufacturing	Glacier Ready Mix in 2001	Glacier NW to -17'	No	Yes, in part of SMA
SMA 20	1.8-1.9 W	T-115	0.8	Most >150	Low	Low	1 CSL; 1 SQS	1 SQS; 1 pass	Phthalates only	No	No, 1 station at 12	Resampled BEHP slightly higher; future dredging planned for T-115 berth modifications	T-115 to -15' in 1993; suitable for open water disposal	-20' at Seafreeze Wharf, Jore Marine Services (T-117) range of -14' to -20'; future T-115 berth modifications planned	No	No
SMA 21	1.9-2.0E	First Ave Bridge, Duwamish Marine Center	0.9	>380	>240	Low	3 SQS (1 SQS at tox pass not counted)	1 CSL	PCBs only	No	No, 1 station at 13	Historic shipyard and hazardous waste storage	No recent dredging	Overwater structures, but no permitted depth, cable area	Yes	Yes, in part of SMA
SMA 22	1.95-2.0W	N. of 1st Ave Bridge	1.7	>380	Some parts >240	Low	1 CSL; 1 SQS (1 SQS at tox pass not counted)	1 pass	BEHP, PCB	No	—	Historic Boeing Plant 1	No recent dredging	Cable area, no berthing	No	No
SMA 23	2.1-2.2W	Alaska Marine Lines, south of First Ave Bridge	1.5	Hot spot >900	1 station >480, rest below	Low	3 SQS	1 SQS	PCBs, 2 PAHs	No CSL	No data; dioxin at 8 in nav channel	First Ave Bridge, historical ship salvage	No recent dredging	Alaska Marine Lines to -15'	Yes	Yes
SMA 25	End of Slip 3	Slip 3	1.8	>380	Low	>20	1 CSL; 1 SQS	1 CSL; 1 SQS	Benzyl alchohol, As	Benzyl alcohol 2.1	No data; dioxin at 11 at end of slip	Current properties are silver bay logging, rainier petoelum, seattle cold storage; historical lumber company	No recent dredging	Northland Services south side of slip and outside slip to -18'; Silver Bay Logging north side of slip to -15'; cable area	No	No
SMA 26	2.2 W	Trotsky	2.1	Most >380	Most >1,300	Low	4 CSL; 1 SQS	—	PCBs, Hg, Pb, BEHP	PCB = 23; Hg = 4.2; BEHP = 2.2	Yes, 1 station >400	Historic and ongoing drum recycling, historic ship construction and salvage	No recent dredging	No, pile group	Yes	Yes
SMA 27A	2.4E	SE of Trotsky Bay	0.7	>380	Low	Low	No exceedances	—	No exceedances		No, 1 station at 33 (at RAL)	Historic machine shop	No recent dredging	Dolphins	No	No
SMA 30A	2.55 W	North side of Beach 5	0.7	>900	Low	Low	1 SQS	—	PAH, HCB	No CSL	—	Current construction companies	No recent dredging	Alaska Washington Building Materials to -12'	Yes	Yes
SMA 30B	2.7 W	2.7 W (outfall/ Hurlen)	2.9	>900	1 station > 240, remainder low	Low	3 CSL, 1 SQS	—	PCB, phthalates, PAHs, benzyl alcohol	PAHs, benzyl alcohol, benzoic acid	—	CSL R3 data for PAH and phtalate, SQS older data for PCB	Hurlen dredged in 1998 to -10'; 2 of 4 DMMUs were suitable for open water disposal	Hurlen Construction wharf and mooring area, range -8' to -20'	Yes	Yes

Table D-1 Chemical and Physical Considerations for Mapping Sediment Management Areas (Category 1 and 2 SubSMAs)

				CHEMICAL DATA								PHYSICAL DATA /LAND USE				
				Interpolated Data			# of SMS Stations		# of Chemicals	Magnitude of Concentrations			Use			
Proposed SMA	River Mile	Location/ Description	Size (acres)	cPAH (µg TEQ/kg)	PCB (µg/kg)	As (mg/kg)	Chemical Exceedances	Toxicity Exceedances	Chemicals > SQS?	CSL EF > 2.0	Dioxin TEQ >37 (ng TEQ/kg)	Other Details (Historic Land Use, Observations)	Recent Dredging?[a]	Active Berthing Area?[a]	In Beach Area?	In Clamming Area?
SMA 31	2.6-2.8 E	2.6-2.8 E, downstream of Slip 4	4.2	1 hot spot >900, remainder mix	Mix	1 station > 20, rest low	1 CSL, 5 SQS (2 CSLs at tox passes not counted)	1 CSL, 2 passes	PCB, Hg, fluoranthene	PCB 2.8	No, 1 station at 4 in front of Slip 4	Historical oil tank cleaning, pipe making, creosote pole treatment, lumber yard	Crowley dredged in Slip 4 but not recently in SMA; 3 of 4 DMMUs not suitable for open water disposal	Cable area, pile group, no berthing	Yes	Yes
SMA 33	Slip 4	mouth of Slip 4	3.7	Some > 150, most low	Some parts >240	Low	2 CSL, 7 SQS	—	PCB	No	No, 1 station at 4	Many historic facilities nearby	Crowley dredged in Slip 4 but not recently in SMA; 3 of 4 DMMUs not suitable for open water disposal	Northland Services 8th Avenue Wharf to -15'	No	No
SMA 35A	3.05 W	South of Morton	0.3	Low	Low	Low	1 CSL	—	HCB	No	—	Duwamish Waterway Park	No recent dredging	No	Yes	Yes
SMA 37B	3.7 - 3.75 W	Upstream of T-117 EAA	0.6	>150 - 380	Low	Low	5 SQS	—	PCB, phenol, HCB	No CSL	—	Upstream of EAA	No recent dredging	No	No	Yes
SMA 38	3.0 - 3.6 navigation channel	Navigation channel near Boeing Plant 2 EAA	0.9	Mix, but all below 900	Some hot spots >1300	Low	Surface sediment hits are in EAA, SMA based on core data		PCB only	No CSL	101 in EAA	Adjacent to EAA, is 321 in EAA?	1999 navigation channel was dredged to -15'	Navigation channel authorized to -15'	No	No
SMA 41	3.7 - 4.0 E	Around Central KCIA	4.5	>900	Most >240	>93	4 CSL; 12 SQS (2 chem CSLs at tox passes and 1 chem SQS at tox pass not counted) in RI dataset; 1 CSL, 13 SQS from Paccar sampling	1 CSL; 2 SQS; 4 passes	PCBs, PAHs, BEHP, Pb, As, benzoic acid, Hg	As 5.2 and 12; PAHs > 2; Hg = 12 (Paccar)	No, 1 station at 5	Former Slip 5, historical steel fabrication, galvanization, log treatment, and heavy truck manufacturing	No recent dredging	No	No	Yes
SMA 42	Slip 6	Slip 6	5.1	1 hot spot >900, remainder >720	All below 240	Some areas >20, remainder low	8 CSL, 4 SQS	—	PCB, PAHs, benzoic acid, phthalates	Benzoic acid 2.9	No, 14 at head, 6 at end	Historical chemical manufacturing, historical and ongoing airplane manufacturing, historical auto wrecking	No recent dredging	Boeing wharf permitted to -18'	No	Yes, outside slip
SMA 46	4.7 W	SW corner of UTB	1.4	Most >150	1 station > 480, remainder low	Low	2 SQS	1 CSL	PCBs, phenol	No CSL	—	Coastal America restoration area, sunken ferry removed from area	No recent dredging	No	Yes	Yes
SMA 47	4.75 - 4.8 E	East of Upper Turning Basin	0.9	1 station >900, remainder low	Low	Low	1 CSL, 1 SQS	—	Lead, acenaphthalen e	No	—	Current Boeing Development Center	No recent dredging	No	No	Yes
SMA 48	4.9 W	Adjacent to Norfolk CSO	1.0	1 hot spot >900, remainder mix	Hot spot >1300, remainder mix	Low, small area >20	3 CSL; 10 SQS (1 CSL at toxicity pass not counted)	1 SQS; 1 pass	PCB, PAHs, BEHP, benzoic acid	PCB = 15; benzoic acid = 6.9	No, 1 station at 5 downstream	Norfolk CSO and Boeing South Storm Drain remediation projects adjacent to SMA	Adjacent sediment removals in 1999 and 2003	No	No	No

Notes:
— = no data
[a] Berthing and dredging elevations in ft MLLW.
As = arsenic; BEHP = bis(2-ethylhexyl)phthalate; CSL = cleanup screening level; DMMU = Dredged Material Management Unit; EAA = early action area; EF = exceedance factor; Hg = mercury; Pb = lead; SMA = sediment management area; SQS = sediment quality standard;Zn = zinc.

Table D-2 Lines of Evidence for Monitored Natural Recovery of SMAs (Category 1, 2 and 3 SubSMAs)

				RI Subsurface Sediment Data			RI Chemical Trends							Physical/Other Considerations				Conclusion
Sediment Management Area	**River Mile**	**Location/ Description**	**Size (Acres)**	**Number of Cores and Core ID**	**Depth of SQS and CSL Exceedances (in ft)**	**Is Highest Concentration in Top Interval of Core?**	**Resampled Risk Drivers in Surface Sediment Stations (lower / higher)[a]**	**Is Recovery Predicted Based on STM? [Time 10 bed (inverse of recovery)[b]]**	**Are Year 10 PCBs Greater than 240 Predicted in Surface Sediment?**	**Are Year 10 cPAHs Greater than 300 Predicted in Surface Sediment?**	**Are Time 10 Arsenic Concentrations Greater than 57 Predicted in Surface Sediment?**	**Are Year 10 SQS Exceedances Predicted in Surface Sediment?[c]**	**Are Time 10 Dioxin/ Furans Greater than 10 Predicted?**	**STM 100-yr Max High-Flow Scour**	**STM Net Sedimentation Rate**	**Empirical Net Sedimentation Rates (Cores)[d]**	**Observed Vessel Scour[e]**	**Is Recovery Expected?[f]**
SMA 1A	0	Harbor Island Marina	2.6	1; SC-1	CSL 0-2' (PCBs); SQS 2-4' (PCBs)	Yes for As (0-2') and cPAHs (0-0.5' and 1.5-2'); No for PCBs (highest concentration 1-2')	—	Yes [20-40% bed]	No	Yes, >900	No	No	—	No high-flow scour	1-2 cm/yr	1-2 cm/yr (SC-1)	No	No
SMA 1B	0	Harbor Island Marina	2.3	No cores			—	Slight [20-60% bed]	No	Yes	No	No	—	No high-flow scour	1-2 cm/yr	No cores in SMA	No	Yes
SMA 2	0.1 E	Ash Grove Cement	1.3	1; SC-2	CSL 0-6' (PCBs, As, Pb, Zn)	Yes for PCBs (0-4') and As (0-6'); No for cPAHs (highest concentration 2-4')	PCBs 1.8x higher (nearby SS 4), 3.8x lower for cPAHs, almost 2x higher for As, 9x lower for BEHP	No [80-100% bed]	Yes	Yes	No	Yes	No	0-2 cm scour to west of SMA	0-1 cm/yr	Core had no time markers	No	No
SMA 3	0.2 E	Ash Grove Cement	2.2	1:SC-4	SQS 0-2' (PCBs, Hg, As); CSL 2-4' (2,4-Dimethylphenol)	Yes for cPAHs (0-2'); No for PCBs (highest concentration 1-4') and As (highest concentration 1-2')	—	Slight [20-60% bed]	No	Yes	No	No	—	No high-flow scour	0-1 cm/yr	1-2 cm/yr (SC-4)	Yes	No
SMA 4A	0.1 - 0.2 W	T103 Park/ Ferguson	1.5	1; SC-5	SQS 0-2' (PCBs, Hg)	Yes for PCBs (0-1') and As (0-2'); No for cPAHs (highest concentration 1-2')	PCBs 2x lower (SS-10 and SS-12), cPAHs 2-4x lower, As SS-12 slightly decreased, SS-10 increased slightly, BEHP 4-8x lower	Yes [20-40% bed]	No	Yes	No	No	No	No high-flow scour	1-2 cm/yr	0-1 cm/yr (SC-5)	No	Yes
SMA 4B	0.1 - 0.25 W	T103 Park/ Ferguson	1.4	No cores			—	Yes [20-40% bed]	No	Yes, in a portion	No	No	No	No high-flow scour	1-2 cm/yr	No cores in SMA	No	Yes
SMA 4C	0.25-0.275 W	T103 Park/ Ferguson	0.5	No cores			—	Yes [20-40% bed]	No	Yes	No	—	No	No high-flow scour	1-3 cm/yr	No cores in SMA	No	Yes
SMA 5	0.25 mid channel - 0.4 W	General Recycling and Herring's House	6.2	SC-6, SC-8, DRO	SC-6: 0-2' pass, 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: Yes for cPAHs (0-4.5'); No for As (highest conc 2-4.5') and PCBs (highest conc 3.5-4.5'). DRO68:Yes for all cPAHs, PCBs, and As (all 0-2'); Yes for cPAHs (0-2'); No for PCBs (highest concentration 1-8') and As (highest concentration 2-6')	All decreased (SS-15) from 0.25x (As) to 17x (BEHP)	Yes [20-40% bed]	No	Yes, >900	No	Yes	—	No high-flow scour	1-2 cm/yr	2.3-3.0 cm/yr (SC-6) and 1.2-3.3cm/yr (SC-8)	Yes in part of SMA	No
SMA 6 A-E	0.3 E - 0.55 nav channel	adjacent to D/D EAA	17.4	5; SC-7, SC-8, SC-9, SC-10 and DUD 258 (SC-8 used as evidence for both SMAs 5 and 6)	SC-7: SQS 0-1' (PCBs) CSL 1-1.5' (PCBs); SC-9: CSL 0-2.5' (PCBs); SC-10: SQS 0-1', 4-5', and 6-8' (PCBs), CSL 1-4' (BEHP, Hg); DUD 258: CSL 1-3' (BEHP), CSL 3-6' (PCBs)	Yes for SC-7 (highest conc: PCBs 0-2.5', As and cPAHs 0-1'); No for SC-10 (highest conc: PCBs 2-4', As and cPAHs 1-4'); Mix for SC-9 (highest conc: PCBs 0-2.5', As and cPAHs 1-2.5')	All decreased (SS-17) from 2x (BEHP) to 10x (PCBs) except As remained consistant	Yes [20-40% bed]	Yes	Yes, >900	No	Yes for 6A-E	—	No high-flow scour	1-2 cm/yr; 2-3 cm/yr in part of D.	0-1 cm/yr (SC-7); 1-2 cm/yr (SC-9)' 2-5 cm/yr (SC9, SC10)	No	Yes in SMA 6A and 6C, no in SMA 6B, 6D, and 6E.
SMA 7A-D	0.5-0.7 W	NW of Kellogg Island	10.3	3; SC-11 (7D), SC-12 and DRO44 (7F)	SC-11: CSL 0-0.5' (PCBs); SC-12: SQS 0-2' (PCBs), CSL 2-6.5' (PCBs, Hg)	Yes for SC-11(PCBs, As, and cPAHs); Mix for DRO44 (highest conc: PCBs 2-4', As 0-2', cPAHs 2-4'), and SC-12 (highest conc: PCBs 2-2.5', As 2-4', cPAHs 0-2')	—	Yes [20-40% bed]	Yes	Yes, >1,500	No	Yes for 7A,C,D	No	No high-flow scour	0.5-2 cm/yr	0-1 cm/yr (SC-11); 2-5 cm/yr (SC-12)	No	Yes in SMA 7B, C and no in SMA 7A, D

Table D-2 Lines of Evidence for Monitored Natural Recovery of SMAs (Category 1, 2 and 3 SubSMAs)

				RI Subsurface Sediment Data			RI Chemical Trends							Physical/Other Considerations				Conclusion
Sediment Management Area	River Mile	Location/ Description	Size (Acres)	Number of Cores and Core ID	Depth of SQS and CSL Exceedances (in ft)	Is Highest Concentration in Top Interval of Core?	Resampled Risk Drivers in Surface Sediment Stations (lower / higher)[a]	Is Recovery Predicted Based on STM? [Time 10 bed (inverse of recovery)[b]]	Are Year 10 PCBs Greater than 240 Predicted in Surface Sediment?	Are Year 10 cPAHs Greater than 300 Predicted in Surface Sediment?	Are Time 10 Arsenic Concentrations Greater than 57 Predicted in Surface Sediment?	Are Year 10 SQS Exceedances Predicted in Surface Sediment?[c]	Are Time 10 Dioxin/ Furans Greater than 10 Predicted?	STM 100-yr Max High-Flow Scour	STM Net Sedimentation Rate	Empirical Net Sedimentation Rates (Cores)[d]	Observed Vessel Scour[e]	Is Recovery Expected?[f]
SMA 7E	0.5-0.55 W	N of Kellogg Island	0.8	No cores			—	Yes [20-40% bed]	No	No	No	No	—	No high-flow scour	1-2 cm/yr	No cores in SMA	No	Yes
SMA 7F	0.7 W	N of Kellogg Island	1.1	No cores			—	Yes [20-40% bed]	No	No	No	No	—	No high-flow scour	1-2 cm/yr	No cores in SMA	No	Yes
SMA 8A	0.85 W	West side Kellogg Island	1.6	No cores			—	Slight [40-60% bed]	Yes	Yes	No	Yes	No	No high-flow scour	0.5-1 cm/yr	No cores in SMA	No	No
SMA 8B	0.7-0.85 W	West side Kellogg Island	4.1	No cores			—	Slight [40-60% bed]	No	No	No	No	No	No high-flow scour	0.5-1 cm/yr	No cores in SMA	No	Yes
SMA 8C	0.9-0.95 W	West side Kellogg Island	2.2	No cores			—	Slight [40-60% bed]	No	No	No	Yes	—	No high-flow scour	0.5-1 cm/yr	No cores in SMA	Yes, in part of SMA	Yes
SMA 9A	0.8-0.9 navigation channel	east of Kellogg Island	3.6	2; SC-13 (8A), SC-14 (8C)	SC-13: SQS 0-2; (PCBs), pass below; SC-14: CSL 0-6' (PCBs, Hg), SQS 6-8.5; (Hg)	Yes for SC-14 (highest conc: PCBs 0-4', As 0-1.5', cPAHs 0-1.5'); Mix for SC-13 (highest conc: PCBs 0-2', As 0-2', cPAHs 2-4')	PCBs 2x increase; As, BEHP, and cPAHs no significant change (SS-B2b)	Mix: [0-100% bed], yes near shoreline (8B), no in center of channel (8A)	Yes	Yes	No	Yes	No	0-2 cm	0-3 cm/yr	1-2 cm/yr (SC-13); 2-5 cm/yr (SC-14)	No	No
SMA 9B	0.8-0.9 west of navigation channel	east of Kellogg Island	2.3	No cores			—	Yes [0-40% bed]	No	No	No	No time 0 exceedances, Year 10 polygon driven by sample in 9A	—	No high-flow scour	1-2 cm/yr	No cores in SMA	No	Yes
SMA 10A,B	Slip 1	Slip 1, almost whole slip	7.5	4; SC-15, SC-16, DRO21 (9B) and SC-17 (9A)	SC-15: SQS 0-4', CSL 4-6' (PCBs); SC-16: SQS 0-2', CSL 2-6' (PCBs); SC-17: CSL 0-4' and 6-8.5' (PCBs, Hg, Zn, Cd); DRO21: SQS 0-2', CSL 2-4' (PCBs)	Mixed, head of slip had highest at top for all chemicals (SC-17), near waterway, cores have highest conc. below top (SC-15, SC-16, DRO21).	All decrease (SS-31 and SS-32) from 0.25x (As, SS-32) to 7.5x (BEHP, SS-32) except As (SS-31) increased 0.25x	Yes [0-40% bed]	No	Yes	Yes, >93	Yes for 10A,B	—	No high-flow scour	1-2 cm/yr, 203 cm/yr in part of SMA 9B.	2-5 cm/yr	Yes	No
SMA 11A-C	1.0-1.1 W	LaFarge berth and dioxin navigation channel	8.4	3; SC-19 (10A), SC-20 (10C); SC-21 (10B) (geochron core SG-4 also)	SC-19: pass 0-1', SQS 1-6', CSL 6-7' (PCBs); SC-20: CSL 0-2', SQS 2-6' (PCBs); SC-21: SQS 0-1' and 2-4', CSL 4-6' (PCBs)	Mix for SC-19 (highest conc: PCBs 6-7', As 2-4', cPAHs 0-2'), Yes in SC-20: PCBs 0-2', As 0-4', cPAHs 0-2'; No for SC-21 (highest conc: PCBs 4-6', As 2-4', cPAHs 2-4')	PCBs increased (north of SMA, DR048) 3x and 7X at SS-37; cPAH and As decrease; BEHP slight increase	Yes [20-40% bed]	Yes in 11C; >1300 Predicted	Yes	No	Yes for 11B, C	Yes	No high-flow scour	1-2 cm/yr	>2 cm/yr (SC-19, SC-21); no markers in SC-20	Yes	Yes in A; No in B,C
SMA 12	1.1 E	Lehigh NW	0.4	1; SC-22	No detected SQS in core	Yes for arsenic, but low concentrations throughout cores for all risk drivers	—	Yes, outside of STM domain, but near 20-40% bed	No	Yes	No	No, based on nearby STM grid-cells	—	No high-flow scour	2-3cm/yr	Core had no time markers	No	Yes
SMA 13	1.1-1.2 navigation channel	Navigation channel (RM 1.1-1.2)	2.7	No cores			PCBs, cPAH and BEHP decrease; As slight increase	Yes [20-40% bed]	No	Yes, small area	No	No	—	No high-flow scour	1-2 cm/yr	No cores in SMA	No	Yes
SMA 14A	1.25 - 1.45 W	Duwamish Shipyard	2.7	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'(PCBs), pass (1-2'), 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' (PCBs); DR054: CSL 0-4' (As, Cu, Zn, Pb, Hg)	Yes for DRO54 (PCBs, cPAHs, and As 0-4'), and SC-25 (PCBs, cPAHs, and As 0-6'); Mix for SC-26 (highest conc: PCBs 6-8', As 0-4' and 6-8', cPAHs 6-8'), and SC-28 (highest conc: PCBs 5.5-7.5'; As 0-1', 2-4' and 5.5-7.5'; cPAHs 5.5- 7.5')	All decrease (SS-44) from 2x (PCBs) to 32x (BEHP), except As increased 0.25x	Yes [0-40% bed]	No	Yes	No	Yes	—	No high-flow scour	1-2 cm/yr	2-5 cm/yr (SC-25); no rates for SC-26 and SC-28	Yes	No

Table D-2 Lines of Evidence for Monitored Natural Recovery of SMAs (Category 1, 2 and 3 SubSMAs)

				RI Subsurface Sediment Data			RI Chemical Trends							Physical/Other Considerations				Conclusion
Sediment Management Area	River Mile	Location/ Description	Size (Acres)	Number of Cores and Core ID	Depth of SQS and CSL Exceedances (in ft)	Is Highest Concentration in Top Interval of Core?	Resampled Risk Drivers in Surface Sediment Stations (lower / higher)[a]	Is Recovery Predicted Based on STM? [Time 10 bed (inverse of recovery)[b]]	Are Year 10 PCBs Greater than 240 Predicted in Surface Sediment?	Are Year 10 cPAHs Greater than 300 Predicted in Surface Sediment?	Are Time 10 Arsenic Concentrations Greater than 57 Predicted in Surface Sediment?	Are Year 10 SQS Exceedances Predicted in Surface Sediment?[c]	Are Time 10 Dioxin/ Furans Greater than 10 Predicted?	STM 100-yr Max High-Flow Scour	STM Net Sedimentation Rate	Empirical Net Sedimentation Rates (Cores)[d]	Observed Vessel Scour[e]	Is Recovery Expected?[f]
SMA 14B	1.2- 1.25 W	N of Duwamish Shipyard	1.0	1; SC-24	SQS 0-1' (PCBs), pass below	Yes for all (0-1')	—	Yes [20-40% bed]	No	Yes, small area	No	No	No	No high-flow scour	1-2 cm/yr	0-1 cm/yr	Yes	Yes
SMA 15	1.3 - 1.4 E	Saint Gobain	2.4	1: SC-27	CSL 0-2' (PCBs), pass below	Yes for As (0-4') and cPAHs (0-2'), No for PCBs (highest concentration 0.5-2.5')	Mixed for PCBs (2x higher at SS-B4b, 8x lower at SS-50),cPAHs mixed (2x decrease at SS-B4b, slight increase at SS-50), BEHP decrease by almost 3x at both locations, As slight increase at both locations	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	2-5 cm/yr	1-2 cm/yr	No	Yes
SMA 16A, B	1.4-1.5 W	Glacier Bay	6.9	1; SC-29; 4 DMMP cores	ND	Yes for PCBs and As (0-1'); No for cPAHs (highest concentration from 1-2')	All decrease (SS-57) from 0.2x (PCBs) to 2x (cPAHs)	Yes [0-40% bed]	No	Yes	Yes, >93	Yes for 16A	Yes	No high-flow scour	2-5 cm/yr	<1 cm/yr (SC-29)	Yes in 16B, no bathymetry data in 16A	Yes for SMA 16B, No for 16A
SMA 17	1.45-1.5 E	E of SMA 14A	2.4	No cores			—	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	1-5 cm/yr	No cores in SMA	No	Yes
SMA 18A	1.55 - 1.7 E	Downstream of Slip 2	1.7	1; SC-30, plus several in James Hardie dredging footprint	No detected SQS in RI core; sediment represented by other cores has been dredged	Yes in RI core, but low concentrations; arsenic ND througout	—	Yes [0-20% bed]	No	No	No	Yes	No	No high-flow scour	2-3cm/yr	1-2 cm/yr (SC-30)	Yes	Yes
SMA 18B	1.55 - 1.7 E	Downstream of Slip 2	2.3	1; SC-31, plus several in James Hardie dredging footprint	SQS 0-3', sediment represented by other cores has been dredged	Yes for all (0-3')	—	Yes [0-20% bed]	No	No	No	No	No	No high-flow scour	2-3cm/yr	2-5 cm/yr	Yes	Yes
SMA 19	Slip 2	Slip 2	3.1	1; SC-32	SQS 0-1'; CSL 1-4'; ND below	Yes for PCB >800 0-4'; As highest 1-4'; cPAH highest 1-2'	Decrease for all chemicals at head of slip	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	2-3cm/yr	2-5 cm/yr (SC-32)	Yes	Yes
SMA 20	1.8-1.9 W	T-115	0.8	2; SC-34, SC 203 (15A)	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, dimehtyl phthalate), CSL 1-4' (BEHP, dimethyl phthalate)	Yes for SC 203 (PCBs 0-1', As 0-4', cPAHs 0-2'); Mix for SC-34 (highest conc: PCBs 1-4', As 0-4', and cPAHs 1-2')	PCBs no change (SS-70); cPAHs slight decrease; As and BEHP increased slightly	Yes [0-40% bed]	No	Yes, small area >900	No	Yes	No	0-2 cm	SMA has mix of rates from STM; <0.5 cm/yr at location of SC-34	2-5 cm/yr (SC-34)	Yes	No
SMA 21	1.9-2.0E	First Ave Bridge, Duwamish Marine Center	0.9	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)	Yes for As; Mix for PCBs and cPAHs: SC-33 highest conc: PCB 1-2' and 2.5-3', cPAHs 0-2'; SC 201 highest conc: PCBs 0-1.5', cPAHs 4-6'	—	Yes [0-20% bed]	No	No	No	No	No	0-6 cm	1-5 cm/yr	2-5 cm/yr (SC-33)	No	Yes
SMA 22A	1.95- 2.0 W	N of First Avenue Bridge/Terminal 115	0.7	1; SC-35	SQS 0-2', pass below	Yes for PCB (0-2'), Yes for As and cPAH (0-4')	All decreased except As consistent	Yes [0-20% bed]	No	No	No	No	—	0-2 cm high-flow scour	2-5 cm/yr	2-5 cm/yr	No	Yes
SMA 22B	1.95- 2.0 Navigation Channel	Navigation Channel RM 1.95-2.0	0.9	No RI cores, S11, S12	SQS 0-4' for both cores	NA - one sample	—	Yes [0-20% bed]	No	No	No	No	—	2-6 cm high-flow scour	2-5 cm/yr	No cores in SMA	No	Yes
SMA 23	2.1-2.2W	Alaska Marine Lines, south of First Ave Bridge	1.5	3; SC-38a, SC-38b, and SC-39	SC-38a: SQS 0-2', CSL 2-3' (PCBs); SC-38b: ND; SC-39: SQS 0-1' and 2-4', CSL 1-2' (PCBs)	Mix for all: SC-38a (highest conc: PCBs and As 2-3', cPAHs 0-3'), SC-38b (highest conc: PCBs and cPAHs 3-3.5', As non detect), SC-39 (highest conc: PCBs1-4', As 2-4', cPAHs 0-1')	—	Yes [0-20% bed]	No	Yes	No	No	—	high-flow scour nearby	2-5 cm/yr	2-5 cm/yr (SC-39)	No	Yes

Table D-2 Lines of Evidence for Monitored Natural Recovery of SMAs (Category 1, 2 and 3 SubSMAs)

				RI Subsurface Sediment Data			RI Chemical Trends							Physical/Other Considerations				Conclusion
Sediment Management Area	**River Mile**	**Location/ Description**	**Size (Acres)**	**Number of Cores and Core ID**	**Depth of SQS and CSL Exceedances (in ft)**	**Is Highest Concentration in Top Interval of Core?**	**Resampled Risk Drivers in Surface Sediment Stations (lower / higher)[a]**	**Is Recovery Predicted Based on STM? [Time 10 bed (inverse of recovery)[b]]**	**Are Year 10 PCBs Greater than 240 Predicted in Surface Sediment?**	**Are Year 10 cPAHs Greater than 300 Predicted in Surface Sediment?**	**Are Time 10 Arsenic Concentrations Greater than 57 Predicted in Surface Sediment?**	**Are Year 10 SQS Exceedances Predicted in Surface Sediment?[c]**	**Are Time 10 Dioxin/ Furans Greater than 10 Predicted?**	**STM 100-yr Max High-Flow Scour**	**STM Net Sedimentation Rate**	**Empirical Net Sedimentation Rates (Cores)[d]**	**Observed Vessel Scour[e]**	**Is Recovery Expected?[f]**
SMA 24	2.05-2.2 E (part of SMA in Navigation Channel)	Mouth and upstream of Slip 3	4.2	2; SC-36, DR112	SC-36: ND SQS 0-4'; DR112: ND SQS 0-4'	Mixed: PCBs: 0-1'(SC-36), 0-4' (DR112); As and cPAHs: 0-1' (SC-36), 2-4' (DR112)	SS-79 only resampled for PCB, lower; SS-81 higher for cPAHs and As, lower for BEHP and PCB	Yes [0-20% bed]	No	Yes	No	No	—	One small scour area, 0-2 cm/yr max	2-5 cm/yr	2-5 cm/yr	No	Yes
SMA 25	Slip 3	end of Slip 3	1.8	1; SC-37	CSL 0-4' (As, 1,2,4-Trichlorobenzene, 1,2-Dichlorobenzene,Cu, Pb, Zn)	Yes for As and cPAHs (0-4'); No for PCBs (highest concentration 1-2')	BEHP, PCB, cPAH decrease near mouth of slip; increase for As	Yes [0-20% bed]	No	Yes	Yes, small area	No	—	No high-flow scour	1-2 cm/yr in SMA, 2-5 cm/yr in rest of slip	1-2 cm/yr (SC-37)	No	No
SMA 26	2.2 W	Trotsky	2.1	1; SC-40 (26A), DR137 (26B)	SC-40: SQS 0-1', ND below, DR137: SQS 0-4'	Yes, but low concentrations from 0-1, ND below	1 resampled station for PCBs only, lower	Mixed, bed is 0-20%, but SQS ER > 18	Yes, >1,300 Predicted at head of bay	No	No	Yes	Yes	0-2 cm high-flow scour	2-3cm/yr	0-1 cm/yr (SC-40)	No	No
SMA 27A	2.4E	SE of Trotsky Bay	0.7	1; SC-41	SC-41: SQS 0-1' and 4-8'	Yes for PCBs (0-6'), As (0-4'); no for cPAHs (4-6' is highest conc.) but surface concentration are lower than 0-2 ft of cores for PCBs, As; but increase for cPAHs	—	Yes [0-20% bed]	No	No	No	No	No	No high-flow scour	2-5 cm/yr	2-5 cm/yr	Yes	Yes
SMA 27B	2.3- 2.4 E (part of SMA in Navigation Channel)	SE of Trotsky Bay	3.0	1; S14	S14: ND SQS 0-4'	Yes for PCBs (0-4'), As (0-4'), cPAHs (0-4')	—	Yes [0-20% bed]	No	No	No	No	—	0-6 cm high-flow scour	2-5 cm/yr	No rate calculated for core	Yes	Yes
SMA 27C	2.36-2.4 W	Upstream of Trotsky Bay	0.6	No cores			—	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	2-5 cm/yr	No cores in SMA	Yes	Yes
SMA 28	2.4-2.45 W	Hurlen-Boyer	1.8	5: C5, C6, WRC-SS-B2, WRC-SS-B3, S15 (only 1 interval in C5, C6, S15)	C5: ND SQS 0-4'; S15 SQS 0-4'; WRC-SS-B2 and WRC-SS-B3: ND SQS PCBs	NA for C5, C6, S15 (1 interval), ND for both WRC-SS-B2 and WRC-SS-B3 for all chemicals	—	Yes [0-20% bed]	No	No	No	No	—	0-2 cm high-flow scour	2 to >5 cm/yr	No cores in SMA	Yes	Yes
SMA 29	2.5 E	SE of Hurlen-Boyer	0.7	No cores			—	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	2 to >5 cm/yr	No cores in SMA	Yes	Yes
SMA 30A	2.55 W	North side of Beach 5	0.7	No cores			—	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	2 to >5 cm/yr	No cores in SMA	No bathy data	Yes
SMA 30B	2.7 W	2.7 W (outfall/ Hurlen)	2.9	1; SC-46; 4 DMMP cores	SQS 0-4' (PCBs, benzyl alcohol, fluoranthene, hexachlorobenzene)	Yes for PCBs and As (highest conc: 0-1' and 2-4'); No for cPAHs (highest concentration from 1-2')	—	Yes [0-20% bed]	No	Yes	No	No	No	0-2 cm high-flow scour	2-5 cm/yr	2-5 cm/yr (SC-46)	Yes	Yes
SMA 31	2.6-2.8 E	2.6-2.8 E, downstream of Slip 4	4.2	3; SC-43, SC-44, SC-45	SC-43: CSL ND; SC-44: SQS 0-3' (PCBs); SC-45: SQS 0-4' (PCBs)	Mix for all: SC-34 PCBs and As non-detect throughout core, cPAHs highest conc: 0-2'; SC-44 highest conc: PCBs 0.5-1', As 0-3.5', cPAHs 0-3.25'; SC-45 highest conc: PCBs 0-4', As and cPAHs 2-4'	3 resampled stations (SS-88, SS-92, and SS-94); 2 stations increased for PCBs; 1 station decreased for PCBs, cPAH, BEHP; 2x increase for As	Mix- all 0-20% bed, except one cell 60-80% bed	Yes	Yes, small area >900	No	Yes	—	Some scour areas with a max of 2-6 cm	Mix:0-1 cm/yr (SC-44); >5 cm/yr (SC-43, SC-45)	1-2 cm/yr (SC-43-45)	No	No
SMA 32	2.8- 2.9 W (part of SMA in Navigation Channel)	Morton- W of Slip 4	4.4	No cores			—	Mixed: 80-100% bed at RM 2.8, 0-20% bed in north and south areas of SMA	Yes, small area	Yes, small area	No	Yes	—	0 to >10 cm/yr	Mixed: 0-2 cm/yr at RM 2.8, 2-5 cm/yr in north and south areas of SMA	No cores in SMA	Yes	No
SMA 33	2.8- 2.86 E	Mouth of Slip 4	3.7	DMMUs 1-4, SC06	DMMU 1,3,4: SQS PCBs 0-4'; DMMU 2: SQS PCBs 0-3'; SC06: SQS 0-6'.	NA for DMMU, No for SC06 PCB 2-4'	—	Yes [0-20% bed]	Yes, at edges of EAA	Yes, at edges of EAA	No	Yes	No	No high-flow scour	2-5 cm/yr	2-5 cm/yr	Yes	No
SMA 34	2.8- 3.0W	South of Morton	0.3	No cores			—	No [80-100% bed]	No	No	No	Yes	—	0-2 cm/yr	<0.5 cm/yr	No cores in SMA	No	No

Table D-2 Lines of Evidence for Monitored Natural Recovery of SMAs (Category 1, 2 and 3 SubSMAs)

				RI Subsurface Sediment Data			RI Chemical Trends							Physical/Other Considerations				Conclusion
Sediment Management Area	River Mile	Location/ Description	Size (Acres)	Number of Cores and Core ID	Depth of SQS and CSL Exceedances (in ft)	Is Highest Concentration in Top Interval of Core?	Resampled Risk Drivers in Surface Sediment Stations (lower / higher)[a]	Is Recovery Predicted Based on STM? [Time 10 bed (inverse of recovery)[b]]	Are Year 10 PCBs Greater than 240 Predicted in Surface Sediment?	Are Year 10 cPAHs Greater than 300 Predicted in Surface Sediment?	Are Time 10 Arsenic Concentrations Greater than 57 Predicted in Surface Sediment?	Are Year 10 SQS Exceedances Predicted in Surface Sediment?[c]	Are Time 10 Dioxin/ Furans Greater than 10 Predicted?	STM 100-yr Max High-Flow Scour	STM Net Sedimentation Rate	Empirical Net Sedimentation Rates (Cores)[d]	Observed Vessel Scour[e]	Is Recovery Expected?[f]
SMA 35A	3.05 W	South of Morton	0.3	1; SC-47	ND SQS 0-1', CSL 1-2' (PCBs), SQS 2-3' (PCBs), pass below	mixed: yes for cPAHs , no for As and PCBs (1-2' highest conc for both)	—	No [80-100% bed]	No	No	No	Yes	No	0-2 cm/yr	0-2 cm/yr	1-2 cm/yr	No	No
SMA 35B	3.2W	West of Boeing Plant 2	0.6	No cores			—	No [60-80% bed]	Yes	No	No	Yes	—	0-2 cm/yr on west side of SMA, 6-10 cm/yr on east side of SMA (bordering Navigation Channel)	0-1 cm/yr on west side of SMA.	No cores in SMA	No	No
SMA 35C	3.25- 3.275 W	West of Boeing Plant 2	0.6	No cores			—	Mixed: 0-20% bed on west side of SMA; 80-100% bed on east side of SMA (bordering Navigation Channel)	Yes	No	No	Yes	No	0-2 cm/yr	0-2 cm/yr	No cores in SMA	No	No
SMA 35D	3.3- 3.35 W	Downstream of South Park	0.7	1; SB-5	CSL 3-5' (PCBs), SQS 0-3' and 5-7.5' (PCBs)	No- highest concentrations: PCBs 2.5-7.5'; As and cPAH 5-7.5'	—	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	2-5 cm/yr on west side of SMA; 1-2 cm/yr on east side of SMA (bordering Navigation Channel)	No cores in SMA	No	Yes
SMA 36	3.05- 3.1 (in Navigation Channel)	South of Morton	0.7	No cores			—	Yes [0-40% bed]	No	No	No	No	—	>10 cm/yr	1-2 cm/yr	No cores in SMA	No	Yes
SMA 37A	3.5W	South Park Marina	0.7	4; T117-SE-COMP1-SC, T117-SE-93-SC, T117-SE-COMP4-SC, T117-SE-COMP2and3-SC	ND SQS PCBs 0-2' (T117-SE-COMP4-SC and T-117-SE-93-SC), 0-4' (T117-SE-COMP1-SE); SQS PCB 0-2' (T117-SE-COMP2and3-SC)	Yes T117-SE-COMP2and3-SC: 2-4' highest concentration; NA for T117-SE-COMP1-SC, T117-SE-93-SC, T117-SE-COMP4-SC.	—	Yes [0-20% bed]	No	No	No	No	—	No high-flow scour	>5 cm/yr	No cores in SMA	No	Yes
SMA 37B	3.7- 3.75 W	Upstream of T-117 EAA	0.6	No cores			Decrease for PCBs, As; no change for cPAHs; BEHP slight increase	No [80-100% bed]	No	No	No	No	—	0-2 cm/yr on west side of SMA, 2-6 cm/yr on east side of SMA (bordering Navigation Channel)	<0.5 cm/yr on west side of SMA, 0.5-1 cm/yr on east side of SMA (bordering Navigation Channel)	No cores in SMA	No	Yes
SMA 38	3.0 - 3.6 nav channel	nav channel near Boeing Plant 2 EAA	0.9	2; SC-49a, SD-321-C	SC-49a: CSL 0-1' (benzoic acid, benzyl alcohol), SQS 2-8' (PCBs); SD-321-C: SQS 1-3.9' (PCBs)	Mix for SC-49a: highest concentrations: PCBs 6-8', As 0-4'. cPAHs 1-2'; No for SD-321-C: highest concentrations: PCBs 1-4', As 1-2'	PCBs increase 0.25x (SD-SWY17 in EAA nearby)	Mixed: 0-20% bed in northern section, 60-100% bed in southern section	Yes, based on EAA interpolation	Yes, small area	No	No	—	high-flow scour >10 cm	2-5 cm/yr	2-5 cm/yr (SC-49)	No	No