Lower Duwamish Waterway Group

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

Appendix K – Lower Duwamish Waterway Conceptual Monitoring Program 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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K1 Introduction

This appendix presents the rationale and conceptual structure for a multifaceted Lower Duwamish Waterway (LDW) monitoring program that serves as the basis for monitoring cost estimates in Section 9 and Appendix I. The program relies on several simplifying assumptions and is not intended to specifically represent the scope and duration of monitoring that may eventually occur in the LDW. A detailed sampling program will likely be assembled during remedial design. However, the 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, sediment toxicity, water quality, tissue chemistry, and bathymetric monitoring. Physical maintenance and repairs of remedy components are discussed separately in Chapter 9. The temporal elements of this monitoring program (as described in the following sections) include:

- Baseline monitoring
- Implementation monitoring
- Post-construction confirmation monitoring
- Operation and maintenance monitoring
- Sediment management area (SMA) compliance monitoring
- Long-term performance monitoring.

This appendix does not contain detailed sampling and analysis information regarding protocols, methods, experimental design, quality assurance and quality control, or data reduction and analysis. Instead, 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 definition of monitoring for purposes of this appendix. This includes the verification monitoring of SMAs that may have already recovered naturally based on the age of the data and recovery potential (see Sections 6 and 8 of the FS). Costs associated with these activities are an assumed component of a broadly encompassing design engineering cost factor (20% of capital costs, see Appendix I). These data may supplement the baseline monitoring dataset.[1]

[1] Verification monitoring is a one-time event in SMAs designated for such. If verification monitoring demonstrates that the SMA has remediated naturally, no further action is required for that SMA. However, if verification monitoring determines that RAOs have not been achieved, appropriate contingency actions (e.g., MNR or active remediation) will be taken (see Appendix I cost assumptions for fraction of verification monitoring area assumed to revert to active remediation).

K2 Guidance on Monitoring Plans

Federal and state guidance recommend long-term monitoring to ensure the structural integrity of the remedy (e.g., a cap) and to determine whether sediment cleanup levels have been achieved. Guidance also recommends monitoring to evaluate risk reduction related to fish and shellfish tissue concentrations and general ecological health (EPA 2005). These objectives translate into a need for chemical (e.g., sediment, tissue, and water quality), biological (e.g., toxicity testing) and physical (e.g., bathymetry and sediment profile imaging) data. The National Research Council (NRC; 2007) independently peer-reviewed and evaluated the effectiveness of sediment dredging at Superfund megasites and concluded that monitoring is an essential component of remedy effectiveness and should include:

- Monitoring of potential short-term risks due to dredging (implementation monitoring)
- Monitoring that the remedial action has achieved its immediate target cleanup levels (post-construction confirmation monitoring)
- Monitoring to determine whether remedial action objectives (RAOs) have been or are likely to be achieved in the expected time frame(s) (SMA compliance and long-term performance monitoring).

In addition to these components, baseline monitoring is needed to characterize pre-remedial conditions for comparison with post-remedial conditions (NRC 2007). These elements, plus operation and maintenance monitoring, are described herein for purposes of estimating costs of the remedial alternatives.

In Washington State, the Sediment Cleanup User Manual (Washington State Department of Ecology [Ecology] 1991) describes the general types of monitoring (physical, chemical, biological) that should be conducted during the sediment cleanup or site closure decision process, and the methods and objectives for collecting these data. The Washington State Sediment Management Standards (SMS) establish minimum requirements for sediment sampling and analysis plans. The plans are required to provide details on all aspects of sediment sample collection, analysis, and quality assurance and quality control. The plans must be consistent with the Puget Sound protocols, as amended, and/or other methods approved by Ecology (1995; WAC 173-204-600).

K3 Assumptions for LDW Monitoring

Broadly speaking, monitoring encompasses all levels of data collection that may occur before, during, and after completion of a remedy. Given the spatial and temporal complexity associated with cleanup of sediment in the LDW, it is helpful to group data in this monitoring discussion into LDW-wide and project-specific categories. Here, project-specific refers to one or more sediment management areas (SMAs) that are remediated as an individual cleanup project.

LDW-wide monitoring data are used to address compliance with RAOs for which numeric cleanup levels are established, as site-wide averages (spatially-weighted average concentrations), area-wide spatial averages (e.g., over specific areas of interest, such as tribal clamming or beach play areas), or on a point basis. These include:

- Human seafood consumption – RAO 1, site-wide
- Direct human contact – RAO 2, area-wide over an exposure area of concern (i.e., site-wide, beach play areas, individual beaches, and tribal clamming areas)
- Protection of benthic invertebrates – RAO 3, point-based
- Protection of ecological receptors – RAO 4, site-wide.

For convenience, the FS assumes that LDW-wide monitoring is conducted by a single entity vested with this responsibility at the programmatic level by either EPA or Ecology or both. It also assumes a complementary baseline monitoring program with parallel metrics and design standards against which to compare the long-term monitoring and remedy effectiveness. In summary, LDW-wide data serve these multiple purposes:

- Baseline data:
  - Establish a point of reference for assessing long-term remedy effectiveness and achievement of RAOs.
  - Update the "current conditions" represented over a 15-year period in the RI baseline dataset.
- Long-term data:
  - Track recovery toward achieving RAOs and assess the long-term equilibration (or steady state) of chemical concentrations in the LDW.

The other data are project-specific. These data are collected from individual SMAs or groups of SMAs which may be managed by a number of different performing parties. Project-specific data are collected during implementation, post-construction, and during the recovery period (could also be long-term). These data serve multiple purposes as described below:

- Implementation data:
  - Ensure compliance with water quality criteria by sampling surface water during construction.

    - Evaluate whether remedial design objectives (i.e., dredging depth or cap thickness) have been achieved through bathymetric soundings.

- Post-construction confirmation data (immediately following construction):
    - Determine whether sediment quality within the remediation footprint meets goals.
    - Evaluate recontamination on the periphery of the remediation footprint.
- SMA compliance data:
    - Determine whether sediment quality within the remedial footprint remains in compliance over the long term.
- Operation and maintenance data:
    - Determine whether a remedy, such as a cap, is remaining in place and performing as designed.
    - Determine whether repair is necessary.

The LDW-wide and project-specific data collection components are summarized in Table K-1. For cost estimation, the FS adopts this framework for collection of data in the LDW as the overall cleanup project moves from remedial design through implementation to long-term monitoring. It is important to recognize that while each of these two broadly defined data groups has a different objective and different entity administering the actual work, they are not mutually exclusive. Uses of the data are likely to overlap in practice (e.g., for calculating site-wide spatially-weighted average concentrations).

K3.1 LDW-wide Monitoring

Table K-1 summarizes the scope of LDW monitoring and lists the six types of monitoring. In particular, this table splits the LDW-wide monitoring into two components: baseline and long-term.

K3.1.1 Baseline Monitoring

Baseline refers to LDW-wide sampling that is assumed to occur before any remediation commences, with the goal of reestablishing “baseline” conditions. Most of the data used in the RI/FS are now somewhat dated (e.g., >10 years old). The pronounced rates at which sediment from the Green/Duwamish River system deposit 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 Record of Decision (ROD) is issued. This argues for a new temporally and spatially consistent LDW-wide dataset. Baseline sampling is assumed to occur following issuance of the ROD and before any remedial activities commence.

K3.1.2 Long-term Performance Monitoring

Long-term LDW-wide monitoring will occur periodically during and after cleanup to track progress towards achieving the RAOs. This monitoring is assumed to occur at three five-year intervals (Years 5, 10, and 15) following completion of construction. The FS assumes that sediment samples are collected on a stratified grid at an average spatial scale of 1 sample for every 4 acres (~100 per round)[2].

All sediment samples are assumed to be analyzed for SMS chemicals, which include three of the four human health risk drivers: polychlorinated biphenyls (PCBs) as Aroclors (with a subset analyzed for PCB congeners), arsenic, and carcinogenic polycyclic aromatic hydrocarbons [cPAHs], which are calculated from the concentrations of individual PAHs). Dioxins/furans, the fourth human health risk driver, are assumed to be analyzed at a lesser frequency because of their high analytical cost.

Tissue samples are assumed to be collected to assess LDW-wide reductions in fish and shellfish tissues. These samples would be analyzed for the risk-driver chemicals (RAOs 1 and 4), with the analysis focusing on PCBs, arsenic, and cPAHs in particular. The study design for each event in the tissue monitoring program is assumed to be similar to studies conducted by LDWG in the LDW in 2005 and 2007 (Windward 2005, 2009).

K3.2 Project-specific Monitoring

On the smaller project-specific scale, data will be collected during implementation, immediately upon completion of construction activities (confirmation monitoring) and over the long term (operation and maintenance monitoring to ensure sediment stability of capping or ENR material and to ensure achievement of RAOs).

K3.2.1 Implementation Monitoring

Implementation monitoring occurs during construction of the active portions of a remedy (i.e., dredging, capping, and ENR). The FS assumes that implementation monitoring consists solely of bathymetry and water quality testing, the latter to ensure compliance with project-specific water quality requirements. Water quality testing includes daily turbidity monitoring, with periodic collection of downstream surface water samples for laboratory testing (e.g., turbidity and select chemicals). Costs are largely associated with labor, equipment, and materials, because the turbidity testing is assumed to occur in the field with meters (see Appendix I), and includes only limited chemical analyses.

[2] This appendix and the estimated costs for monitoring presented in Appendix I assume a discrete point sample and analysis approach for sediments. Other approaches, which composite samples for spatial averaging, are also possible and may reduce costs. Details of the LDW-wide monitoring plan will be determined following issuance of the ROD. Additional samples collected from discrete SMA areas will complement the LDW-wide dataset for an analysis of trends.

K3.2.2 Post-construction Confirmation Monitoring

Post-construction confirmation monitoring is conducted to demonstrate whether, after construction, the cleanup project complies with cleanup requirements (e.g., surface sediment chemical concentrations are below the project-specific remedial action levels [RALs]). This type of monitoring typically applies to active remediation (i.e., dredging, capping, ENR). Alternatively, this monitoring could begin one to three years after completion of active remediation to allow time for residual suspended solids to equilibrate with the surrounding sediment.

K3.2.3 Long-term Operation and Maintenance Monitoring and SMA Compliance Monitoring

Long-term monitoring (operations and maintenance and SMA compliance) verifies that, for all SMAs requiring management (i.e., dredging, capping, ENR, or MNR), the remedy is remaining protective and that source controls are adequate for that SMA. Operation and maintenance monitoring includes physical monitoring of cap and ENR areas to ensure physical stability. Bathymetric surveys are used to inspect cap stability and provide evidence of scour from vessel movement or from high-flow events. Chemical testing is used to ensure recovery toward RAOs and to assess source control progress. Surface sediment samples can also be used to assess potential recontamination from on-going sources or nearby resuspended sediment. For capped and ENR areas, monitoring also includes bathymetry to confirm that the sand cap is remaining intact and isolating buried contaminants. SMA compliance monitoring includes evaluating surface sediment samples for risk-driver chemistry (largely SMS chemicals, with dioxins/furans at a subset of stations). A subset of stations may be tested for sediment toxicity, depending on the sediment chemistry results. Both physical and chemical monitoring efforts will be conducted over several years following construction of the remedial alternative.

The nature of project-specific monitoring is dependent largely on the remedial action undertaken. The spatial density of samples, frequency, and duration of monitoring are expected to vary depending on the action taken. For example, a more intensive program (longer duration and greater sample density) is anticipated for areas undergoing ENR or MNR than for areas subject to dredging or capping. This is reflected in SMA compliance monitoring assumptions made for cost estimating (Table K-1).

K4 Case Studies / Other Examples

This section describes verification and long-term monitoring conducted or being conducted at the two early action areas (EAAs) in the LDW – the Duwamish Diagonal and Norfolk areas. These case studies provide the basis for the monitoring assumptions used in the FS, especially regarding the frequency of sampling events, density of samples collected, and chemical analyses.

K4.1 Duwamish/Diagonal EAA

The 7-acre Duwamish/Diagonal EAA was dredged and capped in 2003-2004. A thin-layer placement of sand was applied to an additional 4-acre area (the ENR area) in 2005 to manage dredged residuals. The long-term monitoring design was adjusted following the thin-layer sand placement.

K4.1.1 Isolation Cap Monitoring

Implementation Monitoring

Water quality was monitored during the dredging, capping, and thin-layer placement activities. Multiple permits required water quality monitoring during dredging to ensure compliance with state water quality standards. Field parameters measured included temperature, pH, turbidity, specific conductance, salinity, and dissolved oxygen. In addition, grab samples were analyzed for metals and select organic compounds. Chemical analyses ceased after eight days of compliance with water quality standards. Turbidity monitoring was sustained throughout the dredging period at EPA's request.

Water quality monitoring during capping consisted of turbidity measurements that were sustained throughout the two-week capping period, although EPA had approved cessation after seven days.

Post-Construction Confirmation Monitoring

Sediment chemistry monitoring was conducted at pre-construction, at three months post-construction, and annually for a period of five years after initial placement. The need for further monitoring will be discussed with the agencies after the fifth year (2009) analytical results are completed. Annually, eight surface sediment samples were collected on the engineered cap (7 acres, just over one sample per acre) and 12 samples were collected in the area around the site, "the perimeter area," until post-thin layer placement in 2005. At this point, the number of perimeter stations was reduced to eight. These samples were analyzed for the SMS chemicals in addition to conventional parameters and grain size.

During the 2005 sampling event, additional monitoring stations were added to the perimeter areas and the adjacent ENR area as a result of the follow-up 4-acre ENR actions, discussed below (Anchor 2007).

K4.1.2 Four-Acre Thin-Layer Sand Placement

Implementation Monitoring

Implementation monitoring conducted during thin-layer placement in the ENR area consisted of water quality monitoring, sediment profile imaging (SPI), and sediment stake installation. Water quality was monitored for turbidity during the five-day placement period. SPI camera surveys were used to survey the sediments before and after the placement of ENR sand. Both the SPI and stakes were used to evaluate sediment thickness of the ENR sand.

Post-Construction Confirmation Monitoring

Post-construction confirmation monitoring included surface sediment grab samples at each of seven stations on the four-acre ENR area annually for five years (>one sample per acre). Eight perimeter stations were also monitored over this period. Samples were analyzed for SMS chemicals.

K4.2 Norfolk Area

The Norfolk Area, located at approximately RM 5.0 in the LDW, consists of the Norfolk combined sewer overflow/storm drain (CSO/SD) and the Boeing Developmental Center south storm drain areas. At both of these areas, sediment removal and capping actions have been performed.

K4.2.1 Norfolk CSO/SD

Sediment removal and capping occurred in February to March 1999 over a 0.6-acre area. Four stations have been repeatedly sampled after placement of the Norfolk CSO/SD cap. Surface sediment samples at the 0-2 cm and the 0-10 cm depths have been collected on the cap over a 5-year period (annual sampling) and analyzed for the SMS chemicals. Baseline sampling occurred in April 1999, and eight-month sampling occurred in October 1999. Following this, sampling occurred annually for five years (2000 to 2004). Seven additional samples were collected in July 2002 in a recontamination study, which was meant to determine the conditions beyond the cap in an inshore area adjacent to the Boeing Developmental Center south storm drain outfall. As a result of this study, the in-shore area underwent sediment removal and capping in September 2003.

Visual observations of the cap have also been conducted by King County staff, especially following disturbances by flood events. The cap is intertidal, so land-based observations are possible at low tide and low flow levels.

K4.2.2 Boeing Developmental Center South Storm Drain

Implementation and post-remedy compliance monitoring plans were not reviewed for this removal and capping area because it was a relatively small cleanup area (approximately 30 ft x 60 ft) compared to the LDW-wide and project-specific monitoring plans.

K5 References

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Table K-1 Conceptual LDW Monitoring Program, Used for Cost Estimation

Monitoring Category	Type	Media or Parameter	Remedial Activity	Description and Purpose	Timing Assumptions	Sample Collection and Analysis Assumptions
LDW-wide	Baseline[a]	• Sediment chemistry • Bathymetry	n/a	Baseline monitoring establishes LDW-wide surface sediment and tissue quality before remediation begins.	One sampling event for sediment and tissue following issuance of ROD and before or during remedial design.	Assume one sample group per 4 acres (~100 stations LDW-wide) and testing as follows: • SMS[b] – all samples • Other chemicals[c] – 25% of samples
		• Tissue				• PCBs as Aroclors – 100% of samples • PCBs as congeners – 20% of samples • Other chemicals[d] – 15% of samples
	Long-Term	• Tissue • Sediment • Sediment toxicity tests	n/a	Long-term monitoring characterizes LDW-wide surface sediment and tissue chemistry. Used for comparison to the PRGs for RAO effectiveness.	Three sediment and tissue sample collection events at 5, 10, and 15 years after completing construction.	Same sample collection density and parameter groups as baseline (see above).
Project-Specific	Implemen-tation	• Water quality	Dredge, Cap, ENR	Field-collected conventional surface water data (e.g., turbidity, DO).	Occurs daily during in-water construction work per water quality certification requirements.	Field measurements may be collected at multiple stations. Some samples may be sent to laboratory for chemical analysis but no specific laboratory testing assumptions are made in for cost estimation purposes.
	Post-Construction Confirmation	• Sediment chemistry • Bathymetry	Dredge, Cap, ENR	Data collected after in-water construction work to determine compliance with RALs and to determine the need for contingency actions (e.g., for residuals management).	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.	Assume four sample groups per acre and the following analytical testing frequencies: • SMS/sediment[b] – all samples • Other chemistry/sediment[c] – 20 to 30% of samples

Monitoring Category and Type		Media or Parameter	Remedial Activity	Description and Purpose	Timing Assumptions	Sample Collection and Analysis Assumptions
Project-Specific	Operation and Maintenance	• Visual inspection • Bathymetry	Cap, ENR	Field inspection data collected over time to ensure cap stability (see Appendix I for cost information).	Monitoring occurs after construction at the following intervals: Years 1, 3, 5, 10, 15, 20, 25, and 30.	n/a (see SMA compliance monitoring below for sediment chemistry requirements)
	SMA Compliance	• Sediment chemistry	Dredge, Cap, ENR, MNR	Recontamination monitoring of dredge and cap areas. Recovery monitoring of ENR and MNR areas during recovery period.	Occurs at the following intervals after construction: • Recontamination: 2, 3, and 5 years • Recovery: 2, 3, 5, 7, and 10 years	Same sample collection density and parameter groups as for post-construction confirmation monitoring (see above).

Notes:

[a] Baseline monitoring may also include sampling and analysis for background conditions; sediment and tissue. Further, data collected during remedial design (including verification monitoring as defined in Section 8) may be used to supplement the baseline dataset.

[b] SMS includes total PCBs (as Aroclors), arsenic, cPAHs, all SMS chemicals, and associated conventional parameters (e.g., TOC, grain size, percent solids).

[c] Other monitoring components include other COCs, dioxins/furans, and sediment toxicity tests, all of which are assumed to be monitored at a reduced percentage of the base sample group density.

[d] Other chemicals include, but are not limited to, inorganic arsenic, cPAHs, PCB congeners, and dioxins/furans.

n/a = not applicable; cPAH = carcinogenic polycyclic aromatic hydrocarbon; DO = dissolved oxygen; ENR = enhanced natural recovery; MNR = monitored natural recovery; RAO = remedial action objective; O&M = operation and maintenance; PCB = polychlorinated biphenyl; PRG = preliminary remediation goal; RAL = remedial action level.