FIELD AND DATA REPORT

DOWNTOWN PORTLAND SEDIMENT CHARACTERIZATION

WILLAMETTE RIVER
PORTLAND, OREGON

Prepared for

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY

January 2009

Prepared by

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LIST OF ACRONYMS

ARI	Analytical Resources Incorporated
CAS	Columbia Analytical Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
City	City of Portland, Bureau of Environmental Services
CLP	Contract Laboratory Program
cm	centimeter
COC	chain-of-custody
DEQ	Oregon Department of Environmental Quality
DPSC	Downtown Portland Sediment Characterization
ECSI	Environmental Cleanup Site Information
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbons
FS	feasibility study
GPS	global positioning system
GSI	GSI Water Solutions, Inc.
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSP	Health and Safety Plan
IDW	investigation derived waste
LCS	laboratory control sample
LWG	Lower Willamette Group
m^2	square meter
MS	matrix spike
MSD	matrix spike duplicate
MSS	Marine Sampling Systems
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PP&R	Portland Parks and Recreation
QA/QC	quality assurance/quality control
RDL	reporting detection limit
RI	remedial investigation
RM	River Mile

SAP	sampling and analysis plan
SCRA	site characterization and risk assessment
SVOC	semivolatile organic compound
SWCA	SWCA Environmental Consultants
TOC	total organic carbon
TPH	total petroleum hydrocarbon
VPH	volatile petroleum hydrocarbons

1.0 INTRODUCTION

This Field and Data Report provides results of the Downtown Portland Sediment Characterization (DPSC). The DPSC is a collaborative effort by the Oregon Department of Environmental Quality (DEQ), the City of Portland (City), ZRZ Realty Company, Portland General Electric (PGE), PacifiCorp, and TriMet to assess the potential presence of environmental contaminants in sediment within the downtown reach of the Willamette River from River Mile (RM) 12 to 16, see Figure 1-1.

The approach and procedures for the DPSC are detailed in the Sampling and Analysis Plan (SAP) prepared by GSI Water Solutions, Inc. (GSI) (GSI, 2008). Deviations from the DPSC SAP are described in this report.

The DPSC is separate and distinct from the ongoing remedial investigation and feasibility study (RI/FS) of the Lower Willamette River (Portland Harbor) Superfund Site. However, the DPSC employed sampling and analytical procedures used by the Lower Willamette Group (LWG), as approved by the U.S. Environmental Protection Agency (EPA), in characterizing the Portland Harbor Superfund Site.

This report is intended to describe field activities and present analytical results. The evaluation of the DPSC data is limited to basic statistical analyses, graphical representations, and mapping of select analytes. A detailed interpretation and discussion of these data are beyond the scope of this report.

This report was prepared by GSI under contract to the City's Bureau of Environmental Services. Key support in preparing this report was provided by GeoEngineers, Inc. (GeoEngineers), QA/QC Solutions LLC, and Axelrod LLC working as subconsultants to GSI.

1.1 BACKGROUND

The downtown reach of the Willamette River has been used and modified for more than 150 years. Various industrial activities have occurred on the banks of the river, including ship building and ship breaking, heavy manufacturing, pesticide formulating, manufactured gas production, power generation and distribution, lumber processing, and commodities importing and exporting. The river banks have been significantly modified and used for automotive transportation, particularly in the lower half of the downtown reach. Waterfront and upland facilities and roadways may have contributed contaminants to the Willamette River via direct discharges (e.g., stormwater and non-stormwater flows), groundwater discharges, overwater activities, overland runoff, or bank erosion.

Limited sediment investigations have taken place in the downtown reach. Most data are confined to three sites that have been remediated or currently are undergoing remediation with DEQ oversight: PGE Substation L, Ross Island, and Zidell. The LWG has summarized and assessed the quality of historical data within the downtown reach (Integral et al., 2007). In addition, the LWG has collected sediment, sediment trap, tissue, and surface water samples within the downtown reach. These LWG samples generally were collected near RM 12, 15, and 16 and represent a relatively small data set. The LWG sediment data are presented in Section 6. Appendix A provides a list of historical sediment investigations conducted between RM 12 and RM 16, as identified in the LWG *Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report* (Integral et al., 2007). Maps showing historical sediment sampling locations (LWG and other studies) also are provided in Appendix A. These sample locations were obtained from the LWG Site Characterization and Risk Assessment (SCRA) Combo database as of August 28, 2008. Similar maps as well as tabulated analytical results were provided in the DPSC SAP. The historical data are provided in a Microsoft Excel® data file along with DPSC and LWG data, as discussed in Sections 5 and 6.[1]

The LWG and DPSC samples share similar characteristics including sampling and analytical procedures, data validation, and regulatory oversight. The LWG samples also were collected recently (since 2004). For these reasons the DPSC sample locations were selected to supplement LWG locations, and analytical results of the LWG samples are included in the statistical analyses presented in Section 6. Other (non-LWG) historical data from the downtown reach may not be directly comparable to the DPSC data because of the variability in sampling and analytical methodologies, uncertainty in data quality, or these data are from sites where sediment remedies have been implemented or are in the process of being remediated under DEQ oversight (PGE Substation L, Ross Island, and Zidell). These data are not included in the statistical analyses presented in Section 6.

1.2 PURPOSE AND OBJECTIVES

The purpose of the DPSC is to gain a preliminary understanding of the nature and extent of hazardous substances in the Willamette River sediments between RM 12 and 16. A better understanding of this segment of the river is necessary to determine where source control measures should be implemented to minimize potential contamination, protect human health and the environment, and ensure a healthy river. Furthermore, any needed cleanup and source control activities within the downtown reach should be conducted in

[1] The DPSC includes sediment core samples collected on behalf of Portland Parks and Recreation (PP&R) as discussed in Section 1.2.

coordination with downstream areas including, but not limited to, the Portland Harbor Superfund Site.

The DPSC is not intended to be a comprehensive study of all potential contaminant pathways or sources. It is anticipated that the City and other parties will work with DEQ to identify additional activities that may be warranted, including sampling, source tracing, source control, and remedial actions, based on the results of the DPSC.

Sampling locations and analytical parameters for the DPSC were selected to address the following objectives:

- Outfalls – Assess the potential impact to river sediments from current or historical discharges originating from a variety of land uses and operations including sites identified in DEQ's Environmental Cleanup Site Information (ECSI) database.[2]
- Riverfront Industries – Assess the potential impact to river sediments from current or historical riverfront industries.
- Ambient Stations – Assess ambient levels of hazardous substances within the downtown reach.

The design and rationale for the DPSC were developed on the basis of these objectives and in consideration of the general river dynamics and unique features of the Willamette River within the downtown reach, as discussed in the SAP.

Two additional objectives were incorporated in the DPSC following completion of the DPSC SAP:

- Benthic Macroinvertebrate Survey – A benthic macroinvertebrate survey was conducted to support current and future assessments of river ecology and to provide baseline macroinvertebrate data for the downtown reach. This benthic survey was performed by SWCA Environmental Consultants (SWCA).
- Sediment Sampling for Portland Parks and Recreation – Six sediment cores were collected on behalf of Portland Parks and Recreation (PP&R) to assess subsurface sediment conditions and to comply with federal permit requirements for a proposed development of the South Waterfront Greenway.

[2] Outfalls targeted in this study primarily are active public stormwater outfalls.

1.3 DOCUMENT ORGANIZATION

This report presents the field and laboratory procedures and findings of the DPSC. Additional details of the investigative approach and sampling procedures are provided in the DPSC SAP. This report is organized into the following sections: Section 1 provides an introduction; Section 2 outlines the project organization; Section 3 summarizes the field sampling, sample handling, and documentation procedures; Section 4 describes the laboratory analysis program, including laboratory quality assurance/quality control (QA/QC) protocols and data validation procedures; Section 5 describes data management procedures; Section 6 summarizes analytical results; and Section 7 lists cited references. Supporting documentation is provided in the appendices.

2.0 PROJECT ORGANIZATION

This section summarizes the organizational structure, responsibilities, and resources employed to support the DPSC, including field activities, laboratory services, data validation, and data management and reporting. Additional details are provided in the DPSC SAP.

2.1 TEAM ORGANIZATION AND RESPONSIBILITIES

The DPSC was implemented by GSI under its contract with the City. Additional support was provided by the following subconsultants and contractors:

- Axelrod LLC – Field and technical support
- Browning Environmental Services – Field support
- Columbia Analytical Services (CAS) – Analytical support
- GeoEngineers – Database management
- Marine Sampling Systems (MSS) – Operation of sampling vessel and equipment
- QA/QC Solutions LLC – Data validation
- SWCA – Field support, benthic analysis, processing facility

A notable change from the project organization in the DPSC SAP was the addition of SWCA, which developed and implemented the benthic macroinvertebrate survey. SWCA also provided its field facility for processing the sediment cores, including the refrigeration and storage of samples before lab pickup, and general staging of field activities.

2.2 HEALTH AND SAFETY

Field activities associated with the DPSC were completed in compliance with Hazardous Waste Operations and Emergency Response (HAZWOPER) regulations under Chapter 29 Code of Federal Regulations (CFR) 1910.120. Consultants, subconsultants, and subcontractors performing field work under the DPSC prepared their own health and safety plans (HSP) and were responsible for their health and safety under the general direction of the Field Director, as described in the DPSC SAP.

2.3 PROJECT SCHEDULE

The DPSC SAP was approved by DEQ in May 2008. Sediment sampling was conducted between May 12 and June 10, 2008. Laboratory analyses, including the reanalysis of selected samples, and data validation were performed between May and October 2008.

3.0 SAMPLE COLLECTION

The DPSC SAP specifies the procedures and methods used for sample collection, record keeping, sample handling, storage, shipping, and field quality control. Deviations from the DPSC SAP field procedures are described in this section.

3.1 SAMPLING VESSEL

Power-grab and vibracore samples were collected using a 36-foot-long catamaran operated by MSS as specified in the DPSC SAP. However, two locations, behind the Eastside Esplanade walkway, could not be accessed by this vessel. Samples DPSC-G060 and DPSC-G061 were collected from these locations with a handheld Eckman grab sampler deployed from an 8-foot-long, flat-bottom Zodiac. This vessel was operated by MSS.

3.2 STATION POSITIONING AND VERTICAL CONTROL

Station positioning from the primary sampling vessel was accomplished using the methods described in the DPSC SAP. Latitude and longitude coordinates were obtained using a global positioning system (GPS) receiver and the vertical positioning was established using a lead line or fathometer immediately before or during sample collection at each station. Detailed maps of the sampling locations shown with river bathymetry are provided in Appendix B.

The two stations[3] sampled with the Eckman grab sampler (DPSC-G060 and -G061) were located using a hand-held Garmin GPS. Vertical positioning was determined in a manner consistent with the other sampling locations.

Water depths were not converted to elevations (feet above/below the Columbia River Datum) as described in the DPSC SAP. This conversion can be made if further interpretation of the DPSC sample results is needed in the future.

3.3 FIELD LOGBOOK AND DOCUMENTATION

Field activities were documented through grab sample description logs, core collection and processing logs, and grab and core photographs, which provide important

[3] Throughout this report sample "stations" and "locations" are used interchangeably.

information on sediment properties. This documentation is provided in Appendices C through G, as identified below.

- Appendix C - Grab Sample Description Logs
- Appendix D - Grab Photographs
- Appendix E - Core Collection Logs
- Appendix F - Core Processing Logs
- Appendix G - Core Photographic Mosaics

Field activities and observations also were documented in bound field logbooks. These logbooks were used to describe information such as personnel, date, time, station designation, sampler(s), types of samples collected, and any observed modifications to the DPSC SAP. Scanned images of the field notebooks are available in Appendix H.

3.4 SAMPLE IDENTIFICATION

All samples were assigned unique identifiers and codes, as described in the DPSC SAP. The sample identification scheme was designed to distinguish among the individual surface sediment, subsurface sediment, and field QC samples. Surface (grab) sample locations are preceded by the letter "G" to distinguish them from subsurface (core) sample locations, which are preceded by the letter "C."

For the purposes of this study, "surface" samples are synonymous with "grab" samples and "subsurface" samples are synonymous with "core" samples, consistent with LWG data reporting. While the uppermost "A" section of the DPSC cores represents surface sediment from zero to a maximum 30 centimeters (cm) depth, chemical analyses were not performed on these sections. Therefore, all DPSC core samples represent subsurface sediment (below the "A" section). For the PP&R cores, the "A" section extends from zero to an approximately 60 cm depth, consistent with the unique PP&R sampling objectives. The PP&R samples, including the "A" sections, are classified as subsurface samples.

The sample identification specified in the DPSC SAP was modified for field QC duplicate (split) samples. The modified approach is designed to designate all field duplicates as "500" series samples. For example, the duplicate of surface sediment sample DPSC-G041 was named DPSC-G541. Similarly, the duplicate of subsurface sediment sample DPSC-C021-C was named DPSC-C521-C. This change was made to better disguise the identity of the parent sample from the laboratory.

Three samples were reanalyzed by the laboratory at the direction of the Project Manager to confirm atypical results (DPSC-G005, -C039, and -C539). These samples were

designated with "RE#" in the sample code, where "#" indicates the first or second reanalysis. For example, surface sample DPSC-G005 was reanalyzed to confirm the concentration of butyltins. The reanalyzed sample was named DPSC-G005-RE1.

Discrepancies in the designated nomenclature were corrected as discussed in Section 3.6.

3.5 EQUIPMENT DECONTAMINATION PROCEDURES

Decontamination of equipment was performed as specified in the DPSC SAP to avoid cross-contamination between samples. Equipment that came in direct contact with sediment samples was decontaminated before use at each station and between field duplicate sample collections. The sediment grab equipment was rinsed in the field between stations with site water. Where the grab sampler contacted visibly contaminated sediment (e.g., oily residue), the sampler was thoroughly washed using phosphate-free detergent and rinsed with site water before sampling resumed. For the vibracore sampling, the aluminum core tubes and stainless-steel core catchers were fully decontaminated, and the ends wrapped in foil and sealed onshore before on-water operations. Additional tubes were prepared onshore as needed throughout the sampling event to ensure that coring operations continued without the need to decontaminate tubes on the sampling vessel.

3.6 SEDIMENT SAMPLE COLLECTION

Sediment samples were collected in accordance with the procedures described in the DPSC SAP. These procedures generally followed those developed by the LWG and approved by the EPA for the Portland Harbor Superfund Site. Modifications to the procedures outlined in the DPSC SAP are described in this section.

Figure 3-1 and Figures 3-2a through 3-2d show locations where samples were successfully collected. The detailed sampling maps in Appendix B show all locations where sampling was attempted (successful and unsuccessful). Tables 3-1, 3-2, and 3-3 list sample locations, penetration depths, and collection and processing dates. Table 3-4 identifies sample stations for which the locations deviated from the SAP. This includes samples relocated more than 50 feet from target, samples eliminated, or samples added. Table 3-5 identifies samples that were renamed to correct inaccuracies or inconsistencies, as discussed in Section 3.6.3.

3.6.1 Surface Sediment

Surface sediment samples were successfully collected from 81 stations, as shown in Figure 3-1 and Figures 3-2a through 3-2d and listed in Table 3-1. Samples from three of these locations (DPSC-G034, -G042[4], and -G082) were not analyzed due to the absence of sufficient fine grained material upon inspection at the contract laboratory. These samples were archived at the laboratory.

Multiple attempts were required at many locations to obtain an acceptable grab sample (adequate penetration depth and sufficient fine-grained material for chemical analysis). In a few instances, after numerous attempts and consultation with the Project Manager, a penetration depth as shallow as 7 cm was deemed acceptable. Surface sediment sample locations, penetration depths, and other relevant data are described in Table 3-2.

If a surface sediment sample was deemed acceptable, a representative aliquot of sediment was collected and processed in accordance with the DPSC SAP. Of the 81 successful sample stations, samples from three locations (DPSC-G034, DPSC-G042[5], and DPSC-G082) that were submitted to the laboratory were not analyzed because of insufficient fine-grained material. Surface sediment could not be collected at stations DPCS-G004, DPSC-G081, DPSC-G083, and DPSC-G084 for the reasons specified in Table 3-4. Table 3-6 lists the surface sediment samples submitted to the laboratory for physical and chemical analyses and archiving.

The following physical characteristics of the sediment were described and recorded on field logs or sample description forms: sediment texture, sediment color, odors, grab penetration depth (nearest cm), degree of leakage or sediment surface disturbance, and any obvious features or characteristics such as wood or shell fragments or large aquatic organisms. Grab sample description logs are provided in Appendix C and photographs of the grab samples are provided in Appendix D.

3.6.2 Subsurface Sediment

Subsurface sediment samples were successfully collected from 36 stations as shown in Figure 3-1 and Figures 3-2a through 3-2d and listed in Table 3-1.

Core logging and processing occurred at the SWCA facility located at 935 SE 12th Avenue in Portland, Oregon. Each core tube was cut open using a circular saw and photographed, logged, and sampled as described in the DPSC SAP. Sediment lithology

[4] Sample DPSC-G042 was analyzed for total organic carbon. A suitable sample eventually was collected from this location and identified as DPSC-G085.

[5] This sample was inadvertently analyzed for total organic carbon before the laboratory was instructed to discontinue further analysis.

(dominant grain size and color) was the primary criteria used to determine depth intervals to section the core. In accordance with LWG protocol, the core was divided into "A," "B," "C," etc. sections with the uppermost "A" section representing surface sediment from zero to a maximum 30 cm depth.[6] Sediment from the "A" section of each core was archived and the deeper core section showing the most evidence of contamination was selected for chemical testing. If no intervals exhibited signs of contamination, the "B" section was selected for chemical testing. Representative material from each section was homogenized, placed into sample containers, and submitted to the laboratory for analysis or archiving.

In addition to the subsurface sediment samples specified in the DPSC SAP, cores were collected from six stations specified by the PP&R to satisfy federal permitting requirements for a planned greenway restoration. At these stations, DPSC-C034 through DPSC-C039, cores were collected and processed following the protocols specified in the DPSC SAP with the following exceptions. The target depth for these cores was 120 cm and the cores were split into an upper "A" section (zero to 60 cm below mudline) and a deeper "B" section (60 to 120 cm below mudline). Only the "B" sections from two of the PP&R cores initially were submitted for physical and chemical analysis while the other sections were archived. Analysis of the archived sections was requested on August 11, 2008, and the resulted are included in this report.

Subsurface sediment sample locations, core measurements, collection and processing dates, and other relevant data are described in Table 3-3. Subsurface sediment could not be collected at four stations (DPSC-C012, DPSC-C013, DPSC-C015, and DPSC-C040) for reasons specified in Table 3-4. Table 3-7 lists the subsurface sediment samples submitted to the laboratory for physical and chemical analyses and for archiving. The core collection logs and core processing logs are presented in Appendix E and Appendix F, respectively. Photographs of discrete core sections were digitally assimilated into a single photographic mosaic for each core station (Appendix G).

3.6.3 Modified Sample Names

Several samples were incorrectly labeled by the field crew or the sample identification was incorrectly stated by the contract laboratory. These sample labeling errors were corrected in the database. A typical field error was to specify one more or one less digit in the sample name (e.g., DPSC-G03 instead of DPSC-G003). Another field error was to assign an alphabetical digit to the multiple attempts at successfully collecting a sample from a grab station DPSC-G022 (e.g., DPSC-G022A). A typical laboratory labeling

[6] The "A" sections at two core stations (DPSC-C001 and DPSC-C014) did not appear to be present in the core tubes based on sediment characteristics of the co-located grab samples. For these samples the "B" sections were extended to the top of the core

error was to distinguish a reanalyzed sample as "-Arch" or "-Orig" or "-RE". Consistent and more appropriate identifiers have been applied to these samples as indicated in Table 3-5.

3.7 BENTHIC MACROINVERTEBRATE SAMPLE COLLECTION

A benthic macroinvertebrate survey was added to the scope of the DPSC following completion of the SAP. During the study, 79 sediment samples were collected for the benthic macroinvertebrate survey. The benthic samples were co-located with select DPSC stations planned for surface sediment sample collection. The approach and findings of the benthic macroinvertebrate survey are provided in Appendix I. The sediment collection procedures for macroinvertebrate sampling are summarized below.

At stations designated for benthic sampling, undisturbed sediment was collected during the power-grab sampling operation, as previously described. A portion of the undisturbed sediment was sampled over a depth of 10 cm using a marked metal tube (11.5 cm diameter) and retained for benthic macroinvertebrate enumeration and identification. Four subsamples per sediment grab were collected to retain 0.042 square meter (m^2) total area of biologically active benthic sediment per sample. Grab samples with insufficient sediment quantity or with large materials that could not be collected with the subsampling cylinder were documented as qualitative. For qualitative samples, any observed organisms, or the remaining upper 10 cm of the grab sample, were placed in jars for qualitative analysis.

Sample depths were documented with the sampling vessel's depth sounder or a lead line. Sediment grain size was provided by CAS. The macroinvertebrate samples were transported daily from the sampling vessel to the processing lab (SWCA) and analyzed as described in Section 4.2.

3.8 WASTE MANAGEMENT

Liquid and solid waste from DPSC activities was managed as specified in the DPSC SAP. Excess water or sediment remaining after sampling and processing on the vessel was returned to the Willamette River near the collection site. Sediment containing oily sheen was placed in 55-gallon drums stored on the sampling vessel and labeled as investigation derived waste (IDW). Additional IDW was generated during core processing activities at the onshore facility and placed in 55-gallon drums. IDW was managed, characterized, and disposed of in accordance with the DPSC SAP and

tube (zero cm).

applicable regulations. Four drums of sediment were collected and retained during field activities. Samples were collected from these drums and analyzed for characteristics of hazardous waste in consultation with Waste Management, Inc. Results of these analyses are presented in Section 6. Based on the analytical results, the drums were determined to be non-hazardous waste and were disposed of at the Waste Management, Inc., Hillsboro Landfill, a DEQ-licensed Subtitle D solid waste landfill. This transaction was documented by solid waste profile number 102324OR and ticket number 1188674.

Limited volumes of decontamination solutions containing phosphate-free detergent, nitric acid, and methanol were generated during the sampling event on the vessel and at the onshore core processing facility. These liquids were managed in sealed 5-gallon plastic buckets and were disposed of in the sanitary sewer at the processing facility as approved by the City's Bureau of Environmental Services.

All disposable materials used in sample collection and processing, such as paper towels and disposable coveralls and gloves, were placed in heavyweight garbage bags. These materials were disposed of as municipal waste.

3.9 SAMPLE HANDLING, TRANSPORT, AND CUSTODY

Samples collected during the DPSC sampling event were tracked from the time of sample collection through laboratory and data analysis using standard chain-of-custody (COC) and sample shipping/transfer procedures. These procedures are detailed in the DPSC SAP. Copies of the COC forms are provided with the laboratory reports in Appendix J.

3.10 FIELD QUALITY CONTROL SAMPLES

QC samples were collected during field sampling to ensure that data quality objectives were met. Field QC samples collected during the DPSC are specified in the DPSC SAP. These samples included field duplicate (split) samples and rinsate samples, both of which were collected at approximately 5 percent of the sediment sampling stations. A temperature blank was included in each cooler transmitting samples to the laboratory. A trip blank was included in each cooler transmitting samples being analyzed for volatile organic compounds (i.e., PP&R samples).

4.0 LABORATORY ANALYSIS AND QUALITY ASSURANCE AND QUALITY CONTROL

This section summarizes the physical and chemical analyses, and the benthic analyses performed on sediment samples collected during the DPSC. Laboratory QC and data validation protocols also are described. These protocols were followed to ensure that data quality and representation are in accordance with method requirements and data usability is appropriately assessed for the project objectives.

4.1 PHYSICAL AND CHEMICAL ANALYSES

CAS, of Kelso, Washington, performed the physical and chemical analyses on all DPSC samples, except for dioxin/furan analyses, which were completed by CAS's laboratory in Houston, Texas, and volatile petroleum hydrocarbons (VPH) and extractable petroleum hydrocarbons (EPH), which were analyzed by Analytical Resources Incorporated (ARI) in Tukwila, Washington.

The DPSC sediment samples were analyzed for a broad spectrum of parameters (Tables 3-5 and 3-6) including metals, polycyclic aromatic hydrocarbons (PAH), alkylated PAHs, polychlorinated biphenyl (PCB) aroclors, semivolatile organic compounds (SVOC), total petroleum hydrocarbon (TPH) (as diesel- and oil-range petroleum hydrocarbons, with silica gel treatment), phenols, pesticides, and butyltins. Select samples also were analyzed for dioxins and furans as discussed in the DPSC SAP. The following conventional parameters also were analyzed at each station: grain size, total solids, and total organic carbon (TOC). The analytical methods for sediment testing are presented in Table 4-1.

The PP&R sediment samples were analyzed for metals, PAHs, SVOCs, pesticides, PCB aroclors, EPH/VPH, and butyltins. The following conventional parameters also were analyzed at select stations: grain size, total solids, TOC, total sulfide, and ammonia as nitrogen.

4.2 BENTHIC ANALYSES

As described in Section 3.7, a subset of the surface sediment samples was used for characterization of benthic macroinvertebrates. The sediment samples were washed in a 500-micron (0.5 mm) sieve to remove fines. The retained material was preserved in 70 to 80 percent ethanol for sorting and identification. Preserved samples were sorted on a white sorting tray, and invertebrates examined at 1x to 25x magnifications using a stereo dissecting microscope. Multiple trays of material were sorted per sample, with every

third tray re-examined by a second aquatic biologist for QC. Organisms were identified to coarse levels. Preserved invertebrates were archived for future retrieval and re-examination, if necessary.

Benthic invertebrates from qualitative samples were identified and noted, but not included in further analysis. Only whole organisms, or parts that were identified as whole live specimens before preservation (e.g., lamprey ammocoetes), were included in tallies for further analysis. Data entry was quality checked by a second aquatic biologist and compared to field sampling notes, log books, and post sampling maps. Additional detail on the benthic analyses and results is provided in Appendix I.

4.3 LABORATORY QA/QC PROCEDURES

Laboratory QA/QC was maintained through the use of standard EPA methods and other accepted methods and standard analytical procedures for the DPSC analytes. The analytical methods and QC measurements and criteria used are based on current Contract Laboratory Program (CLP) and SW-846 requirements, and EPA guidance. The method-specific and other analytical and laboratory QC procedures and protocols followed are detailed in the DPSC SAP. These procedures incorporated the collection and analysis of the following laboratory QA/QC components:

- Internal QC samples
- Method reporting limit checks
- Method blanks
- Laboratory duplicates
- Surrogate spikes
- Laboratory control samples
- Matrix spike (MS) and matrix spike duplicate (MSD) samples.

Analytical QC measurements were performed exclusively on sample matrices from the DPSC project.

4.4 DATA REVIEW, VERIFICATION, AND VALIDATION PROCEDURES

Field and laboratory data collected for the DPSC were subjected to a formal verification and validation process in accordance with EPA guidance documents as described in the DPSC SAP.

QA/QC Solutions LLC performed the data validation to determine the usability of the data toward meeting project objectives. Approximately 10 percent of the data were

subject to full data review and an abbreviated validation review was performed on the remaining 90 percent of the data. A comprehensive (100 percent) validation review was performed on all chromatograms from the analysis of pesticides and PCBs.

For the abbreviated data validation (i.e., a summary review of the results reported), the following laboratory data deliverables were reviewed:

- Case narratives discussing analytical problems (if any) and procedures.
- COC documentation to verify completeness of the data set.
- Sample preparation logs or laboratory summary result forms to verify analytical holding times were met.
- Results for applicable instrument tuning and calibrations to assess instrument performance.
- Results for applicable instrument blanks, method blanks, and equipment rinsate blanks to determine whether an analyte reported as detected in any sample was the result of possible contamination introduced at the laboratory, or during field sampling, respectively.
- Results for applicable internal standards to ensure that instrument sensitivity and response was stable during the analysis of the samples.
- Results for applicable method-specific QC measurements (e.g., serial dilutions and interference check samples for metals analyses and dual-column confirmation results for applicable organic compound analyses) to assess potential matrix interference effects.
- Results for applicable surrogate compound, laboratory control sample (LCS) (i.e., blank spike), duplicate LCS, MS, and MSD recoveries to assess analytical accuracy.
- Results for applicable duplicate LCS and MSD analyses to assess analytical precision.
- Results for the field duplicate samples to provide additional information.
- Laboratory summaries of analytical results reported for the analyses completed.

For the 100 percent data validation, the following additional items were evaluated:

- A review of instrument printouts (e.g., chromatograms, mass spectra, and quantification reports) to assess the validity of analyte identification as either detected or undetected.
- Verifying quantification of sample results and applicable QC measurement (e.g., instrument calibrations; surrogate, MS/MSD, and LCS recoveries; and other applicable information for accuracy and precision) results by recalculation.

Performance-based control limits established by the laboratory and control limits provided in the method protocols were used to evaluate data quality and determine the need for data qualification. Data qualifiers were assigned during data validation to the electronic data deliverables (EDD) when applicable QA/QC limits were not met and the qualification was warranted following guidance specified by EPA (1999, 2002, 2004, and 2005), QC requirements specified in the SAP, and method-specific QC requirements, as applicable. Data validation qualifiers and definitions are presented in Table 4-2.

Final, qualified (as necessary) laboratory results were transmitted in EDDs to the Data Manager for data management, further evaluation, and reporting as described in Section 5. Data validation reports were prepared to document the validation process and these reports are provided in Appendix K.

4.5 DATA QUALITY AND USABILITY

Data generated in the field and at the laboratories were verified and validated according to the criteria and procedures described in the DPSC SAP. Data quality and usability were evaluated on the basis of the results of the data validation and the data quality objectives established for this investigation. Performance criteria included analytical goals for precision, accuracy, representativeness, and comparability of the data, which were assessed during data validation, as described above, in Appendix K, and in the DPSC SAP. Completeness was calculated by comparing the total number of acceptable data (non-rejected data) to the total number of data points generated. Overall, completeness for the DPSC sediment data is greater than 99 percent.

Selected data not meeting applicable data quality criteria were qualified as estimated, undetected, or rejected during data validation. Data qualified as estimated (J or UJ) have a generally acceptable degree of uncertainty and represent data of generally good quality, reasonable confidence, and are usable for their intended purposes, with the knowledge that these data may be less precise or less accurate than unqualified data. Data qualified as undetected are usable for all intended purposes. All data that were rejected (R) are not usable for any purpose and should not be used. The percent completeness by parameter group is presented in Table 4-3.

In some instances, selected samples were diluted, as determined to be necessary by the analytical laboratory or as required by the analytical methods. Dilution was sometimes used to distinguish concentrations of target compounds present in the sample that were within the linear range of the instrument or to minimize the effects of matrix interferences to obtain reportable results for undetected and/or detected target compounds.

In many samples, both PCBs and organochlorine pesticides were reported as detected. In this situation, interferences from the inability of the instrument to differentiate selected PCB congeners from certain organochlorine pesticides may occur. As such, it is possible that some target compounds may be reported as a false positive or the concentration that was quantified may exhibit a positive bias because of the co-elution (or interference) with one, or more, organochlorine pesticide and/or PCB congener. The contract laboratory is aware of this co-elution issue and was careful to identify and report as accurately as possible the concentrations of each organochlorine pesticide and PCB mixture identified as present in the affected samples.

The number of DPSC surface and subsurface samples, PP&R subsurface samples, and field QC samples submitted for each parameter group is summarized in Table 4-4. More detailed discussion regarding the qualification of the data can be found in the data validation summaries in Appendix K.

5.0 DATA MANAGEMENT

Data generated as part of the DPSC were documented and managed as described in previous sections and in accordance with the DPSC SAP. These data consisted of field data sheets, photographs, field notebooks, and electronic data files. To the extent practicable, all measurements and other quantitative and qualitative data were incorporated into an EQuIS® database (EarthSoft, Inc.).

Sediment samples were sent to CAS for chemical analyses. After analyses were completed, the laboratory provided electronic EDDs following the EQuIS® four-file format (sample, test, batch, and results). The EDDs were organized by sample delivery groups and in a comma-delimited text file format. The EDDs were sent from the laboratory to QA/QC Solutions LLC. The unvalidated files were forwarded to GeoEngineers for storage while QA/QC Solutions LLC proceeded with data validation according to the DPSC SAP. Copies of the EDDs were made and the contents were modified to reflect adjustments identified during the data validation process. The primary modification was the addition of a validator qualifier field, where the final qualifier for the result was placed. This ensured the original laboratory qualifiers also remained intact. The modified EDDs were sent to GeoEngineers where they were checked for proper EQuIS® structure and content. Additional information needed to complete the database (such as sampling locations, composite information, and field replicate and split information) was compiled by GSI and forwarded to GeoEngineers for inclusion into the DPSC database.

Before uploading the EDDs, GeoEngineers developed an EQuIS® version 3 database based on the valid values or reference values of the LWG EQuIS® database. During the process of loading the EDDs, EQuIS® was used to check the EDDs for: correct reference codes (such as for analytes, test methods, and sample matrices); proper relationships for results, tests, batches, and samples (to ensure all results matched with a test, tests with samples, and sample/test pairs with batches); and, that all derived samples (such as replicates, splits, and MS) had corresponding parent samples.

Additionally, EQuIS® was used to check information such as date and time formats, and text field lengths to ensure consistency throughout the database. EQuIS® was used to prevent any EDD with code or format errors from successfully uploading until the errors were corrected. Original copies of the EDDs that were uploaded successfully were saved for purposes of documenting and tracking the data.

The DPSC project database contains all of the data reported by the analytical laboratories. These data include field splits, laboratory duplicates, laboratory dilutions,

results for the same analyte from multiple analytical methods (e.g., SW8270 and SW8270-SIM), and laboratory QA samples such as MS, surrogates, and method blanks.

Two documents were used as guidelines for data reduction and handling:

- Portland Harbor RI/FS Technical Memorandum: Guidelines for Data Averaging and Treatment of Non-detected Values for the Round 1 Database (Kennedy/Jenks et al., 2004).
- Portland Harbor RI/FS Round 3B Sediment Data Report, Appendix F, Summation Rules and SCRA Combo Database, Excel® Flat File Format (Integral Consulting Inc., August 2008).

The guidelines describe the rules used for averaging data and retaining or modifying qualifiers, and were used to reduce the DPSC and PP&R data to a single value per sample analyte. The resulting data were checked and verified for 100 percent of the resulting DPSC EQuIS® database.

Samples subject to averaging included laboratory QC duplicates for metals, field QC splits, and samples reanalyzed at the direction of the Project Manager to confirm potentially anomalous results. Original sample results are contained in the DPSC EQuIS® database. Laboratory QC duplicate results and their parent sample results were averaged before inclusion in the Section 6 tables. Analytical results for individual field QC split and reanalyzed samples are presented in the Section 6 tables along with their averaged values. Only the averaged values are used in the statistical analyses, scatter plots, analyte concentration maps, and Excel® data files, as discussed in Section 6.

The LWG averaging rules address three general combinations of detected and non-detected results:

- If the analyte was detected in two or more samples, only the detected results were averaged (the non-detected results are ignored).
- If the analyte was detected in only one sample, the detected value was reported as the average (the non-detected results are ignored).
- If the analyte was not detected in any samples, the lowest reporting detection limit (RDL) was reported as the average.

When averaging multiple results, the data validation qualifiers were propagated according to the LWG guidelines. If all of the results in the calculated average include the same qualifier (Table 4-2), then the qualifier was applied to the calculated average. If one or more of the results are qualified as estimated (J - flagged), then the calculated average was similarly qualified (J). A "T" qualifier was added to all results that are mathematically derived, including averaged and summed results.

The LWG guidelines also specify summation rules for select analytical groups such as: PCB aroclors, butyltins, polychlorinated dibenzo-p-dioxin and furan (PCDD/F), PAHs, PCB congeners, DDx, and chlordanes. In general, the calculated totals are the sum of all detected concentrations. If all of the analytes were not detected, then the highest RDL was selected for the calculated total, and a "U" qualifier was carried through to indicate that all results were reported as undetected. All calculated totals are flagged with a "T" indicating they are mathematically derived values.

As per the LWG guidelines, total LPAHs were calculated using the concentrations for 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene. Total HPAHs were calculated using the concentrations for benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3,-cd)pyrene, and pyrene. Total PAHs were calculated by summing the LPAH and HPAH values.

Total DDx values were calculated with the concentrations of the six DDx compounds: 2,4′-DDD; 4,4′-DDD; 2,4′-DDE; 4,4′ DDE; 2,4′-DDT; and 4,4′-DDT. Total DDD values were calculated with 2,4′-DDD and 4,4′-DDD; total DDE values were calculated with 2,4′-DDE and 4,4′-DDE; and total DDT was calculated by summing 2,4′-DDT and 4,4′-DDT.

Total chlordanes were calculated as the sum of the following compounds: cis-chlordane, trans-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor.

The LWG guidelines address the retention of significant figures and these guidelines were generally followed in generating and maintaining the DPSC EQuIS® database. The number of significant figures provided by the analytical laboratory was maintained in the DPSC EQuIS® database. In addition, significant figures were maintained during calculations, such as averaging splits and summing totals. However, the final results of these calculations were not rounded to the smallest number of significant figures for the values included in the calculations. That is, the final results from the averaging and totaling calculations may contain too many significant figures. The inclusion of additional significant figures should not affect the interpretation of the DPSC analytical data.

6.0 RESULTS

Analytical results of the surface and subsurface samples have been tabulated for the DPSC, PP&R, and LWG sample groups. As discussed in Section 1.1, historical LWG sediment data contained in the LWG SCRA Combo database as of August 28, 2008, are included in the tables in this section.

Analytical results of DPSC and PP&R field QC split samples and reanalyzed samples are provided in Table 6-1. This table also provides the average values for the field QC splits and reanalyzed samples. Results of DPSC and LWG surface sediment samples following data reduction of splits and reanalyzed samples are summarized in Table 6-2a and Table 6-2b, respectively. Similarly, results of DPSC, PP&R, and LWG subsurface sediment samples are presented in Table 6-3a, Table 6-3b, and Table 6-3c, respectively. Data reduction (averaging) of DPSC and PP&R field QC and reanalyzed samples is discussed in Section 5. Data reduction of the LWG samples was performed by the LWG before inclusion in the LWG SCRA Combo database. Tables 6-4 and 6-5 provide analytical results of the field QC rinsate blank samples and IDW samples, respectively.

Statistical analyses were performed on combined analytical results of the DPSC, PP&R, and LWG samples, as provided in Tables 6-6a through 6-6c:

- Surface sediment samples
- Subsurface sediment samples
- Surface and subsurface sediment samples

Statistical parameters include: minimum, maximum, average (mean), median (50^{th} percentile), 75^{th} percentile, 90^{th} percentile, and 95^{th} percentile. Statistics were performed consistent with LWG protocols for data manipulation as described in Section 5 and Appendix L.

Note that one "subsurface sediment" sample collected by the LWG included sediment from the surface horizon (i.e., less than 30 cm in depth). LWG core sample LW3-C782-A was collected from a depth of zero to 30 cm. Also, as discussed in Section 3.4, the PP&R core samples are characterized as "subsurface" samples including the "A" sections collected from the upper 60 cm in accordance with the specific objectives of the PP&R study.

Appendix M contains the Excel® data files for the DPSC, PP&R, and LWG as described in Section 5. The DPSC, PP&R, and LWG data have been reduced to provide average values for laboratory QC duplicates, field QC splits, and reanalyzed samples, and the samples have been keyed for their corresponding percentiles to assist in data mapping.[7]

[7] LWG data were reduced by LWG before inclusion in the LWG SCRA Combo database.

The historical sediment data from other (non-LWG) studies were obtained from the LWG SCRA Combo database (August 28, 2008) and have not been modified, and were not used in the statistical analyses previously described; these data should be used with caution. These other historical data also are provided in Appendix M as a separate Excel® data file.

A series of figures was prepared to help visualize the distribution of analyte concentrations within the downtown reach for the DPSC, PP&R, and LWG samples. Figures 6-1a through 6-1n present scatter plots of analyte concentrations versus RM. Figures 6-2 through 6-15 present maps indicating analyte concentrations at the sample locations. Analytes selected for visualization in these figures are: total PCB Aroclors, total butyltins, TOC, PCDD/F (dioxins/furans), arsenic, chromium, copper, lead, zinc, total PAHs, total DDx, total chlordanes, pentachlorophenol, and bis(2-ethylhexyl)phthalate.

The DPSC SAP indicated that statistical summaries would be performed on 28 sample groups with surface and subsurface samples grouped separately for:

- Entire data set – grab, core
- Ambient stations – grab
- Outfalls (sample in immediate vicinity) – grab, core
- Entire data set, excluding ambient stations – grab
- Entire data set, excluding outfalls and ambient stations – grab, core
- All east-bank – grab, core
- All west-bank – grab, core
- East-bank for each RM segment (four groups) – grab, core
- West-bank for each RM segment (four groups) – grab, core

However, statistics were performed only on three sample groups as previously discussed (surface sediment, subsurface sediment, and combined surface and subsurface sediment). In lieu of the additional statistical tables, this report provides analyte concentration scatter plots and maps. The figures in this section provide for better visualization of analyte distribution within the downtown reach and should assist data review and help identify trends or locations that may warrant further assessment.

7.0 REFERENCES

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