Lower Duwamish Waterway

Groundwater Sampling for PCB Congeners and Aroclors

Sampling and Analysis Plan and Quality Assurance Project Plan

FINAL

Prepared for

Toxics Cleanup Program
Northwest Regional Office
Washington State Department of Ecology
Bellevue, Washington

Prepared by

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Acronyms and Abbreviations

ARI	Analytical Resources, Inc.
CCV	continuing calibration verification
CoC	chain of custody
DQO	data quality objective
EcoChem	EcoChem, Inc.
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EIM	Environmental Information Management
EMF	Electronics Manufacturing Facility
EPA	U.S. Environmental Protection Agency
FM	Field Manager
HSM	Health and Safety Manager
IDW	investigation-derived waste
IPR	initial precision and recovery
KCIA	King County International Airport
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDW	Lower Duwamish Waterway
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
OPR	ongoing precision and recovery
PCB	polychlorinated biphenyl
PPE	personal protective equipment
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
SAP	sampling and analysis plan
TM	Task Manager
Vista	Vista Analytical Laboratories
WAC	Washington Administrative Code

1.0 Introduction

The Lower Duwamish Waterway (LDW) site is an approximately 5-mile portion of the Duwamish River, which flows into Elliott Bay in Puget Sound, Seattle, Washington. The Washington State Department of Ecology (Ecology) is the lead agency for source control on the LDW site, as defined in the U.S. Environmental Protection Agency (EPA) LDW Record of Decision (EPA 2014).

Ecology's Toxics Cleanup Program currently administers Model Toxics Control Act Agreed Orders for remedial investigations, feasibility studies, and cleanup action plans for several cleanup sites adjacent to and near the LDW. Some sites may be sources of polychlorinated biphenyls (PCBs) to the LDW surface water and sediments through the discharge of groundwater. Groundwater discharging to surface water and sediments must meet a very low water quality standard to protect surface water and sediments. Analytical methods for PCB Aroclors (EPA Method 8082) cannot measure low enough PCB concentrations to provide information necessary to determine if concentrations in the groundwater are protective of surface water and sediments. Collection and analysis of groundwater samples for PCB congeners using EPA Method 1668 is consistent with the recently issued Toxics Cleanup Program Implementation Memorandum #12 (Ecology 2015), and will allow for more accurate use and evaluation of data.

During data compilation efforts for the *Green-Duwamish River Watershed PCB Congener Study: Phase 1*, completed by Leidos under a separate work assignment, no groundwater or surface water data for PCB congeners were identified. Data collected as part of this task will help to fill this data gap; in addition, collection of concurrent PCB congener and Aroclor data in groundwater and surface water will provide additional information for source tracing and fingerprinting (pattern) analysis, and will aid Ecology in assessing whether EPA Method 1668 should be used at cleanup sites. This Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) are for work performed as a subtask under Work Assignment C11139QQ, LDW Technical Assistance. This subtask is designated as LDW Groundwater Sampling for PCB Congeners and Aroclors.

Leidos reviewed existing PCB data from multiple media, specific sampling and analysis protocols, and other supporting data collected to date at sites within the LDW basin. Based on this review, a total of 14 sites have been selected to be sampled for the presence of PCBs in groundwater and surface water. All but one of these sites is under an Agreed Order with Ecology. The selection of sites is discussed in Section 2.1. A list of sites and monitoring wells is included in Appendix A, and site maps for each location are presented in Appendix B.

This SAP was prepared in accordance with the requirements outlined in Washington Administrative Code (WAC) 173-340-820. Analytical procedures are identified in the SAP and QAPP in accordance with WAC 173-340-830.

1.1 Purpose and Objectives

The primary purpose of this sampling and analysis effort is to collect groundwater and surface water samples from several sites within the LDW basin and analyze them for PCB congeners and Aroclors. Groundwater samples will be collected from existing wells at Agreed Order sites, and one non-Order site, within the LDW basin. Surface water samples from the LDW will be collected at up to 10 of the Agreed Order sites that are adjacent to the LDW. Sample analytical results may be used for the following purposes:

- Fill data gaps for PCB congeners in groundwater, as identified during data compilation efforts for the *Green-Duwamish River Watershed PCB Congener Study: Phase 1* (Leidos 2016).
- Allow more accurate use and evaluation of PCB data by collecting both Aroclor and congener data from multiple locations with a wide expected range of concentrations.
- Provide information on urban background levels of PCB congeners in groundwater.
- Provide additional information for source tracing and fingerprinting (pattern) analysis.
- Surface water sample results will be compared to groundwater sample results from nearby wells to determine if there is a significant difference in the congener profile.

Leidos and its subcontractors will implement this SAP/QAPP under the direction of Ecology. The following sections describe the key roles and responsibilities of the project team.

1.2 Project Planning and Coordination

Rick Thomas of Ecology will serve as the Ecology Project Manager who will conduct overall project coordination, supply Ecology-furnished services, review reports, and coordinate with contractors. Iris Winstanley of Leidos will serve as the Leidos Project Manager for this work assignment. Tom Dubé of Leidos will serve as the Leidos Task Manager (TM) and be responsible for executing this SAP/QAPP, overseeing the collection and analysis of field samples, and reporting the field and analytical results to Ecology. Vicki Sutton will serve as Ecology's task manager and be responsible for coordinating the project tasks with Ecology site managers.

1.3 Sample Collection

Stuart Brown of Leidos will serve as the Field Manager (FM) responsible for collecting and processing samples in accordance with this SAP/QAPP and transporting samples to the analytical laboratories for analysis. The FM, or delegate appointed by the TM, will oversee field preparation to ensure all sampling equipment meets sampling guidelines.

1.4 Laboratory Coordination and Quality Assurance/Quality Control Management

Joe Peters of Leidos will serve as the laboratory coordinator responsible for subcontracting with state-certified laboratories and ensuring use of established protocols for chemical analysis and data management. He will also serve as the project chemist and project quality assurance

(QA)/quality control (QC) coordinator. Mr. Peters will provide QA oversight for the laboratory programs, including laboratory reporting and holding times, and oversight of the independent third-party data validation subcontractor to ensure that the laboratory analytical and QA/QC data are considered valid and that procedures meet the analytical requirements.

1.5 Health and Safety Manager

Randy Hansen of Leidos will serve as the designated Leidos Health and Safety Manager (HSM). The HSM is responsible for ensuring that all personnel are properly trained and fully aware of potential site hazards. Under Mr. Hansen's direction, a delegated Site Safety and Health Officer is responsible for ensuring that personnel conduct all work in a safe manner, wear appropriate personal protective equipment (PPE), and abide by the conditions set forth in the site-specific Health and Safety Plan.

1.6 Data Manager

Megan Gay of Leidos will serve as the data manager for this project. Ms. Gay is responsible for following data management procedures described in Appendix C, reporting data to the project team as scheduled, managing the project database, and submitting data to Ecology's Environmental Information Management (EIM) database.

1.7 Subcontractor Support

The Leidos project team will consist of the following subcontractors for laboratory analytical services, data validation, and investigation-derived waste (IDW) disposal:

- PCB congener analysis:

  Vista Analytical Laboratories (Vista)
  Martha Maier
  1104 Windfield Way
  El Dorado Hills, CA 95762
  Phone: (916) 995-5171
  Email: mmaier@vista-analytical.com

- All analyses except PCB congener analysis:

  Analytical Resources, Inc. (ARI)
  Amanda Volgardsen
  4611 South 134th Place, Suite 100
  Tukwila, WA 98168
  Phone: (206) 695-6220
  Email: amandav@arilabs.com

- Data validation:

  EcoChem, Inc. (EcoChem)
  Christine Ransom

1011 Western Avenue, Suite 1011
Seattle, WA 98104
Phone: (206) 233-9332, ext. 109
Email: cransom@ecochem.net

- IDW disposal:

  Clean Harbors
  Lucas Menendez
  26328 79th Avenue South
  Kent, WA 98032
  Phone: (253) 638-3549
  Email: menendez.lucas@cleanharbors.com

1.8 Schedule

Mobilization, sampling, and analysis will begin in February 2017 following approval of this SAP/QAPP and will last approximately 6 weeks until mid-March 2017. During this time period, samples will be collected from the selected facilities. Samples will be analyzed after each event. All project analytical results will be independently validated as the data become available.

Sample analysis will require 15 days for all analyses except PCB congener analysis, which requires 21 to 28 days. Data will be validated within 30 days once the data validation subcontractor receives final laboratory reports from the analytical laboratories.

A draft technical memorandum presenting validated analytical results will be submitted to Ecology for review within 2 weeks of the receipt of the validated data. A final technical memorandum will be completed within 4 weeks of receipt of Ecology comments on the draft, but no later than June 30, 2017.

2.0 Field Sampling Plan

The purpose of the Field Sampling Plan is to describe the procedures and methodologies utilized in groundwater and surface water sample collection at the selected LDW Agreed Order sites and upgradient sites. Groundwater samples will be collected from existing and usable groundwater monitoring wells installed at each of the selected sampling sites. In addition, surface water samples will be collected along the LDW or its embayments from the selected Agreed Order sites if sampling can be safely performed.

Prior to the sampling event, a site walk will be completed at each of the selected sites to:

- Verify that selected and alternate groundwater monitoring wells are present and available for sampling (i.e., wells are accessible and not damaged).
- Assess the feasibility of collecting near-shore surface water samples (if applicable) and, if feasible, determine the sample collection method.
- Identify an area to store drum(s) containing IDW consisting of groundwater and decontamination water.

2.1 Sampling Locations

Locations for sampling were selected from 10 "adjacent properties" along the LDW and from 4 "inland properties" (see Appendices A and B). Adjacent properties are those sites located immediately adjacent to the LDW. Inland properties are those sites not immediately adjacent to the LDW. Three of the four inland properties are Agreed Order sites administered by Ecology. The exception is the former Electronics Manufacturing Facility (EMF) at the King County International Airport (KCIA), which is a regional upgradient location. A total of 14 sites were selected, which is more than anticipated in the original scope of work and more than required for data usability. The 14 sites were chosen in the event that access or scheduling difficulties prevent some of these sites from being sampled in a prompt timeframe. Leidos will coordinate with Ecology to determine which sites are most suitable and available for sampling. In this SAP/QAPP, it will be assumed that all 14 sites will be sampled.

At least three groundwater monitoring wells were selected for sampling at the Agreed Order sites: (1) a downgradient well, (2) a well located in the central area of the site, and (3) a well located generally in the upgradient portion of the site. At the adjacent property sites, the downgradient well is also a near-shore well that in most cases is within the tidally influenced zone of the aquifer. Central and upgradient wells that are within this aquifer were selected to ensure that data are comparable at individual sites and across the LDW basin. Wells were not targeted relative to specific local source areas on the sites (e.g., not immediately upgradient or downgradient of hot spots). Additional wells were selected at some sites at the request of the Ecology Project Manager.

At two of the LDW inland properties, one monitoring well at each site was selected for sampling as a regional upgradient well, because the well appears to be located upgradient of any identified PCB contamination in the LDW corridor. One of these locations is on the west side of the LDW

(South Park Landfill), and one is located on the east side of the LDW (EMF/KCIA). For EMF/KCIA, this upgradient well is the only well that will be sampled at this location.

Monitoring wells were selected to target the shallow aquifer at each site. Many sites have aquifers delineated into two or three depth zones, and sometimes perched zones are locally present. At all sites, the water table aquifer wells were selected for sampling. Some locations have wells identified as partially screening a combination of two zones. For example, at South Park Landfill, a number of wells are identified as being screened within a combined perched zone and water table aquifer. Some of these wells were selected for sampling in this study because most of the wells in the northern part of this site are all similarly screened. However, the downgradient wells are screened slightly deeper in the water table aquifer, without a perched water component.

Monitoring wells for sampling were further selected by evaluating previous analytical data for PCB Aroclors in groundwater, although PCBs have not been analyzed at all sites. In this study, one goal was to select wells with a range of PCB concentrations in groundwater across the site, based on past testing results. In order to meet this objective, some wells with samples that previously showed detections of PCBs were selected for use (commonly including those with higher concentrations), and other wells were selected where PCBs had not been previously detected. Although PCB Aroclor concentrations from past testing may not correlate closely with future PCB congener testing, this selection process seemed to provide the best likelihood of yielding a range of congener concentrations in groundwater.

Leidos also identified alternate monitoring well locations at the sites, in the event that preferred wells are unsuitable for sampling during the field phase of this task. A well may be unsuitable for sampling if it is found to be damaged, is inaccessible at the time, has poor groundwater recharge, has low volume of water, has high turbidity, or other field concern. A list of the selected and alternate wells, along with site maps for each location, are presented in Appendices A and B, respectively.

Surface water samples will be collected from the LDW near the shore at up to 10 adjacent properties. Preliminary surface water sampling points will be selected, where feasible, using Ecology's Washington State Coastal Atlas. The feasibility of collecting samples will be determined and finalized during sample collection activities. If site conditions represent a safety hazard to field personnel, a surface water sample will not be collected. Surface water samples will not be collected from the 4 inland properties.

2.2 Sample Collection and Handling Methods

This section describes the methodology for equipment decontamination, sample collection, identification, processing, and waste handling during sampling events.

Sampling activities will be conducted at reasonably low tides, or during the interval following low tides, to increase the likelihood of collecting groundwater samples with minimal amounts of brackish river water that may have intruded the aquifer. This timing is important in the tidally impacted portion of each site, in the vicinity of the LDW shoreline. Prior to sampling, an evaluation of the tidal impact at all sampling wells will be made, in order to determine which wells appear to be significantly impacted by tidal action. This will involve reviewing field or lab measurements of previous groundwater samples (specific conductance, salinity, chloride, total

dissolved solids), evaluating tidal studies where they have been performed (tidal amplitude and tidal lag at each well), and distance to the shoreline. For wells that appear to have a significant tidal impact, those wells will be sampled at or soon after low tide in the LDW (dependent on tidal lag times). Wells that do not appear to have a significant tidal impact will not necessarily be sampled at or soon after low tide. Times of specific low-tide sampling events will be selected based on the LDW tide reaching lower than the average low tide for the months of February and March (+2.75 feet MLLW). Low tides that do not reach down to this level will not qualify as a low-tide sampling event. Times of sampling will also be selected based on field work not extending too late into the evening, such as not beyond about 7:00 pm.

Prior to groundwater sampling, water levels will be measured at each well. Static water level measurements will be made using a decontaminated electronic water level and measured to the nearest 0.01 ft below the well casing. All field measurements will be entered into a bound logbook or field forms.

Groundwater samples will be collected using a low-flow peristaltic pump. To minimize the potential for tubing materials to contaminate the groundwater samples with PCB congeners at low levels, platinum-cured silicone tubing will be utilized through the peristaltic pump. To further avoid the use of polyethylene or Teflon tubing (or other synthetic material), which may also release PCBs into the sample, thin-walled flexible copper tubing (0.25-inch OD) will be used down the well and attached directly to the silicone tubing. New tubing will be used at each monitoring well. Purging of groundwater wells will also allow the sample tubing to be purged with sample water. No filtering will take place during sample collection or in the laboratory.

During the low-flow purging process, field measurements will include the following water quality parameters: pH, specific conductance, turbidity, and temperature. Care will be taken to minimize drawdown of the water column in the well casing during the purging process. A flow rate that ensures minimal drawdown of the water level is typically 100 to 500 mL/min. Purging will be considered complete when the field indicator parameters have stabilized for three successive readings within the following approximate limits:

- pH ±0.1 standard units,
- temperature ±1°C,
- specific conductance ±5 percent
- oxidation reduction potential ±15 mV
- dissolved oxygen ±10 percent (for >0.5 mg/L), and
- turbidity ±10 percent and goal of <50 nephelometric turbidity units.

Water quality field instrumentation appropriate for the measurement of the above parameters will be utilized. Operation of the instrument(s) will be in accordance with manufacturer instructions. Calibration will be performed on a daily basis and recorded in the project field log.

Groundwater samples will be collected from up to 10 adjacent property sites (maximum of 33 groundwater samples and 2 field duplicates). Approximately three equipment rinse samples will be collected during the groundwater sampling activities at these sites. All equipment rinses will use laboratory-supplied reagent-grade water and will be collected on both tubing materials using the peristaltic pump. Rinse samples will be analyzed for PCB congeners and Aroclors.

Groundwater samples will be collected from up to 4 inland property sites (maximum of 11 groundwater samples and 1 field duplicate). One equipment rinse sample will be collected during the groundwater sampling activities at these sites.

Two source water blank samples will also be collected, to provide data on PCBs potentially present in the water used for equipment rinses. These samples will involve pouring laboratory-supplied reagent-grade water directly into sampling jars, and then analyzing for PCB congeners and Aroclors. One source blank sample will be collected during the first half of the field event, and one will be collected during the second half.

Surface water samples will be collected from up to 10 adjacent property sites (maximum of 10 samples and 1 field duplicate). Surface water samples will be collected from the shore or other structure (e.g., barge or dock) using a low-flow peristaltic pump (as stated above) or by dipping a laboratory-certified clean glass jar into the water (the latter where river water depth at the sampling location is very shallow). Similar methods to groundwater sampling will be followed for use of the peristaltic pump in sampling surface water. Field parameters will also be measured for surface water collection. One equipment rinse sample (on tubing material) will be collected during the surface water sampling activities. Where a peristaltic pump is utilized, samples of surface water will be collected from the lower half of the water column at each location, far enough above the bottom layer to avoid entraining sediment into the sample.

Table 2-1 lists the sample analyses and the estimated number of samples. Groundwater and surface water samples will be analyzed using the following methods (further described in the QAPP; see Section 3.0):

- PCBs as congeners by EPA 1668C using an SPB-octyl column,
- PCBs as Aroclors by DE-846 8082,
- Chloride by EPA 300.0,
- Total solids and total dissolved solids by SM2540B/C,
- Total suspended solids by SMS540D, and
- Specific conductance by EPA 120.1.

The list of target parameters, the analytical method by which each parameter will be analyzed, the method holding times, the containers, and the preservatives are included in Section 3.2.2.

Table 2-1. Analyses and Maximum Sample Numbers

Analysis/Sample Type	Sample Numbers of Groundwater + Field Duplicates + Equipment Rinses + Source Blanks	Sample Numbers of Surface Water + Field Duplicates + Equipment Rinses	Approximate Sample Numbers of IDW
PCB Congeners[1]	53	12	--
PCB Aroclors	53	12	--
Chloride	47	11	--
Specific Conductance	47	11	--
Total Solids	47	11	--
Total Suspended Solids	47	11	--
Total Dissolved Solids	47	11	--
Total RCRA 8 Metals[2]	--	--	14

[1] PCB congener analysis will include all 209 congeners.
[2] RCRA 8 metals include arsenic, barium, cadmium, chromium, lead, selenium, and silver by method 6010C/D and mercury by method 7470A.
IDW = Investigation-derived waste.
PCB = Polychlorinated biphenyl.
RCRA = Resource Conservation and Recovery Act.

2.2.1 Sample Identification, Containers, and Labels

Samples will be identified by facility abbreviation, location identifier, date, and sample matrix (Tables 2-2 and 2-3). All samples collected during the investigation will be labeled clearly and legibly.

Table 2-2. Sample Identification Examples

Sample Type	Facility Abbreviation	Location Identifier	Sample Collection Date	Sample Matrix
Groundwater	CMS	MW-1	20170215	W
Surface Water	CMS	SW-1	20170215	W
Equipment Rinse	LER	ER-1	20170215	W

CMS = Crowley Marine Services (see Table 2-3).
LER = Leidos equipment rinse (see Table 2-3).
W = Water.

Table 2-3. Facility Names and Abbreviations

Facility	Abbreviation
8801 East Marginal Way S / PACCAR	8801
Boeing Isaacson Thompson	BIT
Crowley Marine Services	CMS
Douglas Management Dock	DMD
Duwamish Marine Center	DMC
Duwamish Shipyard	DS
Electronics Manufacturing Facility (EMF)	EMF
Glacier Northwest	GNW
Industrial Container Services	ICS
Jorgensen Forge	JF
North Boeing Field	NBF
North Terminal 115	NT115
South Park Landfill	SPL
Whitehead Tyee	WT
Leidos Source Water Blank	LSB
Leidos Equipment Rinse	LER

Sample labels will be self-adhering, waterproof material and will be attached to all sample containers. Indelible ink will be used to complete each sample label, which will contain the project name, sample identification, date and time of collection, analysis and method to be conducted (or a reference to a priority of analysis list on the chain of custody [CoC] form), preservation, and the initials of the person collecting the sample. Modifications to the number of sampling containers filled may be made during sample collection based on available sample volume.

2.2.2 Sample Storage and Delivery

All samples will be stored in sturdy, insulated coolers and preserved by cooling with ice or frozen gel-packs to a temperature of 0 to 6ºC. Maximum sample holding and extraction times will be strictly adhered to by field personnel for sample delivery and by the analytical laboratory (see the QAPP; Section 3.0). Samples will be delivered to the laboratories within a timeframe that allows the samples to remain within the required temperature range. Samples to be analyzed for PCB congeners will be delivered to Vista via a commercial shipping service, such as Federal Express or United Parcel Service. Samples to be analyzed for PCB Aroclors and conventional parameters will be delivered by hand to ARI by Leidos personnel.

Sample shipping containers will include a CoC inside the cooler. The CoC will be signed by the individual relinquishing samples to the shipping service representative or the ARI representative. Upon receipt of samples at the laboratory, the condition of the samples will be recorded by the receiver. The Leidos field personnel will be responsible for the following:

- Packaging the samples,
- Signing the CoC, and
- Notifying the laboratory and project chemist of when the samples are to be delivered.

2.2.3 Waste Disposal and Handling Procedures

IDW generated during the field activities may include purge water, decontamination fluids, PPE, and miscellaneous solid waste generated during sample collection activities.

The following waste handling procedures will be used during implementation of the SAP:

- Final waste determinations will be based on knowledge of where and how the waste was generated and analytical results from the sampling locations. Wherever possible, testing results from analytical samples collected as part of the sampling program will be used to make waste determinations. None of the IDW is expected to be hazardous waste.
- Potentially contaminated groundwater and decontamination fluid will be stored at each site in a steel drum.
- Containers of IDW generated during field activities will be labeled and dated with information appropriate for accurate tracking and identification of the containers and their contents. IDW containers will be labeled as "Pending Analysis" until the results of analytical testing are received.
- Non-hazardous solid wastes that may be generated during field sampling activities, including gloves, foil, paper, plastic bags, disposable sampling equipment and other miscellaneous types of debris, will be placed in plastic bags for disposal in approved municipal waste receptacles.

2.3 Field Documentation

A complete record of field activities will be maintained. Documentation necessary to meet QA objectives for this project include field notes and field forms, sample container labels, and CoC forms. The field documentation will provide descriptions of all sampling activities, sampling personnel, and weather conditions, and will record all modifications, decisions, and/or corrective actions to the study design and procedures identified in this SAP.

A field logbook(s) will be kept onsite during field operations. Daily activities will be recorded in a bound field logbook with water-resistant numbered pages. All entries will be made legibly, in indelible ink, and will be signed and dated daily. Information recorded will include the following:

- Date, time, place, and location of sampling;
- Onsite personnel and visitors;
- Daily safety discussion and any safety issues;
- QA/QC samples collected (i.e., duplicate samples, equipment rinses, source blanks);
- Field measurements (depth to water, etc.) and their units; and
- Observations about the site, location, and samples (weather, odor, appearance, etc.).

Field logbooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occur during project field activities. Entries will be factual, detailed, and objective. Unless restricted by weather conditions, all original data recorded in field logbooks and on sample identification tags, CoC records, and field forms will be written in waterproof ink. If an error is made, the individual responsible may make corrections simply by crossing out the error with a single line and recording the correct information next to it. The erroneous information must not be obliterated. All corrections must be initialed and dated. All documentation, including voided entries, must be maintained within project files.

2.3.1 Chain-of-Custody Procedures

The field crew will retain samples at all times until samples are relinquished to be delivered to the laboratory. CoC forms will be initiated at the time of sample collection to ensure that all collected samples are properly documented and traceable through storage, transport, and analysis. When all line items on the form are completed or when the samples are relinquished, the sample collection custodian will sign and date the form, list the time, and confirm the completeness of all descriptive information contained on the form. Each individual who subsequently assumes responsibility for the sample will sign the CoC form and provide the reason for assuming custody. The field CoC terminates when the laboratory receives the samples. The FM will retain a copy of the completed, signed, form(s) for project files.

2.4 Laboratory Analyses

All of the analytical procedures used in this program will be performed by subcontracted laboratories in accordance with current EPA and Ecology guidelines. The participating laboratories will be accredited by Ecology and have an internal QA/QC plan. Analyses will be required to conform to referenced test methods and the individual laboratory's written QA plan and standard operating procedures.

Target analytes, reporting limits, and method detection limits (MDLs) are presented in the QAPP (see Section 3.0). The target quantitation limits may vary due to elevated chemical concentrations, matrix interferences, and actual sample volumes used for analysis.

2.4.1 Analytical Laboratory Reports

Analytical laboratory reports will be accompanied by sufficient raw data and QC results to enable independent reviewers to evaluate and validate the quality of the data and recalculate the results. The analytical laboratory deliverables are listed in the QAPP (see Section 3.0).

3.0 Quality Assurance Project Plan

The purpose of the QAPP is to provide confidence in the analytical results through a system of QA/QC performance checks with respect to data collection methods, laboratory analysis, data reporting, and appropriate corrective actions to achieve compliance with established performance and data quality criteria. This section presents the QA/QC protocols used to ensure that the data obtained during the investigation are legally defensible and usable for their intended purpose.

3.1 Measurements of Data Quality

The quality of the data reported by the laboratories will be evaluated for accuracy, precision, representativeness, completeness, and comparability as described below.

Accuracy is the degree to which an observed measurement agrees with an accepted reference or true value. Accuracy is a measure of the bias in the system and is expressed as the percent recoveries of spiked analytes in matrix spike/matrix spike duplicate (MS/MSD) and laboratory control sample/laboratory control sample duplicate (LCS/LCSD) samples. Accuracy will also be evaluated through the surrogate spikes in each sample for PCB Aroclor analysis. PCB congener accuracy measurements also include initial precision and recovery (IPR) samples and ongoing precision and recovery (OPR) samples. The performance-based (or method-defined) laboratory control limits for accuracy will be used for the project.

Precision is a measure of mutual agreement among individual measurements of the same property under prescribed conditions. Precision will be assessed by the analysis of MS/MSD samples, field duplicate samples, and LCS/LCSD samples. The calculated relative percent differences (RPDs) for laboratory duplicates or MS/MSD pairs will provide information on the precision of sampling and analytical procedures, and the RPDs for LCS/LCSD pairs will provide information on precision of the analytical procedures. PCB congener precision measurements also include IPR and OPR samples The performance-based (or method-defined) laboratory control limits for precision will be used for the project.

Representativeness expresses the degree to which data accurately and precisely represent an actual condition or characteristic at a particular sampling point. Representativeness is achieved by collecting samples representative of the matrix at the time of collection. Representativeness can be evaluated using replicate samples and blanks. Representativeness is also achieved by ensuring that standard sample handling and analytical methodology are followed.

Completeness refers to the amount of acceptable data points collected relative to the amount needed to achieve the project's technical objectives. Completeness is calculated as the number of valid data points achieved divided by the total number of data points expected for all requested analyses. For this project, the overall completeness objective is 95 percent.

Comparability is based on the use of established EPA-approved methods for the analysis of the selected parameters. The quantification of the analytical parameters is based on published methods, supplemented with well-documented procedures used in the laboratory to ensure reproducibility of the data.

3.2 Quality Assurance and Quality Control

Field and laboratory QA/QC samples will be used to evaluate the data precision, accuracy, representativeness, and comparability of the analytical results. The field QA samples to be collected are described in Section 3.2.1. The laboratory QA samples are discussed in Section 3.2.2.

3.2.1 Field Quality Assurance/Quality Control Samples

Field QC samples will be collected during sampling to evaluate the quality of the sampling procedures and the analytical data. Field QC samples include field duplicate samples, equipment rinses, and source water blanks. Field QC samples will be handled in the same manner as the environmental samples collected. Descriptions of the field QC samples are provided below.

Field Duplicate Samples

Field duplicate samples will be collected at a rate of 1 per 20 samples collected for analysis for groundwater and surface water samples. It is expected that two field duplicate samples will be collected for groundwater, and one for surface water. Field duplicate samples will be collected at the same time and analyzed for the same chemicals as the original sample. Field duplicate sample results are used to assess the precision of the sample collection process and to help determine the representativeness of the sample. If the results of the field duplicate samples exceed QA/QC criteria for precision, this information will be discussed in the data validation report, but data qualifiers will not be applied to the associated results.

Equipment Rinse Samples

Equipment rinse samples provide a QC check on the potential for cross-contamination by measuring the effectiveness of the decontamination procedures of the sampling equipment. The equipment rinse samples consist of reagent-grade water provided by Vista or ARI, as applicable, rinsed across sample collection equipment. It is expected that four equipment rinse samples will be collected for groundwater, and one for surface water, and analyzed for PCB congeners and PCB Aroclors. If chemicals are detected in the equipment rinse samples, the detected concentrations will be compared to the associated environmental sample results to evaluate the potential for contamination. The rinse results will be discussed in the data validation report, and data qualifiers may be applied to the associated sample results using EPA functional guidelines for data validation (EPA 2008, 2016).

Source Water Blanks

Because PCB quantitation limits are very low, two source water blank samples will be collected. This will provide data on PCBs potentially present in the water used for equipment rinses. These source blank samples will involve pouring laboratory-supplied reagent-grade water directly into sampling jars, and then analyzing for PCB congeners and PCB Aroclors. It is expected that two source blanks will be collected, one in the first half of the field event and one in the second half. If chemicals are detected in the source blanks, the detected concentrations will be compared to the associated equipment rinse sample results to evaluate the potential for contamination in the equipment rinses. This comparison will be completed prior to the process of applying the

equipment rinse sample results, as described in the paragraph above. The source blank results will be discussed in the data validation report.

3.2.2 Laboratory Quality Assurance/Quality Control Samples

Instrument calibration and laboratory QA/QC sample requirements are defined in the test methods and the laboratory's written standard operating procedures. An LCSD should be analyzed if the laboratory does not have sufficient sample volume to prepare a project-specific MS/MSD for organic test methods. The results of these samples will provide information on the accuracy and precision of the chemical analysis and will be used to qualify data, as necessary, during data validation using EPA functional guidelines modified as necessary to accommodate non-Contract Laboratory Program (i.e., EPA SW-846 methodology) (EPA 1986) analytical methods (EPA 2008, 2016).

Analytical methods, sample container, and minimum sample volumes are summarized in Table 3-1. The sample volumes provided in Table 3-1 are the amount necessary to perform field sample analysis. Additional sample volume is required for MS/MSDs and will be addressed during the field sampling planning process and placement of the sample container order with Vista and ARI.

Table 3-1. Analytical Methods, Sample Container, and Absolute Minimum Sample Volume Requirements

Laboratory	Analyte Group	Analytical Method	Sample Container	Minimum/Preferred Sample Volume
Groundwater and Surface Water Samples				
Vista	PCB Congeners[1]	EPA 1668C	Two 1-L glass amber bottles with Teflon-lined lid	1,000 mL
ARI	PCB Aroclors	SW-846 8082A	Three 1-L glass amber bottles with Teflon-lined lid	2,000 mL
ARI	Chloride	EPA 300.0	Two 500-mL HDPE bottles	100 mL
ARI	Specific Conductance	EPA 120.1		100 mL
ARI	Total Solids	SM2540B/C		200 mL
ARI	Total Suspended Solids	SM2540D	Two 1,000-mL HDPE bottles	1,000 mL
ARI	Total Dissolved Solids	SM2540B/C	Two 500-mL HDPE bottles	500 mL
Aqueous IDW				
ARI	Total RCRA 8 Metals[2]	SW-846 6010C/D SW-846 7470A	One 500-mL HDPE bottles	200 mL

ARI = Analytical Resources, Inc.
EPA = U.S. Environmental Protection Agency.
HDPE = High-density polyethylene.
IDW = Investigation-derived waste.
PCB = Polychlorinated biphenyl.
RCRA = Resource Conservation and Recovery Act.
Vista = Vista Analytical Laboratories.
[1] PCB congener analysis will include all 209 congeners.
[2] RCRA 8 metals include arsenic, barium, cadmium, chromium, lead, selenium, and silver by method 6010C/D, and mercury by method 7470A.

Table 3-2 lists the analytical methods, holding times, and preservation requirements for all targeted analyses. The frequency requirements for the analysis of laboratory QA/QC samples are summarized in Table 3-3. Acceptance criteria for laboratory QA/QC samples are summarized in Table 3-4. MDLs and reporting limits for each analytical method are provided in Appendix D.

Table 3-2. Analytical Methods, Holding Times, and Preservation Requirements

Analyte Group	Analytical Method	Holding Time	Preservation
Groundwater and Surface Water Samples			
PCB Congeners	EPA 1668C	1 year	Cool (2 – 6°C)
PCB Aroclors	SW-846 8082A	7days to extract, 40 days to analyze	Cool (2 – 6°C)
Chloride	EPA 300.0	28 days	Cool (2 – 6°C)
Specific Conductance	EPA 120.1	28 days	Cool (2 – 6°C)
Total Solids	SM2540B/C	7 days	Cool (2 – 6°C)
Total Suspended Solids	SM2540D	7 days	Cool (2 – 6°C)
Total Dissolved Solids	SM2540B/C	7 days	Cool (2 – 6°C)
IDW Samples			
Total RCRA 8 Metals	SW-846 6010C/D (metals) SW-846 7470A (mercury)	6 months (metals) 28 days (mercury)	Nitric acid to pH ≤ 2

EPA = U.S. Environmental Protection Agency.
IDW = Investigation-derived waste.
PCB = Polychlorinated biphenyl.
RCRA = Resource Conservation and Recovery Act.

Table 3-3. Laboratory QA/QC Sample Frequency Requirements

Analysis	Initial Calibration	CCV	LCS/ OPR	Method Blank	MS/MSD	Surrogates
PCB Congeners	Prior to analysis	Start of batch, every 12 hours	One per prep batch	One per prep batch	MS/MSD at rate of 5 percent of samples if available	NA
PCB Aroclors	Prior to analysis	Start of batch, every 10 field samples, and end of batch	One per prep batch	One per prep batch	MS/MSD at rate of 5 percent of samples if available	Every sample

CCV = Continuing calibration verification.
LCS = Laboratory control sample; an OPR sample may be substituted for an LCS for analysis of PCB congeners.
MS = Matrix spike.
MSD = Matrix spike duplicate.
NA = Not applicable.
OPR = Ongoing precision and recovery.
PCB = Polychlorinated biphenyl.
QA = Quality assurance.
QC = Quality control.

Table 3-4. Laboratory QA/QC Sample Acceptance Criteria – DQOs

Analytical Group	Data Quality Indicator	Measurement Performance Criterion	QC Sample and/or Activity Used to Assess Measurement Performance
PCB Aroclors and Congeners	Completeness	≥95 percent; determined by the number of valid data points achieved divided by the total number of data points expected for all requested analyses (not rejected during validation)	All usable sample data points collected
PCB Congeners	Analytical instrument accuracy	70 – 130 percent (congeners) 50 – 150 percent (internals)	CCV
PCB Congeners	Accuracy and precision	Percent RSD <25 (congeners); mean recovery 70 – 130 (congeners) See Table 6 of EPA 1668C for internal standard acceptance criteria	IPR; performed when commencing the method or when significant changes have been made to the method
PCB Congeners	Accuracy	60 – 135 percent (congeners) See Table 6 of EPA 1668C for internal standard acceptance criteria	LCS/OPR
PCB Congeners	Accuracy and precision	Recovery 60 – 135 percent RPD ≤25 percent	MS/MSD; accuracy and precision limits are advisory limits only
PCB Congeners	Accuracy/Bias contamination	≤Minimum level for each congener	Method blank
PCB Aroclors	Analytical instrument accuracy	80 – 120 percent (Aroclors) 29 – 120 percent (surrogates)	CCV
PCB Aroclors	Accuracy and precision	Recovery 51 – 128 percent RPD ≤30 percent	MS/MSD LCS/LCSD
PCB Aroclors	Accuracy	Recovery 29-120 percent	Surrogate
PCB Aroclors	Accuracy/Bias contamination	< Laboratory reporting limit	Method blank

CCV = Continuing calibration verification.
DQO = Data quality objective.
EPA = U.S. Environmental Protection Agency.
IPR = Initial precision and recovery.
LCS = Laboratory control sample.
LCSD = Laboratory control sample duplicate.
MS = Matrix spike.
MSD = Matrix spike duplicate.
OPR = Ongoing precision and recovery.
PCB = Polychlorinated biphenyl.
QA = Quality assurance.
QC = Quality control.
RPD = Relative percent difference.
RSD = Relative standard deviation.

3.2.3 Data Validation

All PCB congener and PCB Aroclor analytical results obtained during this investigation will undergo independent data validation by EcoChem of Seattle, Washington. The project requires EPA Stage 2B data validation on all PCB Aroclor results and EPA Stage 4 data validation on all PCB congener results following EPA guidance (EPA 2008, 2009, 2016). If data quality concerns

are noted, the laboratory will be contacted, as necessary, and the samples will be reanalyzed, the data will be qualified, and/or the issue will be discussed in the data validation report. The results of the data validation will be summarized in a data validation report, which will be included as an appendix to the data report described in Section 4.3.

The data validation report will include a sample index; a technical report for each method that specifies the QC elements that were reviewed and any outliers/impacts to data quality or usability; criteria tables for each method that define each QC element, acceptance criteria, and qualification decisions; qualifier definitions and reason code definitions; and a table that summarizes qualified data points. In addition, 10 percent of the electronic data deliverable (EDD) data points will be verified against the laboratory data packages and will have data validation qualifiers, data validation qualifier reason codes, and final interpretive qualifiers added.

3.2.4 Analytical Laboratory Reports

Analytical data packages will contain sufficient information to allow for the full-level data validation and review of all sample and laboratory QC sample results (i.e., calibration, method blanks, LCS/LCSD, OPR, surrogates, internals, and MS/MSD), including all raw data needed to recalculate reported results as required to meet EPA Stage 4 data validation on PCB congener results and EPA Stage 2B validation on PCB Aroclor results. The analytical laboratory deliverables will include, but are not limited to, the following:

- MDLs and reporting limits for each sample.
- Laboratory qualifiers reported with analyte concentrations and a summary of qualifier definitions.
- Case narrative, including any problems encountered, protocol modifications, and/or corrective actions taken.
- Sample analytical and QA/QC results with units and control limits.
- All method references used during analyses.
- Any protocol deviations from the approved QAPP.
- Surrogate recovery results and control limits.
- Internal standard recovery results and control limits.
- MS/MSD results and control limits.
- Laboratory duplicate results and control limits.
- Method blank results.
- OPR recovery results and control limits.
- LCS/LCSD results and control limits.
- Initial and continuing calibration results and control limits.
- Sample custody records (including original CoC forms and sample receipt information).
- Sample and QC results in the EDD format specified in Appendix E.

The analytical laboratories will provide electronic copies of the data packages to Leidos and EcoChem (hardcopies are not required).

4.0 Data Analysis, Recordkeeping, and Reporting Requirements

4.1 Analysis of Chemistry Data

The chemical results for groundwater and surface water samples will be processed using the data management rules presented in Appendix C. Data tables will indicate sample locations, unique sample identifiers, sample date, chemical concentrations, final data qualifiers, and chemistry results will be compared to regulatory values, if requested.

4.2 Recordkeeping

At the conclusion of the study, all records including field records, laboratory data reports, data validation reports, and other relevant documentation will be provided to Ecology for archive.

4.3 Data Report

A data report presenting the chemical results and discussing the activities associated with sample collection and chemical analyses of samples will be prepared by Leidos and submitted to Ecology. At a minimum, the following will be included in the report:

- A description of sampling and analysis activities.
- Protocols used during sampling and analysis, and a summary of any deviations from the procedures described in the SAP and QAPP.
- Copies of field data collection forms.
- CoC records.
- Chemistry results summarized in data tables and figure(s):
  - Chemistry results will be compared to regulatory values, if requested.
  - Figures will show the location of sampling sites in the LDW watershed and sampling locations at each site.
- A summary of the data validation.
- Electronic copies of laboratory reports and the data validation reports.

The draft data report (including original laboratory data sheets) will be due to Ecology within 4 weeks after Leidos receives all validated data. The task schedule allows 2 weeks for Ecology to review the draft data report. Leidos will submit the final report to Ecology within 2 weeks following receipt of Ecology's comments on the draft report but no later than June 30, 2017.

The validated chemistry data, recorded in the EDDs, will be uploaded into Ecology's EIM database following completion of the final data report, but no later than June 30, 2017. Information for entering environmental data into EIM can be found on Ecology's website: http://www.ecy.wa.gov/eim/.

5.0 References

Ecology. 2015. Implementation Memorandum #12: *When to Use EPA Method 1668 for PCB Congener Analyses*. Publication No. 15-09-052. From Jeff Johnston, Section Manager, Washington State Department of Ecology Information and Policy Section, Toxics Cleanup Program. July 22, 2015. Available online at: <https://fortress.wa.gov/ecy/publications/documents/1509052.pdf>.

EPA (U.S. Environmental Protection Agency). 1986 and updates. *SW-846 Manual, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.* <http://www.epa.gov/epaoswer/hazwaste/test/sw846.html>.

EPA. 2007. *SW-846 Method 8082A. Polychlorinated Biphenyls by Gas Chromatography.* February.

EPA. 2008. *Contract Laboratory Program, National Functional Guidelines for Organic Data Review*. Office of Emergency and Remedial Response. EPA-540-R-08-01. June.

EPA. 2009. *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use.* Office of Emergency and Remedial Response. EPA-540-R-08-005. January

EPA. 2010. *EPA Method 1668C. Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS*. April.

EPA. 2016. *National Functional Guidelines for High Resolution Superfund Methods Data Review*. Office of Superfund Remediation and Technology Innovation (OSRTI). OLEM 9200.3-115, EPA 542-B-16-001. April.

EPA. 2014. Record of Decision, Lower Duwamish Waterway Superfund Site. Region 10. November.

Leidos. 2016. *Green-Duwamish River Watershed PCB Congener Study: Phase 1*. Prepared for Washington State Department of Ecology, Toxics Cleanup Program. April 2016.

APPENDIX A

Selected Sites and Sampling Locations

PCB Congener Groundwater Sampling
Proposed Sites and Wells

Well ID	Last Sampled	PCB Analyzed (Y/N)	Last Sampling Event PCB Concentration (ug/L)	PCB Last Detected	Maximum PCB Concentration (ug/L)	Down-gradient	Center	Upgradient	Notes
Duwamish Shipyard (LDW Adjacent Property)									
DSI-MW-05	Jan-15	Yes	0.01 U	NA	NA	X			Screen Depth 5.5-15.2
DSI-MW-06	Jan-15	Yes	0.01 U	NA	NA	X			Screen depth 5.4-15.1
DSI-PZ-01	Jan-15	Yes	0.01 U	NA	NA		X		Screen depth 5-14.7
DSIP2-23				NA	NA		X		Estimated screen depth 5-15
DISP2-17		No	NA	NA	NA			X	Estimated screen depth 5-15
DSIP2-19	Jan-15	Yes	0.01 U	NA	NA			X	Estimated screen depth 5-15
DSI-MW-02	Jan-15	Yes	0.01 U	NA	NA			X	Screen depth 5.1 -15
Glacier Northwest (LDW Adjacent Property)									
MW-33S	Sep-15	Yes	0.006	Sep-15	0.006	X			Screen depth 4-11
MW-1S	Sep-15	No	NA	NA	NA	X			Screen depth 4.5-9.5
MW-4S	Sep-15	No	NA	NA	NA		X		Screen depth 5-10
MW-17S	Sep-15	No	NA	NA	NA		X		Screen depth 4.5-11.5
MW-32S	Sep-15	No	NA	NA	NA			X	Screen depth 4-11
North Terminal 115 (LDW Adjacent Property)									
MW-10	Apr-15	No	NA	NA	NA	X			Screen depth 7-11.5
MW-9	Apr-15	No	NA	NA	NA	X			Screen depth 6.5-15.5
MW-3	Apr-15	No	NA	NA	NA		X		Screen depth 8-18
MW-4	Apr-15	No	NA	NA	NA		X		Screen depth 7.5-12.5
MW-5	Jan-15	No	NA	NA	NA		X		Screen depth 7-17
MW-1	Nov-16	No	NA	NA	NA			X	Screen depth 8-13
MW-6	Apr-15	No	NA	NA	NA			X	Screen depth 7.5-12.5
Douglas Management Dock (LDW Adjacent Property)									
MW-01	Jul-14	Yes	0.01 U	NA	NA			X	Screen depth 10-20
MW-04	Jul-14	Yes	0.055	Jul-14	0.055		X		Screen depth 10-20
MW-11	Jul-14	Yes	0.008 J	Jul-14	0.008			X	Screen depth 10-20
MW-14	Jul-14	Yes	0.01 U	NA	NA	X			Screen depth 7-22
MW-15	Jul-14	Yes	0.008	Jul-14	0.023	X			Screen depth 7-22
MW-17	Jul-14	Yes	1.12	Jul-14	1.12		X		Screen depth 7-22
Industrial Container Services (LDW Adjacent Property)									
MWFu	Mar-16	Yes	0.01 U			X			Well added at Ecology's request, screen depth 4.5-14.5
SA-MW2				Mar-16	0.19	X			Screen depth 4-24
SA-MW3				Mar-16	ND	X			Screen depth 4-24
DOF-MW-1	Mar-16	Yes	1.51	Mar-16	1.51		X		Screen depth 12-17
DOF-MW-3	Mar-16	Yes	0.01 U	Mar-16	ND			X	Screen depth 12-22
DOF-MW-5	Mar-16	Yes	0.01 U	NA	ND			X	Screen depth 17-22
DOF-MW-7	Mar-16	Yes	0.057	Mar-16	0.1		X		Located in shallow zone, screen depth 12.7-17.7
DOF-MW-8	Mar-16	Yes	0.01 U	Nov-15	0.033		X		Located in shallow zone, screen depth 12.9-17.9
MWCp	Mar-16	Yes	0.041	Mar-16	0.054		X		Located at water table, screen depth 3.5-8.5
MWGu	Mar-16	Yes	0.01 U				X		Well added at Ecology's request, screen depth 4.5-14.5

PCB Congener Groundwater Sampling
Proposed Sites and Wells

Well ID	Last Sampled	PCB Analyzed (Y/N)	Last Sampling Event PCB Concentration (ug/L)	PCB Last Detected	Maximum PCB Concentration (ug/L)	Down-gradient	Center	Upgradient	Notes
Duwamish Marine Center (LDW Adjacent Property)									
MW2	Jun-08	Yes	0.28	Jan-04	0.48	X			Screen depth 5-15
MW3	Jun-08	Yes	0.05 U	NA	ND	X			Screen depth 5-15
MW-07	Apr-16	Yes	0.01 U	NA	ND		X		Well construction diagram not found
MW-8	Apr-16	Yes	0.01 U	NA	ND		X		Well construction diagram not found
MW-10	Apr-16	Yes	0.01U	NA	NA			X	Well construction diagram not found
MW-12	Apr-16	Yes	0.01 U					X	Well construction diagram not found
Crowley Marine Services (LDW Adjacent Property)									
EMW-13S	12/16/2014	Y	0.026	Jul-13	0.14 J	X			Screen depth 5-19.8
CMW-6						X			Screen depth 5-19
DMW-2							X		Screen depth 5-19
DMW-3	9/30/2013	Y	0.01 UJ	NA	NA		X		Non-detect PQL exceeded proposed site cleanup level. Screen depth 5-19
DMW-6A	12/17/2014	Y	0.03	Dec-14	0.03		X		Well construction diagram not included with boring log
EMW-1S								X	Screen depth 5-19.8
EMW-6S								X	Screen depth 5-19.8
SLR-1								X	Screen depth 5-14.8
Jorgensen Forge (LDW Adjacent Property)									
MW-54	Jan-08	Yes	0.049 U	Jun-03	0.28	X			Well construction diagram not found
MW-53				NA	NA	X			Well construction diagram not found
MW-31	Apr-03	Yes	0.048 U	NA	NA		X		Well construction diagram not found
MW-22				NA	NA		X		Screen depth 5-15
MW-23				NA	NA			X	Screen depth 6-11
MW-9				NA	NA			X	Screen depth 5-20
MW-52									Northwest corner; well added at Ecology's request, Screen depth 23-27
Boeing Isaacson Thompson (LDW Adjacent Property)									
I-203				Sep-12	0.024	X			Well construction diagram not found
MW-10				Sep-12	0.065	X			Screen depth 8-18
MW-12				Dec-11	0.008		X		Screen depth 8.5-23
MW-13				Sep-12	0.015		X		Screen depth 8-18
MW-15								X	Screen depth 8-18
MW-25				Sep-12	0.024			X	Screen depth 8-18

PCB Congener Groundwater Sampling
Proposed Sites and Wells

Well ID	Last Sampled	PCB Analyzed (Y/N)	Last Sampling Event PCB Concentration (ug/L)	PCB Last Detected	Maximum PCB Concentration (ug/L)	Down-gradient	Center	Upgradient	Notes
8801 East Marginal Way S / PACCAR (LDW Adjacent Property)									
MW-30A	Sep-11	Yes	0.1 U	Feb-06	0.07	X			shallow A zone, screen depth 14-24
MW-26A	Oct-11	Yes	0.1 U			X			shallow A zone, screen depth 10-20
MW-42A	Sep-11	Yes	0.1 U	Aug-06	0.23		X		shallow A zone, screen depth 5-20
MW-48A	Aug-11	Yes	0.1 U				X		shallow A zone, screen depth 5-15
MW-16A	Sep-11	Yes	0.25	Sep-11	0.25			X	shallow A zone, screen depth 2-17
MW-34A	Mar-02	Yes	0.02	Mar-02	0.02			X	shallow A zone, screen depth 10-20
South Park Landfill (LDW Inland Property)									
MW-32	Mar-14	No	NA	NA	NA	X			Downgradient area of landfill; screen depth 19-24
MW-31	Mar-14	No	NA	NA	NA	X			Downgradient of landfill; screen depth 18-23
KMW-04	Oct-15	No	NA	NA	NA		X		Center of landfill; screen depth 5-20
KMW-05	Oct-15	No	NA	NA	NA			X	Upgradient area of landfill, CKD; screen depth 5-20
KMW-08	Oct-15	No	NA	NA	NA			**X**	Far upgradient, outside landfill; screen depth 5-20
KMW-07	Oct-15	No	NA	NA	NA			**X**	Far upgradient, outside landfill; screen depth 5-20
Whitehead Tyee (LDW Inland Property)									
WT-MW-06				NA	NA	X			No PCB data available, well construction diagram not found
WT-MW-07				NA	NA	X			Well construction diagram not found
WT-MW-02				NA	NA		X		Well construction diagram not found
WT-MW-03				NA	NA		X		Well construction diagram not found
WT-MW-04				NA	NA		X		Well construction diagram not found
WT-MW-108				NA	NA		X		No PCB data available, screen depth 6-16
WT-MW-109				NA	NA			X	No PCB data available, screen depth 6-16
WT-GP-10				NA	NA			X	Well construction diagram not found
North Boeing Field (LDW Inland Property)									
NGW521	Aug-16	Yes	2.0	Aug-16	2.0		X		Screen depth 5-15
NGW520	Aug-14	Yes	0.03	Aug-14	0.11		X		Screen depth 5-15
NGW252	Nov-13	Yes	0.01 U	NA	ND	X			Screen depth 5-15
Electronics Manufacturing Facility (EMF at KCIA) (LDW Inland Property)									
EMF-MW-7	2001	No	NA		NA			**X**	Far upgradient, beyond EMF plume; screen depth 5-15
EMF-MW-6	2010 or later	No	NA		NA			**X**	Far upgradient, beyond EMF plume; screen depth 5-14

Green: preferred wells
Orange: alternate wells

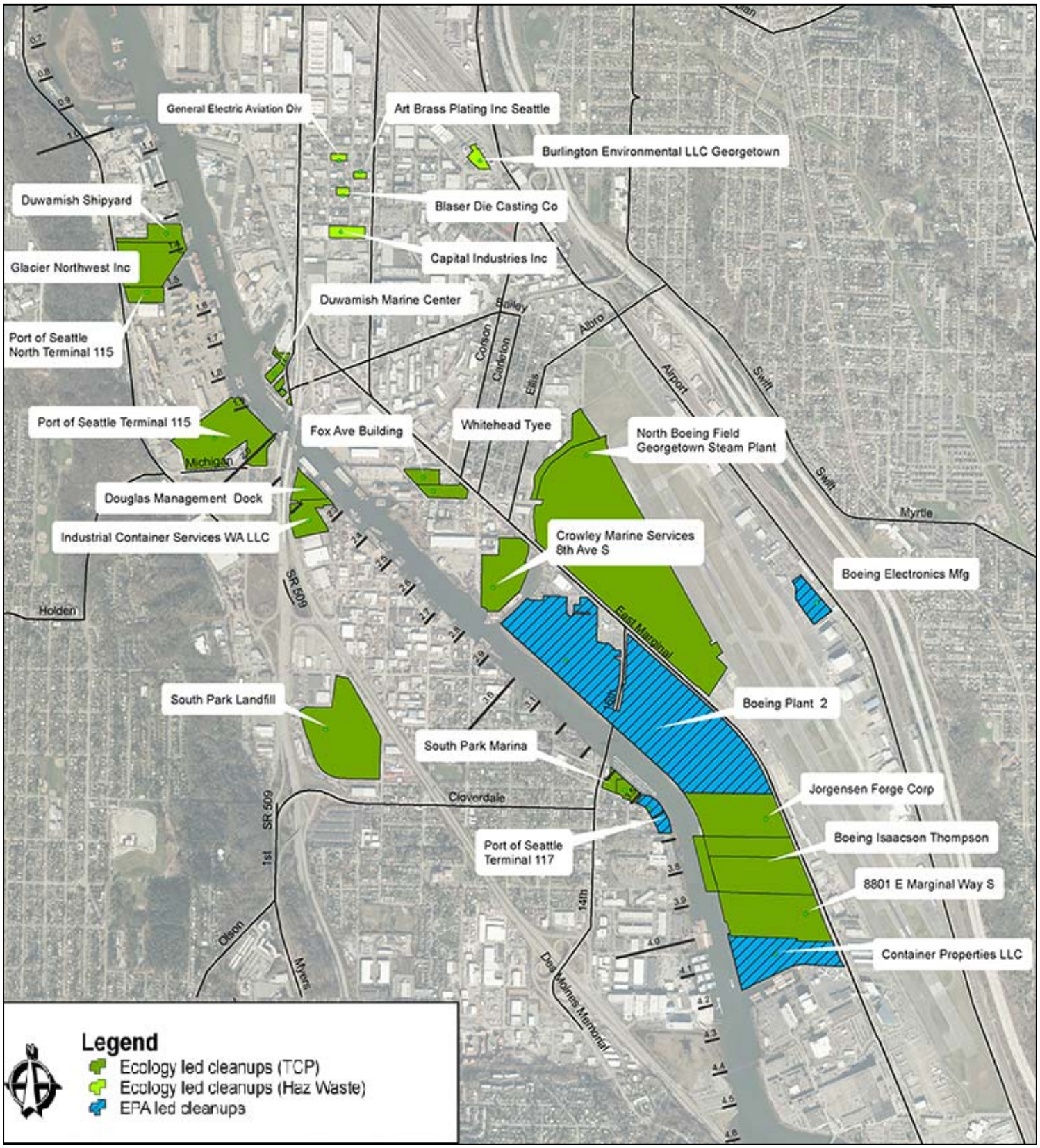
Notes:
"Adjacent Property" refers to sites that are located immediately adjacent to the LDW.
"Inland Property" refers to upland sites not located immediately adjacent to the LDW and will not have affiliated surface water samples collected.
Bold well IDs refer to those wells considered to be regional upgradient wells, outside the area of identified PCB contamination in the LDW corridor.
Screen depths are in feet below ground surface.
Blank cells were intentionally left blank.

Appendix B

Facility Maps

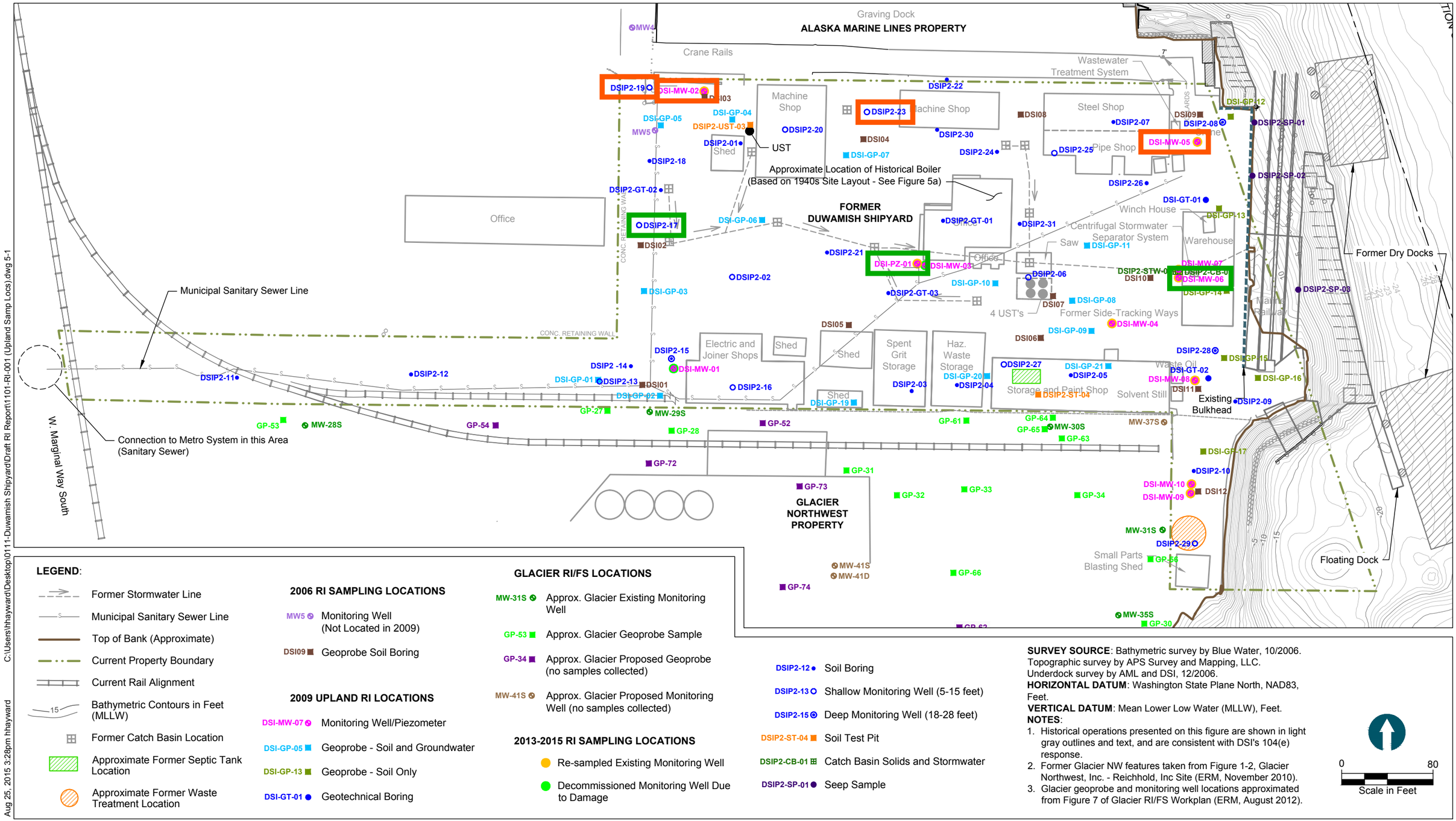
Appendix B
List of Facility Site Maps

1. Location Map of Cleanup Sites along the LDW
2. Duwamish Shipyard
3. Glacier Northwest
4. North Terminal 115
5. Douglas Management Dock
6. Industrial Container Services
7. Duwamish Marine Center
8. Crowley Marine Services
9. Jorgensen Forge
10. Boeing Isaacson Thompson
11. 8801 East Marginal S / PACCAR
12. South Park Landfill
13. Whitehead Tyee
14. North Boeing Field
15. Electronics Manufacturing Facility (EMF at KCIA)



http://www.ecy.wa.gov/programs/tcp/sites_brochure/lower_duwamish/lower_duwamish_hp.html

Location Map of Cleanup Sites along the LDW



LEGEND:

- Former Stormwater Line
- Municipal Sanitary Sewer Line
- Top of Bank (Approximate)
- Current Property Boundary
- Current Rail Alignment
- Bathymetric Contours in Feet (MLLW)
- Former Catch Basin Location
- Approximate Former Septic Tank Location
- Approximate Former Waste Treatment Location

2006 RI SAMPLING LOCATIONS

- MW5 — Monitoring Well (Not Located in 2009)
- DSI09 — Geoprobe Soil Boring

2009 UPLAND RI LOCATIONS

- DSI-MW-07 — Monitoring Well/Piezometer
- DSI-GP-05 — Geoprobe - Soil and Groundwater
- DSI-GP-13 — Geoprobe - Soil Only
- DSI-GT-01 — Geotechnical Boring

GLACIER RI/FS LOCATIONS

- MW-31S — Approx. Glacier Existing Monitoring Well
- GP-53 — Approx. Glacier Geoprobe Sample
- GP-34 — Approx. Glacier Proposed Geoprobe (no samples collected)
- MW-41S — Approx. Glacier Proposed Monitoring Well (no samples collected)

2013-2015 RI SAMPLING LOCATIONS

- Re-sampled Existing Monitoring Well
- Decommissioned Monitoring Well Due to Damage

- DSIP2-12 — Soil Boring
- DSIP2-13 — Shallow Monitoring Well (5-15 feet)
- DSIP2-15 — Deep Monitoring Well (18-28 feet)
- DSIP2-ST-04 — Soil Test Pit
- DSIP2-CB-01 — Catch Basin Solids and Stormwater
- DSIP2-SP-01 — Seep Sample

SURVEY SOURCE: Bathymetric survey by Blue Water, 10/2006. Topographic survey by APS Survey and Mapping, LLC. Underdock survey by AML and DSI, 12/2006.
HORIZONTAL DATUM: Washington State Plane North, NAD83, Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW), Feet.
NOTES:

1. Historical operations presented on this figure are shown in light gray outlines and text, and are consistent with DSI's 104(e) response.
2. Former Glacier NW features taken from Figure 1-2, Glacier Northwest, Inc. - Reichhold, Inc Site (ERM, November 2010).
3. Glacier geoprobe and monitoring well locations approximated from Figure 7 of Glacier RI/FS Workplan (ERM, August 2012).

0 80
Scale in Feet

C:\Users\hhayward\Desktop\0111-Duwamish Shipyard\Draft RI Report\1101-RI-001 (Upland Samp Locs).dwg 5-1
Aug 25, 2015 3:28pm hhayward

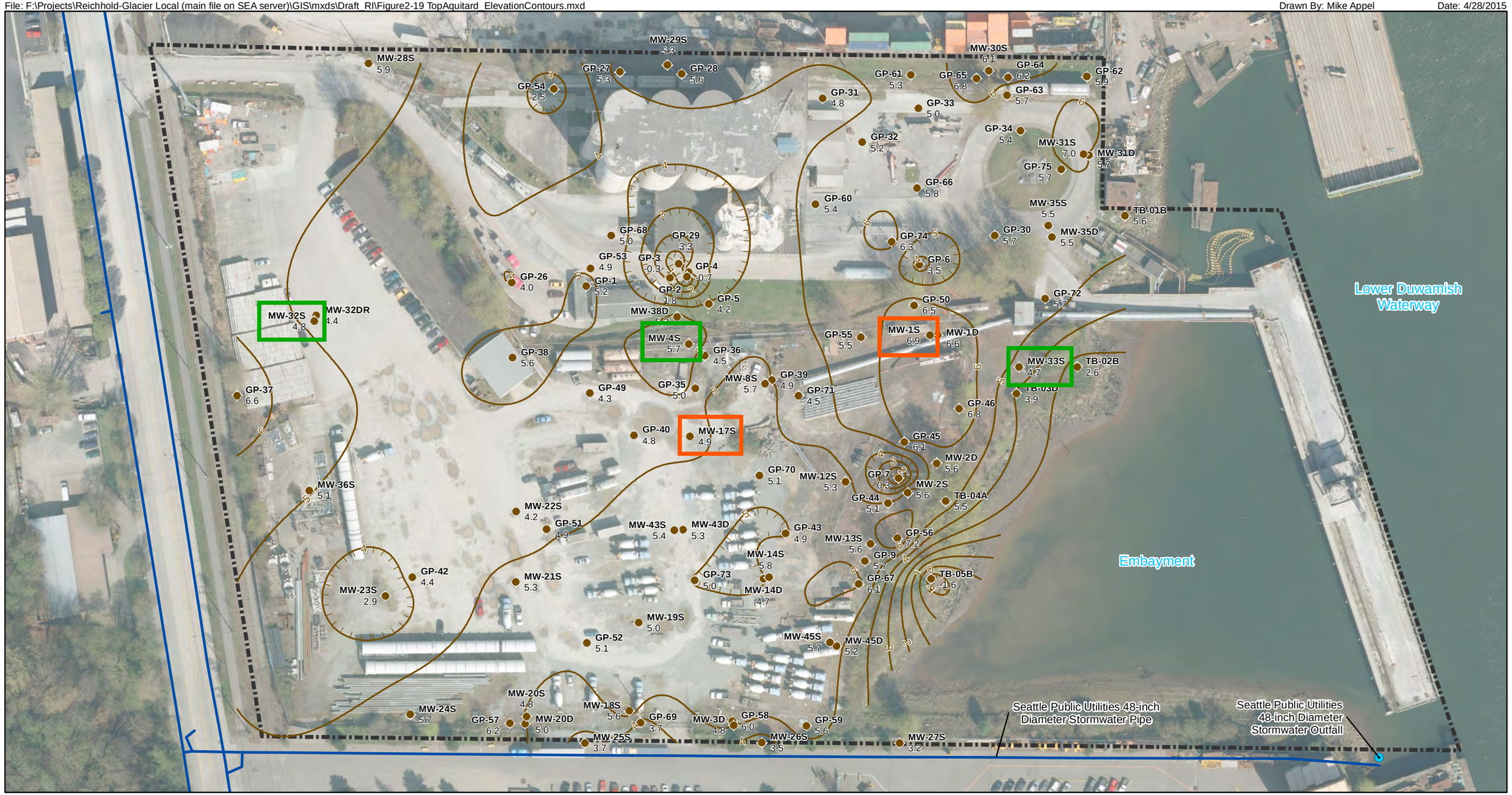
Figure 5-1
Upland Sampling Locations
Draft RI Report
Duwamish Shipyard, Inc.

ANCHOR QEA

File: F:\Projects\Reichhold-Glacier Local (main file on SEA server)\GIS\mxds\Draft_RI\Figure2-19 TopAquitard_ElevationContours.mxd

Drawn By: Mike Appel

Date: 4/28/2015



Legend

- Borehole Location with Top of Aquitard Elevation
- Top of Aquitard Contour (1 ft)
- Stormwater Drainage Mainline
- Stormwater Outfall
- Current Property Boundary

N

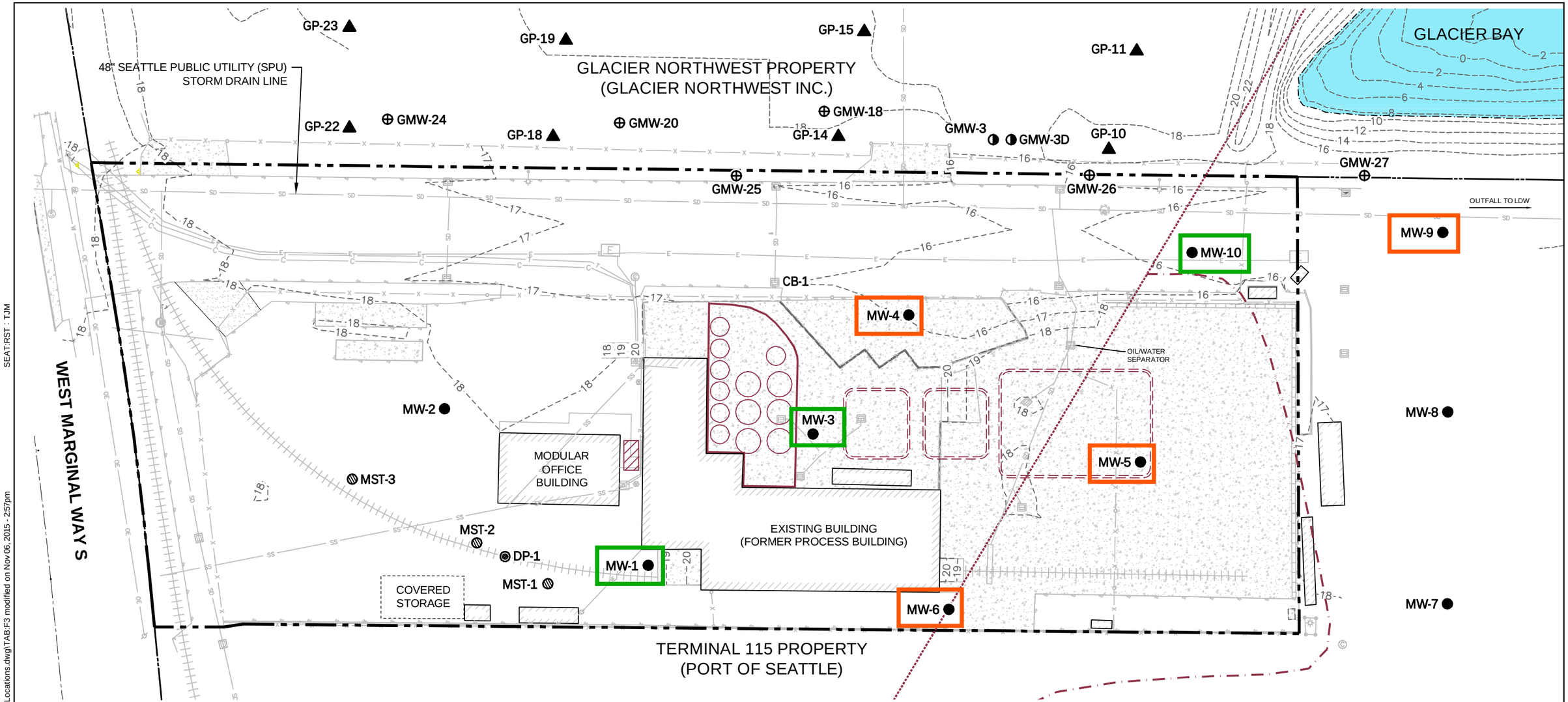
0 50 100 200 Feet

Notes:
- Aerial: King County: 3/23/2012, 0.25 ft per pixel
- Elevations in feet above mean sea level, NAVD88.

FIGURE 2-19

TOP OF AQUITARD ELEVATION CONTOUR MAP
5900 West Marginal Way Site
Seattle, Washington

Environmental Resources Management
1218 3rd Avenue, Suite 1412
Seattle, Washington 98101
425-214-0468



Legend

Sampling Location

- Grab Sample (SKCDPH, 1998)
- Hollw-Stem Auger Exploration (Landau, 2009)
- Direct-Push Exploration (Landau, 2009)
- Hollow-Stem Auger Boring (Shaw, 2003)
- Geoprobe Boring (RETEC, 1995)
- Hollw-Stem Auger Exploration (RETEC, 1995)

Current Feature

- T115N
- Elevation Contours (Feet NAVD88)
- MHHW (+8.68 Feet NAVD88)
- Fence
- Railroad Tracks (Buried)

Historical Feature

- Historical Shoreline (Approximate)
- 1965 Shoreline (Approximate)
- Approximate Location of Former Evaporation/Settling Ponds
- Approximate Location of Former Underground Fuel Storage Tank (UST)
- Former Aboveground Storage Tank (AST)
- AST Spill Containment Curb (Approximate)

N W E S

50 0 50
FEET

Notes

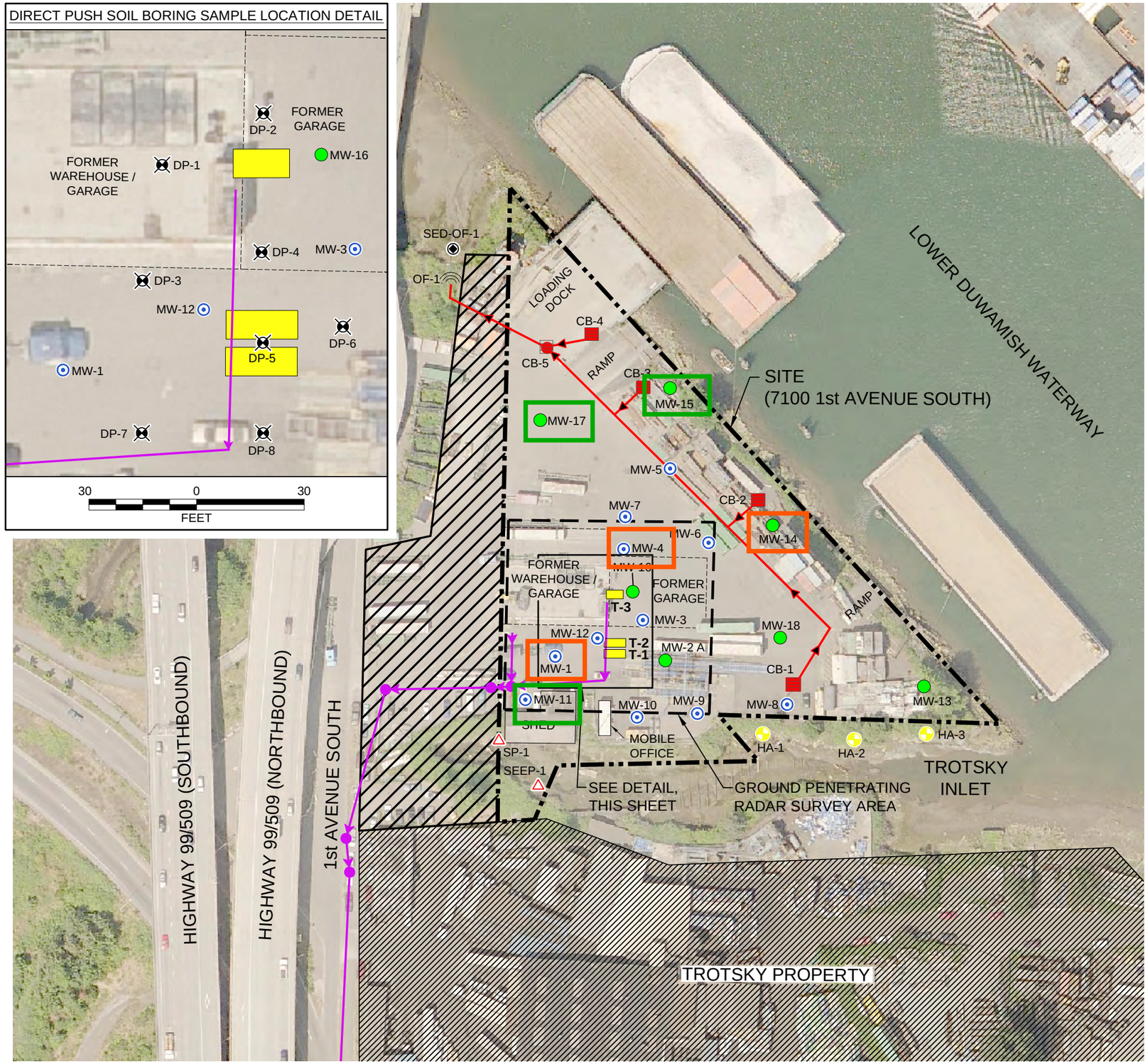
1. Mean Higher High Water (MHHW) referenced from United States Army Corps of Engineers (USACE) Duwamish Waterway Tidal Datum No. 92 for the North Puget Sound Region.
2. NAVD88 is the North American Vertical Data Datum of 1988.
3. The locations of all features shown are approximate.
3. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: Base from Dowl HKM 2014 survey and Bush, Roed and Hitchings, Inc. 2008 survey.

Historical Soil and Stormwater Solids Sampling Locations

Port of Seattle - North Terminal 115
Seattle, Washington

GeoEngineers | Figure 4



Legend

- Site Boundary
- Leased area to 7100 1st Avenue South, Seattle LLC from the Washington State Department of Transportation (WSDOT)
- Former Underground Storage Tank (Removed)
- Storm Drainage (Flows to Sanitary Sewer)
- Storm Drainage (Sewer Flows to LDW)
- LDW = Lower Duwamish Waterway
- MW-1 — Existing Monitoring Well
- MW-1 — Proposed Soil Boring/Monitoring Well
- HA-1 — Proposed Hand Auger Boring Location
- DP-1 — Proposed Direct-Push Soil Boring Location
- CB-1 — Proposed Catch Basin Sampling Location
- OF-1 — Proposed Stormwater Outfall Sample Location
- SP-1 — Proposed Seep Sample Location
- SED-OF-1 — Proposed Surface Sediment Sample Location
- Approximate Limits of Ground Penetrating Radar Survey

N W E S

100 0 100
FEET

Notes

1. The locations of all features shown are approximate.
2. Location of drain and conveyance features are unconfirmed and will be evaluated during RI.
3. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

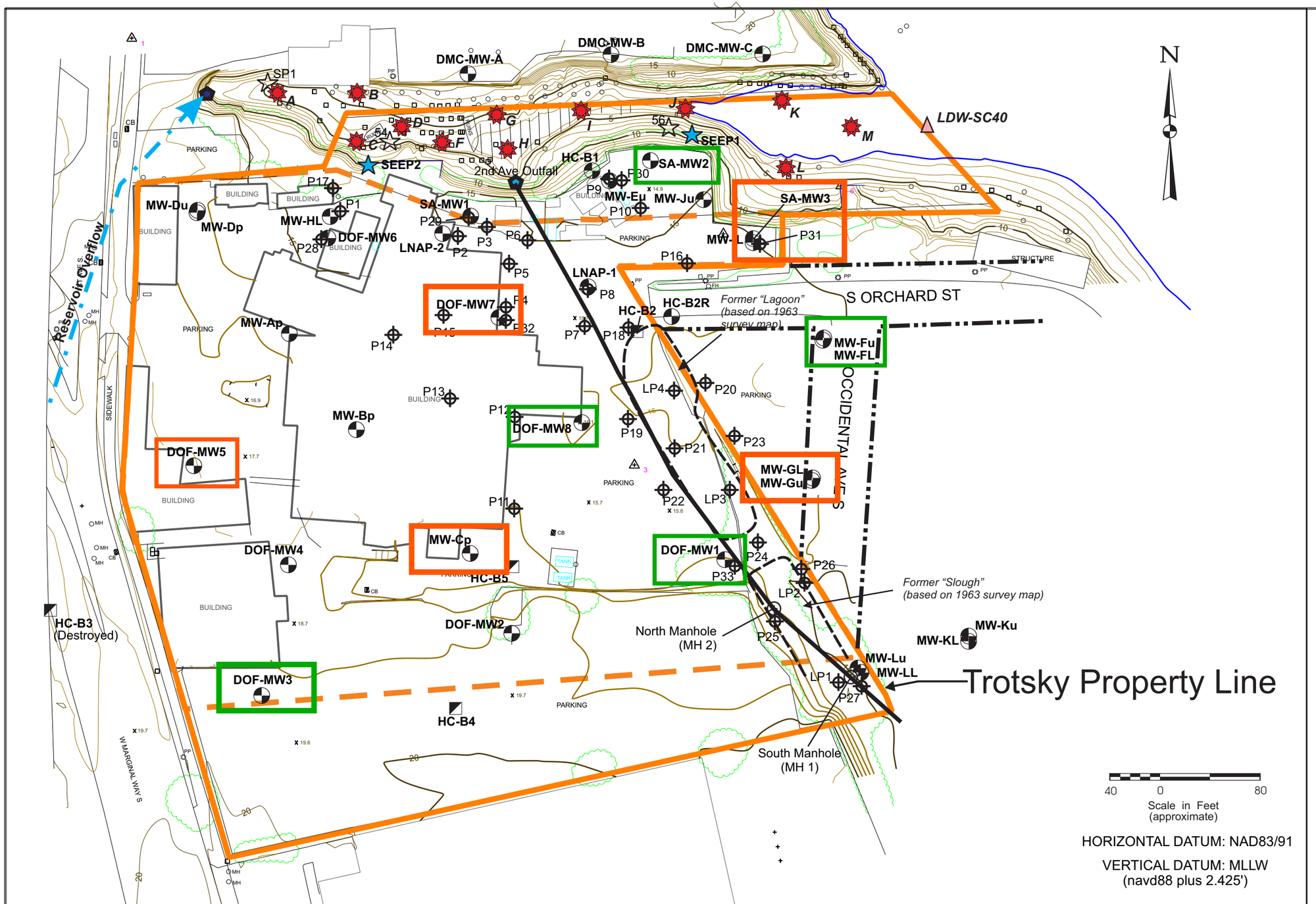
Reference: Aerial image from King County GIS, 2007. Storm drainage features from "Lower Duwamish Waterway, Early Action Area 2, Technical Memorandum: DMC Property Update," by Science Applications International Corporation (SAIC) dated April 2008.

Proposed Sampling Locations

7100 1st Avenue South Site
Seattle, Washington

GeoEngineers | **Figure 19**

P:\0\02750\5\01\CAD\Figures\Ecology Review Document\02750150I_Fig 19 Proposed Sampling Locations.dwg\TAB:Fig 18 modified by tmichaud on Jan 14, 2013 - 14:03



Legend

- Pole/Piling
- Post
- PP Power Pole
- X 15.8 Spot Elevation (ft-MLLW)
- 3 Photogrametry Marker
- CB Catch Basin
- Public Outfall
- Monitoring Well
- Push Probe
- Abandoned Monitoring Well
- Surface Sediment Sample SAIC - 1991
- Surface Sediment Sample SAIC - 2007
- LDW-RI Surface Sample Locations RI Report
- Sediment Core - RI Report (2006)
- Sediment Core - DOF (2012)
- Embayment Seep (2004 to 2008)
- Embayment Seep (2012)
- Discrete Soil Sample (1991)
- Man-hole
- Composit Soil Sample (1986)
- 1986 Soil Spl. Composite Area
- Property Line
- Tax Parcel Boundary

Notes:

1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Ref: Subsurface Locations a.cdr

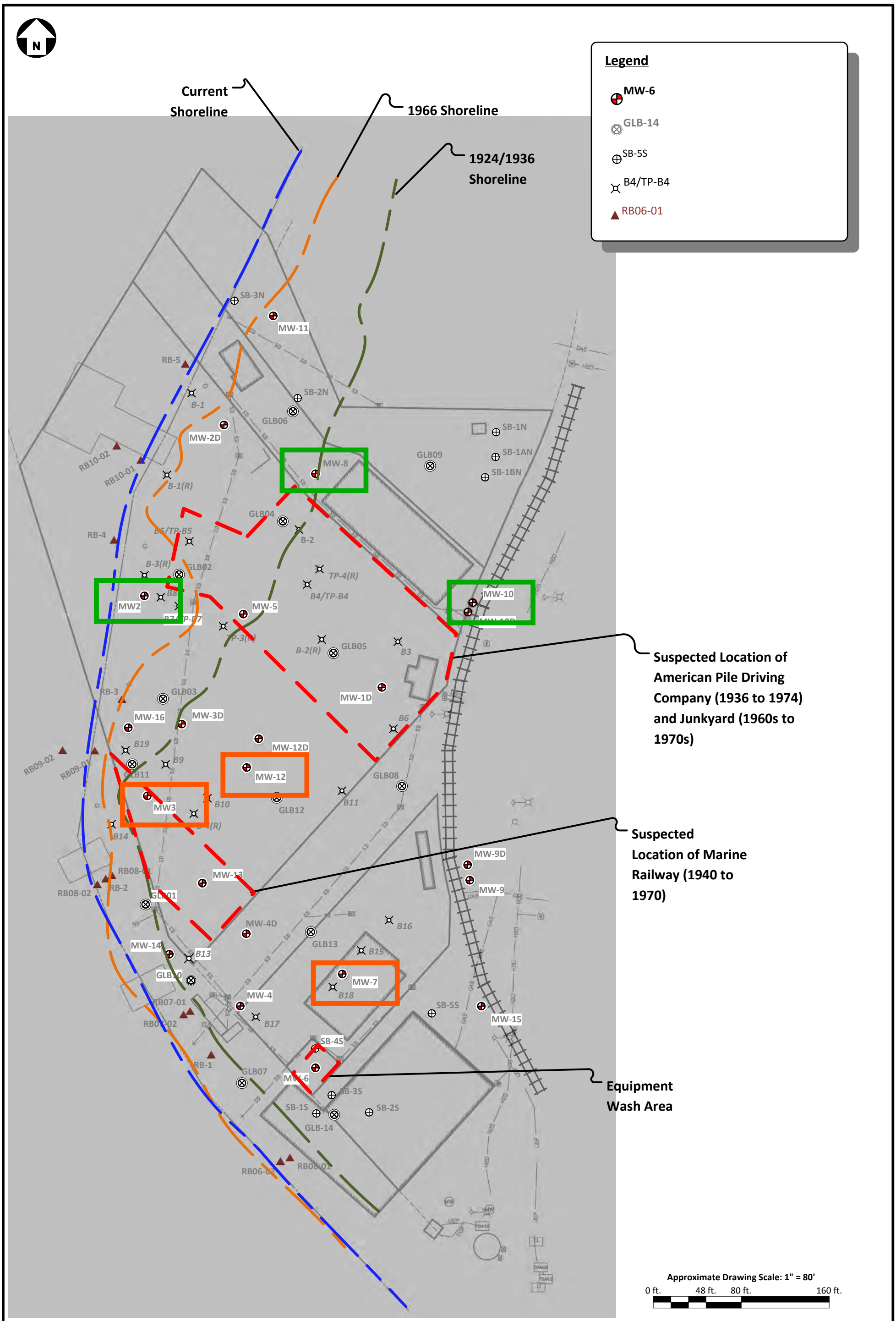
ICS/NW Cooperage Site

Push-Probe, Well and Core Locations

SUM-008-00 (ICS) *July 2016*

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 4-1a



Project File: Historical Practices.vsd

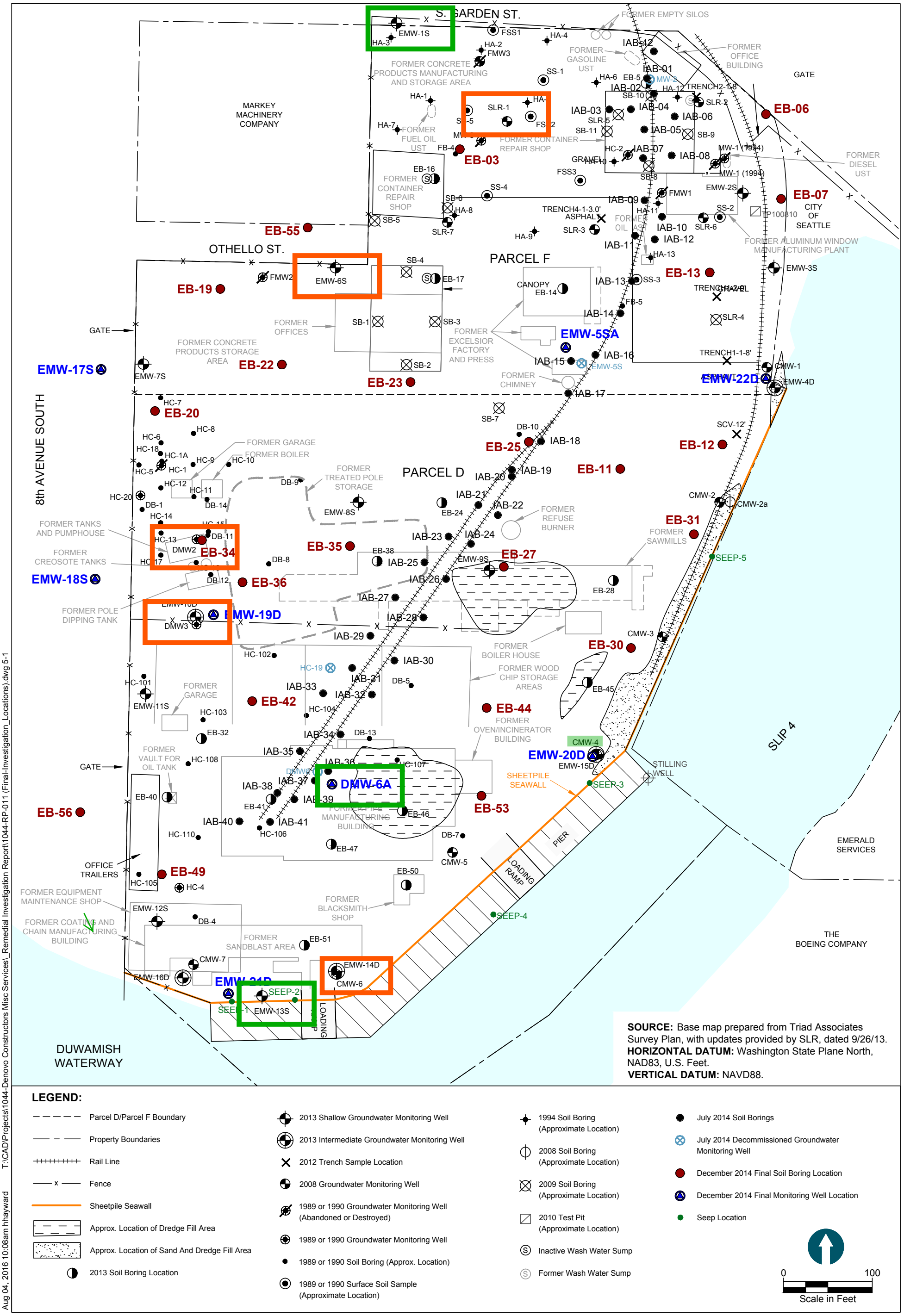
g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Exploration Locations
Duwamish Marine Center
6365 First Avenue South
Seattle, Washington

Figure
0

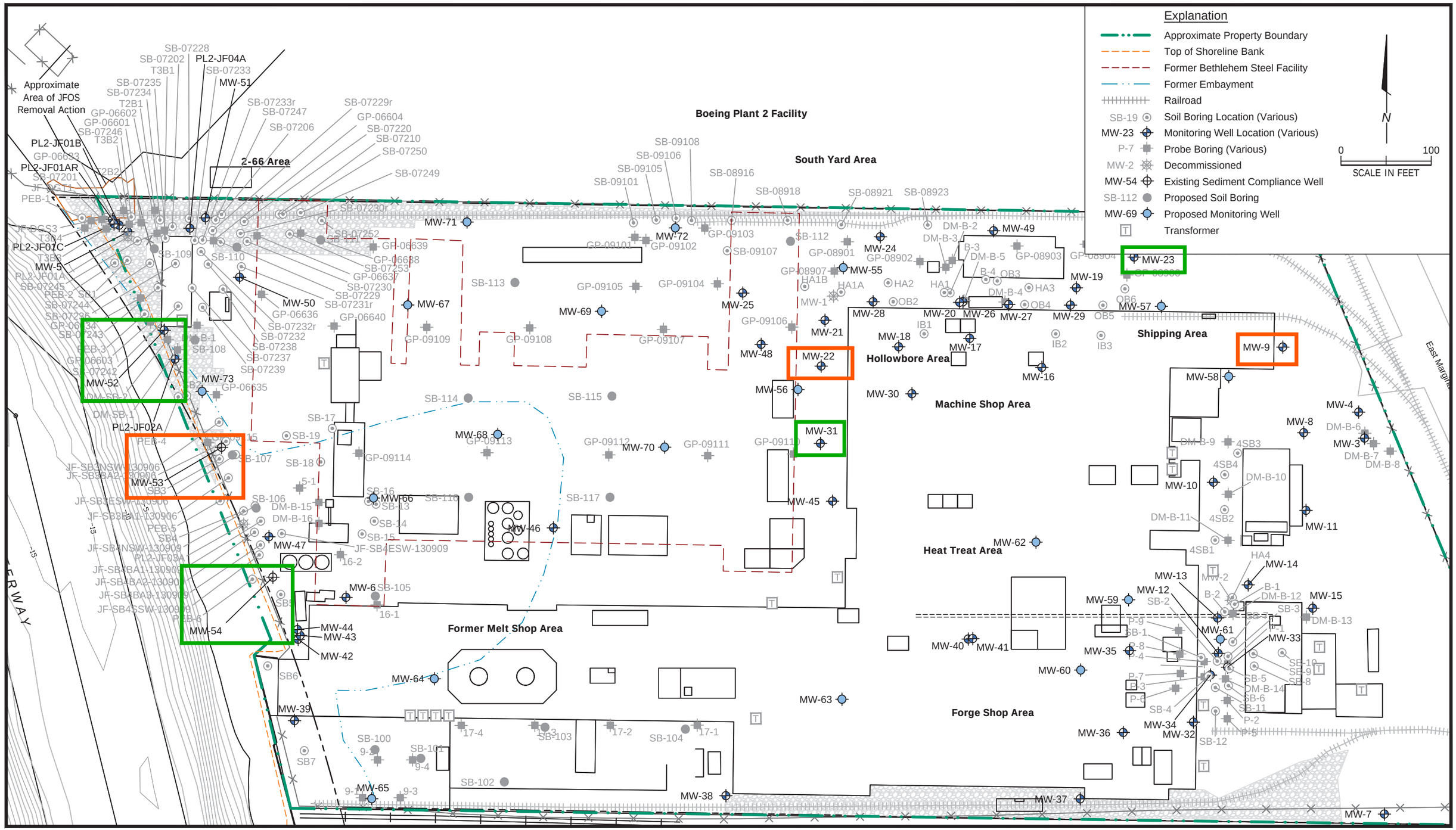
Mapping Reference: SoundEarth Mapping, PLS Inc. Survey, G-Logics Site Measurements



SOURCE: Base map prepared from Triad Associates Survey Plan, with updates provided by SLR, dated 9/26/13.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: NAVD88.

T:\CAD\Projects\1044-Denovo Constructors Misc Services_Remedial Investigation Report\1044-RP-011 (Final-Investigation_Locations).dwg 5-1
Aug 04, 2016 10:08am hhayward

Figure 5-1
Final Soil and Groundwater Investigation Locations
Draft Remedial Investigation Report
8th Avenue Terminals, Inc. Site

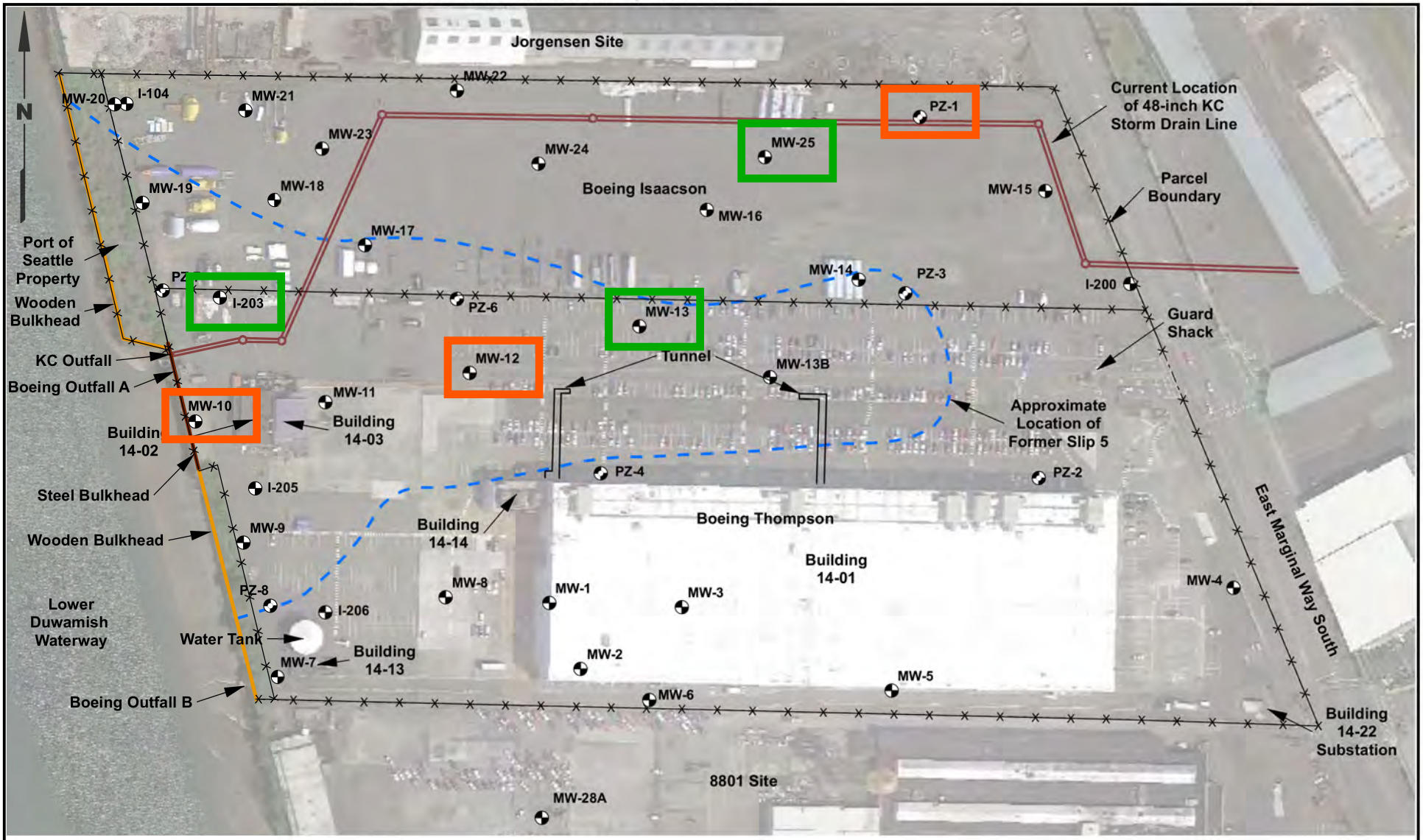


PES Environmental, Inc.
Engineering & Environmental Services

Proposed Groundwater Monitoring Network FIGURE
Jorgensen Forge Facility
8531 East Marginal Way
Seattle, Washington
15

1415.001.01.002	141500101002_15	*WRH*	7/15
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE

G:\Projects\025\190\213\013\RI\ES\FigureES-2CurrentSiteFeatures.mxd 3/28/2014 NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet



Legend

- Monitoring Well
- Piezometer
- Fence

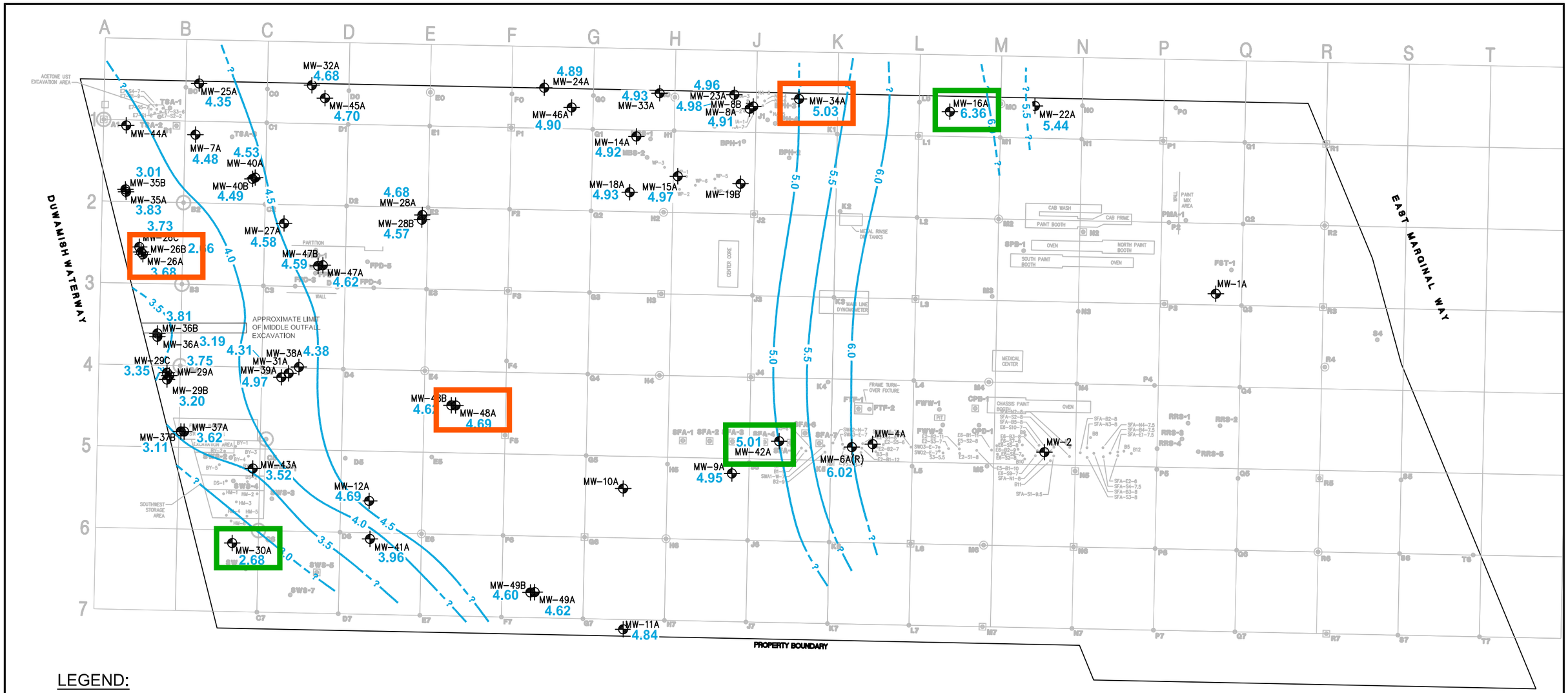
0 200 400

Scale in Feet

Data Sources: Google Earth Pro 2012; King County Parcel Data.

LANDAU ASSOCIATES

Boeing Isaacson-Thompson Site Tukwila, Washington	**Current Site Features**	Figure ES-2



LEGEND:

GROUNDWATER SYMBOLOGY

- GROUNDWATER ELEVATION CONTOUR, DASHED WHERE APPROXIMATE
- 6.0 GROUNDWATER ELEVATION IN FEET (NAVD88)

PHASE II SAMPLE LOCATIONS

- GRID SOIL SAMPLING LOCATION
- MW-36B SHALLOW ZONE GROUNDWATER MONITORING WELL (INSTALLED DURING PHASE II)
- PREVIOUS SOIL BORING LOCATION

NOTE: ALL LOCATIONS ARE APPROXIMATE

0 60 120 240
SCALE IN FEET

CLIENT LOGO

CLIENT: PACCAR INC

AMEC
11810 North Creek Parkway North
Bothell, WA, U.S.A. 98011-8201

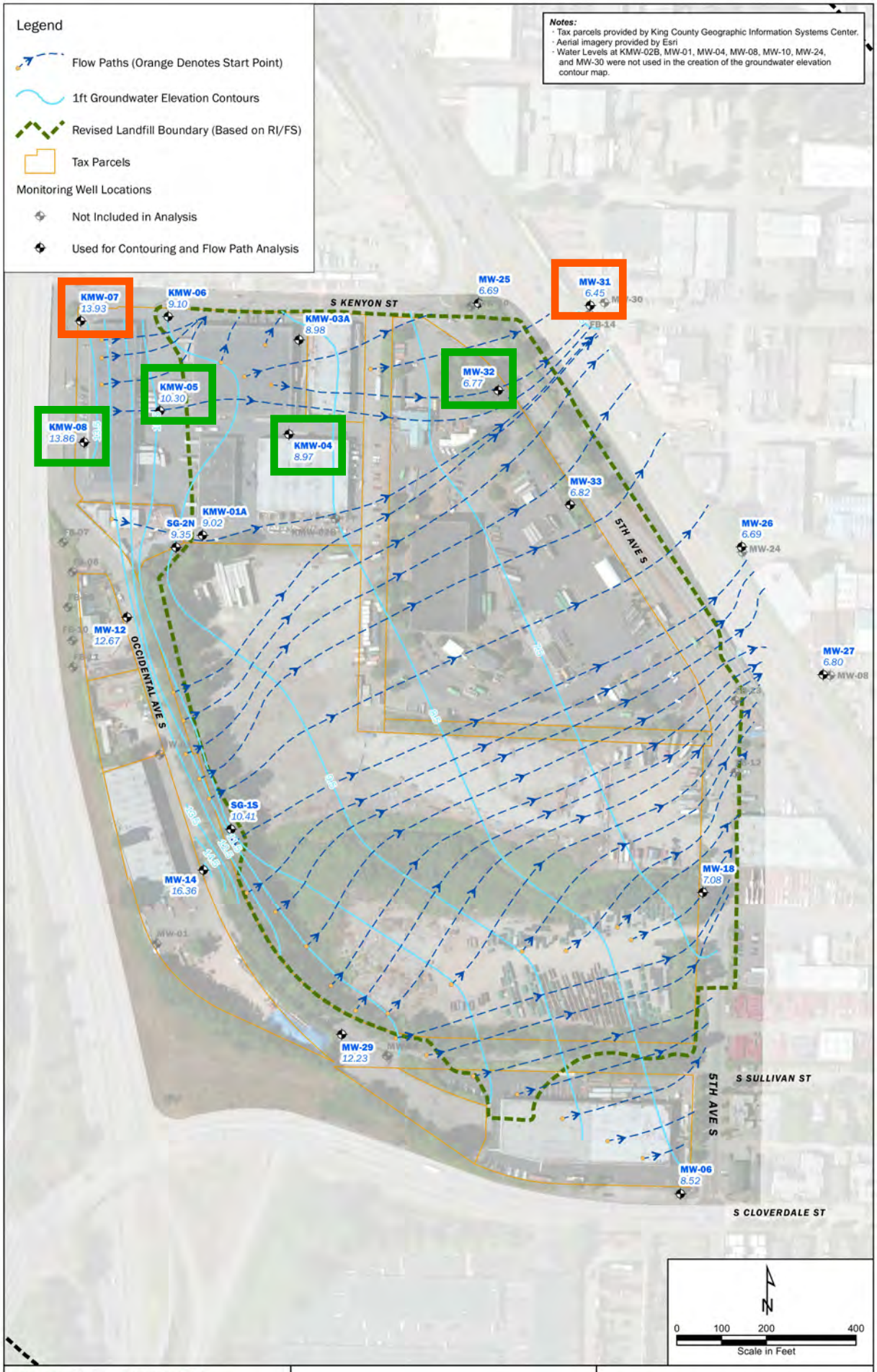
DWN BY:	JRS
CHK'D BY:	MS
DATUM:	NAD27
PROJECTION:	WA SP North
SCALE:	AS SHOWN

PROJECT: 8801 SITE
8801 EAST MARGINAL WAY SOUTH
TUKWILA, WASHINGTON

TITLE: GROUNDWATER ELEVATION
SEPTEMBER 27, 2011 (LOW TIDE)

DATE:	JANUARY 2012
PROJECT NO:	991514995L
REV. NO.:	1
FIGURE No.	3

G:\91\14000\14995-L - PACCAR\14995-L-34.dwg - Layout - Feb. 02, 2012 10:23am - jeffrey.sanders


Legend
Flow Paths (Orange Denotes Start Point)
1ft Groundwater Elevation Contours
Revised Landfill Boundary (Based on RI/FS)
Tax Parcels
Monitoring Well Locations
Not Included in Analysis
Used for Contouring and Flow Path Analysis
Notes:
· Tax parcels provided by King County Geographic Information Systems Center.
· Aerial imagery provided by Esri
· Water Levels at KMW-02B, MW-01, MW-04, MW-08, MW-10, MW-24, and MW-30 were not used in the creation of the groundwater elevation contour map.
KMW-07 13.93
KMW-06 9.10
KMW-03A 8.98
KMW-05 10.30
KMW-08 13.86
KMW-04 8.97
KMW-01A 9.02
SG-2N 9.35
MW-25 6.69
MW-31 6.45
MW-32 6.77
MW-33 6.82
MW-26 6.69
MW-27 6.80
MW-12 12.67
SG-1S 10.41
MW-14 16.36
MW-18 7.08
MW-29 12.23
MW-06 8.52
S KENYON ST
5TH AVE S
OCCIDENTAL AVE S
S SULLIVAN ST
S CLOVERDALE ST
N
0 100 200 400
Scale in Feet
FLOYD | SNIDER
strategy • science • engineering
Aspect
HERRERA
Interim Site-wide Groundwater Monitoring
South Park Landfill
Seattle, Washington
Figure 2.1
Groundwater Elevation Contour Map
April 2013
T:\projects_8\SouthPark_Landfill\Delivered\April2013Monitoring\RevSept20-2013\Fig 2-1 GW Elevation Contour Map.mxd
9/20/2013

Legend

- Monitoring Well (Floyd|Snider 2016)
- Monitoring Well 1st Water Bearing Zone (Fox Avenue Site Well)
- Monitoring Well (SoundEarth 2013, 2014)
- Direct-Push Soil Boring (Floyd|Snider 2013, 2015, 2016)
- Direct-Push Soil Boring (SoundEarth 2013, 2014)
- Water Line
- Sewer Line
- Natural Gas Line
- Rail Line
- 730 S. Myrtle Street Property Boundary
- Former Penta Dip Tank and Penta UST Source Area
- Proposed Stormwater Conveyance and Treatment System

Note:
· Orthoimagery provided by NearMap, 2016.

Abbreviations:
Penta = Pentachlorophenol
UST = Underground storage tank

0 30 60 120
Scale in Feet

N

Fox Avenue Site
Seattle Boiler Works
Seattle Iron & Metals
Whitehead Co, Inc.
730 S. Myrtle Street
S. Myrtle Street
Fox Avenue S.
7th Avenue S.
E. Marginal Way S.

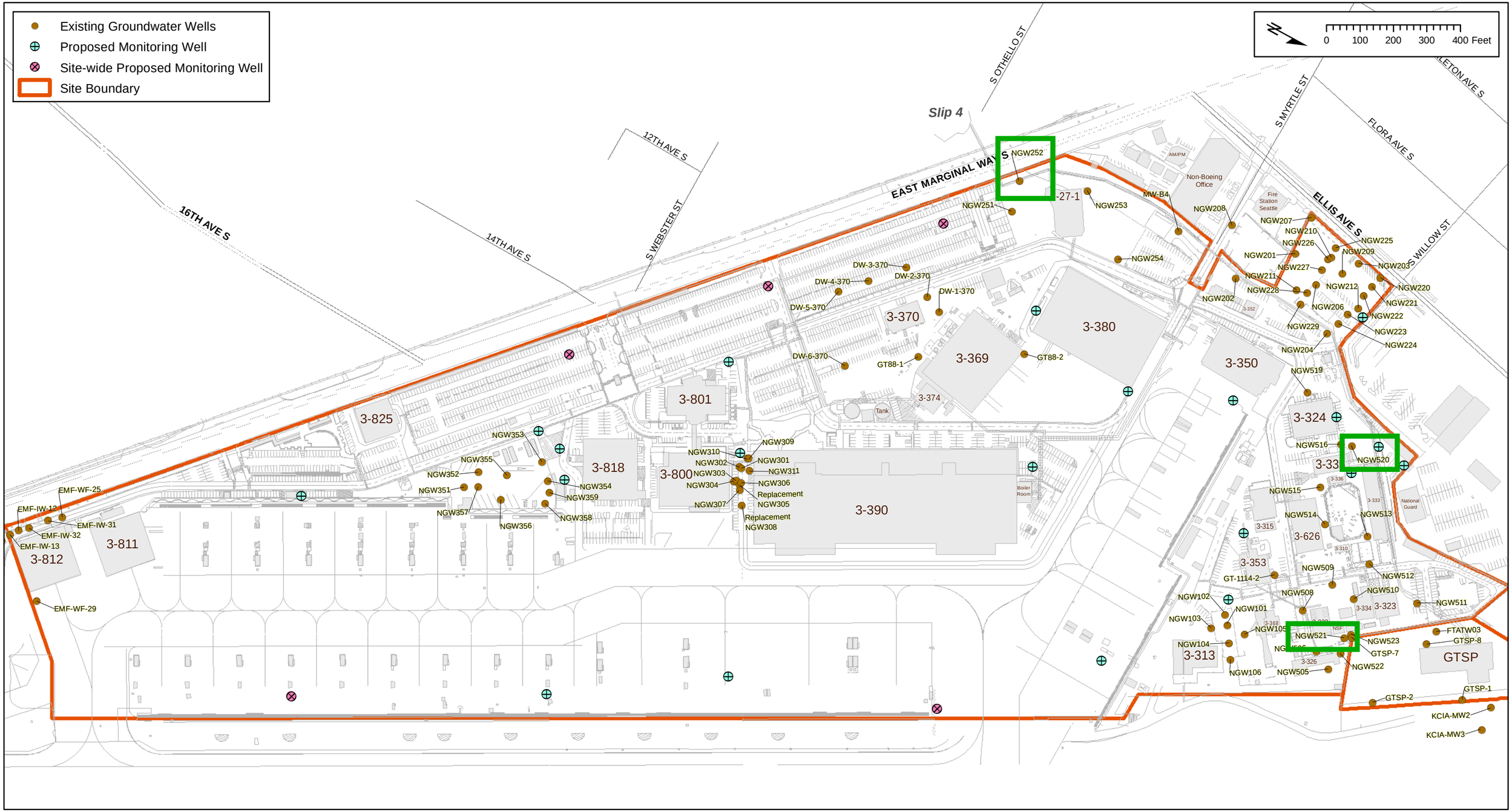
B-49, MW-09, WT-MW-109, WT-GP-7, WT-SB-08, WT-SB-02, MW-07, WT-B10, WT-B11, WT-SB-12, WT-SB-13, WT-B09, WT-MW-04, WT-GP-8, WT-GP-9, WT-SB-14, WT-SB-20, WT-MW-108, WT-SB-01, WT-GP-, WT-SB-06, WT-GP-10, WT-SB-17, WT-SB-19, WT-GP-11, WT-GP-6, WT-SB-15, WT-MW-110, WT-SB-18, B-18, WT-GP-1, WT-GP-2, WT-SB-09, WT-GP-3, WT-SB-16, WT-B05, WT-B06, WT-B08, WT-GP-4, WT-MW-02, WT-MW-03, WT-MW-01, WT-SB-1, WT-B07, WT-SB-05, WT-SB-07, WT-B17, WT-B15, WT-B16, WT-GP-12, B-38, B-36, WT-MW-06, WT-MW-07, WT-MW-05, WT-SB-04

FLOYD | SNIDER
strategy • science • engineering

Interim Action Work Plan
Whitehead Tyee Site
Seattle, Washington

Figure 3.1
Soil Boring and Monitoring Well Locations

I:\GIS\Projects\SIM-730EDR\MXD\Interim Action Work Plan\Figure 3.1 Soil Boring and Monitoring Well Locations.mxd
10/20/2016

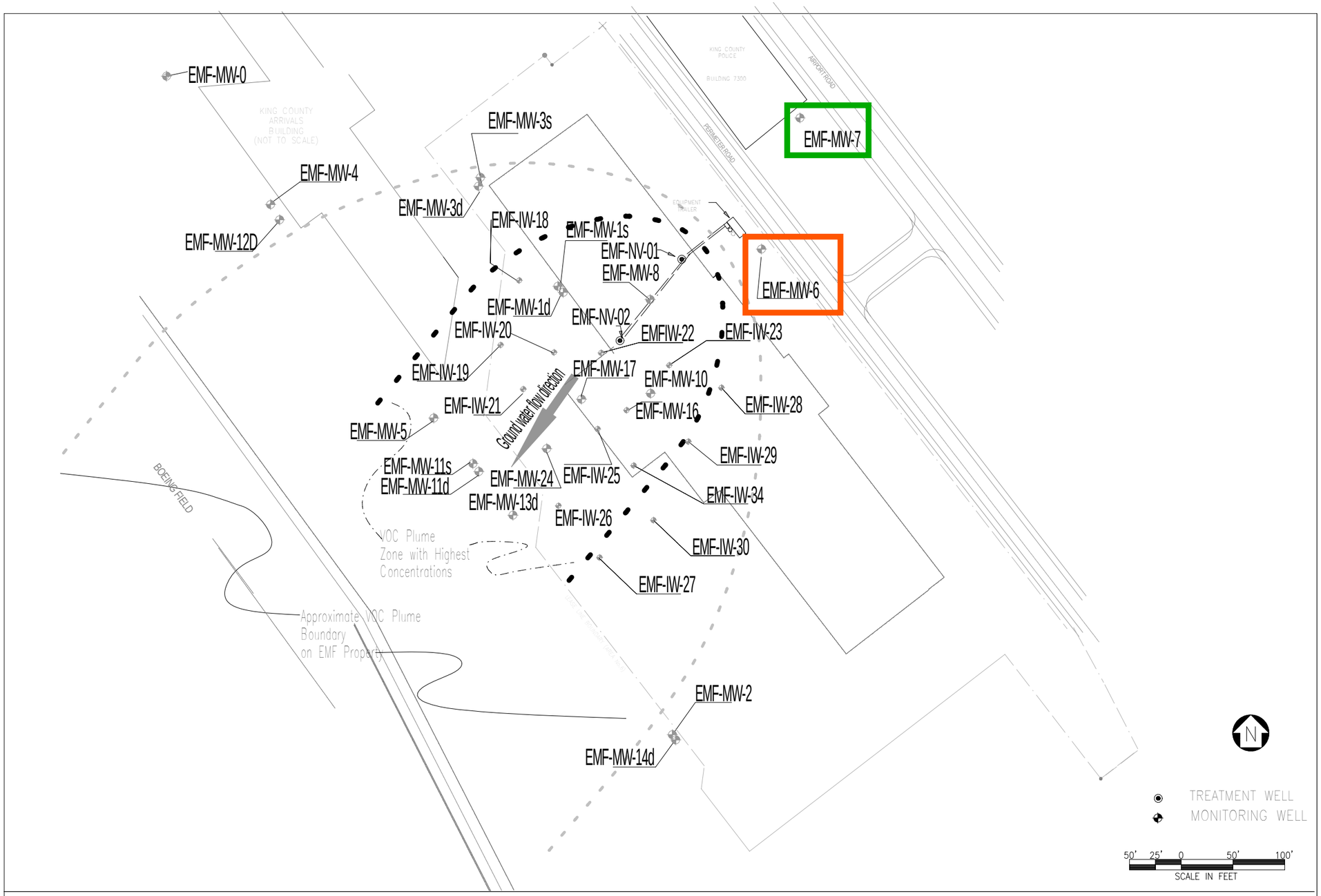


DEPARTMENT OF ECOLOGY
State of Washington

Figure 7.1-80. Existing and Proposed Groundwater Well Locations

SAIC From Science to Solutions

Coordinate System:
NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet
Prepared By: apw/mlf
File: Figure_7_1-80_Existing&Proposed_GW_Wells.mxd
Illustrative purposes only.
Date Saved: 11/5/2013 2:10:31 PM



BOEING®

CALIBRE Systems Inc.

SURVEYING AND MAPPING BY: DUANE HARTMAN AND ASSOCIATES, INC.
HORIZONTAL DATUM: WASHINGTON STATE PLANE COORDINATES, NORTH ZONE NAD83–91 (US FEET)
VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29)

DHA JOB No. 06–1081

Figure 4-3 Monitoring Wells on EMF Property and Approximate VOC Plume Boundary

Appendix C

Data Management Procedures

1.0 Best Result Selection

When multiple results for a single chemical are available for a sample, analyte, and fraction (i.e., total and dissolved metals), one single result must be selected for reporting purposes. Chemicals analyzed by the same analytical method will be qualified by EcoChem, Inc. However, if multiple analyses are involved, then the final result is selected by Leidos. Results not selected as the final result are qualified with a "DNR" to indicate "Do Not Report" in the project database. Results selected as the final result are reported without additional data qualification. The rationale used for best result selection is summarized below.

1.1 Detected Results

When all results are detected, the result with the highest concentration is selected as the final result. If, however, the results are from diluted and non-diluted analyses by the same analytical method, the result from the analysis with the lowest dilution factor is selected. If more than one result with the same concentration and dilution factor is available, then the result with the most certainty is selected; for example, a non-qualified result would be given preference over a result qualified as estimated (J-qualified).

1.2 Non-Detected Results

When all results are non-detected, the result with the lowest reporting limit is selected as the final result. If more than one result with the same reporting limit is available, then the result with the most certainty is selected, if known; for example, a non-qualified result (U-qualified) would be given preference over a result qualified as estimated (UJ-qualified).

1.3 Mixture of Detected and Non-Detected Results

If both detected and non-detected results are available, the detected result will be selected as the final result.

2.0 Reporting and Calculating Procedures

2.1 Significant Figures

Results will be reported by Leidos using the same number of significant figures reported by the laboratory. In summing concentrations, the total value should be reported with the number of significant digits in the individual result with the fewest significant digits.

2.2 Calculated Totals

Calculated analyte totals will be calculated as described below:

- Total PCB Aroclors are calculated in accordance with the procedures described in the Washington State Sediment Management Standards (SMS) using only detected values for seven Aroclor mixtures (Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260). However, if detected concentrations are found for additional Aroclors, they will also be included in the calculated total and will be noted accordingly in the technical memorandum and its data tables. For samples in which none of the Aroclor mixtures are detected, the total PCB Aroclor results will be given a value equal to the highest reporting limit of the individual Aroclor mixtures and assigned a U-qualifier.
- Total PCB congeners are calculated using only detected values for the 209 individual congener results. If an individual sample has none of the 209 PCB congeners detected, the final total PCB congener result will be given a value equal to the highest detection limit of the individual congeners and assigned a U-qualifier. PCB congeners that do not meet minimum method requirements for qualitative determination (i.e., estimated maximum possible concentrations) are treated as non-detected values when calculating the total PCB congener sums and TEQs.

2.3 Weighted Totals

Weighted calculated analyte totals will be calculated as described below:

- PCB congener TEQs are calculated using the World Health Organization consensus toxic equivalency factor (TEF) values (Van den Berg et al. 2006) for mammals, as presented in Table C-1. The TEQ is calculated as the sum of each detected congener concentration multiplied by the corresponding TEF value. When the congener concentration is reported as non-detect, then the TEF is multiplied by one-half the detection limit.

Table C-1. PCB Congener TEFs

PCB Congener IUPAC Number	TEF Value
77	0.0001
81	0.0003
105	0.00003
333114	0.00003
118	0.00003
123	0.00003
126	0.1
156	0.00003
157	0.00003
167	0.00003
169	0.03
189	0.00003

IUPAC = International Union of Pure and Applied Chemistry.
PCB = Polychlorinated biphenyl.
TEF = Toxic equivalency factor.

3.0 Qualifier Mapping

Data qualifiers will be reported by the laboratories, as defined in the data packages. Additional data qualifiers may be applied during data validation using U.S. Environmental Protection Agency functional guidelines. Leidos will review the combination of both laboratory and validation qualifiers and will report final results with a single set of interpreted qualifiers, listed in Table C-2. All data qualifiers will be maintained in the project database. Results rejected for quality assurance/quality control reasons will be reported as rejected, without quantitative values.

Table C-2. Final Data Qualifiers

Final Data Qualifier	Qualifier Definition
J	Estimated concentration
U	Non-detect at the given reporting limit
UJ	Non-detect at the given reporting limit, which is estimated
C	Result is a coelution
CJ	Result is a coelution with an estimated concentration
CU	Non-detected result is a coelution
CUJ	Non-detected result is a coelution with an estimated concentration
R	Rejected

Appendix D

Standard Laboratory Reporting Limits

PCB Congener Reporting Limits

Congener(s)	MDL	RL	Units
PCB-1	1.71	5.00	pg/L
PCB-2	1.79	5.00	pg/L
PCB-3	1.98	5.00	pg/L
PCB-4	2.57	5.00	pg/L
PCB-5	1.71	5.00	pg/L
PCB-6	1.89	5.00	pg/L
PCB-7	1.43	5.00	pg/L
PCB-8	2.24	5.00	pg/L
PCB-9	1.64	5.00	pg/L
PCB-10	1.34	5.00	pg/L
PCB-11	6.89	5.00	pg/L
PCB-12/13	4.18	10.0	pg/L
PCB-14	1.78	5.00	pg/L
PCB-15	3.05	5.00	pg/L
PCB-16	2.13	5.00	pg/L
PCB-17	1.01	5.00	pg/L
PCB-18/30	1.91	5.00	pg/L
PCB-19	0.755	5.00	pg/L
PCB-20/28	1.40	10.0	pg/L
PCB-21/33	1.68	10.0	pg/L
PCB-22	1.73	5.00	pg/L
PCB-23	0.660	5.00	pg/L
PCB-24	1.41	5.00	pg/L
PCB-25	1.03	5.00	pg/L
PCB-26/29	1.28	10.0	pg/L
PCB-27	0.781	5.00	pg/L
PCB-31	1.07	5.00	pg/L
PCB-32	0.495	5.00	pg/L
PCB-34	0.956	5.00	pg/L
PCB-35	1.16	5.00	pg/L
PCB-36	1.56	5.00	pg/L
PCB-37	1.15	5.00	pg/L
PCB-38	0.891	5.00	pg/L
PCB-39	0.683	5.00	pg/L
PCB-40/41/71	3.75	15.0	pg/L
PCB-42	2.18	5.00	pg/L
PCB-43	4.20	5.00	pg/L
PCB-44/47/65	4.40	15.0	pg/L
PCB-45/51	4.92	10.0	pg/L
PCB-46	4.31	5.00	pg/L
PCB-48	0.499	5.00	pg/L
PCB-49/69	1.34	10.0	pg/L
PCB-50/53	3.82	10.0	pg/L
PCB-52	1.48	5.00	pg/L
PCB-54	1.53	5.00	pg/L

Congener(s)	MDL	RL	Units
PCB-55	1.44	5.00	pg/L
PCB-56	1.04	5.00	pg/L
PCB-57	1.43	5.00	pg/L
PCB-58	1.75	5.00	pg/L
PCB-59/62/75	4.21	15.0	pg/L
PCB-60	1.62	5.00	pg/L
PCB-61/70/74/76	3.83	20.0	pg/L
PCB-63	1.20	5.00	pg/L
PCB-64	1.63	5.00	pg/L
PCB-66	1.62	5.00	pg/L
PCB-67	1.29	5.00	pg/L
PCB-68	1.21	5.00	pg/L
PCB-72	1.62	5.00	pg/L
PCB-73	1.26	5.00	pg/L
PCB-77	1.60	5.00	pg/L
PCB-78	2.07	5.00	pg/L
PCB-79	1.53	5.00	pg/L
PCB-80	1.17	5.00	pg/L
PCB-81	1.71	5.00	pg/L
PCB-82	1.18	5.00	pg/L
PCB-83/99	2.41	10.0	pg/L
PCB-84	1.59	5.00	pg/L
PCB-85/116/117	3.03	15.0	pg/L
PCB-86/87/97/108/119/125	5.68	30.0	pg/L
PCB-88/91	2.67	10.0	pg/L
PCB-89	1.55	5.00	pg/L
PCB-90/101/113	3.28	15.0	pg/L
PCB-92	1.13	5.00	pg/L
PCB-93/98/100/102	3.58	5.00	pg/L
PCB-94	0.913	5.00	pg/L
PCB-95	1.71	5.00	pg/L
PCB-96	1.59	5.00	pg/L
PCB-103	0.856	5.00	pg/L
PCB-104	0.913	5.00	pg/L
PCB-105	1.10	5.00	pg/L
PCB-106	2.33	5.00	pg/L
PCB-107/124	2.96	10.0	pg/L
PCB-109	0.932	5.00	pg/L
PCB-110/115	1.64	10.0	pg/L
PCB-111	1.13	5.00	pg/L
PCB-112	1.47	5.00	pg/L
PCB-114	1.24	5.00	pg/L
PCB-118	1.71	5.00	pg/L
PCB-120	1.21	5.00	pg/L
PCB-121	1.12	5.00	pg/L
PCB-122	1.09	5.00	pg/L
PCB-123	1.91	5.00	pg/L

Congener(s)	MDL	RL	Units
PCB-126	1.11	5.00	pg/L
PCB-127	1.03	5.00	pg/L
PCB-128/166	1.61	10.0	pg/L
PCB-129/138/160/163	2.56	20.0	pg/L
PCB-130	1.49	5.00	pg/L
PCB-131	1.70	5.00	pg/L
PCB-132	1.36	5.00	pg/L
PCB-133	1.77	5.00	pg/L
PCB-134/143	2.51	10.0	pg/L
PCB-135/151	3.58	10.0	pg/L
PCB-136	1.59	5.00	pg/L
PCB-137	1.68	5.00	pg/L
PCB-139/140	3.07	10.0	pg/L
PCB-141	1.39	5.00	pg/L
PCB-142	2.05	5.00	pg/L
PCB-144	1.81	5.00	pg/L
PCB-145	1.52	5.00	pg/L
PCB-146	2.23	5.00	pg/L
PCB-147/149	2.46	10.0	pg/L
PCB-148	1.74	5.00	pg/L
PCB-150	1.78	5.00	pg/L
PCB-152	1.98	5.00	pg/L
PCB-153/168	2.99	10.0	pg/L
PCB-154	1.69	5.00	pg/L
PCB-155	1.70	5.00	pg/L
PCB-156/157	2.24	10.0	pg/L
PCB-158	1.14	5.00	pg/L
PCB-159	1.21	5.00	pg/L
PCB-161	1.50	5.00	pg/L
PCB-162	1.12	5.00	pg/L
PCB-164	1.39	5.00	pg/L
PCB-165	1.33	5.00	pg/L
PCB-167	0.535	5.00	pg/L
PCB-169	1.18	5.00	pg/L
PCB-170	0.775	5.00	pg/L
PCB-171/173	1.81	10.0	pg/L
PCB-172	1.38	5.00	pg/L
PCB-174	1.86	5.00	pg/L
PCB-175	1.30	5.00	pg/L
PCB-176	1.08	5.00	pg/L
PCB-177	0.645	5.00	pg/L
PCB-178	1.98	5.00	pg/L
PCB-179	1.46	5.00	pg/L
PCB-180/193	1.69	10.0	pg/L
PCB-181	1.04	5.00	pg/L
PCB-182	2.21	5.00	pg/L
PCB-183/185	0.961	10.0	pg/L

Congener(s)	MDL	RL	Units
PCB-184	1.26	5.00	pg/L
PCB-186	0.912	5.00	pg/L
PCB-187	1.75	5.00	pg/L
PCB-188	0.924	5.00	pg/L
PCB-189	0.516	5.00	pg/L
PCB-190	1.16	5.00	pg/L
PCB-191	1.06	5.00	pg/L
PCB-192	1.01	5.00	pg/L
PCB-194	1.28	5.00	pg/L
PCB-195	1.13	5.00	pg/L
PCB-196	0.767	5.00	pg/L
PCB-197	1.63	5.00	pg/L
PCB-198/199	3.91	10.0	pg/L
PCB-200	1.21	5.00	pg/L
PCB-201	1.45	5.00	pg/L
PCB-202	1.12	5.00	pg/L
PCB-203	1.82	5.00	pg/L
PCB-204	2.12	5.00	pg/L
PCB-205	0.785	5.00	pg/L
PCB-206	0.901	5.00	pg/L
PCB-207	1.32	5.00	pg/L
PCB-208	1.34	5.00	pg/L
PCB-209	0.885	5.00	pg/L

MDL = Method detection limit.
PCB = Polychlorinated biphenyl.
pg/L = Picograms per liter.
RL = Reporting limit.
RL is based on the lowest standard in the calibration curve.
MDL/RL values based on a 1-liter sample extraction; values adjusted accordingly if more or less sample volume is available.

PCB Aroclor Reporting Limits

Aroclor	MDL	RL	Units
Aroclor-1016	0.00248	0.01	µg/L
Aroclor-1221	0.00248	0.01	µg/L
Aroclor-1232	0.00248	0.01	µg/L
Aroclor-1242	0.00248	0.01	µg/L
Aroclor-1248	0.00248	0.01	µg/L
Aroclor-1254	0.00248	0.01	µg/L
Aroclor-1260	0.00276	0.01	µg/L
Aroclor-1262	0.00276	0.01	µg/L
Aroclor-1268	0.00276	0.01	µg/L

MDL = Method detection limit.
µg/L = Micrograms per liter.
RL = Reporting limit.
RL is based on the lowest standard in the calibration curve.
MDL/RL values based on a 1-liter sample extraction; values adjusted accordingly if more or less sample volume is extracted.

Appendix E

Electronic Data Deliverable Format

Laboratory electronic data deliverables (EDDs) will be submitted as tab-delimited text or csv files and will conform to the specifications listed below. This format provides all data required for an Environmental Information Management (EIM) submittal.

Field	Name	Type[1]	Data Required[2]
1	PROJID	T	No
2	STUDYID	T	No
3	FIELDID	T	No
4	LABID	T	Yes
5	LABBATCH	T	Yes
6	CAS NUMBER	T	Special
7	ANALYTE	T	Yes
8	VALUE	N	Yes
9	VALUESF	N	No
10	LABQUAL	T	Special
11	UNITS	T	Yes
12	MDL	N	Special
13	REPLIMIT	N	Yes
14	ANLGROUP	T	No
15	PREPMETHOD	T	No
16	ANLMETHOD	T	Yes
17	MATTYPE	T	Yes
18	BASIS	T	Yes
19	LEACHDATE	T	No
20	EXTRDATE	D	Special
21	ANLDATE	D	Yes
22	DILFACTOR	N	Yes
23	COLUMN	T	Yes
24	FRACTION	T	Yes
25	LABNAME	T	Yes
26	PARENTID	T	Special
27	SAMPLEQTY	N	No
28	QTYUNITS	T	No
29	MOISTURE	N	No
30	QCTYPE1	T	Special
31	QCTYPE2	T	Special
32	SURROGATE	N	Special
33	SPIKE	N	Special
34	RECOVERY	N	No
35	RPD	N	No
36	LOWLIMIT	N	No
37	UPPLIMIT	N	No
38	RPDLIMIT	N	No

Table footnotes are on following page.

[1] ***Type*** field refers to the following data types:

T Text, preferably left justified.

N Numeric, no decimal defined.

D Date/time, date must be eight characters long for the date with the format MM/DD/YY. Time must be six or eight characters long in the format of HH:MM (hours and minutes) or HH:MM:SS (hours, minutes, and seconds). The time must be presented in 24-hour clock (not 12-hour clock).

[2] ***Data required*** field indicates the following:

Yes The field must contain some information and a blank value is not acceptable.

No The field does not require information and, if left blank, is assumed to mean no information was supplied.

Special A special case where the field may be left blank if appropriate; however, a blank field does not represent a lack of information; rather, it indicates some meaning (i.e., a blank in LABQUAL indicates a detected result).

Field Descriptions:

1. **PROJID:** Project name, provided by the client at the beginning of the work assignment and is also listed on the chain of custody (CoC) forms, sample labels, and other project documentation.

2. **STUDYID:** Unique eight-character identifier (ID) to identify the study in the Washington Department of Ecology's EIM database.

3. **FIELDID:** The sample ID number as reported on the CoC form and on sample labels, or the laboratory quality control (QC) sample ID.

   QC samples created by the laboratory from field samples (e.g., laboratory duplicates) must contain the exact SAMPID of the field sample. Other laboratory QC samples (e.g., blanks, spikes, and duplicates) must have unique sample IDs that may be identical to the LABID below.

4. **LABID:** The laboratory internal ID number. The combination of the FIELDID and LABID fields should be sufficient to uniquely define either an environmental or QC sample but may not be sufficient to distinguish reanalyses and dilutions.

5. **LABBATCH:** The laboratory ID number used to associate laboratory generated QC samples.

6. **CAS NUMBER:** A unique identifying number assigned by the Chemical Abstracts Service (CAS) Division of the American Chemical Society to each distinct chemical substance recorded in the CAS Chemical Registry System. The CAS number is accepted nationally and internationally as an identifier for specific, definable chemical substances.

7. **ANALYTE:** Analyte or parameter reported. All compounds should be reported in upper case.

8. **VALUE:** Concentration, value, or result of the compound tested, reported to the correct number of significant figures. The reporting limit (RL) will be reported for non-detect values. Only numbers are acceptable for this field.

   In the case of spiked results, the VALUE will be the spiked sample result and will not be adjusted for the original sample results. If spiked compounds are diluted beyond detection, then the RL shall be reported in the VALUE field and a "U" added with other qualifiers in the LABQUAL field.

9. **VALUESF:** The number of significant figures that should be reported for the VALUE field.

10. **LABQUAL:** Laboratory flags or qualifiers are reported in this field.

    Qualifier codes may be used from the *Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration,* and Document OLM01.0 through revision OLM01.8 (EPA, August 1991). More than one qualifier may be used per record. If other qualifiers are used, then the laboratory must include a list of the definitions of the codes with the electronics. The list may be present as a paper copy or an electronic text file.

    All non-detected results shall be reported with a "U" qualifier. The qualification "ND" for non-detected results is unacceptable. Blank values are acceptable and implied to mean a detected result. If a range will be reported (e.g., greater than 50) the symbol ">" shall be reported in this field.

11. **UNITS:** The units of measure for each record will be reported in this field.

12. **MDL:** Used to report the method detection limit (MDL); a value determined by MDL studies performed in accordance with 40 Code of Federal Regulations or sample-specific estimated detection limits (e.g., 2.5 times signal to noise ratio) for high resolution, isotope dilution test methods. This value is corrected for dilution, percent moisture, or related factors that affect the MDL and/or RL. MDLs are required for all results, as applicable (e.g., not applicable for total solids).

13. **REPLIMIT:** Used to report the RL (presented in REPLIMIT field). Non-detect results reported in the VALUE field should contain the RL corrected for dilution, percent moisture, or related factors that affect the RL.

14. **ANLGROUP:** Field used to group results from various methods. For instance, an entry of 'METALS' may be entered to report results from methods SW-846 6010, SW-846 7041, and SW-846 7470.

15. **PREPMETHOD:** Indicate the extraction or digestion method used (e.g., SW-846 3550B).

16. **ANLMETHOD:** Indicate the analytical method used (e.g., SW-846 8270). Dissolved metals must be clearly identified versus total metals results.

17. **MATTYPE:** Indicate one of the following for the matrix analyzed: SOIL, SEDIMENT, TISSUE, and WATER. If a sample or laboratory QC material does not match one of these, indicate with a code of "X" and explain in the cover letter.

18. **BASIS:** Indicate whether results are reported on a dry weight or wet weight basis, using the terms DRY or WET. If a sample or laboratory QC material does not match one of these, indicate with a code of "X" and explain in the cover letter.

19. **LEACHDATE:** Date the sample was extracted for Toxicity Characteristic Leaching Procedure or Synthetic Precipitation Leaching Procedure test methods. If leaching extraction is not applicable, then the field must be left blank.

20. **EXTRDATE:** Date the sample was extracted or prepared. If an extraction or preparation step is not applicable, then the field may be blank.

21. **ANLDATE:** Date the sample was analyzed.

22. **DILFACTOR:** The dilution factor. This should also reflect "effective" dilutions achieved by increasing or decreasing sample or extracting solvent volumes from standard amounts. That is, pre-concentration steps will result in a dilution factor of less than 1; this is okay.

23. **COLUMN:** This field is used to identify the analytical column from which the result was reported, if applicable.

Code	Definition
1	Primary column
2	Secondary column, also known as conformational column
N	Not applicable

24. **FRACTION:** This field identifies when an aqueous sample is filtered prior to analysis to determine the "dissolved" portion of the chemical of interest. Unfiltered aqueous samples are reported as the "total" fraction. This nomenclature is typically used for metals analysis.

Code	Definition
T	Total
D	Dissolved
N	Not applicable

25. **LABNAME**: The full name (and location if appropriate) or abbreviated name (and location) of the laboratory performing the analysis.

26. **PARENTID**: For duplicate samples only (i.e., laboratory duplicate, matrix spike duplicate, or laboratory control sample duplicate). List the parent sample ID.

27. **SAMPLEQTY:** Quantity or weight of the sample aliquot used for analysis.

28. **QTYUNITS:** The units of measure for the quantity or weight of the sample used for analysis.

29. **MOISTURE:** Moisture content of solid samples, expressed as percent moisture.

30. **QCTYPE1:** This field is used to identify laboratory QC samples. A blank value is acceptable, indicating the record is not one of the sample types below. One of the following codes must be used to identify the laboratory QC sample type:

Code	Definition
RM	Reference material
MB	Method blank
LCS	Laboratory control sample (blank spike or ongoing precision and recovery check)
MS/MSD	Matrix spike/matrix spike duplicate samples
DUP	Duplicate (laboratory duplicates only; field duplicates will have a unique SAMPID)

31. **QCTYPE2:** This field is used to identify analyte types, including tentatively identified compounds (TICs), surrogate compounds, internal standards, and labeled compounds. A blank value is acceptable, indicating the record is not one of the analyte types below. One of the following codes must be used to identify the analyte type:

Code	Definition
SUR	Surrogate or labeled compound result
TIC	Tentatively identified compound
IS	Internal standard

32. **SURROGATE:** If added, this refers to the surrogate or labeled compound concentration or amount expected (e.g., 100 for 100 µg/kg). Units of measure are implied from the UNITS field.

33. **SPIKE:** If added, this refers to the spike concentration or amount expected (e.g., 100 for 100 µg/kg). Units of measure are implied from the UNITS field.

34. **RECOVERY:** Percent recovery. A blank value is acceptable, indicating a non-spiked, non-reference material result. This field should be filled in for surrogates and labeled compounds as well as spiked QC samples and reference materials.

35. **RPD:** Relative percent difference. This field should be filled in for field and laboratory duplicate, matrix spike duplicates, and laboratory control sample duplicates.

36. **LOWLIMIT:** Lower recovery control limit. This field should be filled in for surrogates, QC samples, and reference materials.

37. **UPPLIMIT:** Upper recovery control limit. This field should be filled in for surrogates, QC samples, and reference materials.

38. **RPDLIMIT:** Relative percent difference control limit. This field should be filled in for laboratory duplicates and spiked sample duplicates.

The EDD used for data validation will include all of the fields noted above with data populated by the laboratory, and the following additional fields populated by the data validator.

Field	Name	Type[1]	Data Required[2]
39	val_name	T	Yes
40	val_date	D	Yes
41	val_qual	T	Special
42	val_level	T	Yes
43	val_reason	T	Special
44	val_notes	T	No

[1] ***Type*** field refers to the following data types:

T Text, preferably left justified.

D Date/time, date must be eight characters long for the date with the format MM/DD/YY. Time must be six or eight characters long in the format of HH:MM (hours and minutes) or HH:MM:SS (hours, minutes, and seconds). The time must be presented in 24 -clock (not 12-hour clock).

[2] ***Data required*** field indicates the following:

Yes The field must contain some information and a blank value is not acceptable.

No The field does not require information and, if left blank, is assumed to mean no information was supplied.

Special A special case where the field may be left blank if appropriate; however, a blank field does not represent a lack of information; rather, it indicates some meaning (i.e., a blank in LABQUAL indicates a detected result).

39. **val_name:** The full or abbreviated name of the data validation firm.

40. **val_date:** The date on which data validation was completed.

41. **val_qual:** Any data qualifiers added during data validation.

42. **val_level:** The level of data validation (e.g., full or summary, S2AVEM).

43. **val_reason:** The reason (or reason code) for data qualification. This field is required if validation qualifiers were added.

44. **val_notes:** Any additional notes. If numeric results changed during data validation, it must be noted here.