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Letter of Transmittal

Attention: Roy Kuroiwa
Date: June 8, 2012

Project reference: T-108E / T-106W
Project number: 60160448

We are sending you the following:

Number of originals:	Number of copies:	Description:
	2	Terminal 108 East and 106 West Source Control – Sampling and Analysis Plan (Revision 1)

Dear Mr. Kuroiwa:

Enclosed is the revised Terminal 108 East and 106 West Source Control – Sampling and Analysis Plan (SAP) for your records. The SAP details the scope of work and presents methodologies for conducting the field investigation to address data gaps identified in the Source Control Strategy Plan for Terminals 106 West and 108 East. On May 21, 2012, the Department of Ecology (Ecology) provided comments to the SAP that was issued on May 14, 2012. On June 5, Port of Seattle/AECOM provided response to Ecology's comments and proposed changes to the SAP. The proposed changes were accepted by Ecology on the same day. The changes incorporated into this revision of the SAP are consistent with the correspondences as described above.

Please feel free to call me at (206) 403-4246 should you have any questions or concerns.

Clarence Lo

Clarence Lo
Environmental Engineer
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cc: Richard Thomas – Washington Department of Ecology
File 60160448-0200.1.3 – AECOM

AECOM Environment

Submitted to:
Port of Seattle
Seattle, WA

Submitted by:
AECOM
Seattle, WA
60160448
June 8, 2012

Terminal 108 East and 106 West Source Control – Sampling and Analysis Plan (Revision 1)

AECOM Environment

Submitted to:
Port of Seattle
Seattle, WA

Submitted by:
AECOM
Seattle, WA
60160448
June 8, 2012

Terminal 108 East and 106 West Source Control – Sampling and Analysis Plan (Revision 1)

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Prepared By Shannon Ashurst, Environmental Scientist

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Reviewed By Merv Coover, Environmental Engineer

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1.0 Introduction

This sampling and analysis plan (SAP) was prepared to support Port of Seattle (Port) source control evaluation efforts at Terminal 106 West (T-106W) and Terminal 108 East (T-108E), which are hereafter referred to as the Site. The Site is located on the east bank of the Lower Duwamish Waterway (LDW) in Seattle, Washington (Figure 1-1). The Site is in the Washington State Department of Ecology's (Ecology's) source control program for the LDW. The purpose of the field investigation supported by this SAP is to collect data needed to aid in determining whether the Site is contributing unacceptable levels of contaminants to the LDW.

The Port has initiated work to develop, implement, and manage source control actions for the Site under Ecology's Voluntary Cleanup Program (VCP) of the Model Toxics Control Act (MTCA; Site No. NW2268). In 2008 the Port, in consultation with Ecology, issued a *Source Control Strategy Work Plan* (SCSWP) for T-108[1] (Windward 2008). The work plan outlined an approach for evaluating and developing long-term source control actions at T-108. The Port prepared a subsequent Environmental Conditions Report (ECR) for T-108 that comprehensively describes the property's ownership and operational history, reviews and evaluates existing environmental data, identifies potential pathways of contamination, and suggests options for source control actions (Windward 2009a). T-106W was not considered in the SCSWP or ECR because it was not identified as a potential source of contamination in Ecology's data gaps report (SAIC 2009). T-106W has since been incorporated into source control considerations for completeness since ConGlobal leases T-106W and because stormwater from the southern portion of T-106W drains to the same municipal storm sewer that conveys stormwater runoff from T-108E.

The Port prepared a Source Control Strategy Plan (SCSP) for the Site (AECOM 2011) that developed a conceptual site model (CSM) based on current site uses, the site history, and historical sampling data. The CSM was used to assess potentially complete pathways of contamination to the LDW and identify data gaps in the understanding of those pathways. T-106W and T-108E data gaps are:

- *Stormwater discharge*: Current data do not clearly establish the potential for introduction of contaminants to the LDW from the Site via this pathway.

- *Groundwater discharge*: T-106W groundwater has been evaluated only in limited areas away from the shoreline. Existing T-108 groundwater monitoring data (limited to T-108W only) is not sufficient to determine whether contaminants are of on-going concern.

The purpose of this field investigation is to address the data gaps identified in the SCSP. End-of-pipe solids in stormwater will be sampled at the points of discharge from the Site to the primary storm drains leading to the LDW. This information will help determine if the Site is contributing contaminants at unacceptable levels via the stormwater pathway. Additionally, a more comprehensive groundwater sampling event using shoreline wells will be conducted to clarify whether the groundwater pathway is complete (i.e., is introducing contaminants to the LDW at unacceptable levels).

[1] T-108 is typically discussed in two parts (T-108E and T-108W) based on physical, geographic, and operational distinctions between the eastern and western parcels. T-108W has been evaluated separately from T-108E and is not the focus of this investigation, with the exception of bank sampling detailed in Sections 3 and 4.

This Sampling and Analysis Plan (SAP) summarizes the scope of work and presents methodologies for sample collection, analysis, data management, and reporting. Field activities will be conducted in accordance with this SAP, as well as with the Health and Safety Plan (HASP; prepared under a separate cover).

2.0 Background

2.1 Site Development and Use

T-106W and T-108E are two of the Port's largest off-dock container storage and maintenance terminals, and have been in continuous use as off-dock container yards since 1975. Both properties are currently leased by ConGlobal Industries, Inc. (ConGlobal), North America's largest full-service supplier to the intermodal industry, providing equipment repair, maintenance, storage, and redistribution services to global shipping lines and leasing companies. The container storage and maintenance facility on T-106W encompasses approximately 9 acres, including a 7-acre paved storage yard; a large, covered building used for container maintenance and repair; and an access roadway for container loading and unloading. T-108E is connected to T-106W by a short, paved access road within the S. Oregon Street right-of-way. The approximately 11-acre T-108E parcel includes a paved and graveled container storage yard, a paved chassis maintenance area, and access roadways and railway spurs for cargo loading and unloading. Further details of current and historic Site development and uses are provided in the SCSP, and summarized below.

2.1.1 T-106W

Historically, the majority of T-106W was tidal flats and part of the LDW. Between 1969 and 1970, the parcel was filled with various imported materials, including river dredge spoils and other Port property material. Filling occurred in two phases. Phase I of the filling project included construction of the Nevada Street storm drain line extension, buried within a 440-foot-long dyke situated at a right angle from the former shoreline. Soon thereafter, Phase II filling consisted of the construction of 1,350 feet of new shoreline. The shoreline consists of a fortified bank constructed with select granular fill and supported by a 2- to 4-foot thick riprap wall. The area behind the shoreline dyke was filled with various materials, including "yard fill" from Terminal 102 and LDW dredge material, on top of which a 2-foot lift of a select granular fill material was added and compacted.

The property was acquired by the Port through the Lower Duwamish Industrial Development District Comprehensive Scheme in 1970. At the time of acquisition, the property was an assemblage of vacated ROWs and a Calhoun, Denny, and Ewing Replat. The first tenant to occupy the newly developed site was Coastal Trailer Repair, Inc. between 1975 and 1990, who leased the parcel for off-dock cargo container storage, repair, and cleaning. CCI, who later became ConGlobal, began leasing the property in 1990.

2.1.2 T-108E

As of 1936, T-108E was a roughly graded and undeveloped property. Historic photographs and the ECR indicate that by 1938 the parcel contained one of the City's first wastewater treatment plants, later operated by King County Metro (Windward 2009a). A tidal channel, present up until at least the late 1960s, extended along the north side of the property. This channel was later converted to underground piping. Over the ensuing years, T-108E was used for various industrial purposes and has had several owners and operators. These include:

- **Chiyoda Corporation (1972 – 1980).** No business established. Accomplished minor dredging along north shoreline of the property in 1977. Waste water treatment plant demolished in 1975.

As part of the Slip 1 polychlorinated biphenyl (PCB) transformer spill sediment cleanup, material dredged from the LDW by the Army Corps of Engineers was placed in the former water treatment ponds (Dames and Moore 1981).

- **Port of Seattle (1980 – 1984).** Minor container storage.
- **Chevron USA (1984 – 1992).** Soil stockpiling and equipment yard. Landfarming of petroleum contaminated soil.
- **Port of Seattle (1992 – present).** Property redeveloped into an off-dock container storage and maintenance operations. ConGlobal is the current lessee.

Additional dates and details of the T-108E property use and ownership are provided in the T-108 ECR (Windward 2009a).

2.2 Summary of Environmental Conditions

The SCSP evaluated current Site environmental conditions based on available groundwater, soil, stormwater, and storm drain solids data. T-106W has soil and groundwater data available from studies conducted in 1991 and 1992, stormwater data from ConGlobal's quarterly National Pollutant Discharge Elimination System (NPDES) sampling, and storm drain solids data from a 2008 source tracing study conducted by Seattle Public Utilities. T-108E has soil data available from 1981 and 2006, groundwater data from 2006 and 2007, stormwater data from ConGlobal's quarterly NPDES sampling, and storm drain solids data from the 2008 Seattle Public Utilities study.

A three-step process was applied to available data to identify chemicals of concern (COCs):

- **Step 1**: Maximum concentrations (detected and undetected data) of analytes in site groundwater and soils were compared to the most stringent screening levels for the protection of non-potable surface water and potable groundwater. Screening levels for sites along the LDW were provided by Ecology in April 2011 (Draft Version 13). Analytes exceeding these screening levels (preliminary chemicals of potential concern [COPCs]) were carried forward to Step 2.
- **Step 2**: Preliminary COPCs were compared to site-appropriate screening levels, which are natural background for metals and LDW Boeing Plant 2 Target Media Cleanup Levels (TMCLs) for other analytes. Those exceeding these levels were called final COPCs, regardless of whether they had been detected in on-site media.
- **Step 3**: Potential pathways, reasons to believe final COPCs may be present based on site uses and site history, age of data, practical quantitation limits (PQLs), and additional information on background concentrations were considered. Best professional judgment (BPJ) concerning potential pathways, offsite sources of contamination, frequency of exceedance, and spatial patterns of detected concentrations was also used. Final COPCs that were not eliminated based on these considerations were identified as COCs.

The three-step screening process identified the following COCs for each parcel:

- T-106W
    - Polychlorinated biphenyls (PCBs)
    - Polycyclic aromatic hydrocarbons (PAHs)
    - Total petroleum hydrocarbon (TPH)

- Benzene, toluene, ethylbenzene, and xylene (BTEX)
- Metals (arsenic, barium, cadmium, copper, nickel, lead, selenium, zinc)

- T-108E
  - PCBs
  - PAHs
  - TPH
  - Metals (cadmium, chromium, copper, mercury, manganese, nickel, lead, zinc)

These COCs will be evaluated in this field investigation to provide further resolution of whether the Site is contributing these contaminants to the LDW via the stormwater or groundwater pathways.

Ecology requested that T-108W data gaps associated with the bank erosion pathway be addressed in this field effort. T-108W site conditions and data gaps are detailed in the T-108 ECR (Windward 2009a) and the T-108W SCSP (Windward 2009b). The following COCs will be evaluated in this field investigation.

- T-108W
  - Polychlorinated biphenyls (PCBs)
  - Total organic carbon (TOC)
  - Polycyclic aromatic hydrocarbons (PAHs)
  - Metals (cadmium, chromium, copper, lead, manganese, nickel, selenium, zinc, and mercury)

3.0 Project Overview: Purpose and Scope

The purpose of the field investigation is to address data gaps identified in the SCSP. The intent is to establish whether or not the Site is contributing contaminants to the LDW. This section summarizes the scope of the project, the approximate schedule, and an overview of the project team.

3.1 Summary of Scope

To meet project objectives, the following tasks will be performed:

- Install four shoreline wells in T-106W.
- Collect and analyze groundwater samples from the new wells and existing T-108 shoreline wells (four quarterly events).
- Measure groundwater elevation in three upland wells (one T-106W and two T-108E wells) to provide information on groundwater flow dynamics.
- Collect and analyze end-of-pipe stormwater solids using sediment traps (two events).
- Collect four shoreline/bank soil samples to address T-108W data gaps associated with the bank erosion pathway (Windward 2009b).
- Generate field reports following each event, as well as a final report summarizing all data collected.

3.2 Schedule

Field work will commence following approval of this SAP by Ecology. Field work is expected to begin in the summer of 2012. Well installation and sediment trap design and testing will occur first, followed by sample collection activities. Sampling is expected to span one year, through approximately June 2013. Final data analysis and reporting would occur during the summer of 2013.

3.3 Project Team Overview

The roles, activities, and responsibilities of project participants are summarized in this section and further detailed in Appendix A. The sampling and analysis project team and contact information are presented in Table 3-1. AECOM is the primary consultant for the Port and is responsible for the activities associated with implementing this field investigation.

3.3.1 AECOM Project Team

Key AECOM project team members are the project manager, quality control manager, field manager, and health and safety officer. The project manager will oversee and coordinate the project. The project manager will serve as the technical point of contact to the Port and will manage staff, subcontractors, and project schedule and deliverables. The quality control manager will ensure that the specified field, analytical, and data management procedures are met. The field manager will direct and coordinate all field activities, and collect soil/sediment samples with subcontractor support. The health and safety officer will ensure that project health and safety requirements and objectives are met.

3.3.2 Subcontractors

Subcontractors will assist with various aspects of this project. Cascade Drilling, LP (Cascade) will provide drilling services for sample collection. Analytical Resources, Inc. (ARI) will provide laboratory analytical services. True North Land Surveying will provide any field, licensed surveying that the Port cannot provide. Cardno TEC (TEC) may provide sediment trap installation and monitoring services.

4.0 Sampling and Analysis Methods

To address data gaps identified in the SCSP, groundwater, stormwater solids, and bank sampling will be conducted[2]. Expected field activities, procedures, and laboratory testing are described below.

4.1 Groundwater Sampling

The intent of the current groundwater monitoring is to determine the quality of groundwater discharging at the shoreline from the Site to the LDW. There are already shoreline wells located in T-108; however, there are no shoreline wells in T-106W. Consequently, new wells will need to be installed in T-106W. Once all wells are in place, monitoring will proceed quarterly for one year. Further details are provided below.

4.1.1 Monitoring Well Installation and Development at T-106W

Four shoreline monitoring wells will be installed at T-106W: MW-S1, MW-S2, MW-S3, and MW-S4 (Figure 4-1). Final well locations will be determined in the field based on overhead and underground utilities, accessibility, and safety considerations. Monitoring wells will be placed approximately one container-width away from the fence onsite, since ConGlobal stores containers one-unit deep along the fence at the proposed locations (based on a March 7, 2012, site visit). The ConGlobal site manager will be contacted in advance of any field work. AECOM will coordinate with ConGlobal to ensure that the field schedule and the drilling locations are safe from and provide minimal disruption to facility operations.

Prior to drilling, utilities will be located using the One Call system and a private utility locator. Additionally, each proposed boring location will be cleared to a depth of approximately 5 feet below ground surface (bgs) using an air knife, high-pressure air, and vacuum extraction techniques to avoid damaging underground utilities that may have been missed during the utility survey.

Installation of the four groundwater monitoring wells will occur using a truck-mounted direct push rig. The surface concrete will be cut and removed prior to drilling. Drilling will be completed using a 3.5" outer diameter push probe, and soil samples will be collected every five feet for logging purposes. The direct-push sampling system uses a hydraulic hammer to drive a 3.5" outer diameter probe rod with an extendable point. Soil samples can be collected at regular intervals using an acetate lining that captures soil while pushing the rod into the ground. After being driven to the desired depth, the point is extended and the pre-packed 2" inner diameter well is placed at the desired depth. The pre-packed well consists of a screened PVC inner casing and an outer mesh. Between the mesh and the screened PVC is a 10/20 silica sand pack, or similar. The pre-packed well can be placed directly in the drilled location and finished flush with the surface grade.

Soil samples will not be collected for analytical purposes during well installation because soil erosion is considered an incomplete pathway of recontamination. The T-106W river bank is well armored with a fortified bank supported by a riprap wall. No visible signs of soil erosion or rock slumping have been

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[2] Bank sampling is being conducted to address specific T-108W data gaps (Windward 2009a and b), as requested by Ecology.

reported or observed. Additional details of the T-106W shoreline construction are provided in the SCSP (AECOM 2011). Soil to stormwater or groundwater pathways are being evaluated as part of the stormwater or groundwater pathway, respectively. However, if suspected soil contamination is encountered, the field crew will contact the project manager to discuss. All soil will be logged using the United Soil Classification System (USCS).

Depth to groundwater will be verified using a water level meter, and a monitoring well will be installed with top of the screen placed approximately 1 to 2 feet above where groundwater is encountered. The monitoring wells will be installed in accordance with the requirements for resource protection wells described in Minimum Standards for the Construction and Maintenance of Wells (WAC 173-160) and Standard Operating Procedures (SOPs) #7220 and 7221 (Appendix C). The monitoring wells will be completed using Schedule 40 PVC, 0.01" screen slot, and 10 feet of screen. The borehole annulus will be filled with clean sand to a point approximately 2 feet above the well screen, a bentonite seal will be placed on top of the sand pack at least 1 foot thick to approximately 1 foot bgs, a cement seal will be placed over the bentonite seal and finished flush with the surface. The monitoring wells will be sealed with a locking well cap, and a surface flush mount well head will be constructed. Actual conditions may vary and will be discussed with the project manager before installation.

All augers will be decontaminated between locations to prevent the possibility of cross-contamination. Decontamination will be accomplished by steam cleaning or pressure washing each five foot long auger in a trailer equipped with a washing device and holding tank to contain the water.

Well development will be conducted in accordance with SOP #7221 (Appendix C). Prior to well development, depth to water and total well depth will be measured in each well using an electronic or mechanical water level indicator. A minimum of 10 well volumes (the length of the water column multiplied by the well casing diameter) will be removed from the well during development. The discharge from the well will be continuously monitored, and development will continue until a particulate-free discharge is apparent and field parameters (e.g., pH, conductivity) have stabilized within 10 percent of the previous reading. Field parameters will be recorded on the well development record after each volume is removed. All materials and equipment used for development will be decontaminated using Alconox wash prior to use. Field staff will take care to prevent cross-contamination during well development. Well depths will be measured following development to determine whether sand or silt has accumulated in the well. Table 4-1 summarizes the monitoring well installation and well development details.

All investigation derived waste, including soil, decontamination water, and purge water will be contained in 55-gallon open top drums and stored onsite until analytical results can determine proper waste handling procedures. The storage location will be determined by ConGlobal so as not to interfere with their operations.

Following well installation, all newly installed monitoring wells will be surveyed. In addition, MW-1 (an existing upland well on T-106W that will be used for groundwater elevation measurements) will be surveyed to obtain X, Y, and Z coordinates. The top of the PVC casings will be surveyed to an accuracy of +/- 0.01 foot. The Port will conduct the survey and provide the associated datum.

4.1.2 Groundwater Monitoring and Sampling

Groundwater monitoring will include Site-wide groundwater elevation gauging (i.e., using shoreline and upland wells) and groundwater sample collection from shoreline wells only[3]. T-106W will have four shoreline and one upland monitoring wells (Figure 4-1); T-108 has five shoreline and two upland monitoring wells (Figure 4-2).

Four quarterly groundwater samples will be collected from the designated wells. The first quarterly sampling will occur shortly after the T-106W wells have been installed and developed[4]. General low-flow groundwater sampling protocol can be found in SOP 235 (Appendix C) and is summarized here. Before groundwater samples are collected, groundwater elevation data will be collected from all groundwater monitoring wells using a water level indicator. Also, an oil/water interface probe will be used to screen for heavy surface sheen and free product. If evidence of sheen is present, samples for TPH will be collected from the top of the groundwater table. Groundwater samples will be collected from the shoreline wells using a peristaltic pump and low-flow sampling technique. Clean, new tubing will be used at each well. Groundwater field parameters (temperature, conductivity, dissolved oxygen, oxidation reduction potential, and pH) will be monitored until parameters are stable for three consecutive readings (Table 4-2). A duplicate sample and matrix spike/matrix spike duplicate (MS/MSD) sample will be collected (for laboratory quality control). Groundwater samples will be collected into clean, laboratory-supplied containers and placed on ice until arrival at ARI. Groundwater samples will be submitted for PAH, PCB Aroclors, TPH, and select metals analyses (Table 4-3).

All purge water generated from groundwater sampling will be collected in five gallon buckets during sampling and subsequently stored in 55-gallon open top drums onsite until analytical results can determine proper waste handling procedures. The storage location will be determined by ConGlobal so as not to interfere with their operations.

4.2 Stormwater Solids Sampling

Stormwater solids will be collected at Manholes 001, 002, 003, and 004 (Figures 4-1 and 4-2). These correspond with the ConGlobal NPDES permit stormwater sampling locations. Stormwater discharges from the Site to the LDW via these locations and into the South Nevada Street (T-106W) and Duwamish/Diagonal (T-106W and T-108) storm drains.

Sediment traps will be used to collect the stormwater solids. The intent of using sediment traps is to capture solids that are suspended in the discharging stormwater over a series of storms. This ensures that current discharge conditions are evaluated.

4.2.1 Stormwater Solids – Sediment Trap Installation

Each sediment trap consists of a stainless steel bracket and a certified phthalate-free high-density polyethylene (HDPE) bottle (Figure 4-3). Prior to installation, the bracket will be cleaned using a brush and laboratory-grade detergent, then rinsed in tap water and allowed to dry. The laboratory-supplied

[3] Existing X, Y, and Z coordinate data for previously installed monitoring wells at T-108 are found in PGG 2005. No new surveying of existing wells will be conducted on this property. Upland well MW-1 on T-106W will need to be surveyed, as the X and Y coordinates are not available and the Z coordinate is based on a site benchmark.

[4] Groundwater samples will be collected at least 24 hours after the monitoring wells have been developed.

“certified clean” HDPE bottle will filled with deionized water (to prevent the bottle from floating out of the bracket when there is water present in the pipe).

The traps will be installed by bolting the base of the bracket directly to the location junction or pipe. Installation of the trap anchors (e.g., studs) used to hold the bracket in place can create minor debris that could become a contaminant source. Consequently, once installation of the anchoring mechanism is complete, the work area will be scrubbed with a brush to remove debris, then rinsed with deionized water before the bracket and HDPE bottle are put in place.

4.2.2 Stormwater Solids Sampling

Sediment traps will be in place to collect sediment for two events (wet and dry). When adequate time has elapsed to produce sufficient solids accumulation[5], the sediment traps will be removed from each manhole. The expected deployment interval for each event is at least 3 months. The traps will be inspected monthly.

Once the trap contains at least 70 grams, the bottle will be capped and removed from the trap, stored on ice, and transported to the laboratory. Laboratory personnel will extract the solids from the sample bottle for analysis. Sample analyses are summarized on Table 4-4. In the event that insufficient volume is available, the Port will either prioritize analytes or combine wet and dry season depending on volume availability at all locations. A duplicate sample will be collected from one trap per event, if sufficient volume of solids is available.

4.3 Bank Sampling

Ecology requested that T-108W data gaps associated with the bank erosion pathway be addressed in this field effort (R Kuroiwa, personal comm., 04/10/12). T-108W site conditions and data gaps are detailed in the ECR Windward 2009a) and the T-108W SCSP (Windward 2009b).

Four bank samples are proposed adjacent to T-108 (Figure 4-2). Two samples will be located east of the pier (northern shoreline area), evenly spaced and at approximate elevation of +10 mean lower low water (MLLW). Two samples will be located in the central shoreline area, evenly spaced between the habitat mitigation area and the south end of the pier at the same elevation (+10 MLLW). Final locations will be selected in the field to target areas of bank sloughing. The Port will conduct a survey to delineate the +10 MLLW elevation at the selected locations. Samples at these locations will be collected by hand from the top six inches and be placed into laboratory-supplied containers. One field duplicate and sufficient volume for an MS/MSD will be collected. Samples will be placed in iced coolers for transport. All samples will be analyzed for PCBs, TOC, PAHs, and metals (Table 4-5).

4.4 Analytical Methods

Chemical analyses will be conducted by ARI in Tukwila, Washington. The analyte list for groundwater is PAHs, PCBs, BTEX, TPH, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, and zinc[6]. The analyte list for stormwater solids is PCBs, PAHs, copper, zinc, and total

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[5] The laboratory estimates that, for the list of desired parameters (Section 4.4), at least 70 grams (2.47 ounces) of wet material will be required.

[6] There are some differences in analytical suite between T-108 and T-106W, as detailed in Table 4-3.

organic carbon (TOC). Stormwater solids metals analyses only include copper and zinc, consistent with the ConGlobal stormwater monitoring program, which is defined by the ConGlobal NPDES and Industrial Stormwater General (ISG) permits and the 2010 Stormwater Pollution Prevention Plan (SWPPP). The ISG permit requires all facilities to evaluate the metals zinc and copper; Ecology did not require any additional metals to be monitored in stormwater under the ConGlobal permits. Additionally, zinc and copper were the only metals with criteria exceedances in the Seattle Public Utilities storm drain solids sampling (AECOM 2011). The analyte list for bank soil is PCBs, TOC, PAHs, cadmium, chromium, copper, lead, manganese, nickel, selenium, zinc, and mercury. All samples will be analyzed according to the methods set forth in Tables 4-3 through Table 4-5. All reasonable means, including additional cleanup steps and method modifications, will be used to meet target detection limits. Water screening levels that are above the laboratory detection limit for specific chemicals of concern are indicated in Table 4-3. Detection of analytes between the Method Reporting Limit (MRL) and the Method Detection Limit (MDL) will be "J" flagged and reported as an estimate.

5.0 Documentation and Custody Procedures

This section describes procedures for maintaining sample control through field, sample, and shipping documentation. This section is intended to cover all activities from collection through receipt of the samples by the analytical laboratory and the filing of field records. Appendix B has a copy of all field forms that will be used in the field.

5.1 Field Notes

Field notes will be maintained throughout collection activities by field representatives to provide a daily record of events, observations, and measurements during field investigations. Field notes will include daily logs (e.g., field reports, health and safety meeting forms), as well as sample logs. All entries will be made in waterproof ink and will be signed and dated. Field notes and forms will be kept as a permanent record. Any inadvertent entries or mistakes in the notes will be crossed out with a single line and initialized by the recorder.

The field notes and forms are intended to provide sufficient data and observations to permit reconstruction of events that occurred during the project. The following information will be documented among the field notes and forms:

- Name and title of author, date, and time of entry;
- Names and responsibilities of other field team members;
- Names and titles of any visitors;
- Project name, project number, and location;
- Purpose of sampling activity;
- Material to be sampled;
- Safety meeting;
- Levels of PPE (if applicable): level of protection originally used, changes in protection if required, reason for changes;
- Documentation on samples taken: date, time, location (and depth), type of sample, sample identifications, sample matrix, analyses required, sample characteristics and description (e.g., approximate grain size for classification of soil), and readings taken (if any);
- Equipment utilized;
- Project samples and quality assurance (QA) samples: where they are to be sent, date they are sent, and shipping number (air bill number, if not hand delivered);
- On-site measurement data, parameters, and instruments (e.g., air monitoring device readings);
- Calibration record;
- Field observations and remarks;
- Weather conditions;
- Unusual circumstances or difficulties and resolutions;

- Photographs: include object for scale when taking photo, description, date, and location;
- Deviations to the approved SAP;
- Chain-of-custody record numbers;
- Investigation-derived wastes, such as contents and approximate volume of waste, type and predicted level of contamination, and disposal method; and
- Signature and date (entered by personnel responsible for observations) at close of field day operations.

Chain of custody procedures will be followed according to SOP 1007 (Appendix C). Original data recorded in field notes, sample identifications, chain-of-custody records, and receipt-for-sampling forms will be written with waterproof ink. These documents will not be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. Following completion of field activities, all notes will become part of the final field file.

5.2 Photographs

Photographs of field conditions, collection activities, samples collected, and general conditions are likely to be taken during the sampling events. Photographs taken during field operations will document various sampling and surveying activities. These photographs are valuable in documenting the progress and completion of the field program. All field activity photographs are stored in the project files.

5.3 Sample Documentation

Sample documentation refers to tracking procedures that begin with sample labeling and continue until the conclusion of analysis and sample disposal.

All samples must have properly affixed labels prior to packing and shipment to the laboratory. Information must be legibly written in indelible ink and include, at a minimum, the following information:

- Project name and number;
- Sample identification;
- Sampler’s initials;
- Preservatives (if used);
- Required analysis;
- Date and time of collection; and
- Type of sample/media (e.g. groundwater).

Prior to packaging, the field scientist will check to ensure that both the laboratory sample identification and the field sample identification are recorded in the field notes and forms, and that those numbers match on the sample label.

5.4 Chain-of-Custody Records

Field sample custody procedures for this program are highlighted below. The Sample Log and Chain-of-Custody Form will be initiated at the time a sample is collected, and will accompany the sample until its final disposal. These records are filed in the project files.

A sample is considered to be in custody if any of the following criteria are met:

- The sample is in the physical possession of the sampler;
- The sample is in the sampler's view;
- The sample was in the sampler's possession and then was sealed to prevent tampering; or
- The sample is in a designated secure area.

The chain-of-custody form will contain the following information:

- Sample number;
- Collection date for each sample in the shipment;
- Time the shipment was packed;
- Number of containers of each sample;
- Sample description (environmental matrix);
- Analyses required for each sample;
- Shipping address of the laboratory;
- Date, time, and method of shipment; and
- Signatures as custody is transferred from one individual to another.

Samples will either be hand-delivered or sent overnight to the analytical laboratory. Upon delivery, the analytical laboratory sample custodian will review and transfer the custody forms; a copy of the signed form will be provided to AECOM and filed. A cooler receipt form will also be filled out by the analytical laboratory upon receipt of the samples and will become part of the permanent files.

5.5 Corrections to Documentation

When an error is made on an accountable document, corrections may be made by first placing a single line through the error, initialing and dating the lined-out item, and then entering the correct information. The erroneous information must not be obliterated. All subsequent corrections must be initialed and dated.

5.6 Data Storage and Security

Documents generated during field and laboratory activities will be placed in the permanent field files. Access to these records is controlled and will be restricted to authorized personnel working on the project.

Data transferred to electronic media will be copied onto backup electronic media, along with a hardcopy of those data records, and stored with the permanent files.

6.0 Field Data Management and Reporting

All data collected in the field will be filed and stored at AECOM's Seattle office. This includes field notes, sample logs, and analytical results, as well as other documents produced during the field investigation and subsequent report preparation.

6.1 Field Data Management

Field measurements and observations recorded in field notes, on field data forms, or on similar permanent records by field technicians are to become part of the permanent file. Field data are to be recorded directly and legibly in the field forms with all entries signed and dated.

Managerial documentation consists of:

- Data processing and storage records;
- Sample identification and chain-of-custody records;
- Field changes and variances;
- Document control, inventory, and filing records;
- Quality Assurance/Quality Control (QA/QC) records;
- Health and safety records; and
- Financial and project tracking records.

6.2 Field Data Evaluation

Initial responsibility for verification of accurate entries will lay with the field data logger. At the end of the sampling day, the data logger must sign and date the field notes and logs. Data will then be verified by the QC Manager, who will review all collected data to ensure that all pertinent information has been entered, and that correct codes and units have been used. The Field Manager will direct the field data logger to make any necessary corrections to the record and initial them.

After data are reduced into tables or arrays, the QC Manager will review data sets for anomalous values. Any inconsistencies will be resolved by seeking clarification from the field personnel responsible for data collection. Managerial and technical data will be verified by the Project Manager for reasonableness and completeness.

The QC Manager will monitor and audit performance of the QA procedures to assure that the project is performed in accordance with approved quality assurance procedures. The QC Manager or authorized representative will conduct audits to evaluate the execution of sample identification, field notes, and sampling procedures. The field audit program will have preventative maintenance procedures to ensure vital equipment is functioning properly. These procedures include cleaning/ decontamination of equipment, daily visual inspection, and routine maintenance of parts depending on the type of equipment used.

6.3 Corrective Action

The purpose of the evaluation process is to qualify or eliminate field information or samples that were not collected or documented in accordance with specified protocols outlined in the SAP. The Field Manager will review the procedures being implemented in the field for consistency with the established protocols. Sample collection, preservation, labeling, etc., will be checked for completeness. Where procedures are not in compliance with the specified protocols, the deviations will be field documented and reported to the Project Manager. Corrective actions will be defined by the Field Manager and Project Manager and documented and implemented as appropriate. Deviations and modifications will be documented in the event field reports and summarized in the final report (see Section 8, Reporting).

7.0 Quality Assurance/Quality Control Objectives

This section discusses the data quality objectives (DQOs), laboratory activities, and QA/QC procedures to be implemented in this study. DQOs reflect the overall degree of data quality or uncertainty that the decision-maker is willing to accept during decision-making. DQOs are used to specify the quality of the data, usually in terms of precision, accuracy (bias), representativeness, comparability, and completeness (PARCC). DQOs apply to the entire measurement system (e.g., sampling locations, methods of collection and handling, field analysis, laboratory analysis). QA/QC analyses from the laboratory will include method blanks, matrix spike/matrix spike duplicates, laboratory control samples, laboratory replicates, and surrogates. A field QA/QC sample (i.e., blind field duplicate) will also be collected[7].

7.1 Data Quality Objectives

DQOs are used to ensure that environmental data are scientifically valid, defensible, and of an appropriate level of quality given the intended use for the data (EPA 1996). The PARCC parameters are discussed below.

7.1.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Precision is measured by the relative percent difference (RPD), which is a quantitative measure of the variability of a group of measurements compared to their average value. The overall precision of measurement data is a mixture of sampling and analytical factors. Precision is evaluated through field and laboratory duplicate samples.

7.1.2 Accuracy

Accuracy measures the closeness of an individual measurement, or the average of a number of measurements, to the true value. Accuracy includes a combination of random and systematic error components that result from sampling and analytical operations. Sources of error include the sampling process, field contamination, sample preservation, sample handling, sample matrix, laboratory preparation, and analysis techniques. The most common data quality indicators for accuracy include spiked samples, and various kinds of blanks (EPA 2001).

7.1.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter used to ensure proper design of the sampling program. Representativeness criteria are best satisfied by making certain that sampling locations are selected properly, and a sufficient number of samples are collected.

[7] A field duplicate will be collected for groundwater; collecting a field duplicate for stormwater solids will depend on the amount of solids collected over the quarterly sample interval.

7.1.4 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid measurements. Completeness is defined by the equation below:

$$C\% = \frac{S}{R}(100\%)$$

Where:

C = Completeness;
S = Number of valid analyses; and
R = Number of requested analyses.

The completeness goal is essentially the same for all data uses: that a sufficient amount of valid data be generated. Data that have been qualified as estimated because the quality control criteria were not met or because of elevated detection limits, will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

7.1.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through the use of standard techniques to collect and analyze representative samples and the consistent reporting of analytical results in appropriate units.

7.1.6 Validation

Data for this sampling program will undergo third-party validation to assess data quality. Validation will include a review of holding times, detection limits, precision, accuracy, completeness, and acceptability of test results for method blanks, analytical replicates, matrix spikes, and surrogate recoveries. The validator will generate a summary report noting any issues with the data following the quality control evaluation.

7.2 Quality Control Requirements

7.2.1 Field Quality Control Requirements

One blind duplicate sample will be collected from a groundwater monitoring well during each sampling event. Laboratory analysis of the field duplicate will be used to assess the precision of field sampling techniques. The duplicate will be analyzed for the same analytical suite as the original (parent) sample. Extra groundwater sample volume will also be collected as needed for MS/MSD analyses (further described in Section 7.2.2.4).

7.2.2 Laboratory Control Requirements

This section describes the general QC procedures inherent to the laboratory QA program. All analytical procedures will be documented in writing as laboratory SOPs, with each SOP including a QA section that addresses the minimum QC requirements for the procedure. Certain QC requirements are matrix- or method-specific, but in general, the QA program must include the following:

- Instrument calibration;
- Preparation and analysis of reagent/preparation blanks;
- Analysis of instrument and/or method blanks;
- Preparation and analysis of matrix spikes and matrix spike duplicates;
- Preparation and analysis of surrogate spikes;
- Analysis of laboratory duplicates for inorganics;
- Preparation and analysis of laboratory control samples and standards;
- Identification of internal standard areas and control limits, for GC/MS analysis; and
- System performance checks for both organic and total metals analyses.

The following analytical QC samples will be associated with each batch if the control procedure is applicable to the analysis.

7.2.2.1 Method Blank

A reagent or media blank will be analyzed as a check on laboratory contamination (glassware, reagents, analytical hardware) that might affect analytical results. A sample consisting of laboratory reagent-grade water (distilled and deionized water) or a solid matrix will be analyzed to monitor the analytical instrument for contamination. The method blank is processed through the entire analytical procedure, including sample preparation. The results are used in conjunction with other control data to validate overall system performance and identify bias that may impact data quality. Method blanks must be analyzed per SW-846 for applicable analyses, at least once with each analytical batch.

7.2.2.2 Laboratory Control Samples & Duplicates

Independently prepared laboratory control samples (LCSs) will be processed through the entire analytical procedure. The purpose of these samples is to monitor and assure the accuracy of the procedure in the absence of matrix interference. Results of the LCSs are charted and must meet acceptance criteria. LCSs must be analyzed per SW 846 for applicable analyses, at least once with each analytical batch.

Independently prepared laboratory control sample duplicates (LCSDs) will be processed through the entire analytical procedure. The purpose of the LCSD is to assure the precision of the procedure in the absence of matrix interference. Precision results in RPD are tabulated and charted. LCSDs must be analyzed per SW-846 for applicable analyses, at least once with each analytical batch.

7.2.2.3 Internal Standards

All sample aliquots and laboratory QC samples scheduled for GC/MS analysis will be spiked with internal standards prior to extraction or analysis as applicable. The internal standards to be added will be in compliance with the SW-846 analytical method referenced, and will be detailed in the laboratory method SOP. The purpose of the internal standards is to ensure GC/MS instrument sensitivity and stability, and to provide for accurate target analyte quantitation. The internal standard area counts and retention times are charted and must meet acceptance criteria.

7.2.2.4 Matrix Spikes & Duplicates

An aliquot of a sample will be spiked with a known amount of selected analyte(s). Percent recoveries of the selected spiked analytes are tabulated by subtracting the non-spiked concentration from the spiked sample results. Results are used to assess accuracy in specific matrices. Matrix spikes must be analyzed per SW-846 for applicable analyses, at least once with each matrix-specific analytical batch.

Matrix spike duplicates will be analyzed to monitor the method precision. Results in RPD are tabulated and charted. Matrix spike duplicates must be analyzed per SW-846 for applicable analyses, at least once with each matrix-specific analytical batch.

7.2.3 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

The primary objective of an instrument/equipment testing, inspection, and maintenance program is to help ensure the timely and effective completion of a measurement effort by minimizing the downtime of crucial sampling and/or analytical equipment due to expected or unexpected component failure.

Testing, inspection, and maintenance (TIM) will be carried out on all field and laboratory equipment in accordance with manufacturers' recommendations and professional judgment. Analytical laboratory equipment preventative TIM will be addressed in the laboratory's QA manual, which will be kept on file at the contracted laboratory.

Preventative TIM will be implemented on a scheduled basis to minimize downtime and to ensure accurate measurements from both field and laboratory equipment. This program is designed to achieve results commensurate with the specified capabilities of equipment operation, thus generating data of known quality without concern for misapplication. In addition, backup equipment and critical spare parts will be maintained in order to quickly correct equipment malfunction.

7.2.4 Instrument Calibration and Frequency

Measuring and test equipment (M&TE) used during environmental data collection activities will be subject to calibration requirements. These requirements are summarized below:

- **Identification**: Either the manufacturer's serial number or the calibration system identification number will be used to uniquely identify M&TE. This identification will be attached to the equipment. If this is not possible, records traceable to the equipment will be readily available for reference.
- **Standards**: M&TE will be calibrated, whenever possible, against reference standards having known valid relationships to nationally recognized standards (e.g., National Institute of Standards and Technology) or accepted values. If national standards do not exist, the basis for calibration will be described and documented.
- **Frequency**: M&TE will be calibrated at prescribed intervals and/or prior to use. Frequency will be based on the type of equipment, inherent stability, manufacturers' recommendations, values given in national standards, intended use, and experience. All sensitive equipment to be used in the laboratory will be calibrated or checked prior to use.
- **Records**: Calibration records (certifications, logs, etc.) will be maintained for all M&TE used on the project.

If M&TE are found to be out of calibration, an evaluation will be made and documented to determine the validity of previous measurements and/or corrective action will be implemented. All laboratory calibration requirements must be met before sample analysis can begin. If calibration nonconformance is noted, samples will be reanalyzed under compliant calibration conditions within method-specified holding times.

8.0 Reporting

This section briefly summarizes the interim and final work products that will be generated over the course of the investigation. Subcontractor deliverables will be supplied to AECOM; information contained therein will be subsequently incorporated into AECOM deliverables to the Port of Seattle.

8.1 Subcontractor Work Products and Deliverables

8.1.1 Cascade Drilling

Cascade will generate a bore hole log for each boring and will submit these logs to the Washington State Department of Ecology. Copies will be provided to AECOM.

8.1.2 Analytical Resources, Inc.

ARI will document all the activities associated with sample analyses and will prepare a written report following each sampling event. At a minimum, the following will be included in the report:

- Case narrative describing any deviations from protocols or issues encountered during analysis.
- Results of the laboratory analyses and QA/QC results.
- All protocols used during analyses.
- Chain-of-custody procedures, including explanation of any deviation from those identified herein.

8.2 AECOM

AECOM will generate field reports following each event, as well as a final report summarizing and evaluating all data collected. Each field report will summarize the sampling event and present the associated results. The field reports will be submitted to the Port within two to three weeks of receipt of the validated data. The final report will summarize all field events, present all data generated, and evaluate the potential for contaminant contributions by the pathways of interest from the Site to the LDW. A draft of the final report will be submitted for Ecology review one month following the receipt of validated data from final sampling event. The final written report will be submitted one month after comments on the draft final are received from the agency, allowing for resolution of comments and subsequent revision.

9.0 References

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Dames and Moore 1981. *Report of Site Contamination. Chiyoda Property*. For the Port of Seattle. 01910-056-05. July 23, 1981.

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EPA 2001. *Guidance on Data Quality Indicators*. EPA QA/G-5i. Peer Review Draft. United States Environmental Protection Agency, Office of Environmental Information, Washington, D.C. September.

PGG 2006. Port of Seattle T-108 Interim Soil and Groundwater Investigation. Prepared for Port of Seattle. Prepared by Pacific Groundwater Group. December 2006.

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Windward 2008. *Terminal 108 – Source Control Strategy Work Plan. Final.* Prepared for Port of Seattle. For Submittal to Washington State Department of Ecology. February 2008.

Windward 2009a. *Terminal 108 – Environmental Conditions Report. Final.* Prepared for Port of Seattle. For Submittal to Washington State Department of Ecology. January 2009.

Windward 2009b. *Terminal 108—Western Parcel Source Control Strategy Plan, Final*. Prepared for Port of Seattle. For Submittal to Washington State Department of Ecology. October 30, 2009.

Tables

Table 3-1 Sampling and Analysis Project Team and Contact Information

Role	Name and Address
Technical Points of Contact (Port of Seattle)	Roy Kuroiwa Kym Takasaki 2711 Alaskan Way Seattle, WA 98121 (206) 310-7446 (Roy, cell)
Site Manager (ConGlobal)	Jimmy Banks 1 S Idaho St. Seattle, WA 98134 (206) 624-8180 x221
Project Manager (AECOM) Field Manager (AECOM)	Clarence Lo Mindy Graddon 710 2nd Ave Suite 1000 Seattle, WA 98104 (206) 624-9349
Drilling Services	Jaymen Lauer Cascade Drilling, LP 19404 Woodinville-Snohomish Road Woodinville, WA 98072 (425) 485-8908
Laboratory Services	Cheronne Oreiro Analytical Resources, Inc. (ARI) 4611 S. 134th Place Tukwila, WA 98168-3240 (206) 695-6200
Stormwater Solids Services (as needed)	Curtis Nickerson Cardno TEC 2825 Eastlake Avenue East Suite 300 Seattle WA 98102 (206) 267-1400
Surveying Services (as needed)	Tim Ingraham True North Land Surveying 815 S Weller St # 200 Seattle, WA 98104 (206) 332-0800

Table 4-1 T-106W Monitoring Well Installation and Development Specifications

Monitoring Well Installation

Monitoring Well ID	Soil Sample Interval^	Approximate Depth to Groundwater*	Screen Type	Screen Length	Approximate Total Depth*
MW-S1	Every 5 feet	6-11 feet below ground surface	0.01” slot, Schedule 40 PVC	10 feet	15-25 feet below ground surface
MW-S2					
MW-S3					
MW-S4					

Monitoring Well Development

Monitoring Well ID	Parameters to Monitor	Purge Volume	Method	Volume Calculation
MW-S1	pH, Turbidity, Temperature, Conductivity	At least 10 well volumes	Pump and surge ~3 times: surge ~5 minutes and pump ~3 well volumes	2” well = 0.1632 gallons/foot or 0.6178 liters/foot
MW-S2				
MW-S3				
MW-S4				

Notes

^ Soil samples will be collected for logging purposes only (i.e., not for laboratory analysis).

* Actual depth to groundwater may vary, which will alter the monitoring well total depth

Table 4-2 Groundwater Sampling Program Overview

Groundwater Samples – Quarterly – 4 quarters					
Location	**Monitoring Well ID**	**Well Type**	**Measure Depth to Water**	**Collect Groundwater Samples**	**Duplicate MS/MSD Locations**
T106W	MW-S1	Shoreline	X	X	
	MW-S2	Shoreline	X	X	
	MW-S3	Shoreline	X	X	Duplicate
	MW-S4	Shoreline	X	X	
	MW-1	Upland	X		
T108	PGG-1	Upland	X		
	PGG-4	Upland	X		
	PGG-2	Shoreline	X	X	
	PGG-3	Shoreline	X	X	
	PGG-5	Shoreline	X	X	
	PGG-6	Shoreline	X	X	
	PGG-7	Shoreline	X	X	MS/MSD

Groundwater Stabilization Criteria

Parameter	**Stabilization Criteria**
Temperature	Within +/- 3%
Conductivity	Within +/- 3%
Dissolved Oxygen	Within +/- 10%
Oxidation Reduction Potential	Within +/- 10 millivolts
pH	Within +/- 0.1 unit
Turbidity	Less than 5 NTU or +/- 10%

Notes

Groundwater samples will be collected using low flow sampling technique and will be collected from the middle of the water column. If evidence of sheen is present, samples for TPH will be collected from the top of the groundwater table.

Table 4-3 Groundwater Analytical Methods

Analysis	Laboratory Method	Analyte	Parcel		Hold Times (4°C)	Container Size	Target Detection Limits (µg/L)
			T-108	T-106W			
PAHs	EPA 8270 SIM	Acenaphthene	X (all)	X (all)	7 days until extraction; 40 days to analysis (extracts)	Two 500-mL AG	0.01
		Acenaphthylene					0.01
		Anthracene					0.01
		Benzo(g,h,i)perylene					0.01
		Benzo(a)anthracene					0.01*
		Benzo(a)pyrene					0.01*
		Benzo(b)fluoranthene					0.02*
		Benzo(k)fluoranthene					0.02*
		Chrysene					0.01*
		Dibenzo(a,h)anthracene					0.01*
		Fluoranthene					0.01
		Fluorene					0.01
		Indeno(1,2,3-cd)pyrene					0.01*
		Methylnaphthalene, 2-					0.01
		Naphthalene					0.01
		Phenanthrene					0.01
		Pyrene					0.01
PCBs	EPA 8082B	Aroclors	X	X	7 days until extraction; 40 days to analysis (extracts)	Two 500-mL AG	0.01*
BTEX	EPA 8021B	Benzene		X (all)	14 days (HCl preserved)	Three 40-mL glass	1.0*
		Toluene					1.0
		Ethylbenzene					1.0
		Total Xylenes					2.0
TPH	NWTPH-Gx	Gasoline	X	X	7 days until extraction;	Three 40-mL glass	0.25
	NWTPH-Dx	Diesel	X	X		Two 500-mL AG	0.2
Metals	EPA 200.8	Arsenic		X	180 days	500 mL HDPE	0.5*
		Barium		X			0.5
		Cadmium	X	X			0.1
		Chromium	X				0.5
		Copper	X	X			0.5
		Lead	X	X			0.1
		Manganese	X				0.5
		Nickel	X	X			0.5
		Selenium		X			0.5
		Zinc	X	X			1
	EPA 7470	Mercury	X		28 days	Two 500-mL AG	0.02*

Notes
* = Detection limit exceeds groundwater screening level
AG = Amber Glass
HDPE = High Density Polyethylene
mL = Milliliter
µg/L = Micrograms/liter
PCBs = Polychlorinated Biphenyls
PAHs = Polycyclic Aromatic Hydrocarbons

Table 4-4 Stormwater Solids Analytical Methods

Analysis	Laboratory Method	Analyte	Volume Required for Analysis (grams)	Hold Times (4°C)	Container Size	Target PQL[1]
PCBs	EPA 8082	Aroclors	30	14 days until extraction; 40 days to analysis	1-L HDPE bottle per trap, to be centrifuged by the laboratory for solids collection	6 μg/kg
PAHs	EPA 8270 SIM	Acenaphthene	15	14 days until extraction; 40 days to analysis (extracts)		167 μg/kg
		Acenaphthylene				433 μg/kg
		Anthracene				320 μg/kg
		Benzo(g,h,i)perylene				223 μg/kg
		Benzo(a)anthracene				433 μg/kg
		Benzo(a)pyrene				533 μg/kg
		Benzo(b)fluoranthene				1067 μg/kg
		Benzo(k)fluoranthene				
		Chrysene				467 μg/kg
		Dibenzo(a,h)anthracene				77 μg/kg
		Fluoranthene				567 μg/kg
		Fluorene				180 μg/kg
		Indeno(1,2,3-cd)pyrene				200 μg/kg
		Methylnaphthalene, 2-				223 μg/kg
		Naphthalene				700 μg/kg
		Phenanthrene				500 μg/kg
		Pyrene				867 μg/kg
Metals	EPA 6010	Copper	10	180 days		130 mg/kg
		Zinc				137 mg/kg
TOC	EPA 9060	TOC	15	14 days		0.10%
		Total:	*70*			

Notes
PCBs = Polychlorinated Biphenyls
PAHs = Polycyclic Aromatic Hydrocarbons
TOC = Total Organic Carbon
70 grams = 2.47 ounces = 73.0 milliliters
[1] Practical Quantitation Limit, as given in Table 5 of the February 2008 *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008).
In the event that insufficient volume is available for all analyses, the Port will either prioritize analytes or combine wet and dry season depending on

Table 4-5 Bank Soil Sampling Analytical Methods

Analysis	Laboratory Method	Analyte	Hold Times (4°C)	Container Size	Target PQL[1]
PAHs	EPA 8270 SIM	Acenaphthene	14 days	8 ounce wide mouth glass jar	167 µg/kg
		Acenaphthylene			433 µg/kg
		Anthracene			320 µg/kg
		Benzo(g,h,i)perylene			223 µg/kg
		Benzo(a)anthracene			433 µg/kg
		Benzo(a)pyrene			533 µg/kg
		Benzo(b)fluoranthene			1067 µg/kg
		Benzo(k)fluoranthene			
		Chrysene			467 µg/kg
		Dibenzo(a,h)anthracene			77 µg/kg
		Fluoranthene			567 µg/kg
		Fluorene			180 µg/kg
		Indeno(1,2,3-cd)pyrene			200 µg/kg
		Methylnaphthalene, 2-			223 µg/kg
		Naphthalene			700 µg/kg
		Phenanthrene			500 µg/kg
		Pyrene			867 µg/kg
Metals	EPA 6010B/6020	Cadmium	180 days	4 ounce wide mouth glass jar	1.7 mg/kg
		Chromium			87 mg/kg
		Copper			130 mg/kg
		Lead			150 mg/kg
		Manganese [2]			0.5 mg/kg
		Nickel			47 mg/kg
		Selenium [2]			0.5 mg/kg
		Zinc			137 mg/kg
	EPA 7471A/245.5	Mercury	28 Days		0.14 mg/kg
PCBs	EPA 8082	Aroclors	14 days until extraction; 40 days to analysis (extracts)	8 ounce wide mouth glass with Teflon-lined lid	6 µg/kg
TOC	EPA 9060	TOC	14 days	4 ounce wide mouth glass jar	0.10%

Notes

PCBs = Polychlorinated Biphenyls

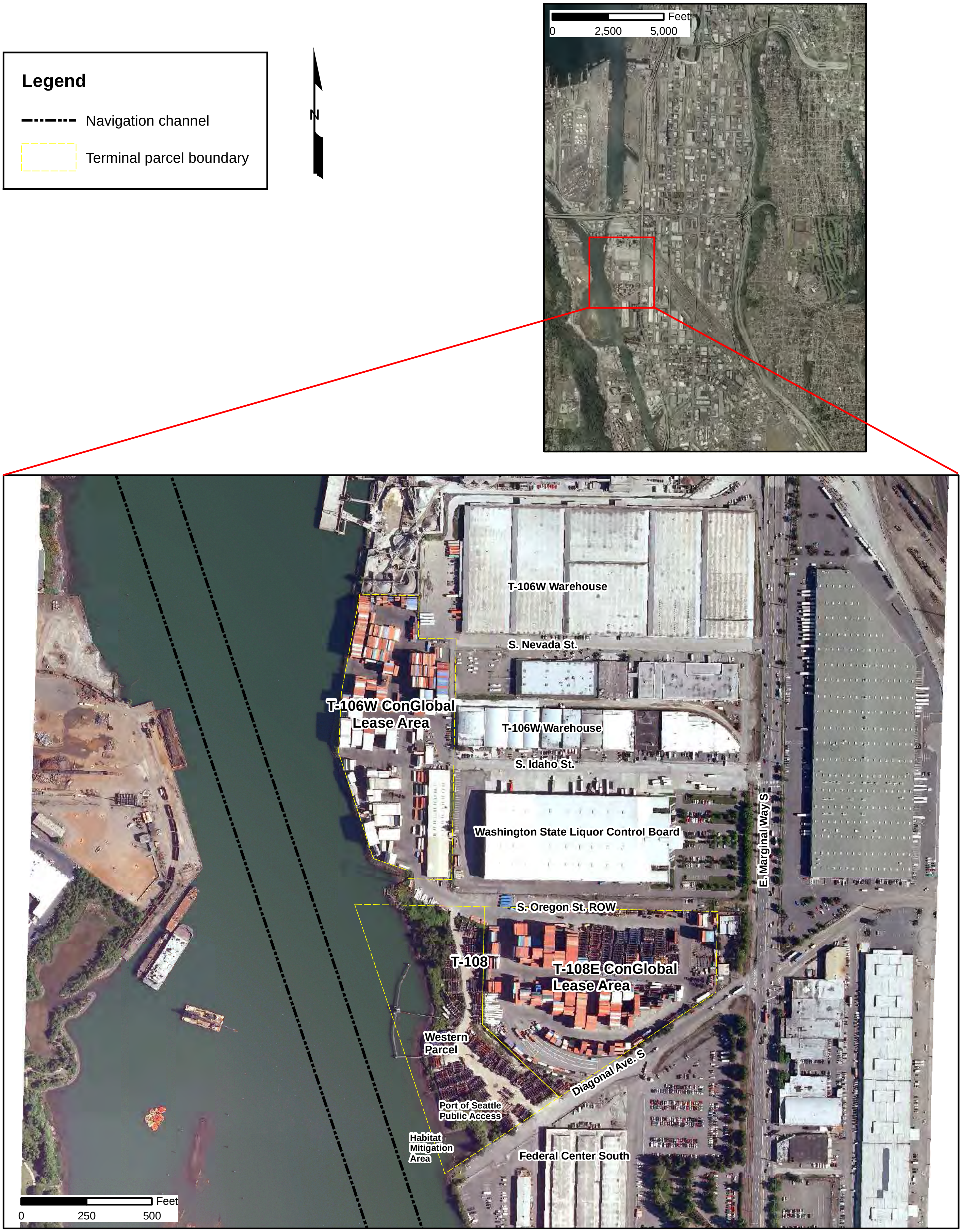
PAHs = Polycyclic Aromatic Hydrocarbons

TOC = Total Organic Carbon

[1] Practical Quantitation Limit, as given in Table 5 of the February 2008 *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008), unless otherwise noted.

[2] Limit of Quantification (LOQ), as given in *Quality Control Parameters for Metals Analysis using ICP-MS* (ARI 2011).

Figures



L:\Terminal 108\MXDs\Figure1_vicinity.mxd

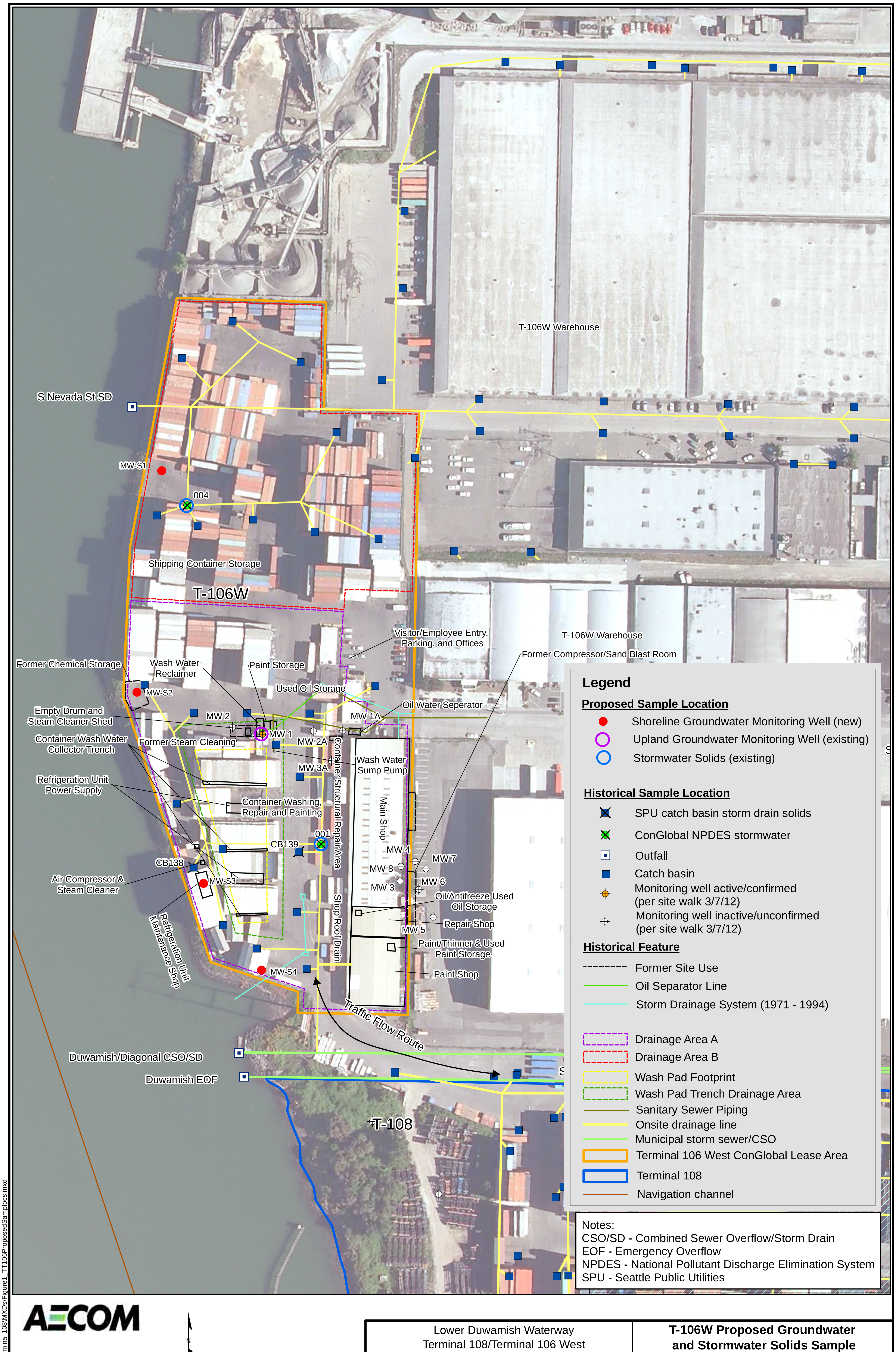
AECOM

Lower Duwamish Waterway
Terminal 108
60160448-0200.2.1

DATE:03/19/12 | DRWN:EM/sea | Revision: 0

Terminals 106W and 108 Location and Layout

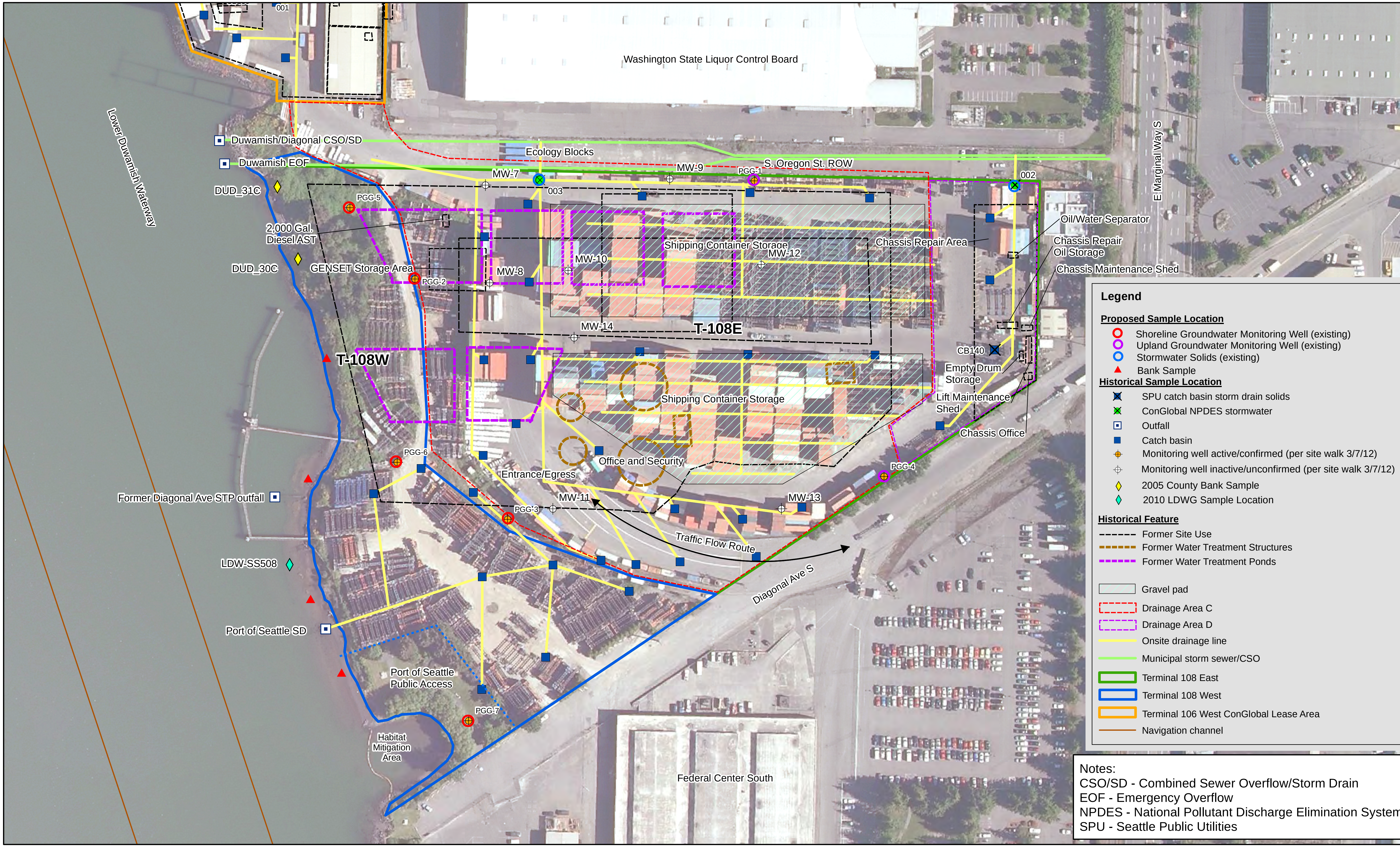
FIGURE 1-1



AECOM

L:\Terminal 108\MXDs\Figure1_TT106ProposedSamplocs.mxd

Lower Duwamish Waterway Terminal 108/Terminal 106 West 60160448-0200.2.1	T-106W Proposed Groundwater and Stormwater Solids Sample Locations
DATE: 05/07/12 DRWN: mvi/SEA Revision: 0	FIGURE 4-1



L:\Terminal 108\MXDs\Figure4-2_T108EProposedSamplocs.mxd

AECOM

Lower Duwamish Waterway
Terminal 108/Terminal 106 West
60160448-0200.2.1

T-108 Proposed Groundwater, Stormwater Solids, and Bank Sample Locations

DATE: 05/07/12 | DRWN: mvi/SEA | Revision: 0

FIGURE 4-2

Note: Photo as presented in *Portland Harbor RI/FS, Round 3A Field Sampling Plan – Stormwater Sampling*.

AECOM

Lower Duwamish Waterway
Terminal 108/Terminal 106 West

60160448-0200.2.1

Sediment Trap Example

Figure 4-3

Appendix A

Project Organization and Responsibilities

A. Project Organization and Responsibilities

The specific roles, activities, and responsibilities of project participants are described in this section. The sampling and analysis project team and contact information are presented in Table 3-1 of the main text. AECOM is the primary consultant for the Port and is responsible for the activities associated with implementing this field investigation.

A.1 Project Team

The following roles have been identified for the T-108E and T-106W SCSP data gap field investigation. Detailed responsibilities for each role are listed below.

A.1.1 Project Manager

The Project Manager (Shannon Ashurst) will:

- Be responsible for supporting the safety culture and monitoring the implementation/enforcement of the health and safety plan;
- Be responsible for coordinating and delegating the project process;
- Be responsible for quality and consistency in the SAP and final report;
- Provide support and oversight in the communication of technical issues related to the project;
- Provide support and oversight in the development and compliance of project scope, schedule, and budget;
- Act as lead communicator for technical issues related to the project;
- Be responsible for managing personnel and orienting staff to the procedures and requirements of the project;
- Be responsible for subcontractors;
- Be responsible for managing field and office task managers;
- Be responsible for planning and managing project resources, including the scope, schedule and budget;
- Be responsible for managing project deliverables;
- Be responsible for ensuring quality, consistency, responsiveness, and timeliness in project work; and
- Be responsible for supporting the safety culture and monitoring the implementation/enforcement of the health and safety plan.

A.1.2 Quality Control Manager

The Quality Control Manager for this project (Clarence Lo) will review and document project performance as it relates to the SAP. As appropriate, the Quality Control Manager will:

- Ensure that the specified field, analytical, and data management procedures are followed and documented, and meet project objectives;
- Coordinate laboratory analyses;

- Schedule and oversee data review, management, and validation; retain laboratory audit records; and follow up on corrective actions; and
- Manage and prepare project deliverables.

A.1.3 Field Manager

The Field Manager (Mindy Graddon) will support the Project Manager. The Field Manager is responsible for implementing and coordinating the day-to-day activities of the field team, including health and safety in the field. The Field Manager will report directly to the Project Manager and will:

- Be responsible for providing day-to-day direction and coordination of field activities associated with the project;
- Be responsible for ensuring quality, consistency, responsiveness, and timeliness in field activities;
- Implement field-related SAP and schedules;
- Implement quality assurance/quality control (QA/QC) for technical data provided by the field staff, including field-measurement data;
- Conduct peer reviews of the field performance and reporting products of field crews;
- Write and approve text and graphics required for field-team effort;
- Coordinate and oversee technical efforts of subcontractors assisting the field team;
- Identify problems at the field-team level, resolve issues in consultation with the Assistant Project Manager, implement and document corrective action procedures, and communicate with team members and upper management;
- Be responsible for supporting the safety culture and monitoring the implementation/enforcement of the health and safety plan; and
- Participate in preparation of the project deliverables.

A.1.4 Health and Safety Officer

The Health and Safety Officer (Mindy Graddon) will be responsible for the health and safety aspects of this project.

A.1.5 Subcontractors

Subcontractors will assist with various aspects of this project. Cascade Drilling, LP (Cascade) will provide drilling services for sample collection, with Jaymen Lauer serving as the point of contact. Analytical Resources Inc. (ARI) will provide chemistry analyses; Cheronne Oreiro is the point of contact. It is expected that all surveying will be conducted by the Port. In the event that the Port cannot conduct certain surveys, True North Land Surveying will provide the necessary survey expertise. Cardno TEC (TEC) may provide sediment trap installation and monitoring services; Curtis Nickerson is the point of contact.

A.2 Special Training Requirements/Certification

Specific training requirements for performing fieldwork are as follows:

- All field personnel must have successfully completed 40 hours of training for hazardous site work in accordance with Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120(e)(3) and be current with their 8-hour refresher training in accordance with OSHA 29 CFR 1910.120(e)(8). Documentation of OSHA training is required prior to personnel being permitted to work on project.
- Personnel managing or supervising work on project will also have successfully completed 8 hours of manager/supervisor training meeting the requirements of OSHA 29 CFR 1910.120(e)(4).
- Personnel must be enrolled in a medical surveillance program meeting the requirements of OSHA 29 CFR 1910.120(f). Personnel must have successfully passed an occupational physical during the past 12 months and be medically cleared to work on a hazardous waste site and capable of wearing appropriate personal protective equipment (PPE) and respiratory protection as may be required.
- Personnel who must wear a respirator must be familiar with the OSHA respiratory standard (29 CFR 1910.134). Personnel who are required to wear respirator protection must have successfully passed a respirator fit test within the last 12 months.

It is the responsibility of the employing organization to provide its employees with the required training, medical monitoring, and fit testing prior to assigning them field work for this project. Each employing organization will be responsible for providing documentation of these requirements to the AECOM Project Manager or Field Manager prior to initiating field activities.

In addition, AECOM personnel will coordinate scheduling, drilling locations, sampling locations and waste storage locations with ConGlobal prior to and during mobilization and field work. Proper notification will ensure all active parties are involved with any site-specific health and safety considerations each day. Specific health and safety concerns regarding the Site include the proximity to stacked containers, large truck traffic, and other site operations. These concerns will be specifically addressed in the HASP.

Appendix B

Field Forms

710 2nd Ave Suite 1000 Seattle, WA

Daily Tailgate H&S Meeting Attendance Sheet

AECOM Project No.:______________________ Client Site No.:______________________

Project Name:______________________ Project Activities:______________________

Presented By:______________________ Date:______________________

Topics Discussed:	**Topics Discussed:**
☐ Contents of Site HASP	☐ Incidents need to be reported as soon as possible.
☐ Review JSAs/JLAs	
☐ Stop Work Authority	
☐ Site Safety Officer:	

Required PPE:

☐ Steel Toe Boots ☐ Hard Hat ☐ Traffic Vest	**Emergency Procedures:** Meeting Location:	**General Housekeeping:** ☐ Clean as We Go ☐ Location to Store Drums:
☐ Safety Glasses ☐ Nitrile Gloves	Nearest Hospital:	**Weather:**
☐ Hearing Protection ☐ Long Sleeves ☐ Long Pants ☐ Knee Pads ☐ Other:	**Safety Equipment Locations:** ☐ First Aid Kit: ☐ Eye Wash Station: ☐ Fire Extinguisher:	**Traffic Control Plan:** ☐ Cones/Barricades ☐ Other:
Contaminants of Concern: ☐ Petroleum Products ☐ Other:	**Driving:** ☐ Accidents are costly ☐ Back up safely ☐ Cell phone use not permitted ☐ All Onsite Equipment / Vehicles Inspected Prior to Work	**Physical Hazards:** ☐ Slips, Trips and Falls ☐ Safe Lifting Technique ☐ Pinch Points ☐ Biological ☐ Other:

☐ Site Specific Hazards: ____

Attendees:

Name	Signature	Company

Field Activity Log

Page: of

Project Name:
Project Number:
Field Activity:

Completed By:
Date:
Weather:
Personnel on site:

Boring ID:
Sheet 1 of

AECOM
Soil Boring Log

Project:	**Contractor:**	**Boring Location:**
Project #:	**Operator:**	
Location:	**Rig Type:**	
Client:	**Method:**	
Start Date and Time:	**Sampling Method:**	
End Date and Time:	**Boring Diameter:**	
Geologist:	**Total Depth:**	
	Water Level:	

							Coarse Grained Soils Only				**Fine Grained Soils Only**										
Depth	**Blow counts**	**% Recovery**	**PID (ppm)**	**Group Symbol/ Group Name**	**Color**	**Content**	**Grain Size**	**Grain Angularity**	**Particle Shape**	**Compactness**	**Dilatency**	**Toughness**	**Plasticity**	**Dry Strength**	**Consistency**	**Moisture**	**Structure**	**Odor - strength and type**	**Sheen - Type**	**Additional Comments (Reaction with HCl, cementation of intact coarse-grained soils etc)**	**Sample Interval/ Sample ID Number**

Form Version: 1
Reviewed By: Renee Knecht
Last Revision: 8/3/2007

Boring ID:
Sheet of

AECOM
Soil Boring Log

							Coarse Grained Soils Only				Fine Grained Soils Only										
Depth	Blow counts	% Recovery	PID (ppm)	Group Symbol/ Group Name	Color	Content	Grain Size	Grain Angularity	Particle Shape	Compactness	Dilatency	Toughness	Plasticity	Dry Strength	Consistency	Moisture	Structure	Odor - strength and type	Sheen - Type	Additional Comments (Reaction with HCl, cementation of intact coarse-grained soils etc)	Sample Interval/ Sample ID Number

Form Version: 1
Reviewed by: Renee Knecht
Last Revision: 8/3/2007

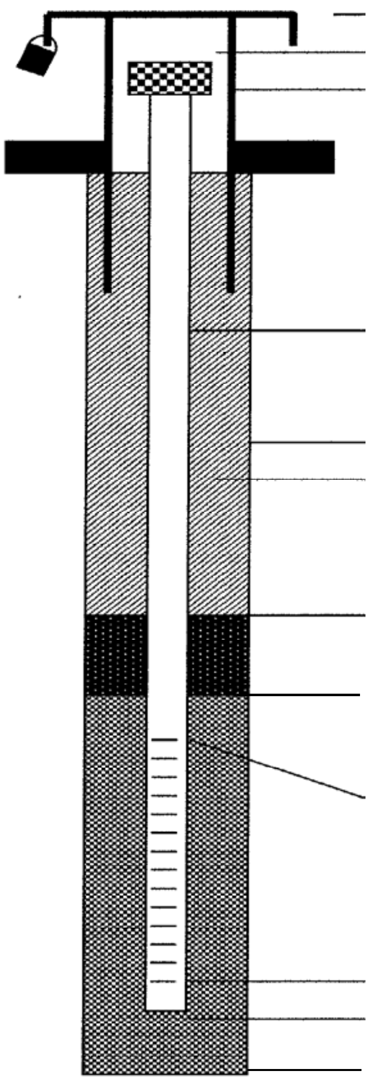
AECOM

Monitoring Well Installation Report

Date of Installation ______________________ Monitoring Well No. __________

Drilling Company ______________________

Field Geologist ______________________



Elevation of Top of Protective Casing____________________

Elevation of Top of Riser Pipe__________________________

I.D. of Protective Casing______________________________

Type of Protective Casing_____________________________

Ground Surface Elevation_____________________________

I.D. of Riser Pipe___________________________________

Type of Riser Pipe__________________________________

Diameter of Borehole________________________________

Type of Backfill_____________________________________

Grout Ratio____

Depth to Top of Seal_________________________________

Type of Seal____

Depth to Top of Sand ________________________________

Type of Sand ____

Depth to Top of Screen_______________________________

I.D. of Screen_______________________________________

Type of Screen______________________________________

Depth to Bottom of Screen____________________________

Depth to Bottom of Sediment Trap_____________________

Depth to Bottom of Sand______________________________

Depth to Bottom of Borehole__________________________

<u>Groundwater Levels</u>

Initial During Drilling_________________________

Upon Completion of Well______________________

WELL DEVELOPMENT LOG

PROJECT NAME ______________________ **WELL NO.** ______________________

PROJECT NO. ______________________ **MONITORED BY** ______________________

DATE ______________________ **WEATHER** ______________________

WELL INFORMATION		
DEPTH TO WATER	(TOC-ft)	
	(wl.prot.-ft)	
DEPTH OF WELL	(ft)	
WELL DIAMETER	(inches)	
FEET OF WATER		
PRODUCT THICK	(ft)	
WELL CONDITION		
WEATHER		

PURGE DATA											
START PURGE TIME:											
TIME											
VOLUME PURGED	(gal)										
DTW	(Ft-TOC)										
FLOW RATE	(gal/min)										
TDS	(g/L)										
pH (units)	(units)										
CONDUCTIVITY	(umhos/cm)										
TEMPERATURE	(deg C)										
ORP	(mv)										
D. O.	(mg/L)										
TURBIDITY	(NTU)										
PURGE EQUIPMENT:											

ADDITIONAL INFORMATION:

TOC=Top of well casing

wl.prot.=top of well protector

comments:

GROUNDWATER SAMPLING LOG

PROJECT NAME	**WELL NO.**
PROJECT NO.	**SAMPLED BY**
DATE / /	**WEATHER**

WELL INFORMATION		
DEPTH TO WATER	(ft) TOC	
DEPTH OF WELL	(ft)	
WELL DIAMETER	(inches)	
FEET OF WATER		
WELL CONDITION		
PUMP ADJUSTMENT	(ft)	**NOTE: Only on Shallow Wells**

Comments

PURGE DATA													
START PURGE TIME:													
TIME													
DTW	(Ft-TOC)												
FLOW RATE	(mL/min)												
TEMPERATURE	(°C)												
CONDUCTIVITY	(uS/cm)												
D. O.	(mg/L)												
pH (units)	(units)												
ORP	(mv)												
TURBIDITY	(NTU)												
PURGE DATA Continued from Above													
TIME													
DTW	(Ft-TOC)												
FLOW RATE	(mL/min)												
TEMPERATURE	(°C)												
CONDUCTIVITY	(uS/cm)												
D. O.	(mg/L)												
pH (units)	(units)												
ORP	(mv)												
TURBIDITY	(NTU)												
PURGE AND SAMPLE EQUIPT:													

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
MW-					
MW-					

ADDITIONAL INFORMATION:

TOC=Top of well casing
wl.prot.=top of well protector
Turbidity: Less than 5 NTU or +/- 10%
DO: +/-10%
Sp Cond: +/- 3%
Temp: +/- 3%
pH: +/- 0.1 standard units
ORP: +/- 10 millivolts

Additional comments:

AECOM

Drum Log

Page ___ of ___

Project Name: ____________________ Completed By: ____________________

Project Number: ____________________ Date Range: ____________________

Field Activity: ____________________ Type of Drum: ____________________

Drum # or other designation	Contents (soil, water, etc)	Date	Origin of Materials (Boring/Well ID #)

Form updated 11-2010

PHOTOGRAPH LOG

AECOM

Project:
Project No.:
Client:

Sample Location:
Field Staff:
Camera (type, serial #):

Picture #	Date	Photographer Initials	Description / Notes

Appendix C

Standard Operating Procedures

Standard Operating Procedure (SOP) 235 Low Flow Groundwater Sampling

1.0 Purpose and Applicability

AECOM SOP 235 describes methods used to obtain the collection of valid and representative groundwater samples from monitoring wells utilizing a low flow sampling technique. This technique is designed to reduce the influx of particulate matter into the well and groundwater sample to ensure a more representative analysis of groundwater quality, and to reduce aeration that can affect geochemical parameters.

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Job Hazard Analysis (JHA), or Site-Specific Health & Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The field sampling coordinator will have responsibility to oversee and ensure that all groundwater sampling is performed in accordance with the project specific sampling program and this SOP. It shall be the responsibility of the field sampling coordinator to observe all activities pertaining to sampling to ensure that all the standard procedures are followed properly, and to record all pertinent data on a field log or field book. The collection, handling, and storage of all samples will be the responsibility of the field sampling coordinator. In addition, the field sampling coordinator must ensure that all field workers are fully apprised of this SOP.

3.0 Health and Safety

This section presents the generic hazards associated with low flow groundwater sampling and is intended to provide general guidance in preparing site-specific health and safety documents. The site-specific HASP and JHA will address additional requirements and will take precedence over this document. Note that low flow groundwater sampling usually requires Level D personal protection unless there is a potential for exposure to airborne site contaminants.

Health and safety hazards include but are not limited to the following:

- Slip, trips, and falls in tall grasses over obstacles and berms near well locations. Review terrain hazards prior to conducting these operations. Ensure there is a safe means of access/egress to the wellhead.

- Dermal exposure to potentially contaminated groundwater. Ensure that proper personal protective equipment (PPE) is used to mitigate the impact of splashes of groundwater to skin and/or eyes.

- Exposure to site contaminants. If there is product in the well (especially gasoline) take all precautions necessary to prevent fire/explosion and/or exposure to airborne vapors.

- Ergonomics. Use appropriate ergonomic techniques when inserting or retrieving equipment for the wells to preclude injury to the arms, shoulders or back.

4.0 Supporting Materials

The following list of equipment will be used to determine the depth to water, purged volume, and analytical parameters.

Sampling/Purging Equipment

- Low flow submersible bladder pump or peristaltic sampling pump
- Teflon and polyethylene tubing
- Water level measurement equipment

Field Analytical Parameter Measurement

- In-line water quality meter (e.g., flow-through cell)

- Water quality meter with individual temperature, pH, specific conductance, dissolved oxygen (DO), turbidity, salinity, and oxidation reduction potential (ORP) probes

- Turbidity meter

Supporting Documents

- Project specific Work Plan

- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants

- A copy of the Site-Specific HASP

- Field data sheets and log book

Decontamination Equipment

- Distilled water
- Isopropanol (laboratory grade)
- Spray bottles for decontamination solutions
- Chemical free paper towels

Sample Collection

- Preservation solutions (if necessary)
- Sample containers
- Coolers

Peristaltic Pump Sample Collection

- Generator and extension cord
- Battery packs

Bladder Pump Sample Collection

- Dedicated bladders
- Pump controller box
- Nitrogen (air supply)
- Detergent/Alconox
- Nitric or hydrochloric acid (laboratory grade)
- Cleaning brushes

Miscellaneous

- Disposable gloves
- Tubing cutters
- Plastic sheeting
- PPE
- Buckets and intermediate containers

5.0 Methods and Procedures

The following sections describe the methods and procedures required to collect representative groundwater samples.

5.1 Water Level Measurement

After unlocking and/or opening a monitoring well, the first task will be to obtain a water-level measurement. A static-water level will be measured in the well prior to the purging and collection of any samples. The water level is needed for estimating the purge volume and may also be used for mapping the potentiometric surface of the groundwater. Water-level measurements will be made using an electronic or mechanical device following the methods described in SOP 231.

Measurement of point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water level measuring point should be marked on the north side of the well casing and noted in the groundwater sampling form (Figure 1). Whatever measuring point is used, the location should be described on the groundwater sampling form.

To obtain a water level measurement lower a decontaminated mechanical or an electronic sounding unit into the monitoring well until the audible sound of the unit is detected or indicates water contact. At this time the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement. The water-level measurement should be entered on the groundwater sampling form. The water-level measurement device shall be decontaminated immediately after use following the procedures outlined in AECOM SOP 120 (Decontamination).

5.2 Purging and Sample Collection

5.2.1 Pumping

Purging must be performed for all groundwater monitoring wells prior to sample collection. The volume of water present in each well must be computed using two measurable lengths, length of water the water column and monitoring well inside diameter. A low flow, electric driven pump (e.g., bladder pump or peristaltic pump) will be used to purge and sample well water.

The inlet of the bladder pump or peristaltic pump tubing will be lowered into the well slowly and carefully to a depth corresponding with the approximate midpoint of the screened interval of the aquifer, or 1-2 feet below the water level in the well, whichever is greater. A depth-to-water measurement device will be lowered into the well to monitor drawdown. The pump will be turned on at a flow rate of about 0.1 liters per minute (L/min). The flow rate will be adjusted up or down to maximize flow, yet ensure minimum drawdown. In no instance should a drawdown of more than 0.5 foot be allowed. The water level in the well should be carefully monitored to ensure that draw down does not increase during purging.

If the well being sampled is newly installed and developed or has been redeveloped, sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24-hours after development to sample a new monitoring well. Wells developed with stressful measures (e.g., backwashing, jetting, compressed air, etc.) may require as long as a 7-day interval before sampling.

5.2.2 Field Parameters

Groundwater will be pumped from the well into a sealed, flow-through chamber containing probes to measure the water temperature, pH, turbidity, conductivity, ORP, and DO using a Water Quality Meter. Field measurements of turbidity will also be obtained using a turbidity meter for comparison purposes. It is essential to properly calibrate the Water Quality Meter for the specific parameters being monitored, according to the procedures identified in the instrument manual. Calibration procedures and results must be documented in the site field notebook.

Field parameters values will be recorded on the Groundwater Sample Collection Record (Figure 1) or in the site field notebook along with the corresponding purge volume. After passing through the flow-through chamber, the water will be discharged into a container of known volume where the pumping rate will be measured with a watch. When the container is full, the water will be properly disposed following Site protocols.

Groundwater samples will be collected for laboratory analysis when the groundwater has stabilized; the change between successive readings of temperature, pH and conductivity are less than 10%, and turbidity is reduced to 10 NTUs or less. This may occur prior to removal of three well volumes. Stabilization of groundwater measurements are considered indicative of sampling fresh formation water and is a more reliable indicator of purging than removal of a standard volume of water.

5.2.3 Decontamination

Decontamination of non-dedicated equipment will follow the procedures outlined in AECOM SOP 120 (Decontamination), or following the procedures listed below for full field decontamination, conducted in the order presented:

- Remove gross contamination from the equipment by brushing or steam cleaning
- Wash with non-phosphate soap/detergent solution
- Rinse with laboratory-grade nitric acid (for potential inorganic contamination)
- Rinse with tap water
- Rinse with laboratory grade isopropanol
- Rinse with tap water
- Rinse with distilled water
- Allow to air dry
- Repeat as necessary

Teflon tubing will be dedicated to each well and will, therefore, not require decontamination.

5.3 Sample Preparation

Proper packaging and shipment of samples will minimize the potential for sample breakage, leakage, or cross contamination and will provide a clear record of sample custody from collection to analysis. Information on sample custody and shipping is also detailed in AECOM SOP 110 (Packaging and Shipment of Samples). Samples will be packaged on ice and shipped in a container able to maintain a temperature at or below 4^{o}C.

6.0 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) requirements include, but are not limited to, blind field duplicates, blind rinsate blanks, and blind field blanks. These samples will be collected on a frequency of one QA/QC sample per 20 field samples or a minimum of one QA/QC sample per day unless otherwise specified in the project specific sampling plan.

7.0 Documentation

The groundwater sampling program will be documented to provide a summary of the sample collection procedures and conditions, shipment method, the analyses requested and the custody history. Such documentation shall include:

- Field notebook
- Groundwater sample collection record
- Sample labels
- Chain-of-custody forms
- Shipping receipts
- Health & Safety forms (JHA and/or Site-Specific HASP amendments)

All documentation shall be placed in the project files and retained following completion of the project.

GROUNDWATER SAMPLING LOG

PROJECT NAME		**WELL NO.**	
PROJECT NO.		**SAMPLED BY**	
DATE	/ /	**WEATHER**	

WELL INFORMATION		
DEPTH TO WATER	(ft) TOC	
DEPTH OF WELL	(ft)	
WELL DIAMETER	(inches)	
FEET OF WATER		
WELL CONDITION		
PUMP ADJUSTMENT	(ft)	**NOTE: Only on Shallow Wells**

Comments

PURGE DATA													
START PURGE TIME:													
TIME													
DTW	(Ft-TOC)												
FLOW RATE	(mL/min)												
TEMPERATURE	(°C)												
CONDUCTIVITY	(uS/cm)												
D. O.	(mg/L)												
pH (units)	(units)												
ORP	(mv)												
TURBIDITY	(NTU)												
PURGE DATA Continued from Above													
TIME													
DTW	(Ft-TOC)												
FLOW RATE	(mL/min)												
TEMPERATURE	(°C)												
CONDUCTIVITY	(uS/cm)												
D. O.	(mg/L)												
pH (units)	(units)												
ORP	(mv)												
TURBIDITY	(NTU)												
PURGE AND SAMPLE EQUIPT:													

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
MW-					
MW-					

ADDITIONAL INFORMATION:

TOC=Top of well casing
wl.prot.=top of well protector
Turbidity: Less than 5 NTU or +/- 10%
DO: +/-10%
Sp Cond: +/- 3%
Temp: +/- 3%
pH: +/- 0.1 standard units
ORP: +/- 10 millivolts

Additional comments:

Standard Operating Procedure (SOP) 1007
Chain of Custody Procedures

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1.0 SCOPE AND APPLICABILITY 3
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3.0 HEALTH AND SAFETY WARNINGS 3
4.0 INTERFERENCES 3
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10.0 REFERENCES 6

LIST OF ACRONYMS

COC	Chain-of-Custody
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes chain-of-custody (COC) procedures applicable to AECOM sampling and analysis programs.

2.0 SUMMARY OF METHOD

The National Enforcement Investigations Center of the U.S. Environmental Protection Agency (USEPA) defines custody of evidence in the following manner:

- It is in your actual possession;
- It is in your view, after being in your physical possession;
- It was in your possession and then you locked or sealed it up to prevent tampering; or
- It is in a secure area.

Samples are physical evidence and should be handled according to certain procedural safeguards described in of this SOP.

3.0 HEALTH AND SAFETY WARNINGS

Not applicable.

4.0 INTERFERENCES

Not applicable.

5.0 PERSONNEL QUALIFICATIONS

Individuals responsible for completing COC documentation must be personnel working on the specific field program, have read this SOP, and have worked under the oversight of experienced personnel.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Sample Labels
- COC Form
- COC Tape
- Field project logbook/pen

7.0 METHODS

7.1 Field Custody

7.1.1 The field personnel is required to complete the following information on the COC form:

- Project Number
- Client or Project Name
- Project Location
- Field Sample Identification Number
- Date and Time of Sample Collection
- Sample Matrix
- Preservative
- Analysis Requested
- Sampler's Signature
- Signature of Person Relinquishing Sample Custody
- Date and Time Relinquished
- Sampler Remarks
- COC Tape Number

7.1.2 The COC must be filled out completely and legibly in ink. Corrections will be made, if necessary, by drawing a single line through and initialing and dating the error. The correct information is then recorded with indelible ink. All transfers from field personnel to laboratory personnel are recorded on the COC form in the "Relinquished By" and "Received By" sections.

7.1.3 If samples are to be shipped by overnight commercial courier (e.g., Federal Express), the field personnel must complete a COC form for each package (e.g., cooler) of samples and place a copy of each completed form inside the associated package before the package is sealed. Each completed COC form must accurately list the sample identification numbers of the samples with which it is packaged, and must contain the identification number of the COC tape on the package. It is not necessary for the shipping company to sign the COC. Sample packaging will be conducted in accordance with AECOM SOP No. 7510 – Packaging and Shipment of Environmental Samples.

7.1.4 If samples are hand carried to a laboratory, the person hand carrying the samples is the sample custodian. If the carrier is a different person than the one who filled out the COC form and packaged the samples, then that person must transfer custody to the carrier by signing and dating each form in the "Relinquished By" section. The carrier must then sign and date each form in the adjacent "Received By" section. When the carrier transfers the samples to the laboratory, he or she must sign and date each form in the next "Relinquished By" section, and the laboratory sample custodian must sign and date each form in the adjacent "Received By" section.

7.2 Laboratory Sample Receipt and Inspection

7.2.1 Upon sample receipt, the coolers or packages are inspected for general condition and the condition of the COC tape. The coolers or boxes are then opened and each sample is inspected for damage.

7.2.2 Sample containers are removed from packing material and sample label field identification numbers are verified against the COC form.

7.2.3 The following information is recorded in the laboratory's records:

- Airbill Number
- Presence/absence of COC forms and COC tape
- Condition of samples
- Discrepancies noted
- Holding time and preservatives
- Sample storage location

7.2.4 The COC form is completed by signing and recording the date and time of receipt.

7.2.5 The AECOM Project Manager or designate must be notified of any breakage, temperature exceedances, or discrepencies between the COC paperwork and the samples.

8.0 DATA AND RECORDS MANAGEMENT

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion, and in the files of the laboratories that have performed the sample analyses.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

The records generated in this procedure are subject to review during data validation, in accordance with the Quality Assurance Project Plan (QAPP).

10.0 REFERENCES

AECOM SOP No. 7510 - Packaging and Shipment of Environmental Samples.

Standard Operating Procedure (SOP) 7720
Monitoring Well Construction and Installation

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APPENDICES

APPENDIX A - GLOSSARY

LIST OF ACRONYMS

FSP	Field Sampling Plan
HASP	Health and Safety Plan
IDW	Investigation Derived Waste
OSHA	Occupational Safety and Health Administration
PVC	Poly Vinyl Chloride
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) provides guidance for installing groundwater monitoring wells. Monitoring wells may be installed to monitor the depth to groundwater, to measure aquifer properties, and to obtain samples of groundwater for chemical analysis.

This SOP is applicable to installation of single monitoring wells within a borehole. The construction and installation of nested, multilevel or other special well designs is not proposed in the Field Sampling Plan (FSP), nor are the methods covered within this SOP.

2.0 SUMMARY OF METHOD

Monitoring well construction and installation generally involves drilling a borehole using conventional drilling equipment, installing commercially available well construction and filter/sealing materials, and development of the well prior to sampling. This SOP covers well construction and installation methods only. Well development methods are covered under AECOM SOP No. 7221 - Monitoring Well Development.

3.0 HEALTH AND SAFETY WARNINGS

Monitoring well installation may involve chemical hazards associated with exposure to materials in the groundwater being investigated and physical hazards associated with drilling equipment and installation methods. When monitoring wells are installed, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences could result from cross-contamination between borehole locations. Minimization of the cross-contamination will occur through the use of clean sampling tools at each location, which will require decontamination of sampling equipment as per AECOM SOP No. 7600 – Decontamination of Field Equipment.

Other potential interferences may be due to the well materials, or to interactions between well materials and the formation. Because the constituents being monitored for this project are primarily metals and inorganics, well materials in contact with groundwater to be sampled will be constructed of plastics and not metals. The process of installing a well necessarily disturbs the geologic formation. Wells will be developed appropriately as described in AECOM SOP No. 7221 – Monitoring Well Development. The wells will be allowed to stabilize a minimum of two weeks after development before a well is sampled.

Cross-contamination may result when surface water runoff or other materials enter the well from the ground surface. To minimize this, wells will be installed with stick-up casings wherever possible. Where such wells may be at risk of damage from traffice (i.e., near roadways), bumpers may be placed around the well to prevent them from being hit. Where flush-mount well completions are necessary, appropriate steps will be taken to reduce the potential for infiltration into the well as described below.

5.0 PERSONNEL QUALIFICATIONS

Well construction and installation requires a moderate degree of training and experience as numerous drilling situations may occur that will require field decisions to be made. It is recommended that inexperienced personnel be supervised for several well installations before working on their own. Geologists or personnel with geologic experience should supervise well installation. The geologic work performed under this SOP will be conducted under the direction of a professional geologist licensed to practice in Washington.

Field and subcontract personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

It is the responsibility of the field personnel to directly oversee the construction and installation of the monitoring well by the drilling subcontractor to ensure that the well installation specifications defined in the FSP are adhered to. It is also the responsibility of the field personnel to be familiar with the procedures outlined within this SOP, quality assurance, and the health and safety requirements outlined within the FSP, Quality Assurance Project Plan (QAPP), and HASP. Field personnel are responsible for monitoring wells being installed in a manner consistent with this SOP, that proper decontamination procedures are followed, as well as proper documentation in the field logbook or field forms (if appropriate).

It will be the responsibility of the drilling subcontractor to provide a trained operator and the necessary equipment for well construction and installation. Well construction materials should be consistent with project requirements as specified in the FSP.

It is the responsibility of the surveying subcontractor to provide one or more of the following well measurements as specified in the FSP: ground surface elevation, horizontal well coordinates, top of well casing elevation (i.e., top-of-casing, or measuring point elevation), and/or top of protective casing elevation.

6.0 EQUIPMENT AND SUPPLIES

6.1 Well Construction Materials

Well construction materials are usually provided by the drilling subcontractor. For this project, because the primary constituents to be analyzes are metals, the wells will consist of commercially available flush-threaded well screen and riser pipe constructed of poly vinyl chloride (PVC) with a minimum 2-inch inside diameter as specified in the FSP.

6.2 Well Completion Materials

Well completion materials include silica sand, bentonite, cement, protective casings, and locks. Completion materials are generally provided by the drilling subcontractor.

6.3 Other Required Materials

Other required materials include the following:

- Monitoring Well Construction Diagrams (Figure 1)
- Potable water supply
- Plastic sheeting
- Trash bags
- Paper towels
- Water level meter
- Waterproof marker or paint (to label wells)
- Equipment decontamination supplies (as required by AECOM SOP No. 7600 – Decontamination of Field Equipment)
- Health and safety supplies (as required by the HASP)
- Appropriate containers and materials to manage investigation-derived waste (IDW) (as specified in the FSP)
- Approved plans (e.g., HASP, FSP, QAPP)
- Field project logbook/pen

7.0 METHODS

7.1 General Preparation

7.1.1 Borehole Preparation

Standard drilling methods should be used by the drilling subcontractor under the supervision of field personnel to achieve the desired drilling/well installation depths specified in the FSP.

The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals. For this project, 2-inch diameter PVC well materials will be installed inside 6-inch diameter augers as specified in the FSP.

7.1.2 Well Material Decontamination

New well materials (well screen and riser pipe) generally arrive at the site boxed and sealed within plastic bags, so decontamination prior to use is not anticipated. However, well materials should be inspected by the field personnel upon delivery to check cleanliness. If the well materials appear dirty, then they should be decontaminated prior to use. Well casing and riser may be decontaminated by steam-cleaning by the drilling subcontractor in accordance with AECOM SOP No. 7600 – Decontamination of Field Equipment. For smaller materials such as caps, they may be decontaminated using detergent and water in accordance with AECOM SOP No. 7600 – Decontamination of Field Equipment.

7.2 Well Construction Procedure

7.2.1 Depth Measurement

Once the target drilling depth has been reached, the drilling subcontractor will measure the total open depth of the borehole with a weighted tape measure. Adjustments of borehole depth can be made at this time by drilling further or installing a small amount of sand filter material to achieve the desired depth. The water table depth may also be checked with a water level indicator if this measurement cannot be obtained with the weighted tape.

7.2.2 Well Construction

The well screen and riser pipe generally are assembled by hand as they are lowered into the borehole through the hollow-stem augers. Before the well screen is inserted into the borehole, the full length of the slotted portion of the well screen as well as the unslotted portion of the bottom of the screen should be measured with a measuring tape. These measurements should be recorded on the well construction diagram.

After the above measurements have been taken, the drilling subcontractor may begin assembling the well. As the assembled well is lowered, care should be taken to ensure that it is centered in the hole. The well should be temporarily capped or covered before filter sand and other annular materials are installed. The well should be set at the base of the borehole, and this should be confirmed by observation or measurement at the time of installation.

7.2.3 Filter Sand Installation

The drilling subcontractor should fill the annular space surrounding the screened section of the monitoring well to at least 1 foot above the top of the screen with an appropriately graded, clean sand or fine gravel. In general, the filter pack should not extend more than 3 feet above the top of the screen to limit the thickness of the monitoring zone. If coarse filter materials are used, an additional 1-foot thick layer of fine sand should be placed immediately above the filter pack to prevent the infiltration of sealing components (bentonite or grout) into the filter pack. As the filter pack is placed, a weighted tape should be lowered into the annular space to verify the depth to the top of the layer. Depending upon depth, some time may be required for these materials to settle. If necessary, to eliminate possible bridging or creation of voids, placement of the sand pack may require the use of a tremie pipe. Tremie pipe sandpack installations are generally suggested for deep water table wells and for wells that are screened some distance beneath the water table. The augers should be gradually removed from around the well as the sand pack is being installed.

7.2.4 Bentonite Seal Installation

A minimum 2-foot thick layer of bentonite pellets or slurry seal will be installed by the drilling subcontractor immediately above the well screen filter pack in all monitoring wells. The purpose of the seal is to provide a barrier to vertical flow of water in the annular space between the borehole and the well casing. Bentonite is used because it swells significantly upon contact with water. Pellets or chips generally can be installed in shallow boreholes by pouring them very slowly from the surface. If they are poured too quickly, they may bridge at some shallow, undesired depth. As an option, powdered bentonite may be mixed with water into a thick slurry and a tremie pipe can be used to inject the material at the desired depth. The bentonite materials will be hydrated by adding water to them after they have been placed in the borehole.

7.2.5 Annular Grout Seal Installation

The remainder of the annular space between the bentonite seal and the ground surface will be filled with grout. This grout seal should consist of a bentonite/cement mix with a ratio of bentonite to cement of between 1:5 and 1:20. The grout ratio should be chosen by the drilling subcontractor based on site conditions with a higher percentage of bentonite generally used for formations with higher porosity. The grout material will be mixed with water and placed into the borehole using a tremie pipe.

The borehole annulus will be grouted with seal materials to within 3 feet of the ground surface. Drill cuttings will not be used as backfill material.

7.2.6 Well Completion

The drilling subcontractor will cut the top of the well to the desired height and install a locking cap. Well casings are usually cut to be a certain height above ground surface (typically 2.5 to 3 feet) or are cut to be flush with the ground surface, depending on the well location.

7.2.7 Protective Casing/Concrete Pad Installation

The drilling subcontractor will install a steel guard pipe on the well as a protective casing. A 2-foot by 2-foot cement apron will be installed to hold the protective casing (i.e., road boxes or stand up casing) in place. The surface of the concrete pad will be sloped so that drainage occurs away from the well. Flush-mount protective casings may not require an extensive concrete pad and should be completed such that they are slightly mounded above the surrounding surface to prevent surface water from running over or ponding on top of the casing. It should be noted that in areas subject to snowfall, flush-mount casings may have to be installed so that they are entirely flush with the ground surface as they may be damaged by snow plows.

Above-ground protective casings should also be vented or should have non-air tight caps. Road box installations should not be vented. Installation of additional guard pipes may be necessary around above-ground well completions in traffic areas. All new monitoring wells will include a locking well cap with locks that are keyed alike.

7.2.8 Well Numbering

The field personnel will number each well casing with an indelible marker or paint to identify the well. This is particularly important with nested or paired wells to distinguish between shallow and deep wells. The well should be labeled on both the outside of the protective casing and inside beneath the protective casing lid. Well identification numbers will be as specified in the FSP.

7.2.9 Measuring Point Identification

The project field personnel will mark the measuring point from which water level measurements will be made at the upper edge of the well casing. PVC wells can easily be notched with a pocket knife or saw, or can be marked with a waterproof marker on the outside of the well casing with an arrow pointing to the measuring point location. The measuring point is the point that will require surveying during the well elevation survey task.

7.2.10 Well Measurements

Upon completion, the following well measurements should be taken by field personnel and recorded on the Monitoring Well Construction Diagram (Figure 1):

- Depth to static water level if water level has stabilized (refer to AECOM SOP No. 101 – Water Level Measurements),
- Total length of well measured from top-of-well casing (refer to AECOM SOP No. 101 – Water Level Measurements),
- Height of well casing above ground surface,
- Height of protective casing above ground surface,
- Depth of bottom of protective casing below ground surface (may be estimated).

Well screen filter pack, bentonite seal and annular seal thicknesses and depths should also be recorded on the Monitoring Well Construction Diagram (Figure 1).

7.2.11 Disposal of Drilling Wastes

Drill cuttings and other disposable materials must be properly contained and disposed of. Site-specific requirements for collection and removal of these waste materials are outlined in the FSP. Containment of these materials should be performed by the drilling subcontractor.

7.2.12 Well Development

At some point after installation of a well and prior to use of the well for water level measurements or collection of water quality samples, development of the well shall be undertaken in accordance with AECOM SOP No. 7221 - Monitoring Well Development.

7.2.13 Well Elevation Survey

At the completion of the well installation program, all monitoring wells will be surveyed to provide, at a minimum, the location (x and y coordinates), and the top-of-casing measuring point elevation for water level monitoring purposes. Other surveyed points required by the FSP include ground surface elevation, top of protective casing elevation, and well coordinate position. Well elevation surveys will be conducted by a surveying subcontractor in accordance with the FSP.

8.0 DATA AND RECORDS MANAGEMENT

All field information will be recorded in the field logbook or on a field collection form by field personnel. In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the well drilling and installation process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel should follow specific quality assurance guidelines as outlined in the QAPP and/or FSP.

Certain quality control measures should be taken to ensure proper well completion.

- The borehole will be checked for total open depth, and extended by further drilling or shortened by backfilling, if necessary, before any well construction materials are placed.

- The water level will be checked during well installation to ensure that the positions of well screen, sand pack, and seal relative to water level conform to project requirements.

- The depth to the top of each layer of packing (i.e., sand, bentonite, grout) will be verified and adjusted if necessary to conform to project requirements before the next layer is placed.

- If water or other drilling fluids (for example, to control running sands) have been introduced into the boring during drilling or well installation, samples of these fluids may be required for analysis of chemical constituents of interest.

10.0 REFERENCES

AECOM SOP No. 101 – Water Level Measurements.

AECOM SOP No. 7221 - Monitoring Well Development.

AECOM SOP 7600 – Decontamination of Field Equipment.

FIGURE 1 – Example Monitoring Well Construction Detail

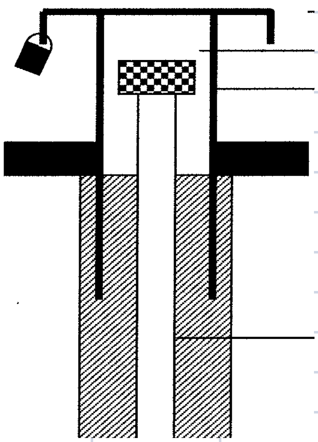
AECOM

Monitoring Well Installation Report

Date of Installation ______________________ Monitoring Well No. ________

Drilling Company ______________________

Field Geologist ______________________



Elevation of Top of Protective Casing____________________

Elevation of Top of Riser Pipe____________________

I.D. of Protective Casing____________________

Type of Protective Casing____________________

Ground Surface Elevation____________________

I.D. of Riser Pipe____________________

Type of Riser Pipe____________________

Diameter of Borehole____________________

Type of Backfill____________________

Grout Ratio____________________

Depth to Top of Seal____________________

Type of Seal____________________

Depth to Top of Sand ____________________

Type of Sand ____________________

Depth to Top of Screen____________________

I.D. of Screen____________________

Type of Screen____________________

Depth to Bottom of Screen____________________

Depth to Bottom of Sediment Trap____________________

Depth to Bottom of Sand____________________

Depth to Bottom of Borehole____________________

<u>Groundwater Levels</u>

Initial During Drilling____________________

Upon Completion of Well____________________

APPENDIX – GLOSSARY

Annulus: The measured width between the borehole wall and the outside of the well screen or riser pipe.

Bentonite Seal: A granular, chip, or pellet-size bentonite material that is often used to provide an annular seal above the well screen filter pack. This seal is typically installed dry followed by in-place hydration with or without the addition of water. Hydrated bentonite is sometimes used as a grout seal.

Bottom Cap/Plug: Threaded or slip-on cap placed at the bottom of the well prior to installation. Often serves as a sump for accumulation of silt which settles within the well. The measured length from the lowermost well screen slot to the bottom of the bottom cap is known as the sump or tail pipe portion of the well.

Expansion Cap/Well Cap: Cap used to cover the opening at the top of the well riser pipe. Expansion caps are equipped with a rubber gasket and threaded wing nut which, when turned, provides a watertight seal. Expansion caps may also be locked, and generally are recommended for use with flush-constructed wells where road box protective casings are also used. Other well caps may include slip-on or threaded caps made of the same material as the well casing.

Filter Pack: A well-graded, clean sand or gravel placed around the well screen to act as a filter in preventing the entry of very fine soil particles into the well.

Grout Seal: A cement/bentonite mixture used to seal a borehole that has been drilled to a depth greater than the final well installation depth or to seal the remaining borehole annulus once the well has been installed. Occasionally, pure cement or pure bentonite is used as a grout seal.

Measuring Point: A selected point at the top of the well casing (riser pipe) used for obtaining periodic water-level measurements. The measuring point should consist of either a notch or indelibly marked point on the upper surface of the casing. Typically, the highest point on the casing (if not level) is used as the measuring point. The measuring point is also the point that is surveyed when well elevation data is obtained.

Protective Casing: A locking metal casing, placed around that portion of the well riser pipe that extends above the ground surface. The protective casing is generally cemented in place when the concrete pad is constructed around the well.

Riser Pipe: The section of unperforated well casing material used to connect the well screen with the ground surface. Frequently, it is made of the same material and has the same diameter as the well screen. Riser pipe is typically available pre-cleaned and pre-threaded for immediate use.

Road Box: A protective casing that is flush-mounted with the ground around a well installation. Road boxes are used in areas where the monitoring well cannot extend above the ground surface for traffic or security reasons. Road boxes usually require a special key to open.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. Typically a well screen is purchased pre-slotted, pre-cleaned, and pre-threaded for immediate use.

Standard Operating Procedure (SOP) 7221
Monitoring Well Development

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APPENDICES

APPENDIX A - GLOSSARY

LIST OF ACRONYMS

FSP	Field Sampling Plan
HASP	Health and Safety Plan
IDW	Investigation Derived Waste
OSHA	Occupational Safety and Health Administration
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods used for developing newly installed monitoring wells and/or existing wells that may require redevelopment/rehabilitation. This SOP is applicable to any wells that require development in accordance with the Field Sampling Plan (FSP).

Monitoring well development and/or redevelopment is necessary for several reasons:

- To improve/restore hydraulic conductivity of the surrounding formations as they have likely been disturbed during the drilling process, or may have become partially plugged with silt;
- To remove drilling fluids (water, mud), when used, from the borehole and surrounding formations; and
- To remove residual fines from well filter materials and reduce turbidity of groundwater, therefore, reducing the chance of chemical alteration of groundwater samples caused by suspended sediments and provide representative groundwater samples.

2.0 SUMMARY OF METHOD

Well development generally involves withdrawal of an un-specified volume of water from a well using a pump, surge block or other suitable method such that, when completed effectively, the well is in good or restored hydraulic connection with the surrounding water bearing unit and is suitable for obtaining representative groundwater samples or for other testing purposes.

3.0 HEALTH AND SAFETY WARNINGS

Monitoring well development may involve chemical hazards associated with exposure to materials in the groundwater being investigated and physical hazards associated with use of well development equipment. When well development is performed, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences could result from cross-contamination between sample locations. Minimization of the cross-contamination will occur through the use of clean tools at each location, which will require decontamination of sampling equipment as per AECOM SOP No. 7600 – Decontamination of Field Equipment.

The process of installing a well necessarily disturbs the geologic formation. Wells will be developed appropriately as described in this SOP. The wells will be allowed to stabilize a minimum of two weeks after development before a well is sampled. In no cases will methods using air (e.g., air jetting) be used for well development on this project as they have a high potential to change geochemical conditions in the vicinity of the well.

5.0 PERSONNEL QUALIFICATIONS

Well development procedures vary in complexity. It is recommended that initial development attempts be supervised by more experienced personnel.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within the FSP, Quality Assurance Project Plan (QAPP), and HASP. Field personnel are responsible for proper well development, decontamination of equipment, as well as proper documentation in the field logbook or field forms (if appropriate).

6.0 EQUIPMENT AND SUPPLIES

Well development can be performed using a variety of methods and equipment. The specific method chosen for development of any given well is governed by the purpose of the well, well diameter and materials, depth, accessibility, geologic conditions, static water level in the well, and type of constituents present, if any.

The following list of equipment, each with their own particular application, may be used to develop and/or purge monitoring wells. In no cases will methods using air (e.g., air jetting) be used on this project as they have a high potential to change geochemical conditions in the vicinity of the well.

6.1 Bailer Purging

A bailer is used to purge silt-laden water from wells after using other devices such as a surge block. In some situations, the bailer can be used to develop a well by bailing and surging, often accompanied with pumping. A bailer can be used for purging in situations where the depth to static water is greater than 25 feet and/or where insufficient hydraulic head is available for use of other development methods.

6.2 Surge Block Development

Surge blocks are commercially available for use with Waterra™-type pumping systems or may be manufactured using a "plunger" attached to a rod or pipe of sufficient length to reach the bottom of the well. Well drillers usually can provide surge blocks if requested. A recommended design is shown in Figure 1.

6.3 Pump Development

A pump is often necessary to remove large quantities of silt-laden ground water from a well after using the surge block. In some situations, the pump alone can be used to develop the well and remove the fines by overpumping. Because the purpose of well development is to remove suspended solids from a well and the surrounding filter pack, the pump must be capable of moving some solids without damage. The preferred pump is a submersible pump, which can be used in both shallow and deep ground water situations. A centrifugal pump may be used in shallow wells, but will work only where the depth to static ground water is less than approximately 25 feet. Pumping may not be successful in low-yielding aquifer materials or in wells with insufficient hydraulic head.

6.4 Other Required Materials:

- Well Development Records (Figure 2)
- Boring and well construction logs (if available)
- Utility knife
- Plastic sheeting
- Buckets
- Paper towels
- Trash bags
- Power source (generator or 12-volt marine battery)
- Water level meter and/or well depth measurement device
- Water quality instrumentation to measure turbidity (i.e., nephelometer)
- Instrument calibration solutions
- Equipment decontamination supplies (as required by AECOM SOP No. 7600 – Decontamination of Field Equipment)
- Health and safety supplies (as required by the HASP)

- Appropriate containers and materials to manage investigation-derived waste (IDW) (as specified in the FSP)
- Approved plans (e.g., HASP, QAPP, FSP)
- Field project logbook/pen

7.0 METHODS

7.1 General Preparation

Well completion diagrams should be reviewed to determine well construction characteristics. Formation characteristics should also be determined from review of available boring logs.

Well development, similar to groundwater sampling, should be conducted in as clean an environment as possible. This usually requires, at a minimum, placing sheet plastic on the ground to provide a clean working area for development equipment.

Provisions should be in place for collection and management of IDW, specifically well development water and miscellaneous expendable materials generated during the development process. The collection of IDW in drums or tanks may be required depending on project-specific requirements. The FSP specifies the requirements for IDW containment.

The water level and well depth should be measured in accordance with AECOM SOP No. 101 – Water Level Measurements and written on the Well Development Record (Figure 2). This information is used to calculate the volume of standing water (i.e., the well volume) within the well.

Drilling fluids such as mud or water, if used during the drilling and well installation process, should be removed during the well development procedure. It is recommended that a minimum of 1.5 times the volume of added fluid be removed from the well during development. If the quantity of added fluid is not known or cannot be reasonably estimated, removal of a minimum of 10 well volumes of water is recommended during the development procedure.

7.2 Development Procedure

7.2.1 Development Method Selection

The construction details of each well shall be used to define the most suitable method of well development. Some consideration should be given to the potential concentrations of constituents in each well as this will impact IDW containment requirements.

The criteria for selecting a well development method include well diameter, total well depth, static water depth, screen length, the likelihood and potential concentrations of constituents, and characteristics of the geologic formation adjacent to the screened interval.

The limitations, if any, of a specific procedure are discussed within each of the following procedures.

7.2.2 General Water Quality Measurements (optional)

Measurements for water quality parameters such as specific conductance may be monitored periodically during development using the available water quality instruments (e.g., AECOM SOP No. 105 - Operation and Calibration of the YSI Multi-Parameter Water Quality Monitor). These measurements may be used to determine whether or not well development is proceeding efficiently, determine whether or not the development process is effective with any given well and, potentially, may identify well construction irregularities (i.e., grout in well, poor well screen slot-size selection). Water quality parameters will be recorded on the Well Development Record (Figure 2).

7.2.3 Turbidity

Turbidity will be monitored during well development to monitor the progress of development (see AECOM SOP No. 108 – Field Measurement of Turbidity. Visual observations on turbidity, such as silty or cloudy water, should be noted in the Well Development Record (Figure 2). Turbidity should also be measured quantitatively using a nephelometer. Turbidity should be measured a minimum of three times during development, including at the completion of development. All turbidity readings will be recorded in the Well Development Record (Figure 2).

7.2.4 Bailer Procedure

As stated previously, bailers shall preferably not be used for well development but may be used in combination with a surge block to remove silt-laden water from the well.

- When using a bailer to purge well water; select the appropriate bailer, then tie a length of bailer cord onto the end of it.

- Lower the bailer into the screened interval of the monitoring well. Silt, if present, will generally accumulate within the lower portions of the well screen.

- The bailer may be raised and lowered repeatedly in the screened interval to further simulate the action of a surge block and pull silt through the well screen.

- Remove the bailer from the well and empty it into the appropriate storage container.

- Continue surging/bailing the well until sediment-free water is obtained. If moderate to heavy siltation is still present, the surge block procedure should be repeated and followed again with bailing. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters, periodically.

7.2.5 Surge Block Procedure

A surge block effectively develops most monitoring wells. This device first forces water within the well through the well screen and out into the formation, and then pulls water back through the screen into the well along with fine soil particles. Surge blocks may be manufactured to meet the design criteria shown in the example (Figure 1) or may be purchased as an adaptor to fit commercially available well purging systems such as the Waterra™ system.

- Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen using the water column to transmit the surge action to the screened interval. A slow initial surging, using plunger strokes of approximately 3 feet, will allow material that is blocking the screen to separate and become suspended.

- After 5 to 10 plunger strokes, silt-laden water will be removed from the well using a pump integrated with the surge block, or removing the surge block to purge the well using a pump or bailer. The returned water should be heavily laden with suspended silt and clay particles. Discharge the purged water into the appropriate storage container.

- Repeat the process. As development continues, slowly increase the depth of surging to the bottom of the well screen. For monitoring wells with long screens (greater than 10 feet) surging should be undertaken along the entire screen length in short intervals (2 to 3 feet) at a time. Continue this cycle of surging and purging until the water yielded by the well is free of visible suspended material. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters periodically.

7.2.6 Pump Procedure

Well development using only a pump is most effective in monitoring wells that will yield water continuously. Theoretically, pumping will increase the hydraulic gradient and velocity of groundwater near the well by drawing the water level down. The increased velocity will move residual fine soil particles into the well and clear the well screen of this material. Effective development cannot be accomplished if the pump has to be shut off to allow the well to recharge.

- When using a submersible pump or surface pump, set the intake of the pump or intake line in the center of the screened interval of the monitoring well.

- Pump a minimum of three well volumes of water from the well and raise and lower the pump line through the screened interval to remove any silt/laden water.

- Continue pumping water from the well until sediment-free water is obtained. This method may be combined with the manual surge block method if well yield is not rapid enough to extract silt from the surrounding formations. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters periodically.

7.3 Equipment Decontamination

All equipment that comes into contact with groundwater (e.g., surge block) will be decontaminated in accordance with AECOM SOP No. 7600 – Decontamination of Field Equipment before moving to the next location. The bailer should be properly discarded and disposed of in accordance with procedures for managing IDW outlined in the FSP.

8.0 DATA AND RECORDS MANAGEMENT

All field information will be recorded in the field logbook or on a field collection form by field personnel. In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the development process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel should follow specific quality assurance guidelines as outlined in the Quality Assurance Project Plan (QAPP) and/or FSP.

A well will have been successfully developed when one or more of the following criteria are met:

- The sediment load in the well has been eliminated or greatly reduced. Use of a nephelometer is required during the well development procedure to measure water turbidity if meeting a specific turbidity value is required by the FSP. Attaining low turbidity values in fine-grained formations may be difficult to achieve.

- If it is not possible to reduce turbidity to acceptable levels, the well will be developed for a maximum of four hours.

10.0 REFERENCES

AECOM SOP No. 105 - Operation and Calibration of the YSI Multi-Parameter Water Quality Monitor.

AECOM SOP No. 108 – Field Measurement of Turbidity.

AECOM SOP No. 101 – Water Level Measurements.

AECOM SOP No. 7600 – Decontamination of Field Equipment.

FIGURE 1 – RECOMMENDED SURGE BLOCK DESIGN

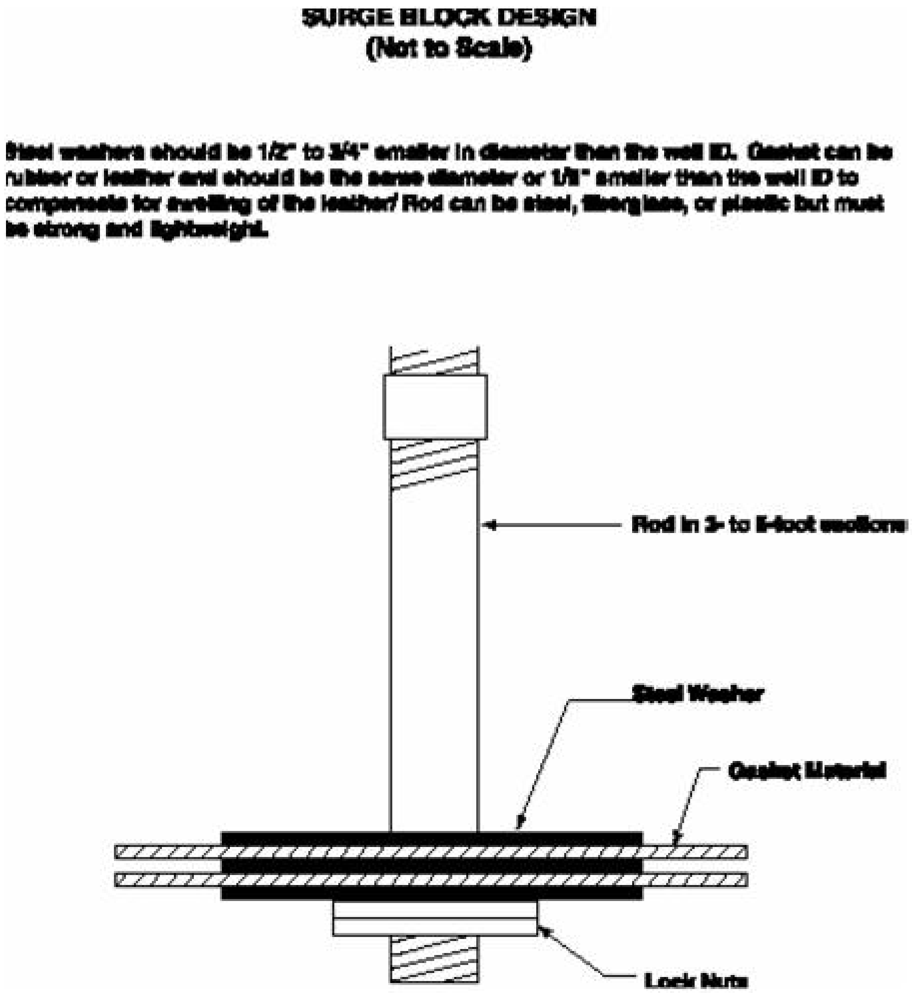

FIGURE 2 – EXAMPLE WELL DEVELOPMENT RECORD

WELL DEVELOPMENT LOG

PROJECT NAME		**WELL NO.**	
PROJECT NO.		**MONITORED BY**	
DATE		**WEATHER**	

WELL INFORMATION		
DEPTH TO WATER	(TOC-ft)	
	(wl.prot.-ft)	
DEPTH OF WELL	(ft)	
WELL DIAMETER	(inches)	
FEET OF WATER		
PRODUCT THICK	(ft)	
WELL CONDITION		
WEATHER		

PURGE DATA											
START PURGE TIME:											
TIME											
VOLUME PURGED	(gal)										
DTW	(Ft-TOC)										
FLOW RATE	(gal/min)										
TDS	(g/L)										
pH (units)	(units)										
CONDUCTIVITY	(umhos/cm)										
TEMPERATURE	(deg C)										
ORP	(mv)										
D. O.	(mg/L)										
TURBIDITY	(NTU)										
PURGE EQUIPMENT:											

ADDITIONAL INFORMATION:

TOC=Top of well casing

wl.prot.=top of well protector

comments:

APPENDIX A – GLOSSARY

Bridging: A condition within the filter pack outside the well screen whereby the smaller particles are wedged together in a manner that causes blockage of pore spaces.

Hydraulic Conductivity: a characteristic property of aquifer materials which describes the permeability of the material with respect to flow of water.

Hydraulic Connection: A properly installed and developed monitoring well should have good hydraulic connection with the aquifer. The well screen and filter material should not provide any restriction to the flow of water from the aquifer into the well.

Permeability Test: Used to determine the hydraulic conductivity of the aquifer formation near a well screen. Generally conducted by displacing the water level in a well and monitoring the rate of recovery of the water level as it returns to equilibrium. Various methods of analysis are available to calculate the hydraulic conductivity from these data.

Static Water Level: The water level in a well that represents an equilibrium or stabilized condition, usually with respect to atmospheric conditions in the case of monitoring wells.

Well Surging: That process of moving water in and out of a well screen to remove fine sand, silt and clay size particles from the adjacent formation.

Well Purging: The process of removing standing water from a well to allow surrounding formation water to enter the well.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. The perforated, or slotted, portion of a well is also known as the screened interval.