COMPLIANCE MONITORING PLAN
TERMINAL 91 TANK FARM CLEANUP

PORT OF SEATTLE
SEATTLE, WASHINGTON

July 11, 2013

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This Compliance Monitoring Plan has been prepared on behalf of the Port of Seattle for the Washington State Department of Ecology by the following licensed professionals:

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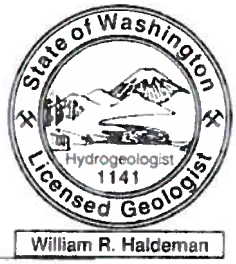

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TABLE OF CONTENTS

CONTENTS (Continued)

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ACRONYMS AND ABBREVIATIONS

1998 AO	Agreed Order No. DE 98HW-N108
2010 AO	Agreed Order No. DE-7321
2012 AO	Agreed Order No. DE 8938
ACM	Asbestos-Containing Materials
AO	Agreed Order No. DE 8938
AOC	Area of Concern
BD	Bridge Document
bgs	Below Ground Surface
BMPs	Best Management Practices
BNSF	Burlington Northern Santa Fe
CAO	Cleanup Action Objective
CAP	Cleanup Action Plan
Chempro	Chemical Processors, Inc.
CMP	Compliance Monitoring Plan
CCWP	Contamination Contingency Work Plan
COC	Chain-of-Custody
CPOC	Conditional Point of Compliance
CQA	Construction Quality Assurance
CQC	Construction Quality Control
CSM	Conceptual Site Model
CSWGP	Construction Stormwater General Permit
CULs	Cleanup Levels
cy	Cubic Yard
DBM	Design Basis Memorandum
DGI	Data Gaps Investigation
DGIWP	Data Gaps Investigation Work Plan
DO	Dissolved Oxygen
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
ESCP	Erosion and Sediment Control Plan
FS	Feasibility Study
Ft	Feet
HASP	Health and Safety Plan
IHS	Indicator Hazardous Substance
KCIW	King County Industrial Waste Program
TFLP	Terminal 91Tank Farm Lease Parcel
LNAPL	Light Non-Aqueous Phase Liquid
MLLW	Mean Low Low Water
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
O&M	Operations and Maintenance
ORP	Oxidation-Reduction Potential
OSHA	Occupational Safety and Health Act

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

PES	PES Environmental, Inc.
PNO	Pacific Northern Oil Corporation
PPP	Public Participation Plan
PVC	Polyvinyl Chloride
Port	The Port of Seattle
RCRA	Resource Conservation and Recovery Act
QAPP	Quality Assurance Project Plan
RCW	Revised Code of Washington
RFA	Terminal 91 RCRA Facility Assessment
RI	Remedial Investigation
SEPA	State Environmental Policy Act
SWMU	Solid Waste Management Unit
SWPPP	Stormwater Pollution Prevention Plan
TFAA	Tank Farm Affected Area
TFLP	Tank Farm Lease Parcel
VOA	Volatile Organic Analysis
WAC	Washington Administrative Code
WQ	Water Quality

1.0 INTRODUCTION

1.1 Purpose

PES Environmental, Inc. (PES) has prepared this compliance monitoring plan (CMP), a required component of the Engineering Design Report (EDR; PES, 2013), for a cleanup action at the Terminal 91 Tank Farm Affected Area (TFAA), a portion of the Port of Seattle's (Port's) Terminal 91 Complex (T-91) in Seattle, Washington (Figure 1). The EDR was developed pursuant to Agreed Order No. DE-8938 (AO) between the Port and the Washington State Department of Ecology (Ecology, 2012). This CMP has been prepared in accordance with the requirements of the Model Toxics Control Act (MTCA), Chapter 173-340-410 of the Washington Administrative Code (WAC).

MTCA defines three components of compliance monitoring:

- Protection monitoring, performed to confirm the protection of human health and the environment during implementation of the cleanup action (WAC 173-340-410(1)(a));
- Performance monitoring, conducted to confirm that the cleanup action has attained performance criteria (WAC 173-340-410(1)(b)); and
- Confirmational monitoring, performed to demonstrate the long-term effectiveness of the cleanup action (WAC 173-340-410(1)(c)).

This CMP and associated Quality Assurance Project Plan (QAPP) replace the 2010 Groundwater Monitoring Plan (GMP) and accompanying QAPP prepared by Kennedy/Jenks Consultants (KJC, 2010a and b) for the TFAA, which were approved by Ecology on October 14, 2010.

This CMP discusses all three components of compliance monitoring and: (1) defines specific scopes of work and objectives, (2) provides guidance for field activities, and (3) defines the quality assurance project plan procedures used during monitoring, sampling, and laboratory analysis.

1.2 Report Organization

The CMP is organized into 14 sections. A brief description of each section is presented below:

- **Section 1 – Introduction.** Section 1 contains the purpose and organization of the CMP;
- **Section 2 – Background Information.** Section 2 provides a brief site description, a summary of subsurface conditions, and summarizes the Conceptual Site Model (CSM), including the cleanup action objectives;
- **Section 3 – Cleanup Action Summary.** Section 3 provides a brief description of the cleanup action;
- **Section 4 –Monitoring Network.** Section 4 contains a summary of the network used to monitor the cleanup action;

- **Section 5 – Protection Monitoring.** Section 5 contains a brief summary of the criteria for protection monitoring provided in WAC 173-340-410;

- **Section 6 – Performance Monitoring.** Section 6 discusses performance monitoring, including the objectives, monitoring locations, and schedule;

- **Section 7 – Confirmational Monitoring.** Section 7 discusses confirmational monitoring of groundwater, including the objectives, monitoring locations, and schedule;

- **Section 8 – Sampling and Analysis Plan.** Section 8 presents the methods used in the monitoring program;

- **Section 9 – Monitoring Network Maintenance.** Section 9 presents the methods used in monitoring well network maintenance;

- **Section 10 – Quality Assurance Project Plan.** Section 10 identifies quality assurance/quality control (QA/QC) procedures for monitoring and laboratory analysis;

- **Section 11 – Data Evaluation.** Section 11 provides the procedures for data validation review; evaluation of the LNAPL monitoring, groundwater level, and groundwater quality data; and periodic cleanup action reviews;

- **Section 12 – Criteria for Meeting Performance and Compliance Standards.** Section 12 discusses the criteria for meeting performance and compliance standards;

- **Section 13 – Reporting.** Section 13 briefly discusses the quarterly, annual, and periodic review reports that will be submitted to Ecology; and

- **Section 14 – References.** Section 14 provides the references cited in the CMP.

2.0 BACKGROUND INFORMATION

The background and history of the TFAA has been described and summarized extensively in previous documents and will not be repeated in this CMP. Detailed information related to the Site is provided in the following documents:

- Final Cleanup Action Plan (CAP; Ecology, 2010);
- Final Draft Feasibility Study Report, Terminal 91 Site, Seattle, Washington (FS Report; PES et al., 2009) approved as final by Ecology on December 15, 2010;
- Remedial Investigation Summary Report for the Terminal 91 Tank Farm Site in Seattle, Washington (RI Summary Report; Roth Consulting, 2007); and
- Documents referenced in the above reports.

In addition to the RI/FS-related and CAP cited above, the Data Gaps Investigation (DGI) was recently conducted pursuant to the DGI Work Plan (DGIWP; PES, 2011) and the results reported in the DGI Technical Memorandum (PES, 2012a); both of these documents are incorporated by reference into the Design Basis Memorandum (DBM PES, 2012b).

For ease of reference, the brief site description and history, summary of the subsurface conditions, and a summary of the CSM including the cleanup action objectives are presented below. A summary of the selected cleanup action is provided in Section 3.

2.1 Site Description and History

T-91 is located at 2001 West Garfield Street, Seattle, Washington and encompasses approximately 216 acres (Figure 1). The TFAA is located in the central portion of T-91 and comprises approximately 17 acres including the Tank Farm Lease Parcel (TFLP), which is a contiguous parcel approximately four acres in size [1]. Figure 2 shows the approximate boundaries of T-91, the TFAA, the TFLP, and other portions of T-91, including the Upland Area, Short Fill Area, and Submerged Lands Area.

The TFAA is flat and paved or covered with buildings. The TFAA generally is bounded to the south by Piers 90 and 91 and the Short Fill Area and Lake Jacobs (Short Fill Impoundment) located between the two piers, to the east by the Burlington Northern Santa Fe (BNSF) Rail Yard and the Washington Army National Guard facility, and to the north and west by the T-91 Upland Area.

The TFLP is located at the north end of the TFAA. The primary historical feature of the TFLP is the bulk petroleum tank farm present from the 1920s through 2005. The aboveground portion of the tank farm, including the tanks, containment walls, and other aboveground piping and equipment, was demolished and removed in 2005 as part of an interim remedial action.

[1] The AO (Ecology 2010a) defines the TFAA as "*the Tank Farm TFLP and any areas where Hazardous Substances originating from the Tank Farm TFLP have come to be located*.", and the TFLP as "*the site of a tank farm, demolished in 2005, which had for a time operated as a Dangerous Waste Facility*".

2.2 Subsurface Conditions

The following is a brief summary of the geology and hydrostratigraphy at the Site.

2.2.1 Geology

As described in detail in the RI and FS Reports, five mappable lithologic units have been identified beneath the TFLP and adjacent areas of the Site. The first four of these units have the potential to be encountered during construction of the cleanup action at the Site. These four units in order of increasing depth include:

- The **Shallow Sand Unit** consists of fill material emplaced over shallow marine and tidal marsh deposits of Smith Cove during the early 1900s. It consists primarily of moderately to poorly sorted, fine- to medium-grained, unconsolidated sand, with laminations of silty sand and gravel lenses occurring locally. The Shallow Sand Unit extends vertically from just below the paved ground surface to between 15 and 20 feet below ground surface (ft bgs).

- The **Silty Sand Unit** is comprised of gray or olive, moderately sorted, fine- to medium-grained, silty sand with traces of coarse sand, shell debris, and wood debris. This unit is interpreted to be native marsh, intertidal, and shallow marine sediments that formed the pre-fill surface in the Smith Cove Waterway and the adjacent tidelands. Beneath the TFLP and adjacent upland areas, the top of the Silty Sand Unit generally occurs at depths of 15 to 20 ft bgs, and varies from 20-ft thick beneath the rail yard, east of the TFLP, to 5 ft or less in the southwest corner of the TFLP. A moderately to poorly sorted, silty sandy gravel layer was found within the Silty Sand Unit in some locations at depths of approximately 24 to 28 ft bgs.

- The **Deep Sand Unit** directly underlies the Silty Sand Unit and is composed primarily of poorly to moderately sorted, medium- to coarse-grained sand and gravelly sand, with only isolated occurrences of silt. However, beneath the northern portion of the TFLP (borings CP_115B and CP_205B), the Deep Sand Unit is composed of only 6 to 8 ft of sand, gravelly sand and sandy gravel, with the remaining deeper portions of the unit characterized by interbedded silty sand and sand. The depth to the top of the Deep Sand Unit varies from approximately 25 ft bgs at the center of the TFLP to as much as 45 ft beneath the north end of Pier 90.

- The **Silty Clayey Sand Unit** underlies the Deep Sand Unit and is composed of soft to stiff fine-grained sediments, primarily silty clay and clayey silt, with lesser amounts of silt and silty clayey sand. The top of the Silty Clayey Sand Unit is shallowest beneath the eastern portion of the TFLP, where it occurs as shallow as 42 ft bgs, in boring CP_106B.

2.2.2 Hydrostratigraphy

Shallow Aquifer. The shallow aquifer is generally present in the Shallow Sand Unit beneath the Site and is separated from the Deep Confined Aquifer by the Silty Sand Unit which acts as an

upper confining unit. Water level data collected during routine monitoring of monitoring wells at the Site show that the dominant unconfined groundwater flow direction is towards the south beneath the TFLP and to the southwest beneath AOC 11. Recorded water elevations in the monitoring wells in and around the former tank farm have varied between 9.5 and 13.6 ft mean low low water (MLLW) and generally correspond to seasonal variations in precipitation rates, with the highest water levels observed during the wetter winter months. The typical horizontal gradient beneath the TFLP is approximately 0.001 ft/ft.

Downward vertical gradients between the Shallow Aquifer and Deep Confined Aquifer have been noted throughout the Site. Vertical gradients typically range from approximately 0.018 to 0.040 ft/ft, with vertical gradients decreasing to the south. Despite the presence of downward vertical gradients, significant downward movement of Shallow Aquifer groundwater under most of the Site is considered unlikely due to the low measured vertical permeability in the upper confining unit (Silty Sand Unit).

Deep Confined Aquifer. The deep confined aquifer is present in the Deep Sand Unit. Average groundwater flow direction in the Deep Confined Aquifer beneath and shoreward of the TFLP is towards the south. As in the Shallow Aquifer, water levels in the Deep Confined Aquifer respond to seasonal variations in precipitation rates, with the highest water levels observed during the wetter winter months. The typical Deep Confined Aquifer horizontal gradient is relatively constant at approximately 0.003 ft/ft beneath the Site.

3.0 TANK FARM LEASE PARCEL REMEDY DESCRIPTION

The selected remedy for the TFLP will include long term operations and maintenance (O&M) of a subsurface cutoff wall around the perimeter of the former tank farm, an enhanced LNAPL recovery system, an asphalt final cover, and a stormwater drainage system. A detailed description and the long-term O&M of the remedial actions are outlined in the O&M Plan (PES, 2013b). The primary objective of these passive systems is to prevent LNAPL migration from the TFLP and adjacent source area systems and to prevent future surface product seeps from occurring.

Details of the cleanup are provided in the following documents:

- Engineering Design Report (PES et al, 2013a);
- Construction Drawings – Terminal 91 Tank Farm Cleanup; and
- Technical Specifications – Terminal 91 Tank Farm Cleanup.

4.0 MONITORING NETWORK

The locations of the network monitoring wells are shown on Figure 3. A summary of wells and piezometer included in the CMP groundwater and LNAPL network is provided in Table 2.

Groundwater monitoring prior to the CAP completion was performed in accordance with the 2010 GMP (KJC, 2010a). The previous GMP network included a total of 70 on-site and off-site monitoring wells which were monitored at the following frequency and criteria: monthly for LANPL (22 wells), annually for groundwater quality (13 wells) and annually for groundwater level monitoring (70 wells)

4.1 Monitoring Well Decommissioning

A total of 16 wells (which include former LNAPL extraction and monitoring wells) will be decommissioned during the cleanup action implementation. The decommissioning of the wells will be conducted in accordance with the procedures outline in the EDR (PES, 2013a). The following wells will be eliminated from the monitoring program: PNO_EW01, PNO_MW102, PNO_MW03, UT-MW39-2, and CP_PR01 through CP_PR12.

4.2 CMP Monitoring Wells

The CMP groundwater monitoring network consists of 47 monitoring locations (46 wells and one piezometer (Figure 3). Seven wells (UT_MW154 1 through UT_MW152-7) that are located north of the TFAA and were previously included in the GMP as part of the larger T91 Complex (Discrete Unit A.1 listed in Exhibit C of the 2010 agreed order) are not included in this CMP.

The CMP monitoring network will include the wells described below by task.

4.2.1 LNAPL Monitoring

The LNAPL monitoring network will include at least four LNAPL monitoring wells (CP-107, CP-110, PNO-MW104, and UT-MW39-3) which historically contained LNAPL (Table 2). Additional LNAPL monitoring may be conducted at TFAA wells if the presence of LNAPL is detected during groundwater level monitoring or sampling.

4.2.2 Groundwater Level Monitoring

Groundwater level monitoring will be conducted at a total of 47 monitoring locations, which will include 37 shallow, 9 deep aquifer wells, and one shallow peizometer (Table 2). The data collected from these wells will be used to confirm the groundwater flow pattern after installation of the cutoff wall and new asphalt cap.

4.2.3 Groundwater Quality Monitoring

Groundwater sampling will be conducted at total of 18 shallow and five deep groundwater monitoring wells listed in Table 2. The shallow wells were selected to provide water quality data

along three flow paths from the source area to potential receptors while the deep wells were selected to monitor potential post-construction changes in groundwater quality. The groundwater sampling network includes the following wells along the three flow paths (see Figure 3):

- **Tank Farm (Pier 90) Flow Path.** CP_108A; CP_GP02; CP_GP01A; and CP_GP08.
- **Tank Farm/SWMU 30 (Pier 91) Flow Path.** CP_103A; PNO_MW02, PNO_MW06A; PNO_MW103; CP_GP03A; CP_GP09 and CP_GP10.
- **Tank Farm/AOC 11 Flow Path.** CP_104A; CP_GP11; PNO_MW101; CP_GP05 and CP_GP14.
- **Background Wells:** CP_114 and CP_106A.
- **Deep Wells:** CP_108B; CP_203B; CP-205B; CP_GP01B; and PNO_MW06B.

If post construction monitoring indicates significant changes to groundwater flow and/or chemistry, then the need for additional monitoring wells and or adjustments to the CMP monitoring network will be considered.

5.0 PROTECTION MONITORING

Protection monitoring will be conducted to confirm the protection of human health and the environment during implementation of the long-term monitoring component of the cleanup action. Protection monitoring will consist of the activities described below.

5.1 Health and Safety Compliance

All workers associated with the CMP activities will be required to provide and implement a project specific health and safety plan (HASP) prior to starting work at the Site. The HASP will be prepared consistent with the requirements outlined in the Worker Health and Safety guidelines (WAC 173-340-810) and the Occupational Safety and Health Act (OSHA, 29 CFR 1900).

5.2 Site Safety Procedures

All work procedures associated with the CMP (monitoring activities) will adhere to all Port of Seattle safety procedures. All personnel will maintain a high degree of awareness of moving vehicles and any other hazards associated with the Site CMP activities. Prior to the implementation of CMP activities, all personnel will conduct the following:

- Meet with the Project Manger or Client Contact at the start of fieldwork to discuss equipment and personnel access to the work area;
- Obtain any facility-related emergency information, i.e., evacuation areas and or special hazards;
- Implement a plan for the protection and handling of equipment and personnel that may impact the facility. Equipment will be handled and maintained in accordance with the procedures outline in the HASP by marking equipment and work zones with high visibility features (i.e. traffic cones), and installing safety equipment (i.e., structural driving ramps over hoses and electrical cords);
- Plan and design work activities, when possible, to accommodate operations and limitations; and
- Conduct periodic monitoring of impacts during the monitoring events to ensure that any installed safety features are maintained and functioning properly to protect personnel and equipment.

6.0 PERFORMANCE MONITORING

The objective of performance monitoring is to confirm that the cleanup action has attained cleanup levels at the conditional points of compliance (CPOC) wells (WAC 173-340-410(1)(b)). Performance monitoring will be conducted to evaluate three aspects of the cleanup action: (1) the impact of the cutoff wall and cap on LNAPL migration, (2) the impact of the cutoff wall and cap on groundwater flow, and (3) the impact of the cutoff wall and cap on groundwater quality. LNAPL performance monitoring will be conducted in at least 4 monitoring wells (based on historical LNAPL presence) within the TFAA CMP network in addition to 5 LNAPL collection trenches described in the O&M Plan (PES, 2013b). Performance groundwater level monitoring will be conducted in all Site monitoring wells to confirm groundwater flow direction(s) after implementation of the cleanup actions. Performance groundwater monitoring will be conducted at select wells within the monitoring network to assess how the cleanup action is affecting groundwater quality associated and to assess monitored natural attenuation (MNA).

Performance LNAPL monitoring will be conducted until the performance criteria outlined in Section 12 has been met. Performance groundwater monitoring will be conducted to confirm that groundwater cleanup levels continue to be achieved for Site IHSs at the CPOC wells near the downgradient property boundary after constructing the cleanup action.

Tables 2 and 3 summarize the performance monitoring well network, monitoring frequency, and monitored parameters. Well completion details for all TFAA monitoring wells are provided in Appendix A. CMP well locations are shown on Figure 3. All groundwater monitoring activities will be conducted in accordance with the procedures outlined in this monitoring plan, and the Port's standard operating guidelines (SOGs), which are provided in Appendix B.

The following sections provide an overview of the three components of performance monitoring.

6.1 LNAPL Monitoring

6.1.1 Monitoring Objectives

The objective of the LNAPL monitoring is to evaluate the presence of LNAPL in TFAA monitoring wells. Based on the historic distribution of LNAPL, at least four monitoring wells will be monitored for LNAPL, however if indications of LNAPL are detected in additional TFAA wells, they will be included in the LNAPL monitoring program.

6.1.2 Monitoring Overview

The CMP network wells (Table 2) will be monitored for LNAPL within the specified wells (with historic LNAPL detections) concurrent with the groundwater monitoring schedule. Monitoring will be conducted on a quarterly basis for the first two years after cleanup actions are conducted, semiannually for the third and fourth years after cleanup actions are conducted, and annually for subsequent years. Monitoring wells which contain at least 0.25 feet of LNAPL will be skimmed to remove the accumulated LNAPL. Product recovery/skimming procedures are not included in this CMP but are outline in the O&M Plan ([PES, 2013b]).

6.2 Groundwater Level Measurements

6.2.1 Monitoring Objectives

Performance groundwater level monitoring will be conducted in all CMP monitoring wells (Table 2) to confirm the groundwater flow directions, horizontal hydraulic gradients, and vertical gradients between the shallow aquifer and the deeper confined aquifer beneath the property after implementation of the cleanup actions.

6.2.2 Monitoring Overview

Groundwater levels will be monitored concurrent with the groundwater quality monitoring schedule; quarterly for the first two years after cleanup actions are conducted, semiannually for the third and fourth years after cleanup actions are conducted, and annually for subsequent years. If post-construction monitoring indicates significant changes to groundwater flow, the need for additional monitoring wells and/or adjustments to the CMP will be considered.

6.3 Groundwater Sampling

6.3.1 Monitoring Objectives

The objective of groundwater quality monitoring will be to assess how the cleanup action is affecting groundwater quality temporally and spatially and to confirm that cleanup levels continue to be met at the point of compliance after cleanup action implementation.

6.3.2 Monitoring Overview

The groundwater performance monitoring well network includes 18 shallow wells and five deep wells (Table 3) along the following three flow paths (Figure 3):

- **Tank Farm (Pier 90) Flowpath Wells:** CP_108A (source); CP_GP02 and CP_GP01A (plume); and CP_GP08 (sentinel).
- **Tank Farm/SWMU 30 (Pier 91) Flowpath Wells.** CP_103A (source); PNO_MW02, PNO_MW06A, PNO_MW103, and CP_GP03A (plume); and CP_GP09 and CP_GP10 (sentinel). Two of the plume wells (PNO_MW02 and PNO_MW06A) are located in a secondary source area (SWMU 30).
- **Tank Farm/AOC 11 Flowpath Wells:** CP_104A (source); CP_GP11, PNO_MW101, and CP_GP05 (plume); and CP_GP14 (sentinel). Two of the plume wells (CP_GP11 and PNO_MW101) are located near a potential secondary source (AOC 11).
- **Background/Upgradient Wells:** CP_106A and CP-114.
- **Deep Wells:** CP_108B; CP_203B; CP-205B; CP_GP01B; and PNO_MW06B.

If post-construction monitoring indicates significant changes to groundwater flow and/or chemistry, the need for new monitoring wells and/or adjustments to the CMP will be considered.

Performance monitoring wells will be monitored for the following field parameters:

- Temperature;
- pH;
- Specific conductance;
- Turbidity
- Dissolved oxygen (DO); and
- Oxidation reduction potential (ORP).

Performance monitoring samples will be collected for the following laboratory analyses (Table 3):

- Gasoline-range, diesel-range, and oil-range hydrocarbons using Ecology Methods NWTPH-Gx and NWTPH-Dx; and
- BTEX using EPA Method 8260.

Semiannually for the first two years of monitoring and annually thereafter, samples will also be submitted for the analysis of the following secondary geochemical indicators:

- Sulfate and nitrate (EPA Method 300.0);
- Manganese (EPA Method 6010B);
- Methane (Modified RSK Method 175 or equivalent);
- Ferrous iron (field kit, Hach Method 8146 or equivalent); and
- Alkalinity (field kit, Hach Method AL AP MG-L or equivalent).

These secondary geochemical indicators, which are used to assist with the evaluation of MNA, will be only be submitted for the shallow monitoring wells; the deep wells are not being evaluated for MNA and do not require these parameters. Groundwater performance monitoring will be conducted on a quarterly basis for the first two years after cleanup actions are conducted, semiannually for the third and fourth years after cleanup actions are conducted, and annually for subsequent years until the performance criteria (Section 12) have been obtained at the points of compliance. Upon completion of the performance monitoring program, the confirmational monitoring program outlined below will be implemented, consistent with natural attenuation as the final phase of cleanup.

7.0 CONFIRMATIONAL MONITORING

The objective of confirmational monitoring is to confirm the long-term effectiveness of the cleanup action. Cleanup standards are currently being achieved at the CPOCs, however performance and compliance monitoring will continue to confirm compliance. (WAC 173-340-410(1)(c)). Confirmational monitoring will consist of water level monitoring and groundwater sampling of monitoring wells.

7.1 LNAPL Monitoring

7.1.1 Monitoring Objectives

Confirmational LNAPL monitoring will be conducted, if present, within the TFAA monitoring wells to confirm long-term trends consistent with the final phase of the cleanup action.

7.1.2 Monitoring Overview

LNAPL monitoring will be conducted annually, if present, in the specified LNAPL monitoring wells (Table 2). Wells that have completed the performance monitoring phase and do not have measurable LNAPL will be moved into the confirmational water level monitoring program. LNAPL monitoring will be conducted concurrent with the groundwater level and quality monitoring.

7.2 Groundwater Level Measurements

7.2.1 Monitoring Objectives

Confirmational groundwater level monitoring will be conducted in all Site monitoring wells to confirm long-term groundwater flow trends consistent with the final phase of the cleanup action.

7.2.2 Monitoring Overview

Groundwater levels will be monitored annually in all Site monitoring wells concurrent with the groundwater quality monitoring.

7.3 Groundwater Sampling

7.3.1 Monitoring Objectives

Confirmational groundwater quality monitoring will be conducted to confirm the long-term effectiveness of the cleanup action.

7.3.2 Monitoring Overview

A summary of the confirmational monitoring program schedule and analytical parameters is provided in Table 3. The confirmational monitoring well network, field parameters, and analysis will include a subset of the performance monitoring well network based on the performance monitoring results (i.e. CPOCs and one source well per flow path).

Confirmational groundwater monitoring will be conducted annually to confirm that IHSs are below the established CULs at the COPC. Upon consistent attainment of CULs, a formal request to Ecology (if appropriate) will be submitted for a reduction in the monitoring frequency, parameters, and monitoring network.

8.0 SAMPLING AND ANALYSIS PLAN

The sampling and analysis plan for the project has been developed to collect high quality environmental data. The overall goal of the compliance monitoring plan is to generate data that are acceptable for use in evaluating the groundwater quality with respect to the Site cleanup levels and long-term trends. Specific sampling tasks for this investigation were previously outlined and are summarized as follows:

- Monitor LNAPL levels in Site monitoring wells to evaluate potential migration after the installation of the cutoff wall and cap;
- Monitor water levels on the prescribed basis to confirm the groundwater flow paths in both the shallow and deep zones at the Site; and
- Monitor shallow groundwater conditions to provide a continuing assessment of the groundwater quality at the Site.

As previously stated, previously approved Ecology sampling and analysis procedures have been reiterated and incorporated into this CMP, where applicable. The Port's SOGs for measuring LNAPL, measuring water levels, and groundwater sampling are included in Appendix B.

8.1 LNAPL Monitoring

8.1.1 Monitoring Locations and Schedule

LNAPL monitoring will be conducted in four TFAA monitoring wells listed on Table 2. If LNAPL presence is detected (i.e. sheen on water level probe tip) in any additional wells, then they will be included in the LNAPL monitoring program per this CMP.

Monitoring of the TFAA monitoring wells will be conducted on a quarterly basis for the first year after cleanup actions are conducted, semiannually for the second and third years after cleanup actions are conducted, and annually for subsequent years.

8.1.2 Equipment

Equipment used for LNAPL monitoring is listed in the SOGs (Appendix B). The equipment consists of an electronic oil/water interface probe for detection of LNAPL and water, and includes two types of responses: one for detection of LNAPL, and the other for detection of water. This detector consists of a permanently marked coaxial cable or plastic-coated flat wire with 0.01-foot calibrations, a detection probe, and electronic controls contained in a spool or reel.

8.1.3 LNAPL Monitoring Methods

LNAPL levels will be measured using the procedures outlined in the LNAPL monitoring SOG (Appendix B). The following provides a summary of the procedures:

1. Open the well monument, and remove any standing water and debris (i.e., sediment, vegetation, or refuse) prior to removing the well cap.

2. Open the well by carefully removing the well cap and allow the well to vent. Record the time at which the well is initially vented to the atmosphere (i.e., time of well cap removal). Document initial conditions (i.e., well over-pressurized or under-pressurized relative to the atmosphere) on the Water Level Form (Appendix C).
3. After opening and venting the well, measure LNAPL or water level to the nearest 0.01 foot. If LNAPL is present (or suspected) measure an oil/water interface detector or, if no LNAPL is present, measure water level using an electric water-level indicator.
4. After measuring the depth to LNAPL in the well, and before retrieving the probe from the well, slowly lower the probe further into the well. When the LNAPL/water (or air/water) interface is detected, measure the depth to the interface. Record the result to the nearest 0.01 foot.
5. Measure the water level at the surveyed measuring point (MP) on the north side of the top of the PVC casing.
6. Duplicate the water level measurement in each well in the field to ensure that the reading is accurate. Record all results (times, measured values, etc.) on the Water Level Form (Appendix C).
7. Rinse the probe tip with distilled water between each well to avoid cross contaminating monitoring wells. If LNAPL has high viscosity or is not readily removed using distilled water rinse, the equipment decontamination procedures included in Appendix B will be followed.
8. Replace the well cap on each well upon completing the water level measurement.
9. Periodically, check the time needed for water level equilibration after cap removal by measuring the water level in a well, allowing the well to vent for a more extended period of time (at least 1 hour), and measuring the water level a second time. Record all results on the Water Level Form.
10. Upon completion of the LNAPL/water level measurements, replace and tightly seal each of the well caps and surface monuments.

8.2 Groundwater Level Measurements

8.2.1 Monitoring Locations and Schedule

Groundwater levels will be measured per the frequency outlined in Sections 6.2.2 and 7.2.2 in each network monitoring well (Table 2 and Figure 3) using an electronic groundwater probe. Note that if the presence of LNAPL is detected (i.e. sheen) in any well during the water level monitoring, then the specified well will be monitored per the procedures in Section 8.1. The water level monitoring events will be conducted on a quarterly basis for the first year after cleanup actions are conducted, semiannually for years 2 and 3 post cleanup actions, and annually for subsequent years.

8.2.2 Equipment

Equipment used for groundwater level monitoring is listed in the SOGs (Appendix B). An electronic water level meter (e-tape) will be used to measure depth-to-water within the monitoring wells. The meter consists of a permanently marked coaxial cable or plastic-coated flat wire with 0.01-foot calibrations, a detection probe, and electronic controls contained in a spool or reel. The water level meter/sounder registers a response when the probe attached to the cable contacts an electrically conductive medium, such as water, thereby completing the electrical circuit. The response is visible (e.g., red light), audible (e.g., alarm), or a combination of the two.

8.2.3 Groundwater Level Monitoring Methods

Groundwater levels will be measured using the SOGs in Appendix B for measuring water levels. A summary of the procedures follows:

1. Open the well monument, and remove any standing water and debris (i.e., sediment, vegetation, or refuse) prior to removing the well cap.
2. Open the well by carefully removing the well cap and allow the well to vent. Record the time at which the well is initially vented to the atmosphere (i.e., time of well cap removal). Document initial conditions (i.e., well over-pressurized or under-pressurized relative to the atmosphere) on the Water Level Form (Appendix C).
3. After opening and venting the well, measure the initial water level to the nearest 0.01 foot, using electronic water level probe.
4. Measure the water level at the surveyed measuring point (MP) on the north side of the top of the PVC casing.
5. Duplicate the water level measurement in each well in the field to ensure that the reading is accurate. Record all results (times, measured values, etc.) on the Water Level Form (Appendix C).
6. Rinse the probe tip with distilled water between each well to avoid cross contaminating monitoring wells.
7. Replace the well cap on each well upon completing the water level measurement.
8. Periodically, check the time needed for water level equilibration after cap removal by measuring the water level in a well, allowing the well to vent for a more extended period of time (at least 1 hour), and measuring the water level a second time. Record all results on the Water Level Form.
9. Upon completion of the water level measurements, replace and tightly seal each of the well caps and surface monuments.

8.3 Groundwater Sampling

8.3.1 Monitoring Locations and Schedule

Groundwater samples will be collected according to the following schedule; quarterly for the first year after cleanup actions are conducted, semiannually for the second and third years after cleanup actions are conducted, and annually for subsequent years. Based on the previous 2010 AO and GMP, annual groundwater monitoring was conducted during the month of September. To maintain historical consistency, the groundwater sampling events will be conducted during the last month of each quarter to coincide with the historical sampling months: quarterly sampling will be conducted in March, June, September, and December, semiannual sampling will be conducted in March and September, and annual sampling will be conducted in September.

Groundwater samples will be collected from 18 monitoring wells (Table 3 and Figure 3) using low-flow sampling techniques (Section 8.3.2) and submitted for laboratory analysis for the parameters outlined in Section 8.4:

8.3.2 Groundwater Sampling Equipment and Methods

Groundwater samples will be collected using Port approved SOGs provided in Appendix B. All wells will be purged using the "low flow" method. The purge rate is designed to be low enough to simulate natural groundwater flow conditions and to pull groundwater from a discrete zone within the adjacent aquifer near the pump intake, rather than pulling stagnant groundwater from within the well or from a large area around the well. A low purge rate is also intended to reduce the possibility of stripping volatile constituents from groundwater and to reduce the likelihood of mobilizing colloids in the subsurface that are typically immobile under natural groundwater flow conditions. A summary of the sampling procedures is outlined below.

Sampling Preparation. Prior to the initiation of any sampling activities, all of the necessary field equipment and documentation materials (e.g. field notebook and sampling forms) will be prepared. A summary of the sampling tools and equipment to be used during the CMP activities are listed in the SOG for groundwater sampling (Appendix B). Prior to the commencement of purging and sampling, each of the field instruments will be calibrated with standard solutions at a minimum of once per day. Laboratory supplied sample bottles will be inspected for proper preservative (Table 4). The depth to water will be measured prior to sampling using the procedures outlined in Section 8.2.3.

Low-Flow Purging with Peristaltic Pump. New disposable polyethylene tubing or dedicated polyethylene tubing will be used to sample each monitoring well. The polyethylene tubing will be slowly lowered into the well until the tubing intake is at the midpoint of the well screen. Table 3 provides the well screen depths for each of the groundwater sampling monitoring wells. The monitoring well will be purged with the peristaltic pump fitted with new disposable silicon tubing in the pump head. The polyethylene tubing in the well will be connected to the silicon tubing in the pump head. The time will be recorded on a Groundwater Sampling Form (Appendix C), and the pump will be started. Pumping rates will be measured with a stopwatch and graduated cylinder, graduated cup, or volatile organic analysis (VOA) 40 milliliter (mL) vial,

depending on flow rate. Low flow purging will be conducted at a pumping rate between 100 and 500 mL per minute (mL/min).

During purging, the water level will be measured approximately every 3 to 5 minutes, until a steady water level is determined. If possible, a drawdown of 0.3 feet or less will be maintained in the well, with the pumping rate lowered to a minimum rate of 100 mL/min if necessary to maintain a drawdown of 0.3 feet or less. The water level in the well will be maintained above the tubing intake depth at all times. If the well yield is sufficiently poor that the water level drops to the tubing intake, the pump will be stopped until the water level recovers to near the pre-pumping level. The process will then be repeated until the field parameters have stabilized. The final purge volume will be at least as great as the submerged tubing volume plus the stabilized drawdown volume. All measured water levels and pumping rate changes will be recorded on a Groundwater Sampling Form (Appendix C).

Field Parameter Measurements. Field indicator parameters will be measured approximately every 3 to 5 minutes during purging. Field parameters will include pH, specific conductance, temperature, turbidity, dissolved oxygen (DO), and ORP. Measurements will be recorded to the following standards:

- pH to ±0.01 units;
- Specific conductance to ±1 microSiemens;
- Temperature to ±0.1^{o}C;
- Turbidity to ±1 units;
- DO to ±0.1 milligrams per liter (mg/L); and
- ORP to ±1millivolts (mV).

Samples will not be collected until these parameters have stabilized for three consecutive readings to the following criteria:

- pH to ±0.2 pH unit;
- Specific conductance to ±3 percent; and
- Temperature to ±3 percent.

Attempts to stabilize turbidity, DO, and ORP measurements should be made, but will not be used to determine stability. If field parameters do not stabilize after 1 hour of pumping, a sample will be collected. Well purging data will be recorded on a Groundwater Sampling Form. Field instruments will be calibrated using known, standard solutions, a minimum of once per day.

Sample Collection. Samples will be collected according to the methods outlined in the SOGs (Appendix B). Upon completion of purging, samples will be collected from the discharge end of the peristaltic pump tubing. The same pump rate used at the end of well purging will be used during sample collection. Samples will be collected by allowing the sample water to pour down the inside of the VOA vials and without splashing onto the base. All sample containers will be prepared and provided by the analytical laboratory (Table 4).

After collection of the sample from each well, the disposable polyethylene tubing will be removed from the well, the well cap will be replaced, and the well cap or monument locked. All

used tubing will be discarded appropriately. If dedicated tubing is used, it will either be secured in the well casing or removed from the well and placed in a dedicated storage bag.

Decontamination and purge water will be handled in accordance to the residuals management procedures outlined in Sections 8.6 and 8.7, respectively.

8.4 Laboratory Analytical Procedures

Tables 3 and 4 identify the wells, analyses, and laboratory methods for groundwater samples. Performance and confirmation groundwater samples will be submitted to a Washington State accredited laboratory for the following analytical parameters:

- Gasoline-range, diesel-range, and oil-range hydrocarbons using Ecology Methods NWTPH-Gx and NWTPH-Dx; and
- BTEX using EPA Method 8260.

The following secondary geochemical parameters will be also be analyzed semiannually for the first two years of monitoring and annually thereafter:

- Sulfate and nitrate (EPA Method 300.0);
- Manganese (EPA Method 6010B);
- Methane (Modified RSK Method 175 or equivalent);
- Ferrous iron (field kit, Hach Method 8146 or equivalent); and
- Alkalinity (field kit, Hach Method AL AP MG-L or equivalent).

8.5 Sample Labeling, Shipping, and Chain-of-Custody

Sample labeling, shipping, and chain-of-custody will be performed consistent with the procedures described below.

8.5.1 Sample Labeling

Sample container labels will be completed immediately before or immediately following sample collection. Container labels will include the following information:

- Project name;
- Sample name labeled with a unique sample identification number. The sample number consists of the appropriate monitoring well designation followed by a date identification code. The date identification code consists of a four-digit number that represents the month and year that the sample was collected. For example, the sample number CP-104A-120113 denotes a sample collected in December 1, 2013 from monitoring well CP-104A;
- Date and time of collection;
- Initials of collector;
- Preservatives added to the sample; and
- Parameter(s) for which the sample to be analyzed.

Field duplicates and field blanks will be submitted blind to the analytical laboratory. Sample numbers associated with field duplicates and field blanks will include a generic (distinct from any wells that are being sampled) well number (e.g., D-100) and four digit date identification, as described above. The actual sample numbers and associated samples (for field duplicates) will be recorded in a field notebook and or Groundwater Sampling Form.

All trip blanks are provided by the analytical laboratory and are labeled as "Trip Blank" with a date identification code as described above. Distinctions among multiple field or trip blanks can be made by the associated dates.

8.5.2 Sample Shipping

Samples will be shipped to the analytical laboratory using the procedures outlined in the SOG Sample Packaging and Shipping. General guidelines are summarized below:

- Sample containers will be place in a sealed, iced cooler or other suitable shipping container after sample collection. This container will be used for transporting the samples to the analytical laboratory;
- In each shipping container, glass bottles will be separated by a shock absorbing material to prevent breakage and leakage;
- Ice sealed in separate plastic bags or "gel ice" packs, will be placed into each shipping container with the samples;
- All sample shipments will be accompanied by a chain-of-custody form (COC). The completed form will be sealed in a plastic bag, which will be taped to the inside lid of the shipping container;
- Signed and dated COC seals will be placed on all shipping containers; and
- The name and address of the analytical laboratory, along with the sampling company name and office (return) address, will be placed on each shipping container prior to shipping.

8.5.3 Chain-of-Custody

Once a sample is collected, it will remain in the custody of the sampler or other approved project personnel until shipment to the laboratory. Upon transfer of sample possession to subsequent custodians, a COC will be signed by the persons transferring custody of the sample container. A signed and dated chain-of-custody seal will be placed on each shipping container prior to shipping. Chain-of-custody records will be included in the analytical report prepared by the laboratory.

8.6 Decontamination

Decontamination procedures will be performed consistent with the procedures described in the SOG Equipment Decontamination (Appendix B). All non-disposable sampling equipment will

be decontaminated prior to initial use, between sampling locations, and at the completion of the site-specific sampling.

Decontamination of personnel involved in sampling activities will be accomplished as described in a site-specific health and safety plan.

8.7 Sampling Residuals

Investigative derived waste (IDW) will be properly contained after each sampling event, and disposed of according to local, state, and federal laws. Purge water, non-dedicated disposable tubing, and used personal protective equipment (PPE) will be contained onsite in drums for subsequent disposal by the Port under its waste handing program.

The following procedures will be used for the investigation residuals, including groundwater sampling purge water and decontamination water:

- Purge water and decontamination water generated during the investigation activities will be placed in 55-gallon drums and stored on site. The drums will be managed as Satellite Accumulation drums and stored in the appropriate areas until they have been filled; and
- Disposable clothing and equipment will be placed in plastic bags and disposed of as solid waste.

9.0 MONITORING NETWORK MAINTENANCE

This section describes a program to provide regular inspection, and if necessary, maintenance of the groundwater monitoring wells and associated equipment.

9.1 Well Inspection

Monitoring wells in the network are inspected by the sampling team during routine monitoring to assess their integrity. The inspection involves a visual inspection of the well to determine if the well has been damaged or tampered with. The well inspection verifies the physical condition of the well at the ground surface, the internal well casing, and the dedicated sampling equipment. Monitoring wells will also be fully inspected after any major physical event that may affect the wells, such as an earthquake or heavy construction in the vicinity of a well.

Problems discovered during the inspection will be recorded on field forms and a well maintenance form, which will be provided by the field personnel to the Project Manager. Problems that require immediate attention will be reported to the Project Manager so as to remedy the condition prior to the next sampling event. If a significant problem, such as a broken wellhead, bent casing, or other damage that compromises well access is discovered, it may be necessary to remedy the problem as soon as possible and/or before sampling. A problem with the well integrity may require a modification of the sampling schedule or some other change in the sampling program. All decisions regarding such modifications will be reported immediately by the field personnel to the Project Manager. The Project Manager will be responsible for maintaining technical liaison with Ecology and the Port regarding such issues.

9.2 Maintenance

Total well depths within the 18 groundwater sampling monitoring wells (Table 3) will be measured once per year to evaluate the well integrity. All other wells (TFAA water level monitoring wells, Table 1) will be monitored once every 4 years to evaluate the integrity of the well. The procedure for sounding the wells is given in the SOGs (Appendix B). If more than 1 foot of sediment has built up in the bottom of a well, the well will be redeveloped and the sediment removed, as described in SOG – Well Development (Appendix B).

All sampling equipment used for groundwater monitoring will be maintained regularly by the sampling team members according to the appropriate equipment standard operation procedures (SOP) or the manufacturer's equipment manuals.

9.3 Monitoring Well Replacement

If any monitoring well in the monitoring well network must be replaced, the Port will notify Ecology prior to replacement. The replacement will be completed upon approval of Ecology and preferably prior to the next scheduled groundwater sampling event.

If it is agreed that the well has become unsuitable for groundwater sample collection, the Port will propose the location of a replacement well, if a replacement well is considered necessary,

consistent with the needs of the groundwater monitoring program. The location of any replacement well may or may not be near the previous well location. A monitoring well construction form will be completed for the new well, and a copy will be submitted to Ecology.

Wells will be decommissioned in accordance with WAC 173-160-460 (Abandonment of Resource Protection Wells). The Port's drilling contractor will file the appropriate notification of well abandonment with Ecology.

Field personnel will inspect the drilling and construction of all new or replacement monitoring wells. A detailed drilling log of each well will be constructed, and this CMP will be revised to reflect changes in the monitoring well network, as necessary.

10.0 QUALITY ASSURANCE PROJECT PLAN

The QAPP describes the measures undertaken so that the data collected during the project are acceptable for their intended use(s) and includes the elements from Ecology's QAPP guidance document (Ecology, 2004). The specific requirements pertaining to this CMP are described in the project QAPP provided in Appendix D.

A summary of the project QAPP requirements are described in this section.

10.1 Quality Assurance Project Plan Objectives

The overall QAPP objective for measurement data is to provide data of known and acceptable quality. All measurements will be made to yield accurate and precise results representative of the media and conditions measured. Chemical analyses will be performed in accordance with the requirements of the analytical methods. All sample results will be calculated and reported in consistent units to allow comparison of the sample data with regulatory criteria and federal, state, and local databases. QAPP objectives for precision, accuracy, and completeness have been established for each measurement variable, where possible, and are discussed below.

10.2 Chemical Analyses

Analysis of environmental samples will be performed in accordance with the laboratory analytical methods summarized in the QAPP (Appendix D) and on Table 4. The laboratory will report the results to levels specified in the QAPP as necessary to meet the cleanup levels. Any special analytical methods or modifications to methods will be determined with laboratory concurrence prior to beginning sample analysis.

10.3 Laboratory Quality Control

The QAPP presents quality control (QC) requirements for the analytical laboratory. The purpose of this QC program is to produce data of known quality meeting project objectives and the requirements of the standard methods of analysis. Laboratory QC samples will include laboratory control samples (LCSs), matrix spike/matrix spike duplicate (MS/MSD) samples, and method blanks.

10.4 Field Quality Assurance

Field QC samples will be collected during groundwater sampling and will include trip blanks, equipment blanks, and field duplicates. Field QC samples will be collected as summarized in the QAPP and on Table 5. A summary of the field QC samples is described below.

10.4.1 Trip Blanks

One trip blank per sampling event will be included with the shipment of samples to the laboratory and will be analyzed for VOCs. If an analyte is detected in a trip blank, the data will be qualified during the data review per the QAPP.

10.4.2 Equipment/Field Blanks

Equipment blank samples are collected to identify potential contamination from the sample collection equipment and to identify potential cross-contamination between sampling locations. One equipment blank sample will be collected during each sampling event. The equipment blank sample is collected by rinsing or pumping through the sampling equipment with distilled or deionized water and placing the collected water in an appropriate container with preservative, as necessary. One equipment blank per sampling event will be included with the shipment of samples to the laboratory and will be analyzed for VOCs. If an analyte is detected in a blank sample, the data will be qualified during the data review per the QAPP.

10.4.3 Field Duplicates

A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate samples are collected simultaneously or in immediate succession, using identical sampling techniques, and treated in an identical manner during storage, transportation, and analysis. The sample containers are assigned an identification number in the field so that they cannot be identified (blind duplicate) as duplicate samples by laboratory personnel performing the analysis. Duplicate sample identification guidelines are specified in the QAPP (Appendix D). Duplicate sample results are used to assess precision of the sample collection process. Per the QAPP, one duplicate sample will be collected for approximately every 20 project samples.

10.5 Data Reporting and Review

The laboratory performing sample analyses will be required to submit summary data and QA information per the QAPP (Appendix D) to permit independent determination of data quality.

11.0 DATA EVALUATION

11.1 Data Validation

The purpose of data validation is to verify that the data are of known quality, are technically valid, are legally defensible, satisfy the project objectives, and are usable for their intended purpose. All chemistry data will be validated per the project the guidelines specified in the QAPP (Appendix D) and per USEPA data review guidelines (USEPA, 1999 and 2002).

11.2 Data Evaluation

The following data collected as part of the CMP will be evaluated to determine if the CAOs have been met following the cleanup action implementation.

11.2.1 LNAPL Monitoring

LNAPL monitoring data will be evaluated to determine the post-cleanup migration patterns and levels with respect to historical data.

11.2.2 Groundwater Levels

Groundwater level data will be evaluated to determine the post-cleanup flow paths and hydraulic gradients with respect to historical data. The data evaluation will help determine if the existing monitoring network is sufficient to for flow path analysis.

11.2.3 Groundwater Quality

Groundwater quality data will be evaluated to determine the effects of cleanup actions on the groundwater quality. More specifically the data will be evaluated to confirm that groundwater containing IHSs (if detected) remain at concentrations below the applicable CULs at the specified CPOCs.

11.3 One Year Site Review

The one year site review will be conducted to evaluate the impact of the cleanup actions to the Site groundwater quality and to evaluate that MNA is occurring.

11.4 Five Year Site Review

After 5 years of groundwater and LNAPL monitoring, an evaluation report will be prepared that will include a summary of the five preceding annual reports and discussions about longer term trends in groundwater data.

After several years of monitoring, if the plume is determined to be stable or shrinking and less frequent monitoring of the trends would be sufficient to demonstrate that CULs continue to be met, the Port may propose less frequent monitoring or a reduction in the monitoring network to Ecology.

12.0 CRITERIA FOR MEETING PERFORMANCE AND COMPLIANCE STANDARDS

Cleanup levels for the Site were developed for IHSs in groundwater that could potentially contribute to human health or ecological risks (FS Report; PES et al., 2009). Table 1 presents the CMP IHSs and associated CULs determined in the FS. The primary numeric cleanup standards for the Site are the groundwater cleanup levels that address protection of human and aquatic receptors. The other cleanup standard applicable to the Site relates to the prevention of LNAPL from accumulating on the groundwater. Compliance with each of the two standards is discussed below.

The concentration of IHSs in groundwater are currently below cleanup levels at all CPOC wells. Implementation of the CMP program (which incorporates MNA) included in the presumptive cleanup actions will document whether or not cleanup levels continue to be met at these wells in the future.

12.1 Performance Monitoring

The groundwater performance monitoring program is designed to assess how the cleanup action is affecting groundwater quality and to determine if the cleanup levels continue to be achieved at the CPOC. The four current CPOC wells are located at the downgradient end of three shallow groundwater flow paths at the Site (Figure 3). CP_GP08 is located at the downgradient end of the Pier 90 flow path, CP_GP09R and CP_GP10 are located at the downgradient end of the Pier 91 flow path, and CP_GP14 is the CPOC for the AOC 11 flow path. The groundwater performance monitoring program will be conducted under the schedule specified in Section 6.3. If, after 3 years, the cleanup levels continue to be met at the CPOC wells, the plume concentrations are stable or decreasing, and LNAPL monitoring shows stable to decreasing LNAPL levels, the Port may make a request to Ecology to proceed to Site confirmational groundwater monitoring with a decrease in monitoring frequency. If the CPOC wells show short-term exceedances in CULs due to disturbances caused by cleanup action construction, then performance monitoring will continue until concentrations decrease. LNAPL monitoring will continue during the entire performance monitoring period.

12.2 Confirmational Monitoring

Confirmational groundwater monitoring will be initiated when the performance criteria listed above have been met. Confirmational monitoring will be conducted annually to confirm that IHSs remain below the established CULs in the CPOC wells. The FS assumed that MNA monitoring would continue for 30 years, but if after 4 years the cleanup levels continue to be met at the CPOC wells, the plume concentrations are stable or decreasing, and LNAPL monitoring shows stable to decreasing LNAPL levels, the Port may make a request to Ecology to reduce the monitoring frequency, reduce the number of parameters monitored, reduce the number of wells within the network, or request a modification of the CPOCs.

13.0 REPORTING

13.1 Progress Reports

In accordance with AO No. DE 8938, quarterly status reports will be submitted to Ecology to quarterly on or before January 20, April 20, July 20, and October 20 of each year, and continuing until all of the requirements of the AO are completed to Ecology's satisfaction.

Each status report will include the following:

- All work conducted pursuant to the Agreed Order during the last three month period;
- Occurrence of any problems, how problems were rectified, deviations from the work plans and an explanation of all deviations;
- Projected work to occur in the upcoming three months;
- Summaries of significant findings, changes in personnel, summaries of significant contacts with all federal, state, local community, and public interest groups; and
- Monitoring data collected pursuant to this CMP, not separately reported, (as copies of the original laboratory reporting data sheets, and in tabulated data format) for which quality assurance procedures are completed during the three month period; note, groundwater data will not be included in the quarterly progress reports as it will be submitted each year in the annual progress report.

In addition to the quarterly status reports, annual groundwater monitoring reports will be prepared and submitted to Ecology. The annual groundwater monitoring reports will include at a minimum:

- An overview of current cleanup status, identifying significant results and data trends;
- Water level contour maps using data from all groundwater monitoring wells sampled during each sampling event;
- Tabulated concentrations of IHSs and water table elevation data from the previous year's sample events. Tables will note groundwater cleanup levels;
- Copies of all laboratory analytical data sheets, chain of custody forms, and field activity logs; and
- A narrative discussion of data validation and a description of all data qualified or rejected.

13.2 Five-Year Review Report

After 5 years of system operation, an evaluation report will be prepared that will include a summary of the five preceding annual reports and discussions about longer term trends in the groundwater data.

14.0 REFERENCES

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TABLES

Indicator Hazardous Substances and Cleanup Levels
Compliance Monitoring Plan
Port of Seattle Terminal 91

Indicator Hazardous Substance	Final Cleanup Level (µg/L)[1]
Benzene	9.7
Toluene	8,260
Ethylbenzene	2,100
Total Xylenes	1,160
TPH-Gasoline	800
TPH-Diesel	500
TPH-Heavy Oil	500

Notes:

TPH = Total Petroleum Hydrocarbons.

µg/L = micrograms per liter.

1. Final groundwater cleanup levels from 2009 Final Feasibility Study Report (PES, 2009).

Table 2

Monitoring Well Summary
Compliance Monitoring Plan
Port of SeattleTerminal 91 Site

Well I.D.	Aquifer	Top of Casing Elevation	Well Depth	Historic LNAPL Presence	Groundwater Level Monitoring	Groundwater Sampling
B1-93	Shallow	17.24	30.00		X	
CP-103A	Shallow	17.11	15.00		X	X
CP-104A	Shallow	17.13	15.00		X	X
CP-104B	Deep	16.86	50.00		X	
CP-106A	Shallow	18.00	15.00		X	X
CP-106B	Deep	17.91	41.50		X	
CP-107	Shallow	17.15	20.00	X	X	
CP-108A	Shallow	16.58	15.00		X	X
CP-108B	Deep	16.77	60.00		X	X
CP-110	Shallow	17.42	16.50	X	X	
CP-111	Shallow	17.64	15.00		X	
CP-112	Shallow	17.04	15.00		X	
CP-113	Shallow	17.29	17.00		X	
CP-114	Shallow	17.94	14.00		X	X
CP-115A	Shallow	17.74	21.00		X	
CP-115B	Shallow	17.64	42.50		X	
CP-121	Shallow	17.61	21.00		X	
CP-122B	Deep	16.90	42.50		X	
CP-203B	Deep	16.99	59.95		X	X
CP-205A	Shallow	17.74	14.00		X	
CP-205B	Deep	17.73	50.00		X	X
CP-GP01A	Shallow	17.68	19.20		X	X
CP-GP01B	Deep	17.60	64.50		X	X
CP-GP02	Shallow	17.39	20.10		X	X
CP-GP03AR	Shallow	17.77	19.85		X	X
CP-GP03BR	Deep	17.74	64.50		X	
CP-GP04R	Shallow	17.90	19.83		X	
CP-GP05	Shallow	17.44	10.00		X	X
CP-GP06	Shallow	17.46	17.50		X	
CP-GP07R	Shallow	18.08	19.85		X	
CP-GP08	Shallow	17.37	18.00		X	X
CP-GP09R	Shallow	17.45	18.00		X	X
CP-GP10	Shallow	17.92	17.85		X	X
CP-GP11	Shallow	16.94	20.00		X	X
CP-GP12	Shallow	17.42	20.00		X	
CP-GP13	Shallow	17.01	20.00		X	
CP-GP14	Shallow	17.63	20.00		X	X
CP-PR-13	Shallow	17.31	12.90		X	
CP-W210	Shallow	17.11	14.95		X	
PNO-MW02	Shallow	17.71	17.00		X	X
PNO-MW06A	Shallow	18.05	17.50		X	X

Table 2

Monitoring Well Summary
Compliance Monitoring Plan
Port of SeattleTerminal 91 Site

Well I.D.	Aquifer	Top of Casing Elevation	Well Depth	Historic LNAPL Presence	Groundwater Level Monitoring	Groundwater Sampling
PNO-MW06B	Deep	17.98	55.40		X	X
PNO-MW101	Shallow	17.74	16.30		X	X
PNO-MW103	Shallow	17.48	17.00		X	X
PNO-MW104	Shallow	17.43	17.40	X	X	
UT-MW39-1	Shallow	16.65	17.50		X	
UT-MW39-3	Shallow	17.33	14.00	X	X	

Notes:

LNAPL = Light non-aqueous phase liquid

1. Elevation at top of PVC casing relative to mean low low water vertical datum.
2. Groundwater Level Monitoring, LNAPL Monitoring and Groundwater Sampling will be conducted quarterly for one year after cleanup actions conducted, semiannually for years 2 & 3 post cleanup actions, annually thereafter.
3. Monitoring of LNAPL trenches is included in the O&M plan (PES, 2013b).

Groundwater Monitoring Well Sampling Summary
Compliance Monitoring Plan - Port of SeattleTerminal 91 Site

Well I.D.	Northing	Easting	Monitoring Point Elevation	Screen Depth	Field Parameters	MNA Parameters	MNA Secondary Geochemical Indicators
Shallow Monitoring Wells							
CP-103A	234,971.67	1,258,579.33	17.11	5 - 15	Q/SA/A	Q/SA/A	SA/A
CP-104A	235,420.29	1,258,579.32	17.13	5 - 15	Q/SA/A	Q/SA/A	SA/A
CP-106A	235,302.65	1,258,919.98	18.00	5 - 15	Q/SA/A	Q/SA/A	SA/A
CP-108A	234,962.43	1,258,930.72	16.58	5 - 15	Q/SA/A	Q/SA/A	SA/A
CP-114	235,478.09	1,258,827.37	17.94	4 - 14	Q/SA/A	Q/SA/A	SA/A
CP-GP01A	234,782.73	1,259,137.79	17.68	4 - 19	Q/SA/A	Q/SA/A	SA/A
CP-GP02	234,870.03	1,259,056.75	17.39	5 - 20	Q/SA/A	Q/SA/A	SA/A
CP-GP03AR	234,502.63	1,258,278.08	17.77	5 - 20	Q/SA/A	Q/SA/A	SA/A
CP-GP05	234,924.05	1,258,076.80	17.44	8 - 18	Q/SA/A	Q/SA/A	SA/A
CP-GP08	234,461.44	1,259,036.57	17.37	8 - 18	Q/SA/A	Q/SA/A	SA/A
CP-GP09R	234,286.11	1,258,445.22	17.45	8 - 18	Q/SA/A	Q/SA/A	SA/A
CP-GP10	234,298.17	1,258,331.41	17.92	8 - 18	Q/SA/A	Q/SA/A	SA/A
CP-GP11	235,154.00	1,258,335.00	16.94	3 - 11	Q/SA/A	Q/SA/A	SA/A
CP-GP14	234,925.00	1,257,822.00	17.63	4 - 19	Q/SA/A	Q/SA/A	SA/A
PNO-MW02	234,813.86	1,258,465.11	17.71	7 - 17	Q/SA/A	Q/SA/A	SA/A
PNO-MW06A	234,774.15	1,258,423.77	18.05	7.5 - 17.5	Q/SA/A	Q/SA/A	SA/A
PNO-MW101	234,996.13	1,258,274.86	17.74	7 - 16.3	Q/SA/A	Q/SA/A	SA/A
PNO-MW103	234,473.41	1,258,455.40	17.48	7 - 17	Q/SA/A	Q/SA/A	SA/A
Deep Monitoring Wells							
CP-108B	234,962.11	1,258,926.05	16.77	50 - 60	Q/SA/A	Q/SA/A	NA
CP-203B	234,970.82	1,258,601.63	16.99	50-60	Q/SA/A	Q/SA/A	NA
CP-205B	235,681.35	1,258,725.57	17.73	34.5 - 44.5	Q/SA/A	Q/SA/A	NA
CP-GP01B	234,780.26	1,259,129.54	17.60	4 - 19	Q/SA/A	Q/SA/A	NA
PNO-MW06B	234,764.73	1,258,423.75	17.98	45-55	Q/SA/A	Q/SA/A	NA

Notes:

1. Northing and easting in feet relative to the Washington State Plane System North Zone (NAD 27).
2. Elevations in feet relative to the North American Vertical Datum (NAVD 88).
3. Monitoring point = top of the PVC well casing.
4. All depths shown in feet below ground surface.
3. Q = Quarterly.
4. SA = Semiannually.
5. A = Annually
5. Q/SA/A = Quarterly for 2 years after cleanup actions conducted, semiannually for years 3 & 4 post cleanup actions, annually thereafter.
6. SA/A = Semiannually for 2 years after cleanup actions conducted, annually thereafter.
7. Field parameters include pH, conductivity, temperature, dissolved oxygen and redox potential,
8. MNA Parameters = Gasoline-range, diesel-range, and oil-range hydrocarbons using Ecology Methods NWTPH-Gx and NWTPH-Dx and BTEX using EPA Method 8260.
9. MNA Secondary Geochecmical Indicators = Sulfate and Nitrate (EPA Method 300.0), Manganese (EPA Method 6010B), Methane (Modified RSK Method 175 or equivalent); Ferrous Iron (field kit, Hach Method 8146 or equivalent), and Alkalinity (field kit, HACH Method AL AP MG-L or equivalent).
10. NA = Not applicable to deep aquifer monitoring.

Table 4

Analytical Methods and Sample Handling Details
Compliance Monitoring Plan
Port of Seattle Terminal 91 Site

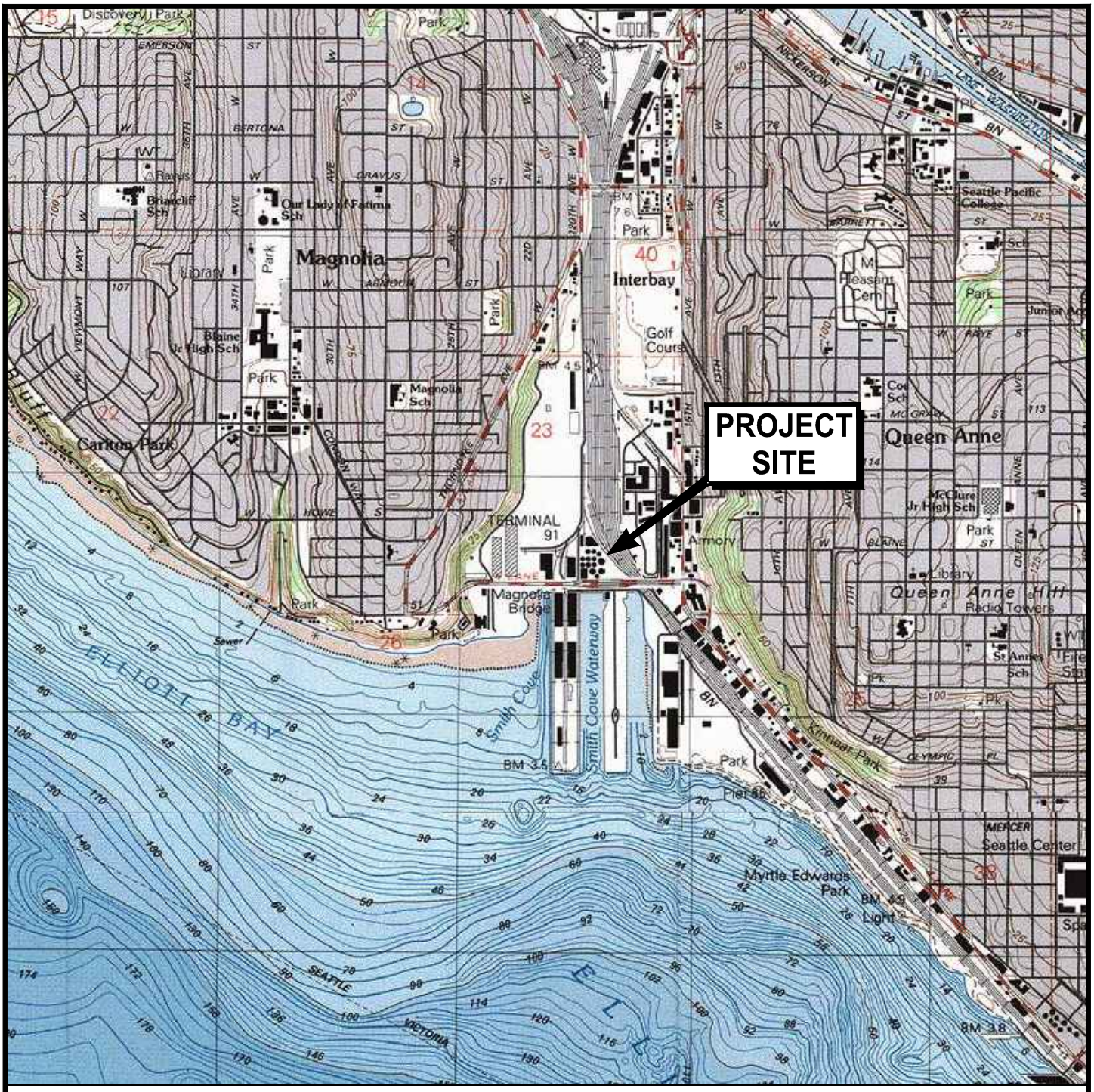
Analyses	Analytical Method	Water Sample Container	Preservation	Max Holding Time
Total Petroleum Hydrocarbons (TPH) - Gasoline Range	NWTPH-Gx	2 x 40 mL VOA vial	Cool, 4°C, HCL, pH <2	14 days
TPH - Diesel Range and Oil Range	NWTPH-Dx	1 Liter Amber	Cool, 4°C, HCL, pH <2	14 days
Volatile Organic Compunds (VOCs) - BTEX only	EPA 8260	2 x 40 mL VOA vial	Cool, 4°C, HCL, pH <2	14 days
Nitrate	EPA 300.0/9056	500 mL HDPE	Cool, 4°C	48 hours
Sulfate	EPA 300.0/9056	500 mL HDPE	Cool, 4°C	28 days
Total Alkalinity	SM 2320/Hach AL AP MG-L[a]	500 mL HDPE	Cool, 4°C	14 days
Manganese	6010B	500 mL HDPE	Cool, 4°C, HNO_3, pH<2	28 days
Ferrous Iron	SM 3500-Fe/Hach 8146	1 Liter Amber	Cool, 4°C	24 hours[b]
Dissolved Gases	EPA RSK 175	2 x 40 mL VOA vial	Cool, 4°C, HCL, pH <2	14 days

Notes: 1. Gasoline-range, diesel-range, and oil-range hydrocarbons using Ecology Methods NWTPH-Gx and NWTPH-Dx.
2. HDPE = high density polyethelyene.
3. Analyses will be conducted by the methods specified or equivalent methods.
[a] Hach field test kit.
[b] Analyze immediately upon receipt at laboratory.

Laboratory and Field Quality Control Sample Summary
Compliance Monitoring Plan
Port of Seattle Terminal 91 Site

Matrix	QA/QC Analyses	Frequency
Field		
Water	Trip blank	1 per sampling event when samples are analyzed for VOCs
Water	Equipment Blank	1 per sampling event when samples are analyzed for VOCs
Water	Field duplicate	1 per 20 project samples
Laboratory		
Water	Laboratory control sample (LCS)	Every analytical batch
Water	MS/MSD	1 per 20 project samples
Water	Method blank	Every analytical batch

FIGURES



U.S.G.S. Topo Map - Seattle North W, WA, 7.5-minute quadrangle.1983

PES Environmental, Inc.
Engineering & Environmental Services

Site Location Map
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
1

948.002.04.005	94800704005_CMP_1		2/13
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE

94800704005_CMP_2

For areas shown as Tank Farm Affected Area ("TFAA") that are outside the Tank Farm Lease Parcel, the TFAA includes only soil and ground water below the water table. Soil above the water table (and outside the Tank Farm Lease Parcel) is outside the TFAA.

Note:

N

0 700 feet

The locations of all features are approximate.

Explanation

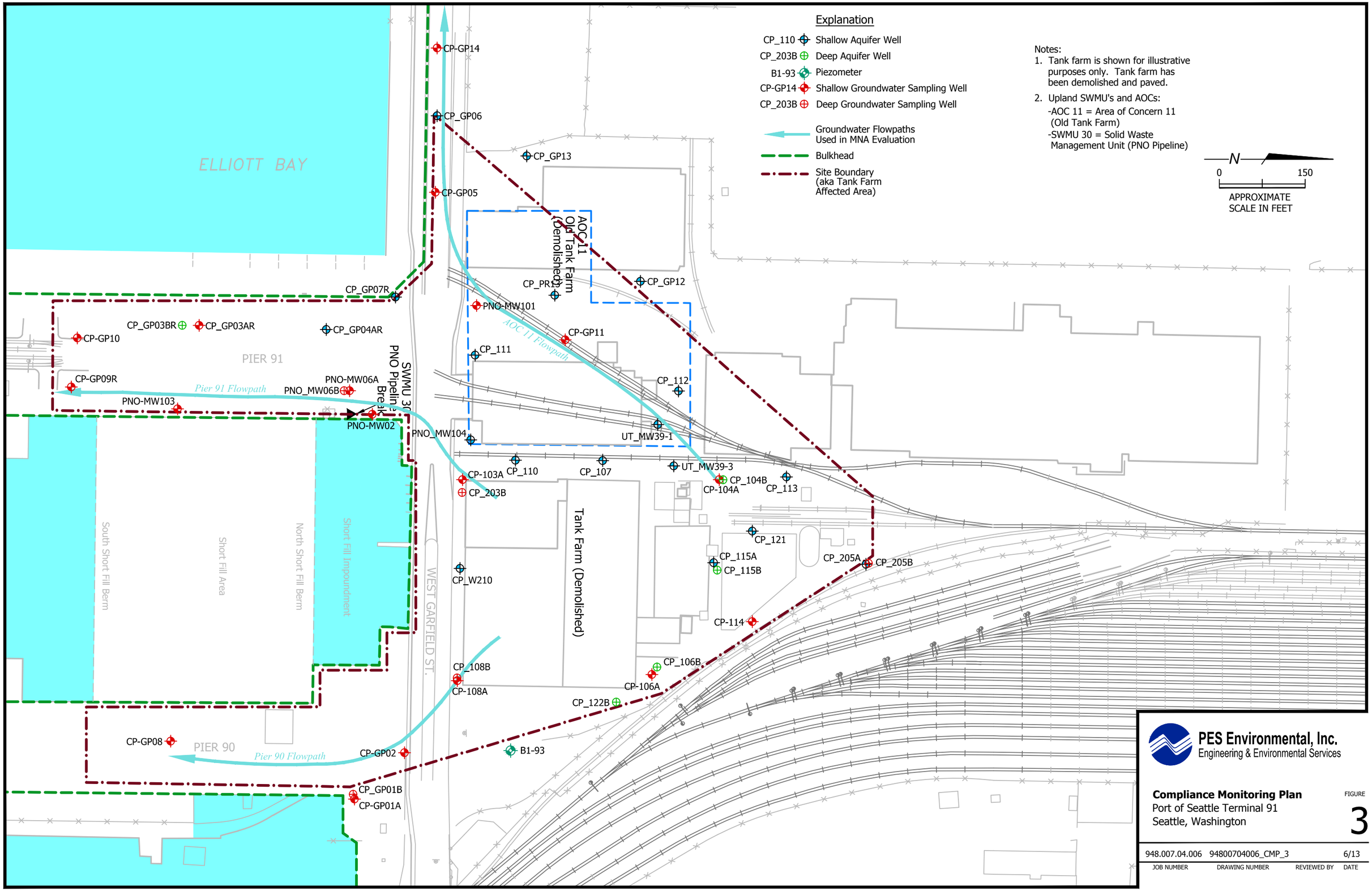
- Port of Seattle Property Limits
- Tank Farm Lease Parcel
- Tank Farm Affected Area
- Submerged Land

PES Environmental, Inc.
Engineering & Environmental Services

FIGURE 2

Port of Seattle Terminal 91 Facility and Tank Farm Lease Parcel
Port of Seattle Terminal 91
Seattle, Washington

948.007.04.005	94800704005_CMP_2		2/13
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE



PES Environmental, Inc.
Engineering & Environmental Services

Compliance Monitoring Plan
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
3

948.007.04.006	94800704006_CMP_3		6/13
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE

APPENDIX A

WELL LOGS

CP-104A

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Pier 91

Location See Figure 2.1

Surface Elevation

Total Depth 15'

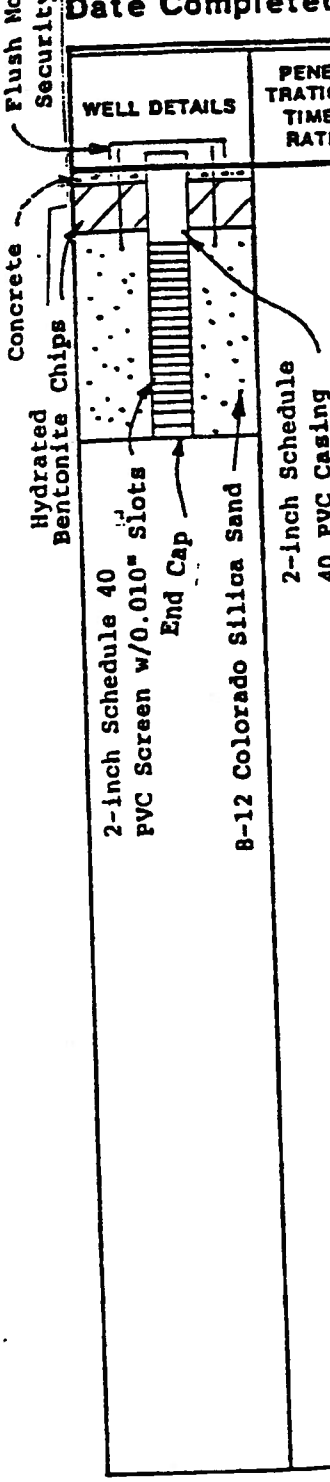
Date Completed 11/28/87

Boring No. CP-104-A

Drilling Method Mobil B-56 with 4.25" I.D. 7.5" O.D. Hollow Stem Auger

Drilled By Tacoma Pump & Drilling

Logged By S. R. Henshaw



WELL DETAILS	PENETRATION TIME/RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
			No	Sample		SP	0-10' SAND, medium grained, cuttings became wet at 6', gray.	
		10	101-A	SPT		GW	10-12' GRAVELLY SAND, 10-20% subrounded gravel, less than 5% shell fragments, medium to coarse grained sand, gray, gravels are basalts, quartzite, metavolcanics, petroleum odor, saturated.	
			No	Sample				
		20				SM	12-15' SILTY SAND, 5-10% pebble size sand, 60% medium sand, 30% silt, gray, strong petroleum odor, sat.	
							Terminated boring at 15' 11/28/87	

CP_106A

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Pier 91

Location See Figure 2.1

Surface Elevation

Total Depth 15'

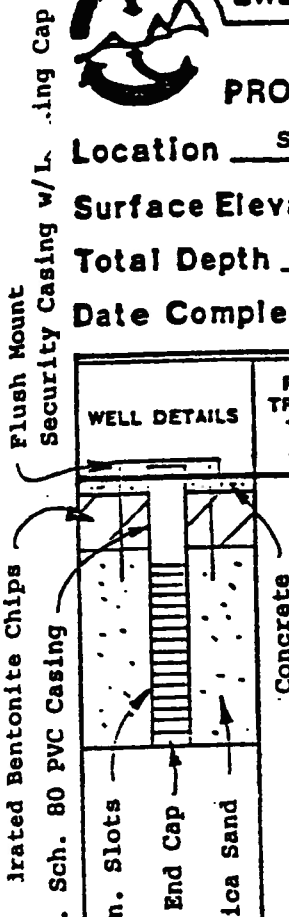
Date Completed 11/28/87

Boring No. CP-106-A

Drilling Method Mobil B-56 with 4.25" I.D. 7.5"O.D. Hollow Stem Aug

Drilled By Tacoma Pump & Drilling

Logged By S. R. Henshaw



WELL DETAILS	PENETRATION TIME/RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
							Concrete Pavement	
		10	106-A	SPT		SP	2-15' SAND, dark gray, fine to medium grained, less than 5% shell fragments, 5-10% silt, petroleum odor, saturated.	
							12-15' increasing gravels and cobbles up to 4".	
		20	No Sample				Terminated boring at 15' 11/28/87	

CP_103A

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Pier 91 Page 1 of 1

Location See Figure 2.1 Boring No. CP-103-A

Surface Elevation _____ Drilling Method Cable Tool Rig with 6" Bit

Total Depth 15' Drilled By Holt Drilling

Date Completed 12/2/87 Logged By S. R. Henshaw

WELL DETAILS	PENE-TRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERME-ABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
							See Boring Log CP-103-B	
		10					Terminated boring at 15' 12/2/87	
		20						

Flush Mount Security Casing w/ King Cap

Concrete

Hydrated Bentonite Pellets

2-inch Schedule 40 PVC Screen w/0.010" Slots

8-12 Colorado Silica Sand

2-inch Schedule 40 PVC Casing

SEA-300-02a

CP-107

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-107
LOCATION	Pier 91	PAGE	1 OF 1
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	5.10'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	17.00'
LOGGED BY	S. Nelson	DATE COMPLETED	12/29/88

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	LITHOLOGIC DESCRIPTION
			0 - 0.3 foot: ASPHALT. (AS)
			0.3 - 2.0 feet: GRAVELLY SAND; light to dark brown, fine to medium, 25% subangular gravel to 3 inches in diameter, 0-5% silt, dry, compact. (SW) (FILL)
1	3" SS	29-49-25	
			2.0 - 3.6 feet: SAND; light olive, fine to medium, 10% subround gravel to 2 inches in diameter, 10% shell debris, dry. (SP) (FILL)
2	3" SS	16-21-25	
			3.6 - 12.0 feet: GRAVELLY SAND; light to medium olive, fine to medium, 20-30% subround gravel to 2 inches in diameter. 0-5% shell debris. Saturated, with oily odor below 6.0 feet. Some silt and coarse sand layers below 6.0 feet. (SW) (FILL)
3	3" SS	8-13-18	
4	3" SS	7-10-13	
5		7-10-11	
			12.0 - 15.8 feet: SAND; dark olive, medium to coarse, 5% subround gravel to 1 inch in diameter, trace shells. Petroleum odor, saturated. (SP) (FILL)
6	3" SS	7-14-16	
			15.8 - 16.5 feet: SILTY SAND; olive, 20-50% silt, fine to coarse sand; organic decay odor, saturated. (SM)
			Borehole terminated at 17.0 feet BGS on 12/29/88.

REMARKS

1) Specific Location: NC Warehouse. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 6.0 feet BGS, at 11:00 on 12/29/88. 5) Reference elevation at top of PVC casing, City of Seattle datum.

SWEET-EDWARDS/EMCON

S94-07.03 CHEMP SMJ 04/12/95

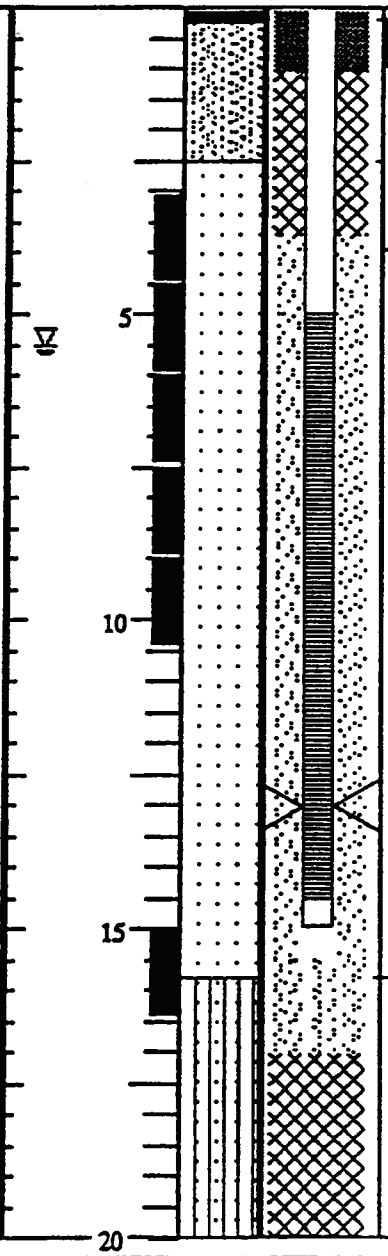
CP_108A

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108A
LOCATION	Pier 91	PAGE	1 OF 2
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.67'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	21.50'
LOGGED BY	S. Nelson	DATE COMPLETED	12/28/88

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)
1	3" SS	11-9-12
2	3" SS	7-10-11
3	3" SS	6-10-11
4	2" SS	5-6-7
5	2" SS	4-2-9
6	3" SS	11-35-50

GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOLOGIC COLUMN | WELL DETAILS



LITHOLOGIC DESCRIPTION

0 - 0.25 foot: ASPHALT. (AS)

0.25 - 2.5 feet: GRAVELLY SAND; brown, fine to medium, 15% subround gravel to 1 inch in diameter. Trace to 5% shell fragments, 0-5% silt, compact, dry. (SW) (FILL)

2.5 - 15.8 feet: SAND; light olive brown to olive, fine to medium, 5-10% subround gravel to 1 inch in diameter, 0-5% shell debris, some banding. Saturated, with petroleum odor below 5.5 feet. (SP)

— @ 8.0-9.0 feet: coarse sand layer with strong petroleum odor.

15.8 - 24.0 feet: SILTY SAND; olive, very fine to medium, 5-40% silt, 0-10% wood debris, organic decay - H2S odor. Saturated. (SM)

REMARKS

1) Specific Location: Garfield / East Route. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon Sample. 4) Water measurement at 5.5 feet BGS, at 10:15 on 12/28/88. See ADDITIONAL REMARKS at end of Description column.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108A
LOCATION	Pier 91	PAGE	2 OF 2
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.67'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	21.50'
LOGGED BY	S. Nelson	DATE COMPLETED	12/28/88

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
7	3" SS	12-14-12		25 30 35 40				15.8 - 21.5 feet: SILTY SAND; see previous page for Description. Borehole terminated at 21.5 BGS on 12/28/88. ADDITIONAL REMARKS: 5) Reference elevation at top of PVC casing, City of Seattle datum. Lithologic description for CP-108-A is the same as CP-108-B to depth of 21.5 feet.

REMARKS

1) Specific Location: Garfield / East Route. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon Sample. 4) Water measurement at 5.5 feet BGS, at 10:15 on 12/28/88. See ADDITIONAL REMARKS at end of Description column.

CP_110

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-110
LOCATION	Pier 91	PAGE	1 OF 1
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.68'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	20.00'
LOGGED BY	S. Nelson	DATE COMPLETED	12/30/88

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	LITHOLOGIC DESCRIPTION
			0 - 0.3 foot: ASPHALT. (AS)
			0.3 - 1.5 feet: GRAVELLY SAND; light brown, fine to medium, 15-20% subround to subangular gravel to 3 inches in diameter, 0-5% silt, dry, compact. (SW) (FILL)
1	3" SS	13-23-20	
2	3" SS	10-17-17	1.5 - 7.3 feet: SAND; light to medium olive, fine to medium, 10-15% subround gravel to 1 inch in diameter, trace shell and wood debris, some banding, saturated at 6.8 feet with strong petroleum odor. (SP) (FILL)
3	3" SS	13-22-24	
4	2" SS	7-13-25	7.3 - 16.1 feet: GRAVELLY SAND; olive, fine to medium, 15-20% subround gravel to 1 inch in diameter, 0-5% silt, coarse (sand) and/or shell debris, petroleum odor, saturated, oily sheen on coarse grains below 7.0 feet. (SW) (FILL)
5	2" SS	17-26-33	
			—@ 14.0 feet: petroleum odor decreasing.
6	3" SS	16-25-30	
			16.1 - 16.5 feet: SILTY SAND; olive, fine to medium, 30% silt, trace coarse sand, faint banding, organic decay odor. Saturated. (SM)
			Borehole terminated at 20.0 feet BGS on 12/30/88.

REMARKS

1) Specific Location: NC Warehouse. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 7.0 feet BGS, at 10:00 on 12/30/88. 5)Reference elevation at top of PVC casing, City of Seattle datum.

SWEET-EDWARDS/EMCON

594-07.03 CHEMP.SM1 04/12/89

CP_104B

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-104B
LOCATION	Pier 91	PAGE	1 OF 3
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.91'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	46.50'
LOGGED BY	S. Nelson	DATE COMPLETED	1/25/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
			▽	5				0 - 0.6 foot: CONCRETE. (CON) 0.6 - 15.0 feet: SAND; olive, fine to medium, 5-20% subround gravel to 1.5 inches in diameter, 0-5% shell debris. Saturated, petroleum odor below 6.0 feet. (SP)
				10				
				15				15.0 - 26.5 feet: SILTY SAND; olive, fine, 0-5% fine gravel, shell and wood debris. Saturated, 10-30% subround gravel to 2 inches in diameter at 25-26.5 feet. (SM)
				20				

REMARKS

1) Specific Location: Pit Separator. 2) H.S.Auger = Hollow Stem Auger. 3) Water measurement at 5.5 feet BGS, at 15:00 on 1/20/89. 4) Reference elevation at top of PVC casing, City of Seattle datum.

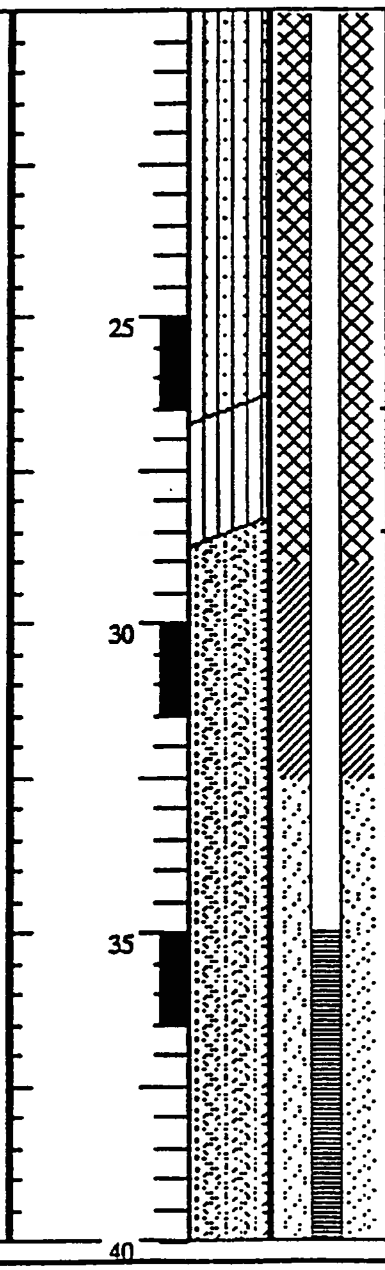
SWEET-EDWARDS/EMCON

S94-07.03 CHEMP SM1 04/12/89

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-104B
LOCATION	Pier 91	PAGE	2 OF 3
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.91'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	46.50'
LOGGED BY	S. Nelson	DATE COMPLETED	1/25/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
								15.0 - 26.5 feet: SILTY SAND; see previous page for Description.
1	BAILER			25				
								26.5 - 28.5 feet: SILT; olive, 0-5% wood and shell debris, organic decay odor. (ML)
								28.5 - 46.0 feet: GRAVELLY SAND; olive grey, medium to coarse, 5-40% subround to round gravel up to 3 inches in diameter, size increases with depth, 5-10% shell debris. Strong organic decay odor. (SW)
2	BAILER			30				
3	BAILER			35				
				40				



REMARKS

1) Specific Location: Pit Separator. 2) H.S.Auger = Hollow Stem Auger. 3) Water measurement at 5.5 feet BGS, at 15:00 on 1/20/89. 4) Reference elevation at top of PVC casing, City of Seattle datum.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-104B
LOCATION	Pier 91	PAGE	3 OF 3
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.91'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	46.50'
LOGGED BY	S. Nelson	DATE COMPLETED	1/25/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
4	BAILER							28.5 - 46.0 feet: GRAVELLY SAND; see previous page for Description.
5	BAILER			45				Borehole terminated at 46.0 BGS on 1/24/89.
				50				
				55				
				60				

REMARKS

1) Specific Location: Pit Separator. 2) H.S.Auger = Hollow Stem Auger. 3) Water measurement at 5.5 feet BGS, at 15:00 on 1/20/89. 4) Reference elevation at top of PVC casing, City of Seattle datum.

CP_108B

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	1 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
				5				0 - 0.25 foot: ASPHALT. (AS) 0.25 - 2.5 feet: GRAVELLY SAND; brown, fine to medium, 15% subround gravel to 1 inch in diameter. Trace to 5% shell fragments, 0-5% silt, compact, dry. (SW) (FILL) 2.5 - 15.8 feet: SAND; light olive brown to olive, fine to medium, 5-10% subround gravel to 1 inch in diameter, 0-5% shell debris, some banding. Saturated, petroleum odor below 5.5 feet. (SP) — @ 8.0-9.0 feet: coarse sand layer with strong petroleum odor.
			▽	10				
				15				15.8 - 45.0 feet: SILTY SAND; olive, very fine to medium, 5-40% silt, 0-10% wood debris, organic decay - H2S odor. Saturated. Silt decreasing to 5% at 30.0 feet, wood and shell debris increase to 10%. Gravel increases to 20% at 35.0 feet, silt to 15% at 40.0 feet. (SM)
				20				

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

SWEET-EDWARDS/EMCON

594-07.03 CHEMP SM/ 06/12/89

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	2 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
								15.8 - 45.0 feet: SILTY SAND; see previous page for Description.
1	3" SS	5-5-7		25				
2	3" SS	3-17-16		30				
3	3" SS	5-6-8		35				
				40				

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	3 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
4	3" SS	3-3-4						
5	3" SS	7-7-9		45				45.0 - 60.0 feet: SAND; olive, medium, 5-25% subround gravel to 1 1/2 inch in diameter, 3-10% shell debris, gravel increases in size and quantity with depth. (SP)
				50				
				55				
				60				

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	4 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

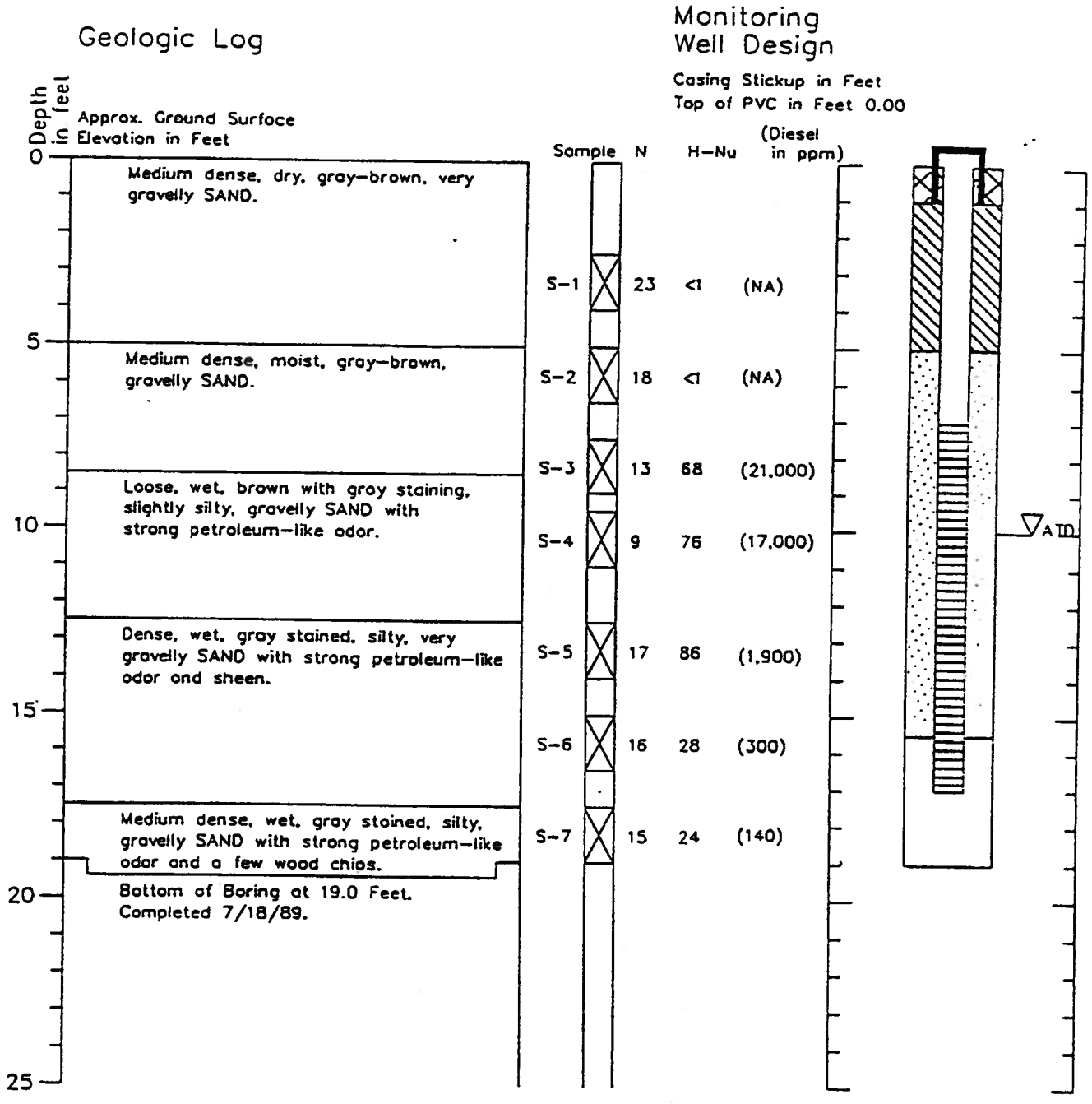
SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
				65				Borehole terminated at 62.0 BGS on 1/20/89.
				70				ADDITIONAL REMARKS: 5) Reference elevation at top of PVC casing, City of Seattle datum. 6) Lithologic description for CP-108-A is the same as CP-108-B to depth of 21.5 feet. Samples were taken with a Dames & Moore sampler and 300 lb. jars.
				75				
				80				

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

PND_MW02

Boring Log and Construction Data for Monitoring Well B-2



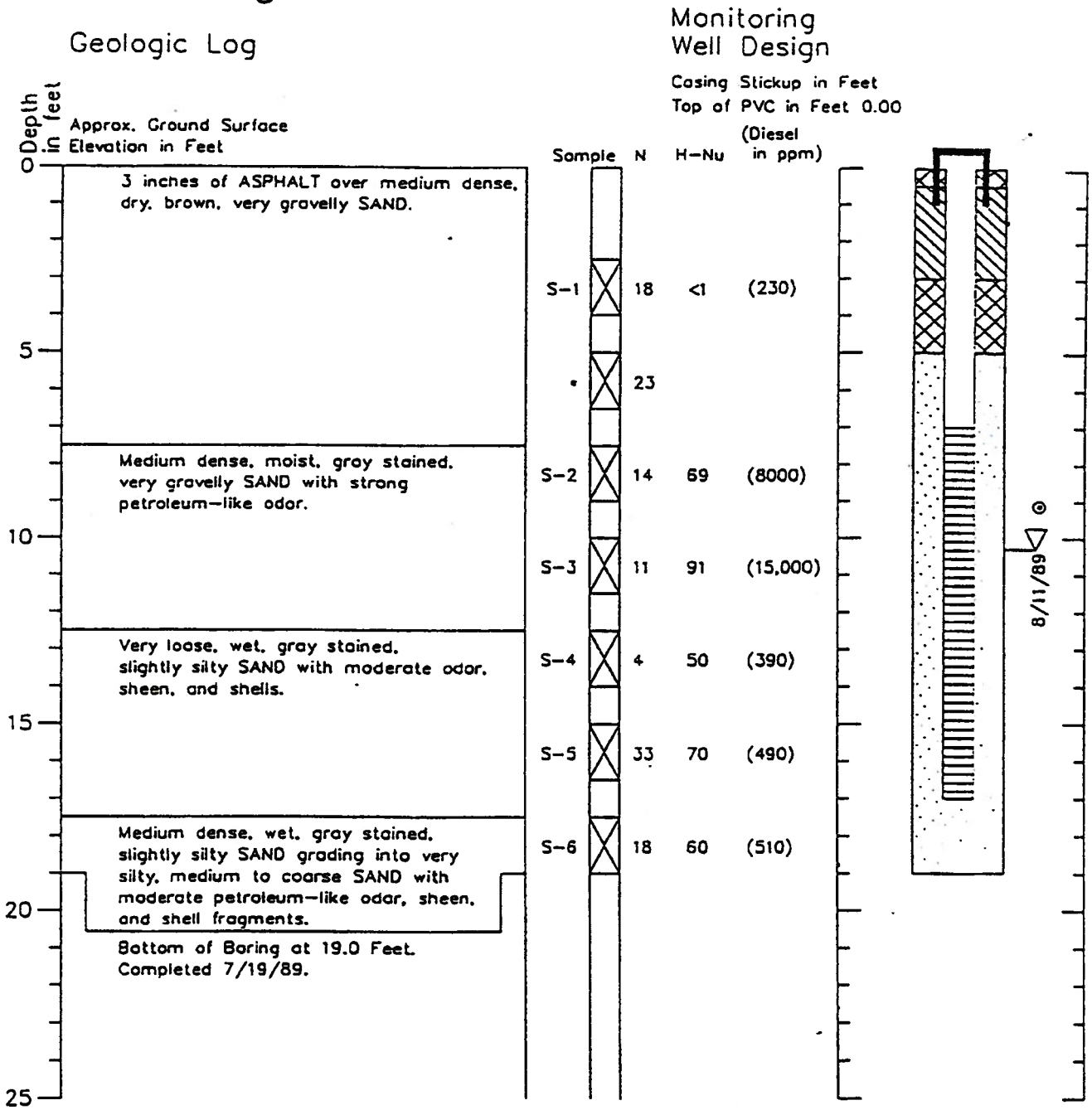
1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-2500 7/89

Figure 4

PNO_MW03

Boring Log and Construction Data for Monitoring Well B-3



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

⊙ Depth to free product at 9.4 feet.

HARTCROWSER

J-2500 7/8

Figure 5

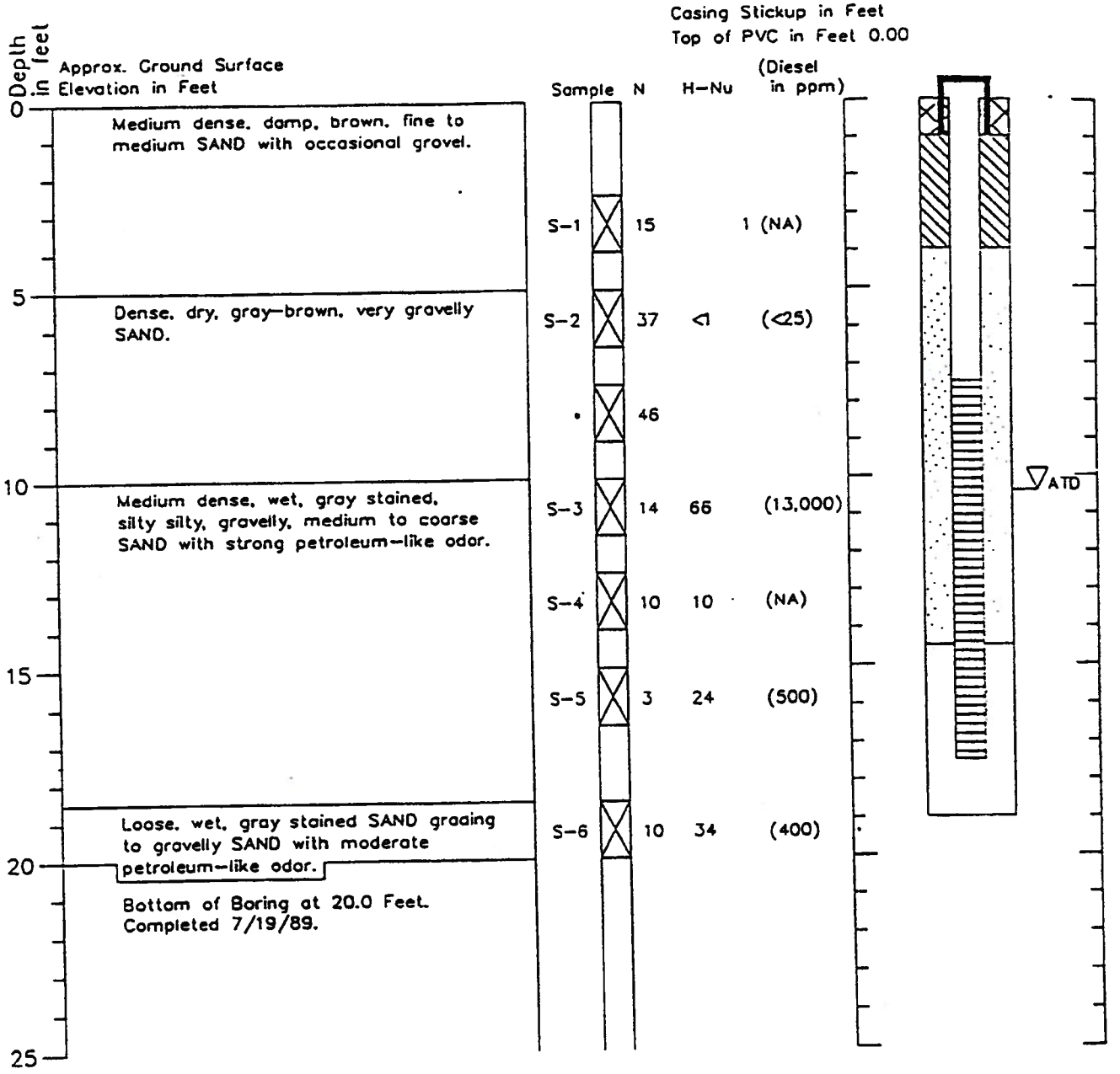
PND_MW06A

Boring Log and Construction Data for Monitoring Well B-6

Geologic Log

Monitoring Well Design

Casing Stickup in Feet
Top of PVC in Feet 0.00



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-2500 7/8

Figure 8

PNO_MW101

Converse GES — Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
89-45527	MW-101	1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.55
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Start Date: November 29, 1989
Drilling Contractor: GeoBoring Develop.
Finish Date: November 29, 1989
Drilling Method: HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	Hnu Test	Description
	locking, water tight, flush metal monument			14 7 7		Asphalt 2-inches SAND WITH GRAVEL (Fill); brown, medium; medium dense, dry
	concrete grout annular seal				0 ppm	
2				.		SAND (Fill); brown, little gray pea gravel; dense, dry
	blank well casing 4" ID PVC schedule 40			3 14 24	0 ppm	
4	bentonite seal					GRAVEL (Fill); medium to coarse; very dense, moist - encountered hard flat surface, drilled to refusal - boring moved 4 feet south and restarted
				19 18 10	17 ppm	SAND; gray, coarse; medium dense, moist
6						
	12/6/89					
		C		7 8 10	10 ppm	SANDY GRAVEL; gray, coarse sand matrix, trace shell fragments; medium dense, wet (strong petroleum odor)
8	ATD					
	well screen, 4"ID PVC schedule 40, .010 slot width					
10		C		1 1 2	4 ppm	SAND; gray; coarse; loose, wet (strong petroleum odor and sheen)
12	filter pack 16/30 Colorado silica sand	C		4 5 7	5 ppm	SANDY GRAVEL; gray, coarse sand matrix, trace shell fragments; medium dense, wet (strong petroleum odor and sheen)
14				5 9 12	3 ppm	
16						Total depth of boring at 16.3 feet.
18						

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- ▽ Water Level

Logged by: JJS
Approved by: EWM

Figure No. A-1

PNO-MW102

Converse GES

Monitoring Well Geologic & Construction Log

Project Number: 89-45527 | Well Number: MW-102 | Sheet 1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.5
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Start Date: November 30, 1989
Drilling Contractor: GeoBoring Develop.
Finish Date: November 30, 1989
Drilling Method: HSA

Depth feet	Well Construction	Lab Tests	S	Blows/6"	Hnu Test	Description
	locking, water tight, flush metal monument			24 38 62		Asphalt 2-inches SAND (Fill); gray brown, little pea-gravel; very dense, moist
	concrete grout annular seal					
2						-no sample recovery driving on pea-gravel
	blank well casing 4"ID PVC schedule 40			4 6 3		
4						
	bentonite seal			7 15 11	0 ppm	SAND; gray, little gravel, with stringers of fine sandy silt; medium dense, very moist
6						
		C		5 4 2	6 ppm	SANDY GRAVEL; gray, fine to medium sand matrix; loose, wet
8	ATD 12/6/89					
	well screen 4" ID PVC schedule 40,.010 slot width	C		2 3 2	60 ppm	SAND; dark gray, coarse, trace shell fragments; loose, wet (strong petroleum odor)
12		C		3 5 6	3 ppm	SAND; dark gray, medium sand, grading into coarse gray sand, tr: shell fragments; medium dense, wet (strong petroleum odor)
14	filter pack 16/30 Colorado silica sand			4 6 7	1 ppm	- sand grades with 1/8-inch stringers of gray clay, thinly bedded with gray sand, trace shell fragments; medium dense, wet
16						
18						Total depth of boring 17 feet.

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: JJS
Approved by: EWM

Figure No. A-2

PNO_MW103

Converse GES — Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
89-45527	MW-103	1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.43
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Drilling Contractor: GeoBoring Develop.
Start Date: November 29, 1989
Drilling Method: HSA
Finish Date: November 29, 1989

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	Hnu Test	Description
	locking, water tight, flush metal monument			17 23		Asphalt 2-inches SAND (Fill); brown, medium, trace pea-gravel; very dense, dry
	concrete annular seal					SAND (Fill); brown, fine thinly bedded with gray coarse sand; medium dense, moist
2				7 10 12	0 ppm	
	blank well casing 4" ID PVC schedule 40					
4	bentonite seal					
				8 5 10	0 ppm	SAND; gray to iron stained; fine to medium; medium dense, moist
6						
	well screen, 4"ID PVC schedule 40,.010 slot width	C		8 14 13	1 ppm	SAND; gray, coarse, trace gravel; medium dense, moist (petroleum odor)
8						
	12/6/89					
10	ATD	C		7 9 11	3 ppm	SANDY GRAVEL; gray, coarse sand matrix; wet (petroleum odor)
12						SAND; gray, coarse, thinly bedded with silty sand, trace shell fragments; loose, wet
		C		3 2 3		
14	filter pack 16/30 Colorado silica sand					-grades with less shell fragments (petroleum sheen)
				2 6 10	1 ppm	
16						
						Total depth 17 feet.
18						

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: JJS
Approved by: EWM

Figure No. A-3

PNO_MW104

Converse GES — Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
89-45527	MW-104	1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.46
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Start Date: November 30, 1989
Drilling Contractor: GeoBoring Develop.
Finish Date: November 30, 1989
Drilling Method: HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	Hnu Test	Description
	locking, water tight, flush metal monument; concrete grout annular seal			13 11 13		Asphalt 2-inches SAND (Fill); brown, medium sand, little gravel; medium dense, dry
					0 ppm	
2						SAND; tan, coarse, trace shell fragments; medium dense, dry
				3 5 7	0 ppm	
	bentonite seal					
4						
	blank well casing 4" ID PVC schedule 40			2 3 3	0 ppm	grades to thinly bedded with gray coarse sand, trace shell fragments; loose, very moist
6						
	12/6/89					
		C		6 9 12	10 ppm	SANDY GRAVEL; gray, coarse sand matrix; medium dense, wet
8	ATD					
	well screen, 4" ID PVC schedule 40, .010 slot width					
10		C		5 9 8	20 ppm	- grades with strong petroleum odor
12	filter pack 16/30 Colorado silica sand					-grades with slight petroleum odor
		C		4 9 8	2 ppm	
14						
				2 3 5	2 ppm	SANDY GRAVEL; dark gray, thinly bedded with coarse sand; medium dense, wet (petroleum sheen on soils)
16						
18						Total depth 17.4 feet.

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: JJS
Approved by: EWM

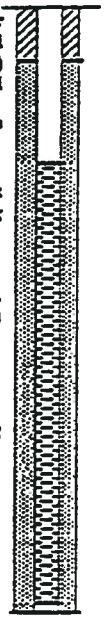
Figure No. A-4

UT_MW39-1

Top of Casing 16.65 ft

Equipment Mobile B-61 HSA

Elevation 17.28 ft Date 1/18/90



Depth ft	Sample	Blows/ft	Core Rec.	HC Odor	OVM	
0						4-6" CONCRETE BROWN SAND (SP) dry, loose, fine sand, with some coarse sand and fine gravel, trace of coarse gravel
		23	15	No		
5						
		25	18	No		gray, wet, loose, fine to medium sand, no odor
10						
		14	2	No		grades with fine gravel, wet, no odor
15						
						Boring terminated at 17.5 feet. Well completed on 1/18/90.
20						
25						
30						
35						
40						

MW-39-1 Coordinates
N 35003.2
E 20575.1

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring MW-39-1

(sheet 1 of 1) PLATE

Port of Seattle
Seattle, Washington

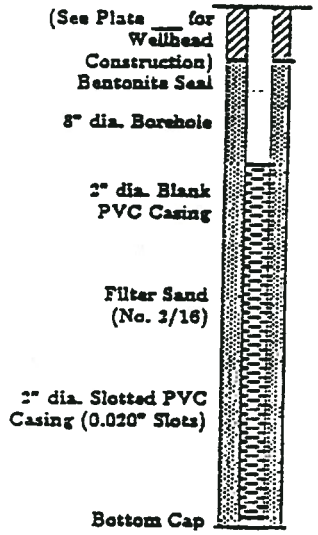
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	14124,011.09		6/90		

UT_MW39-2

Top of Casing 16.84 ft

Equipment Mobile B-61 HSA

Elevation 17.63 ft Date 1/18/90



Depth ft	Sample	Blows/ft	Core Rec.	HC Odor	OVM	
0						CONCRETE
						DARK GRAY SAND (SP) dry, fine to medium sand, with some coarse sand and fine gravel, trace coarse gravel
		43	2	Yes	2.0	
		31	12	Yes	63.0	black, with free product, old product odor
5						
		11	15	Yes	39.0	gray, fine to coarse sand and fine gravel
						GRAY SILTY CLAY (ML-CL) saturated, with root fragments, HC odor, with free product
10						
		18		Yes	7.0	DARK GRAY SAND (SP) fine to medium sand, with some silt and trace gravel
15						Boring completed at 15.0 feet on 1/18/90. Well completed on 1/18/90.
20						
25						
30						
35						
40						

MW-39-2 Coordinates
N 34998.2
E 20619.3

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring MW-39-2

(sheet 1 of 1) PLATE

Port of Seattle
Seattle, Washington

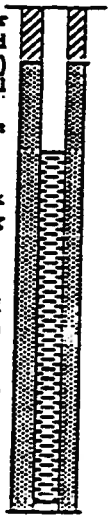
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	14124,011.09		6/90		

UT_MW39-3

Top of Casing 17.35 ft

Equipment Mobile B-61 HSA

Elevation 17.77 ft Date 1/18/90



Depth ft	Sample	Blows/ft	Core Rec.	HC Odor	OVM	
0						ASPHALT DARK BROWN SAND (SP) dry, medium to coarse sand, with some fine to coarse gravel, no odor
		41	9	No		
5						gray, wet, fine to medium sand, with shell fragments, some rounded gravel, product saturated
		36	12	Yes		moist, medium sand, with trace of coarse sand, product odor
10						
		33	8	Yes		dark gray, wet, medium to coarse sand, with some fine to medium gravel, HC odor
15						Boring terminated at 14.0 feet. Well completed on 1/19/90.
20						
25						
30						
35						
40						

MW-39-3 Coordinates
N 35032.4
E 20648.0

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring MW-39-3

(sheet 1 of 1) PLATE

Port of Seattle
Seattle, Washington

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	14124,011.09		6/90		

CP_111

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington		Date(s): 10/10/92 – 10/10/92					
Drilling Contractor: Burlington		Elevation: 5.70					
Drilling Method: Hollow Stem Auger		Datum: City of Seattle Datum					
Location: Pier 91	Logged By: James Peale	Approved By:					
	Surface Casing: 0.00in N/A	From	0.0	to	0.0	ft	
Identification: CP–111	Well Casing: 2.00in PVC	From	0.0	to	5.0	ft	
State Permit # 046927 / Permit Date: 09/08/92	Sand Pack: 10–20 Silica	From	4.0	to	15.0	ft	
Remarks: Specific Location: South of Whse 39 Reference Elevation: Top of Casing	Slot Size: 0.010in	From	5.0	to	15.0	ft	
	Seal Type: No. 1 Grout	From	0.0	to	1.0	ft	
	Seal Type: No. 2 Bentonite	From	1.0	to	4.0	ft	

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description
	0				(0–0.5') ASPHALT (AS)
			2–4		(0.5–4') SAND (SP), dark gray brown, fine– to medium–grained, trace fine gravel, slightly damp, dense.
			4–6		(4–6') SAND (SP), dark gray brown, fine– to medium–grained, some fine to coarse gravel, trace silt, damp, petroleum odor.
	0.70		6–8		(6–8') SAND (SP), black, wet, strong petroleum odor, otherwise as above.
			8–10		(8–14') SAND (SP), dark gray, otherwise as above.
	10		10–12		
			12–14		
			14–16		(14–20') SAND (SP), dark gray, fine– to coarse–grained, some fine gravel, strong petroleum odor.
	-9.30		16–18		
			18–20		
	20		20–22		(20–21') SAND (SP), dark gray, fine–grained, some fine gravel, some silt, no odor. (21–24') SILTY SAND (SM), gray, fine–grained, moist, slightly plastic.
			22–24		
	-19.30				TD = 24.00 feet
	30				
	-29.30				
	40				
	-39.30				
	50				
	-49.30				
	60				

Well Construction

MP. EL. 5.33

CD=15.00

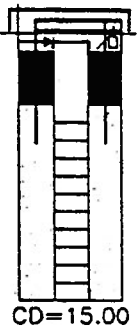
CP_112

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington		Date(s): 10/10/92 – 10/10/92					
Drilling Contractor: Burlington		Elevation: 5.30					
Drilling Method: Hollow Stem Auger		Datum: City of Seattle Datum					
Location: Pier 91	Logged By: James Peale	Approved By:					
	Surface Casing: 0.00in N/A	From	0.0	to	0.0	ft	
Identification: CP–112	Well Casing: 2.00in PVC	From	0.0	to	5.0	ft	
State Permit # 046927 / Permit Date: 09/08/92	Sand Pack: 10–20 Silica	From	4.0	to	15.0	ft	
Remarks: Specific Location: North of Whse 39 Reference Elevation: Top of Casing	Slot Size: 0.010in	From	5.0	to	15.0	ft	
	Seal Type: No. 1 Grout	From	0.0	to	1.0	ft	
	Seal Type: No. 2 Bentonite	From	1.0	to	4.0	ft	

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description
	0		2–4		(0–0.5') ASPHALT (AS) (0.5–4') SAND (SP), dark brown, fine– to medium–grained, trace coarse gravel, slightly damp.
	0.30		4–6		(4–8') SILTY SAND (SM), dark gray brown, fine– to medium–grained, gravel, some silt, damp.
			6–8		
			8–10		(8–10') SILT (ML), dark gray, black laminations, wet, medium plasticity.
	10		10–12		(10–12') SANDY GRAVEL (GP), dark gray, fine gravel, fine–grained sand, wet.
			12–14		(12–15') GRAVELLY SAND (SW), dark gray, fine– to coarse–grained, fine gravel.
	–9.70		14–16		(15–16') SILT (ML), dark gray, trace fine–grained sand, low plasticity.
	20				TD = 16.00 feet
	–19.70				
	30				
	–29.70				
	40				
	–39.70				
	50				
	–49.70				
	60				

Well Construction



CP_113

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington			Date(s): 10/11/92 – 10/11/9				
Drilling Contractor: Burlington			Elevation: 5.50				
Drilling Method: Hollow Stem Auger			Datum: City of Seattle Datum				
Location: Pier 91	Logged By: James Peale		Approved By:				
Identification: CP–113	Surface Casing: 0.00in N/A	From	0.0	to	0.0	ft	
	Well Casing: 2.00in PVC	From	0.0	to	5.0	ft	
State Permit # 046927 Permit Date: 09/08/92	Sand Pack: 10–20 Silica	From	4.0	to	15.0	ft	
Remarks: Specific Location: West of BE Whse Reference Elevation: Top of Casing Constructed with 2–ft DNAPL Collection Sump	Slot Size: 0.010in	From	5.0	to	15.0	ft	
	Seal Type: No. 1 Grout	From	0.0	to	1.0	ft	
	Seal Type: No. 2 Bentonite	From	1.0	to	4.0	ft	

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description	Well Construction
	0				(0–0.5') CONCRETE (CR) (0.5–8') SAND (SP), light brown–gray, fine– to medium–grained, trace fine gravel, dry, loose.	MP. EL. 5.12
	0.50		2–4 4–6			
			6–8 8–10		(8–15') SAND (SP), dark gray, medium– to coarse–grained, some fine gravel, trace silt, wet, strong petroleum odor.	
	10		10–12 12–14			
	–9.50		14–16		(15–17') SILTY SAND (SM), light gray, fine–grained, medium plasticity, stiff, slight odor.	
	20				TD = 17.00 feet	CD=17.00
	–19.50					
	30					
	–29.50					
	40					
	–39.50					
	50					
	–49.50					
	60					

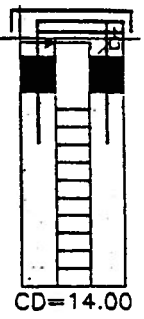
CP_114

BURLINGTON ENVIRONMENTAL

Location: Pier 91	Consulting Firm: Burlington		Date(s):10/08/92 – 10/08/92				
	Drilling Contractor: Burlington		Elevation: 6.00				
Identification: CP–114	Drilling Method: Hollow Stem Auger		Datum: City of Seattle Datum				
State Permit # 046927 Permit Date: 09/08/92	Logged By: James Peale		Approved By:				
Remarks: Specific Location: SW Corner of BE Whse Reference Elevation: Top of Casing	Surface Casing: 0.00in N/A		From	0.0	to	0.0	ft
	Well Casing: 2.00in PVC		From	0.0	to	4.0	ft
	Sand Pack: 10–20 Silica		From	3.0	to	14.0	ft
	Slot Size: 0.010in		From	4.0	to	14.0	ft
	Seal Type:	No. 1 Grout	From	0.0	to	1.0	ft
		No. 2 Bentonite	From	1.0	to	3.0	ft

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description
	0				(0–0.5') ASPHALT (AS)
			2–4		(0.5–8') SAND (SP), dark brown, fine– to medium–grained, some fine gravel, dry, loose.
			4–6		
	1.00		6–8		
			8–10		(8–12') SAND (SP), as above, some fine gravel, wet.
	10		10–12		
			12–14		(12–14') SILTY SAND (SM), gray, fine–grained, medium plasticity, stiff.
-9.00					TD = 14.50 feet
	20				
-19.00					
	30				
-29.00					
	40				
-39.00					
	50				
-49.00					
	60				

Well Construction



CP-115A

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington		Date(s): 10/08/92 – 10/08/92					
Drilling Contractor: Burlington		Elevation: 5.70					
Drilling Method: Hollow Stem Auger		Datum: City of Seattle Datum					
Location: Pier 91	Logged By: James Peale	Approved By:					
	Surface Casing: 0.00in N/A	From	0.0	to	0.0	ft	
Identification: CP-115A	Well Casing: 2.00in PVC	From	0.0	to	4.0	ft	
State Permit # 046927 / Permit Date: 09/08/92	Sand Pack: 10-20 Silica	From	3.0	to	19.0	ft	
Remarks: Specific Location: Alley South of BE Whse Reference Elevation: Top of Casing Constructed with 2-ft DNAPL Collection Sump	Slot Size: 0.010in	From	4.0	to	19.0	ft	
	Seal Type: No. 1 Grout	From	0.0	to	1.0	ft	
	Seal Type: No. 2 Bentonite	From	1.0	to	3.0	ft	

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description
	0				(0–0.5') CONCRETE (CR)
			2–4		(0.5–4') SAND (SP), dark gray, fine- to medium-grained, trace fine gravel, damp.
			4–6		(4–6') SILTY SAND (SM), dark gray, fine-grained, damp, some shell debris.
-0.70	0.70		6–8		(6–8') SAND (SP), very dark gray-black, fine- to medium-grained sand, trace fine gravel, wet, slight petroleum odor, oily-black sheen observed.
			8–10		(8–18') SAND (SP), dark gray, fine- to medium-grained sand, trace silt, trace fine gravel, petroleum odor and sheen, trace shell debris.
	10		10–12		
			12–14		
-9.30			14–16		
			16–18		
	20		18–20		(18–20') SILTY SAND (SM), light gray, fine-grained, some silt.
-19.30					TD = 21.00 feet
	30				
-29.30					
	40				
-39.30					
	50				
-49.30					
	60				

Well Construction

MP. EL. 5.48

CD=21.00

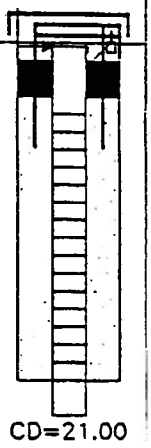
CP_121

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington			Date(s):10/07/92 – 10/07/92				
Drilling Contractor: Burlington			Elevation: 5.70				
Drilling Method: Hollow Stem Auger			Datum: City of Seattle Datum				
Location: Pier 91	Logged By: James Peale		Approved By:				
	Surface Casing: 0.00in N/A		From	0.0	to	0.0	ft
Identification: CP–121	Well Casing: 2.00in PVC		From	0.0	to	4.0	ft
State Permit # 046927 / Permit Date: 09/08/92	Sand Pack: 10–20 Silica		From	3.0	to	19.0	ft
Remarks: Specific Location: W of BE Whse Reference Elevation: Top of Casing Constructed with 2–ft DNAPL Collection Sump	Slot Size: 0.010in		From	4.0	to	19.0	ft
	Seal Type:	No. 1 Grout	From	0.0	to	1.0	ft
		No. 2 Bentonite	From	1.0	to	3.0	ft

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description
	0		2–4		(0–0.5') CONCRETE (CR) (0.5–4') SAND (SP), light brown to red, fine– to medium–grained, trace fine gravel, loose, dry, trace brick fragments.
0.70			4–6		(4–6') SAND (SP), as above, damp.
	10		6–8 8–10 10–12		(6–10') SAND (SP), light brown and black, fine– to medium–grained, some fine gravel, medium dense, wet, strong petroleum odor.
			12–14 14–16		(10–16') SAND (SP), dark brown to black, fine– to coarse–grained, some fine gravel, loose, strong petroleum odor.
–9.30			16–18		
	20		18–20 20–22		(17.5–22.5') SILTY SAND (SM), light gray, fine–grained, moist, no odor.
–19.30					TD = 22.50 feet
	30				
–29.30					
	40				
–39.30					
	50				
–49.30					
	60				

Well Construction



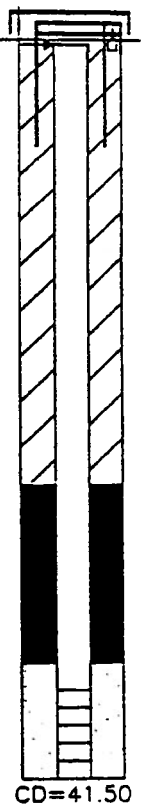
CP_106B

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington					Date(s):01/25/93 – 03/02/93		
Drilling Contractor: Burlington					Elevation: 5.90		
Drilling Method: HSA/CT					Datum: City of Seattle Datum		
Location: Pier 91	Logged By: James Peale				Approved By:		
	Surface Casing: 8.00in Mild Steel	From	0.0	to	0.0	ft	
Identification: CP–106B	Well Casing: 2.00in PVC	From	0.0	to	36.5	ft	
State Permit # 046934 / Permit Date: 01/19/92	Sand Pack: 10–20 Silica	From	35.0	to	41.5	ft	
Remarks: Specific Location: N of MDO Yard Reference Elevation: Top of Casing	Slot Size: 0.010in	From	36.5	to	41.5	ft	
	Seal Type: No. 1 Grout	From	0.0	to	25.0	ft	
	Seal Type: No. 2 Bentonite	From	25.0	to	35.0	ft	

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description
	0				(0–0.8') CONCRETE (CR) (0.8–6') SAND (SP), black, fine– to coarse–grained, some fine gravel, strong petroleum odor, sheen, slightly damp.
			2–4		
			4–6		
	0.90		6–8		(6–8') SAND (SP), black, coarse–grained, moist, strong petroleum odor and sheen.
			8–10		(8–10') SAND (SP), gray, fine–grained, strong petroleum odor, wet.
	10		10–12		(10–18') SAND (SP), as above, some shell debris.
			12–14		
			14–16		
	-9.10		16–18		
			18–20		(18–25') SILTY SAND (SM), dark gray, fine grained, wet, trace silt.
	20		20–22		
			22–24		
	-19.10		25–27		(25–29') SILTY SAND (SM), gray, fine–grained, trace coarse sand, moist, slight petroleum odor.
			27–29		
			29–31		(29–37.5') SILTY SAND (SM), gray, fine–grained, slight sulfur odor, trace wood and shell debris.
	30		31–33		
			33–35		
	-29.10		35–37		
			37–39		(37.5–41.5') SAND (SP), gray, fine– to medium–grained, trace coarse sand, some wood and shell debris.
			39–41		
	40		41–45		(41.5–49') CLAYEY SILT (ML), light gray, trace fine sand, damp, high plasticity, very stiff, slight sulfur odor.
	-39.10		45–49		
					TD = 49.00 feet
	50				
	-49.10				
	60				

Well Construction



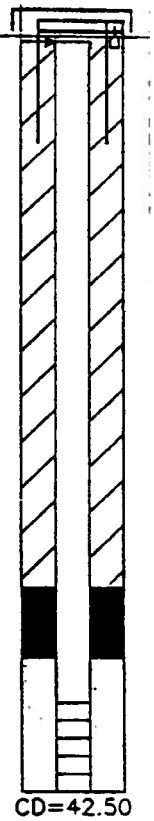
CP_115B

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington			Date(s):02/02/93 – 03/03/93				
Drilling Contractor: Burlington			Elevation: 5.80				
Drilling Method: HSA/CT			Datum: City of Seattle Datum				
Location: Pier 91	Logged By: James Peale		Approved By:				
Identification: CP–115B	Surface Casing: 8.00in Mild Steel		From 0.0	to	25.0	ft	
	Well Casing: 2.00in PVC		From 0.0	to	37.5	ft	
State Permit # 046934 / Permit Date: 01/19/92	Sand Pack: 10–20 Silica		From 35.0	to	42.5	ft	
Remarks: Specific Location: See CP–115 Reference Elevation: Top of Casing	Slot Size: 0.010in		From 37.5	to	42.5	ft	
	Seal Type:	No. 1 Grout	From 0.0	to	31.0	ft	
		No. 2 Bentonite	From 31.0	to	35.0	ft	

ELEVATION (feet)	DEPTH (feet)	SAMPLE (REC %)	SAMPLE NO.	GRAPHIC LOG	Material Description
	0				(0–0.5') CONCRETE (CR)
	0.80		4–6		(0.5–10') SAND (SP), gray–brown, fine– to coarse–grained, wet, strong petroleum odor.
			6–8		
			8–10		
	10		10–12		(10–17.5') SAND (SW), dark gray, fine– to coarse–grained, trace fine to coarse gravel.
			12–14		
	-9.20		14–16		
			16–18		(17.5–26.5') SILTY SAND (SM), light gray, fine–grained, low plasticity, no odor.
	20		18–20		
			20–22		
			22–24		
	-19.20		24–26		
			26–28		(26.5–28') SAND (SP), dark gray, fine–grained, little fine to coarse gravel, trace silt, some shell debris.
			28–30		(28–32') GRAVEL (GM), light gray–brown, fine to coarse, some silt, trace fine sand, slight sulfur odor.
	30		30–32		
			32–34		(32–38.5') SILTY SAND (SM), dark gray, fine– to medium–grained, slight sulfur odor.
	-29.20		34–36		
			36–38		
			38–40		(38.5–42.5') SAND (SP), dark gray, fine–grained, some silt, medium plasticity, no odor.
	40		40–42		
			42–44		(42.5–46') SILTY CLAYEY SAND (SC), olive–gray, fine–grained, some clay, stiff, high plasticity, moist.
	-39.20		44–46		
			46–48		(46–56') SILTY SAND (SM), olive–gray, fine–grained, trace clay, stiff, high plasticity, damp, trace wood and shell debris.
			48–50		
	50		50–52		
			52–54		
	-49.20		54–56		
	60				TD = 56.00 feet

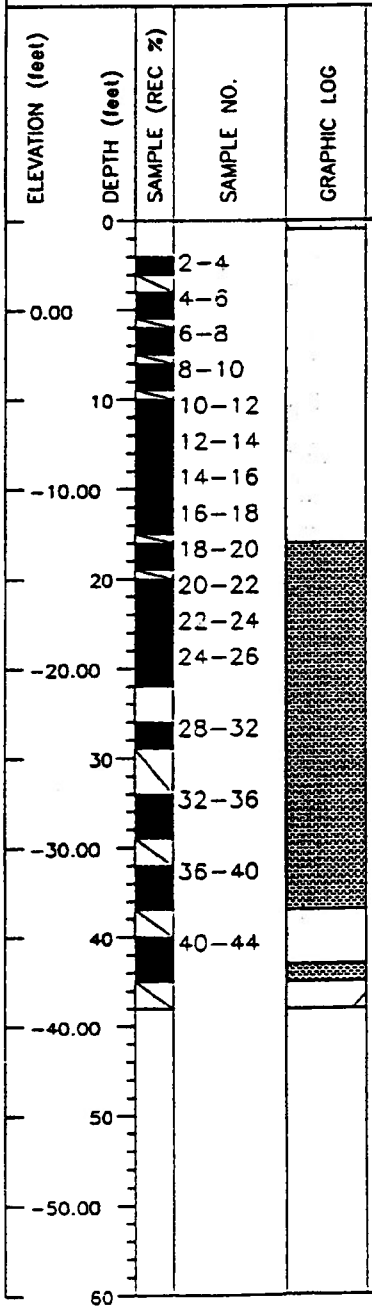
Well Construction



CP_122B

BURLINGTON ENVIRONMENTAL

Consulting Firm: Burlington		Date(s):01/19/93 – 03/01/93				
Drilling Contractor: Burlington		Elevation: 5.00				
Drilling Method: HSA/CT :		Datum: City of Seattle Datum				
Location: Pier 91		Logged By: James Peale		Approved By:		
		Surface Casing: 12.0in Mild Steel	From 0.0	to 24.0	ft	
Identification: CP–122B		Well Casing: 2.00in PVC	From 0.0	to 37.5	ft	
State Permit # 046934	Permit Date: 01/19/92	Sand Pack: 10–20 Silica	From 35.0	to 42.5	ft	
Remarks: Specific Location: E of MDO Yard Reference Elevation: Top of Casing		Slot Size: 0.010in	From 37.5	to 42.5	ft	
		Seal Type: No. 1 Grout	From 0.5	to 21.0	ft	
		Seal Type: No. 2 Bentonite	From 21.0	to 35.0	ft	



Material Description

(0–0.5') CONCRETE (CR)
(0.5–4') SAND (SP), dark brown, medium– to coarse–grained, some coarse gravel, dry, loose, slight petroleum odor.

(4–6') SAND (SP), light brown–gray, medium– to coarse–grained, trace silt, trace fine gravel, damp, loose, slight petroleum odor.
(6–8') SAND (SP), as above, dark gray, wet.

(8–18') SAND (SP), as above, dark gray, fine– to medium–grained.

(18–36') SILTY SAND (SM), dark gray, fine–grained, wet, stiff, medium plasticity.

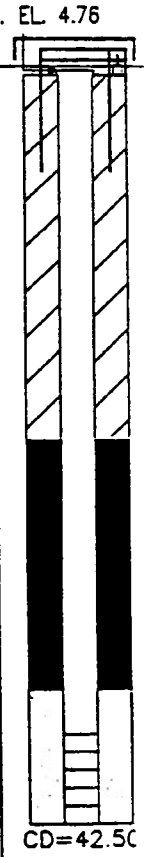
(36–38.5') SILTY SAND (SM), as above, slight sulfur odor.

(38.5–41.5') SAND (SP), olive–dark gray, fine– to medium–grained, trace silt, damp, slight sulfur odor.

(41.5–42.5') SILTY SAND (SM), olive–dark gray, fine–grained, some silt, damp, medium plasticity.
(42.5–44') CLAYEY SAND (SC), light gray, fine–grained, some clay, damp, stiff, medium to high plasticity, slight sulfur odor.

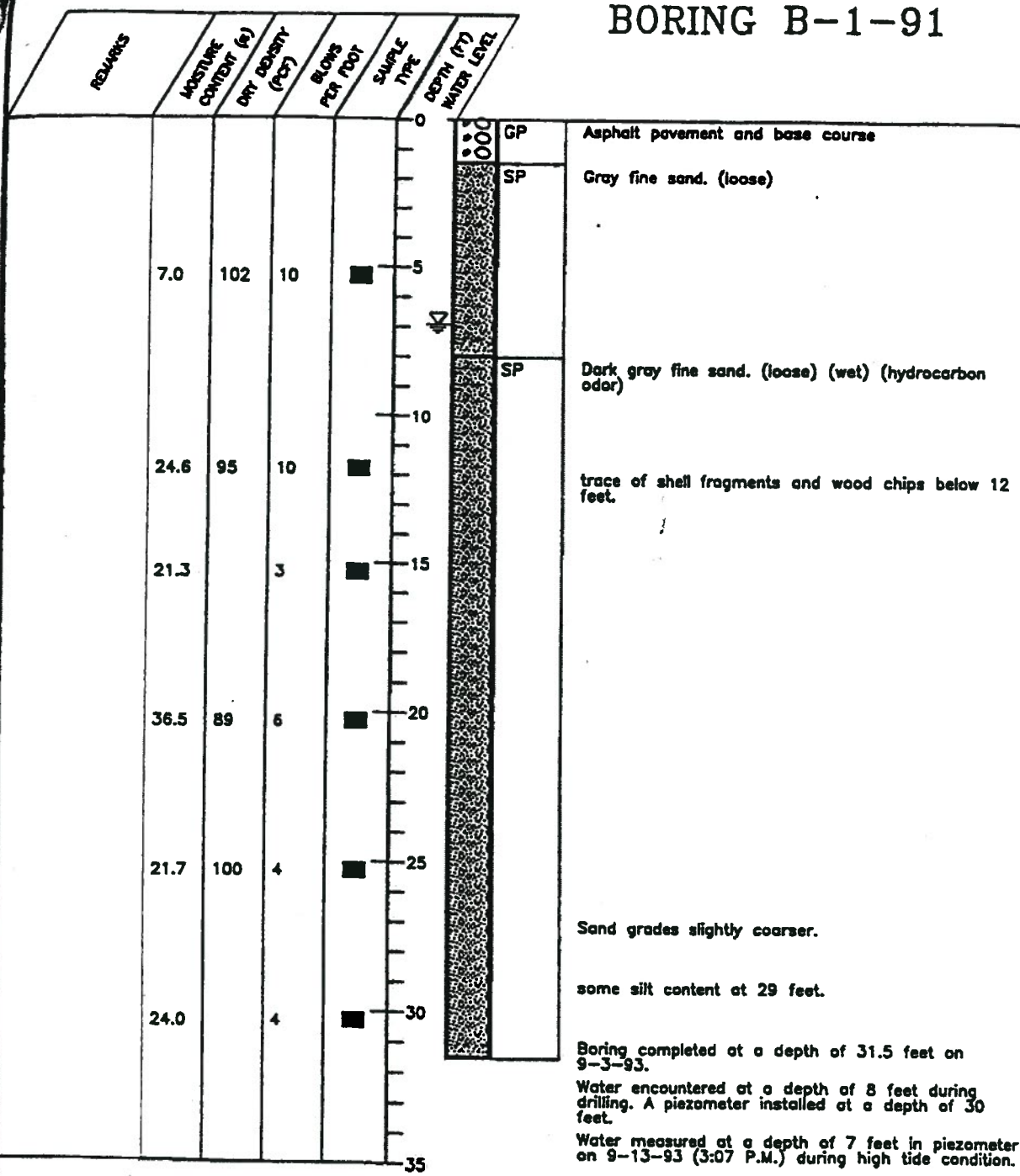
TD = 44.00 feet

Well Construction



B1-91

BORING B-1-91



LOG OF BORING

Dames & Moore

Job No. 01910-092-016

PLATE A-1

CP_205A

Pacific Northern Geoscience

BORING NUMBER **CP205-A** SHEET 1 OF 1
PROJECT **PIER 91 WELL REPLACEMENT**
LOCATION **Seattle, Washington**
PROJECT NUMBER **95-33258-01**
COORDINATES **N 235,736.0 E 1,618,605.0**
SURFACE ELEVATION **5.50** DATUM **Seattle** LOGGED BY **CVG**

Depth Feet	Lab Sample	Samp. No.	Blow Counts	Rec. %	PID ppm	STRATA	DESCRIPTION	BOREHOLE/WELL CONSTRUCTION DETAIL	ELEVATION FEET
							asphalt	Flush Mount Monument/Concrete Surface Seal	5
		1	20 25 26	100			SAND (sp); grey to green, fine- to very fine-grained, shell fragments, trace fine gravel; damp, no odor	Bentonite Chips (1 bag)	
		2	13 14 15	100			as above; wet at 5.0', no odor	2" ID PVC Riser from 0-4'	
5		3	10 15 16	100			SAND; black, fine- to medium-gravel; loose, wet, no odor	10/20 Colorado Sand (3 bags)	0
		4	18 21 24	100			GRAVELLY SAND (swg); grey, medium- to very coarse-grained, gravel to 1/2"; loose, wet, no odor	2" ID .010" Slot PVC Screen from 4-14'	
		5	18 20 25	100			GRAVELLY SAND; grey, medium- to very coarse-grained, gravel 1/2"; wet, loose, moderate petroleum odor, sheen test positive		
10		6	19 20 21	100			SANDY GRAVEL (gw); gray-black, gravel to 1", sand matrix very coarse; loose, wet, faint petroleum odor		-5
		7	18 19 20	100			GRAVELLY SAND (swg); gray-black, medium- to coarse-grained, gravel to 1"; loose, wet, faint H2S odor		
		8	12 12 13	100			as above		
							SILTY SAND (sm); gray, very silty, abundant wood debris and shell fragments; fine, moist to wet, no odor	2" ID PVC Tail Pipe from 14-14.25'	
							EOB at 14.5 feet.		

DRILLING CONTRACTOR **Cascade Drilling**
DRILLING METHOD **4 1/4" HSA**
SAMPLING EQUIPMENT **Split Spoon**
DRILLING STARTED **11/20/95** ENDED **11/20/95**

REMARKS

WLLNEW P. .../15/96

CP_205B

Pacific Northern Geoscience

BORING NUMBER CP205-B SHEET 1 OF 2
PROJECT PIER 91 WELL REPLACEMENT
LOCATION Seattle, Washington
PROJECT NUMBER 95-33258-01
COORDINATES N 235,740.0 E 1,618,603.0
SURFACE ELEVATION 5.53 DATUM Seattle
LOGGED BY WVG

Depth Feet	Lab Sample	Samp. No.	Blow Counts	Rec. %	PID ppm	STRATA	DESCRIPTION	BOREHOLE/WELL CONSTRUCTION DETAIL	ELEVATION FEET
							asphalt	Flush Mount Mounument/Concrete Surface Seal	5
		1	14 16 17	100			SAND (sp): gray to green, fine- to very fine-grained, shell fragments; loose, damp, no odor		
5		2	18 25 27	100			as above; trace gravel, saturated at 5.5'	9" ID Mild Steel Casing Grouted in place with 10% Bentonite Cement Grout from 0-16.9' (85 Gallons Total)	0
		3	18 25 26	100			GRAVELLY SAND (swg): gray-black, medium- to coarse-grained, gravel to 3/4"; loose, wet, slight petroleum odor		
10		4	15 19 20	100			as above: gravel to 1"; wet, no odor		-5
		5	14 15 16	100			as above: slightly silty, gravel to 1/2"; wet, no odor		
15		6	12 14 16	100			as above: gray to black, fining down to very silty sand with gravel at 16'		-10
							SILTY SAND (sm): gray-black, very silty, trace gravel; firm, wet	Medium Bentonite Chips (11 bags)	
		7	12 14 16	100			SILTY SAND (sm): gray, medium- to very fine-grained, slightly to moderately silty; slightly firm, wet	2" ID Schedule 40 PVC Riser from 0-34.5'	
20		8	10 12 13	100			as above; abundant shell fragments; wet, no odor		-15
							GRAVELLY SAND (swg): gray-black, slightly silty; wet, no odor		
		9	25 30 33	100			SANDY GRAVEL (gw): gray to black, gravel to 3", sand fine to very coarse grained; loose, wet, no odor		
25		10	30 32 35	100			as above		-20
		11	18 20 23	100			SANDY SILT (ml): gray-green, moderately plastic; firm, moist to wet, no odor		
		12	18 30 35	100			SILTY SAND (sm): gray-green, wood fragments; firm, moist to wet		

DRILLING CONTRACTOR Cascade
DRILLING METHOD 10.25" & 4.25"ID HSA
SAMPLING EQUIPMENT Split Spoon
DRILLING STARTED 11/20/95 ENDED 11/21/95

REMARKS Drilling Sequence - Drilled to 26.5' w/ 4 1/4" HSA's. Opened hole to 16.5' w/ 10 1/4" HSA's. Grouted 9" casing at 16.5' and let set for 24 hours. Cleaned out casing and drilled to 44.5' w/ 4 1/4" HSA's

BIGWELL PNG 1/15/96

Pacific Northern Geoscience

BORING NUMBER **CP205-B** SHEET 2 OF 2

PROJECT **PIER 91 WELL REPLACEMENT**

LOCATION **Seattle, Washington**

PROJECT NUMBER **95-33258-01**

COORDINATES **N 235,740.0 E 1,618,603.0**

SURFACE ELEVATION **5.53** DATUM **Seattle** LOGGED BY **WVG**

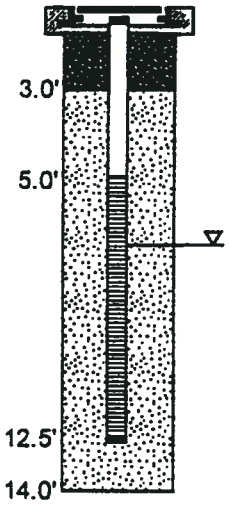
SAMPLE INFORMATION						STRATA	DESCRIPTION	BOREHOLE/WELL CONSTRUCTION DETAIL	ELEVATION FEET
Depth Feet	Lab Sample	Samp. No.	Blow Counts	Rec. %	PID ppm				
		13	32 33	100			SILTY SAND (sm); gray, fine- to medium-grained, abundant wood fragments and shells; loose to slightly firm, wet, H2S odor		-25
		14	36 38	100				10/20 Colorado Sand (3.5 bags)	
		15	40 45	100			as above; thin silt-rich horizons; H2S odor		
		16	32 40 41	100			as above; fine- to very-fine grained; H2S odor		
35		17	40 42 47	100			as above		-30
		18	20 28 35	100			as above	2" ID .010" Slot PVC Screen from 34.5-44.5'	
		19	22 27 33	100			as above		
40		20	18 20 22	100			as above		-35
		21	21 21 24	100			as above; gray-green, fine grained, very silty; firm, wet, H2S odor		
		22	16 18 24	100			SILTY SAND (sm-ml); gray-green, very silty, with thin silt horizons to 1/2", wood fragments; firm (silt layers moderately plastic), moist to wet		
							EOB at 44.75 feet.	2" ID PVC Tail Pipe from 44.5-44.75'	

BIOWELL h.. 1/15/98

UT_MW152-1

Equipment Mobil B-59

Land Surface Elevation 17.71 feet Date 5/7/96



Depth (feet)	Sample	Blows per Foot	OVM	Sheen	
0					Asphalt.
		13	44		GRAY SAND (SP) medium dense, moist; medium grained with trace silt and fine gravel, contains interbedded gray silt (ML), HC-like odor.
5		5	60		Becomes saturated with some fine to coarse gravel.
10		2	-		Boring terminated at 14.0 feet bgs. Groundwater encountered at 7.0 feet bgs.
15					
20					
25					
30					
35					
40					

AGI TECHNOLOGIES

Log of Monitoring Well MW152-1
Port of Seattle/Terminal 91
Seattle, Washington

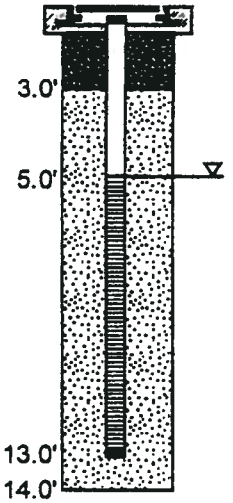
PLATE 3

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
wellog.cdr 14,124.112	ECR	28 May 96			

UT_MW152-2

Equipment Mobil B-59

Land Surface Elevation 17.76 feet Date 5/7/96



Sheen	OVM	Blows per Foot	Depth (feet)	Sample	
			0		Asphalt GRAY SAND (SW) medium dense, moist; trace silt, with some fine to coarse gravel.
	0	13			
	7	10	5		Becomes saturated.
			10		GRAY SILTY SAND (SM) very loose, saturated.
	0	2			
			15		Boring terminated at 14.0 feet bgs. Groundwater encountered at 5.0 feet bgs.
			20		
			25		
			30		
			35		
			40		

AGI TECHNOLOGIES

Log of Monitoring Well MW152-2
Port of Seattle/Terminal 91
Seattle, Washington

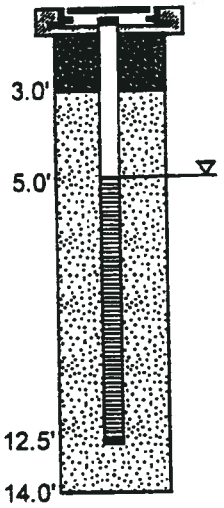
PLATE 4

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
wellog.cdr 14.124.112	ECR	28 May 96			

VT_MW152-3

Equipment Mobil B-59

Land Surface Elevation 17.71 feet Date 5/7/96



Depth (feet)	Sample	Blows per Foot	OVM	Sheen	
0					Asphalt
		27	0		BROWN SAND (SP) medium dense, moist; medium grained, with some fine to coarse gravel.
5		17	0		Becomes saturated.
10					GRAY SILTY SAND (SM) very loose, saturated; fine sand.
		3	0		
15					Boring terminated at 14.0 feet bgs. Groundwater encountered at 5.0 feet bgs.
20					
25					
30					
35					
40					

AGI TECHNOLOGIES

Log of Monitoring Well MW152-3
Port of Seattle/Terminal 91
Seattle, Washington

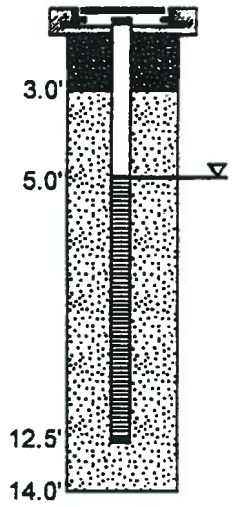
PLATE 5

PROJECT NO. DRAWN DATE APPROVED REVISED DATE

UT-MW152-4

Equipment Mobil B-59

Land Surface Elevation 17.44 feet Date 5/7/96



Depth (feet)	Sample	Blows per Foot	OVM	Sheen	
0					Asphalt
		5	0		BROWN SAND (SP) loose, moist; medium grained, with trace fine to coarse gravel, contains interbedded brown silt (ML).
5		7	0		Becomes saturated.
10					GRAY SILTY SAND (SM) very loose, saturated; fine grained sand.
		1	0		
15					Boring terminated at 14.0 feet bgs. Groundwater encountered at 5.0 feet bgs.
20					
25					
30					
35					
40					

AGI TECHNOLOGIES

Log of Monitoring Well MW152-4

Port of Seattle/Terminal 91
Seattle, Washington

PLATE 6

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14.124.112	ECR	28 May 96	PJB		

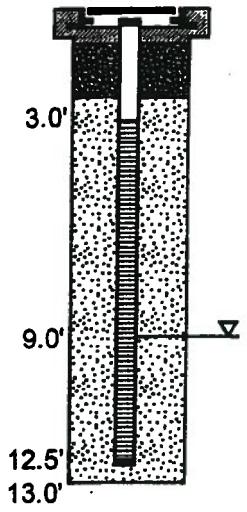
wellog.cdr

UT-MW152-6

S_MW743

Equipment Mobil B-59

Land Surface Elevation 17.36 feet Date 10/15/96



Depth (feet)	Sample	OVM (ppm)	Blows per Foot	
0				Asphalt
				GRAVEL (GP) crushed rock.
				BROWN SILTY SAND (SM) medium dense.
		0	9	GRAY SILT (ML) stiff, moist; with some fine to medium grained sand.
5				Becomes wet.
		0	3	GRAY SILTY SAND (SM) very loose, wet; becomes saturated at 8.5' bgs, fine to medium grained sand with silt.
10				
		0	6	Boring terminated at 13.0 feet bgs. Groundwater encountered at 9.0 feet bgs.
15				
20				
25				
30				
35				
40				

AGI TECHNOLOGIES

Log of Monitoring Well MW152-6
Port of Seattle/Terminal 91
Seattle, Washington

PLATE A8

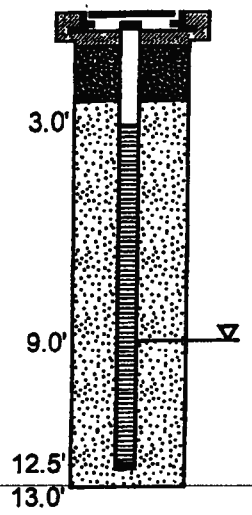
wellog.cdr	PROJECT NO. 14,124.112	DRAWN ECR	DATE 28 May 96	APPROVED PPB	REVISED	DATE

VT_MW152-5

S_MW742

Equipment Mobil B-59

Land Surface Elevation 18.09 feet Date 10/15/96



Depth (feet)	Sample	OVM (ppm)	Blows per Foot	
0				Asphalt GRAVEL (GP) base coarse.
		0	4	GRAY SILT (ML) medium stiff, moist.
5				GRAY SILTY SAND (SM) medium dense, wet; fine to medium grained sand with trace to some silt.
		0	19	Becomes light brown.
10				Becomes saturated.
		0	13	Boring terminated at 13.0 feet bgs. Groundwater encountered at 9.0 feet bgs.
15				
20				
25				
30				
35				
40				

AGI TECHNOLOGIES

Log of Monitoring Well MW152-5
Port of Seattle/Terminal 91
Seattle, Washington

PLATE A7

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,124.112	ECR	28 May 96	PPB		

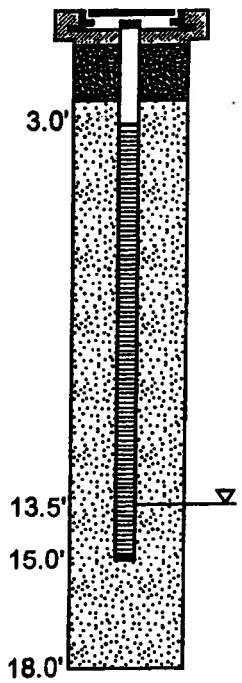
wellog.cdr

VT_MW152-7

S_MW744

Equipment Mobil B-59

Land Surface Elevation 18.55 feet Date 10/15/96



Depth (feet)	Sample	OVM (ppm)	Blows per Foot	
0				Asphalt GRAVEL (GP) crushed rock.
		0	10	BROWN SILTY SAND (SM) medium dense, moist; fine to medium grained sand, with some silt and fine gravel.
5				GRAY SILT (ML) stiff, moist; with some fine grained sand.
		0	12	
10				GRAY SILT (ML) stiff, moist; with some fine grained sand.
		0	6	Becomes wet, with fine grained sand.
15				GRAY SILT TO SILTY SAND (ML/SM) saturated; thin layers of each, silt, silty sand, silt with fine grained sand.
		0	3	Boring terminated at 18.0 feet bgs. Groundwater seepage encountered at 13.5 feet bgs.
20				
25				
30				
35				
40				

AGI TECHNOLOGIES

Log of Monitoring Well MW152-7
Port of Seattle/Terminal 91
Seattle, Washington

PLATE **A9**

PROJECT NO	DRAWN	DATE	APPROVED	REVISED	DATE
14,124.112	ECR	28 May 96	PAB		

wellog.cdr

CP_ GP01A

Boring and Well Construction Log

Roth Consulting

Boring Location Head of Pier 89/90 Slip			**Boring/Well Name:** GP01 (PZ-1)
Drilling Company Cascade Drilling	**Driller** Brian Gose		**Project Name:** T91 Tank Farm Site
Drilling Method(s) Hollow-Stem Auger	**Drill Bit Size** 8" O.D.		**Elevation and Datum (ft)** 17.68 MSL / **Total Depth (ft bgs)** 19.0
Isolation Casing N/A	**From**	**To** ft bgs	**Date Started** February 28, 2001
Blank Casing 2" Schedule 40 PVC	**From** 0.0	**To** 4.0 ft bgs	**Date Completed** February 28, 2001
Perforated Casing 0.010" Slot 2" Schedule 40 PVC	**From** 4.0	**To** 19.0 ft bgs	**Depth to Water (ft bgs)** 7.5
Size and Type of Filter Pack 2-12 Monterey Sand	**From** 3.0	**To** 19.0 ft bgs	**Logged by** Susan Roth
Seal Bentonite Chips	**From** 1.0	**To** 3.0 ft bgs	**Sampling Methods** Dames & Moore Sampler
Grout Concrete Surface Seal	**From** 0.0	**To** 1.0 ft bgs	**Well Monument:** x Flush Mount ☐ Standpipe (___ ft above ground surface)

Ft	Recovery (ft)	Blow Counts	PID (ppm)	Well Construction Details	USCS	Soil Type	Description
							Few inches asphalt.
	0.5	18 18 5					Poorly graded sand--brown, moist no odor. Few gravel, few shell fragments.
5	1.0	9 9 12					Some rounded gravel. Few shells.
	1.0	6 3 9					Wet at about 7.5 ft bgs. Poorly graded sand with silt--gray.
10	1.0	12 13 18			SP		Mostly fine sand; abundant wood chunks and stems; strong odor--wood and/or fuel?
	0.5	5 11 12					Pine needles; fine to medium sand.
15	1.0	12 13 31					
	1.0	9 15 18			SM		Silty sand--gray, weak odor, contains wood.
20							
25							

CP_ GP02

Boring and Well Construction Log

Roth Consulting

Boring Location Just South of Magnolia Bridge, Pier 90			**Boring/Well Name:** GP02 (PZ-2)
Drilling Company Cascade Drilling	**Driller** James Gowan		**Project Name:** T91 Tank Farm Site
Drilling Method(s) Hollow-Stem Auger	**Drill Bit Size** 8" O.D.		**Elevation and Datum (ft)** 17.39 MSL / **Total Depth (ft bgs)** 20.0
Isolation Casing N/A	**From**	**To** ft bgs	**Date Started** May 14, 2001
Blank Casing 2" Schedule 40 PVC	**From** 0.0	**To** 5.0 ft bgs	**Date Completed** May 14, 2001
Perforated Casing 0.010" Slot 2" Schedule 40 PVC	**From** 5.0	**To** 20.0 ft bgs	**Depth to Water (ft bgs)** 7.5
Size and Type of Filter Pack 2-12 Monterey Sand	**From** 4.0	**To** 20.0 ft bgs	**Logged by** Susan Roth
Seal Bentonite Chips	**From** 1.0	**To** 4.0 ft bgs	**Sampling Methods** Dames & Moore Sampler
Grout Concrete Surface Seal	**From** 0.0	**To** 1.0 ft bgs	**Well Monument:** X Flush Mount ☐ Standpipe (____ ft above ground surface)

Ft	Recovery (ft)	Blow Counts	PID (ppm)	Well Construction Details	USCS	Soil Type	Description
							3 inches asphalt. Poorly graded sand--brown, mostly fine sand, some medium sand, no chemical odor, few shells.
	1.0	15 18 18					
5	1.0	13 18 16					Strong fuel odor, wet, gray (changes color at about 7.8 ft bgs).
	1.0	9 11 12			SP		
10	1.0	10 11 15					Coarser sand with some gravel; shells; strong odor. Petroleum sheen, wood fragments and wood debris.
	1.0	15 12 11					
15	1.0	9 9 12					
	1.0	5 5 9			ML		Silt and wood.
20					SP		Sand in sample shoe.
25							

CP_GP05

Boring and Well Construction Log

Roth Consulting

Boring Location Beneath Magnolia Bridge			**Boring/Well Name:** GP05 (MW-01-3)
Drilling Company Cascade Drilling	**Driller** James Gowan		**Project Name:** T91 Upland
Drilling Method(s) Hollow-Stem Auger	**Drill Bit Size** 8" O.D.		**Elevation and Datum (ft)** 17.44 MSL / **Total Depth (ft bgs)** 10.0
Isolation Casing N/A	**From**	**To** ft bgs	**Date Started** May 14, 2001
Blank Casing 2" Schedule 40 PVC	**From** 0.0	**To** 5.0 ft bgs	**Date Completed** May 14, 2001
Perforated Casing 0.010" Slot 2" Schedule 40 PVC	**From** 5.0	**To** 10.0 ft bgs	**Depth to Water (ft bgs)** 8.5
Size and Type of Filter Pack 2-12 Monterey Sand	**From** 4.0	**To** 10.0 ft bgs	**Logged by** Susan Roth
Seal Bentonite Chips	**From** 1.0	**To** 4.0 ft bgs	**Sampling Methods** Dames & Moore Sampler
Grout Concrete Surface Seal	**From** 0.0	**To** 1.0 ft bgs	**Well Monument:** x Flush Mount ☐ Standpipe (___ ft above ground surface)

Ft	Recovery (ft)	Blow Counts	PID (ppm)	Well Construction Details	USCS	Soil Type	Description
5	0.0	6 8 13			GP-GM		3 inches asphalt over fill. Poorly graded gravel with silt and sand–dark brown, moist, no chemical odor; few shell fragments.
	1.0	12 13 16			SP		Poorly graded sand with gravel–tan to brown, no fuel odor; wet at 8.5 ft.
10	1.0	4 4 5			SM		Silty sand–gray, wet, no chemical odor.
	1.0	3 4 6			ML		Silt–gray, wet, with small stems and organic fragments. No chemical odor.
15							Backfilled bottom of boring with bentonite chips.
20							
25							

CP_ GP06

Boring and Well Construction Log

Roth Consulting

Boring Location Under Magnolia Bridge			**Boring/Well Name:** GP06 (MW-01-4)
Drilling Company Cascade Drilling	**Driller** James Gowan		**Project Name:** T91 Upland
Drilling Method(s) Hollow-Stem Auger	**Drill Bit Size** 8" O.D.		**Elevation and Datum (ft)** 17.46 MSL; **Total Depth (ft bgs)** 18.0
Isolation Casing N/A	**From**	**To** ft bgs	**Date Started** May 14, 2001
Blank Casing 2" Schedule 40 PVC	**From** 0.0	**To** 5.0 ft bgs	**Date Completed** May 14, 2001
Perforated Casing 0.010" Slot 2" Schedule 40 PVC	**From** 5.0	**To** 18.0 ft bgs	**Depth to Water (ft bgs)** 8.0
Size and Type of Filter Pack 2-12 Monterey Sand	**From** 4.0	**To** 18.0 ft bgs	**Logged by** Susan Roth
Seal Bentonite Chips	**From** 1.0	**To** 4.0 ft bgs	**Sampling Methods** Dames & Moore Sampler
Grout Concrete Surface Seal	**From** 0.0	**To** 1.0 ft bgs	**Well Monument:** ☐ Standpipe (___ ft above ground surface) x Flush Mount

Ft	Recovery (ft)	Blow Counts	PID (ppm)	Well Construction Details	USCS	Soil Type	Description
							3 inches asphalt.
	0.0	13 24 11					Poorly graded gravel with sand--brown; moist; no chemical odor.
5	0.5	7 6 9			GP		
	0.4	37 50					Wet at 8 ft bgs. Increasing sand.
10	0.1	19 21 22					
	0.5	8 16 21					
15	0.6	20 50			SP		Poorly graded sand--gray; few gravel, shell fragments; wet; no chemical odor. Heaving sand.
	0.5	4 5 6			SM		Silt--gray; abundant wood fragments; slight fetid odor.
20							
25							

CP_203B

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	CP-203B	1 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, 10" to 25', 4" to 61'	Date Start/Finish	6/10/2003-6/11/2003
Hammer Weight/Drop	140 lb / 30"	Hole Diameter (in)	10"

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Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
				Loose, moist, brown fine to medium SAND, shell fragments (SP)			
		S-1				1 1 1 4 3 4	▲
5		S-2		•Loose to medium dense, wet, trace gravel, wood		9 4 3 4	▲
		S-3		•Gray, no gravel, strong petroleum-like odor and sheen		3 3 4 4 4 3	▲
10		S-4				3 3	
				Medium dense, wet, gray SAND to slightly silty SAND (SP-SM)		2 2	▲
		S-5				3 4 2 5 6 7	▲
				•Fine to coarse gravel lens 14' - 14.5'			
15		S-6		•Loose, trace organics, trace shell fragments		5 4 2 3	▲
		S-7				2 3 3 5 4 4	▲
				•Silt content decreasing			
20		S-8		•Trace silt, fine gravel lenses		5 6 4 6	▲
		S-9		Medium dense, wet, gray SANDY GRAVEL, trace silt, trace wood, trace shells (GP)		5 9 10 8 6 4	▲

Sampler Type (ST):
- No Recovery
- 2" OD Split Spoon
- 3" OD Dames & Moore
- Shelby Tube

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 2

FINAL 91 TERMINAL 91.GPJ April 14, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	CP-203B	2 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, 10" to 25', 4" to 61'	Date Start/Finish	6/10/2003-6/11/2003
Hammer Weight/Drop	140 lb / 30"	Hole Diameter (in)	10"

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Depth, ft	USCS	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
	SP	S-10		Medium dense, wet, gray GRAVELLY SAND, trace silt, trace wood, trace shell fragments (SP)		5 6 6	
		S-11				5 7 9	
30		S-12				14 15 15	
				•Decreasing silt content		6 7 11 12	
		S-13		Very dense, wet, gray, black and white SAND, trace silt, silt interbeds, trace shell fragments (SP)		10 25 29 28 28 27	50+
35		S-14		•Medium dense		7 14 14 14	
		S-15		•Wood and shell fragments		7 9 15 20 20 22	
				•Dense, gravelly, trace silt			
40		S-16				7 14 18 20	
				•Dark gray, trace shell fragments			
		S-17				9 8 12 15 25 29	
				•Very dense			
45		S-18		•Wood and shell interbeds, no gravel		8 8 27 30	
		S-19				7 14 22 20 29 35	
				•Peat interbeds			

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 2

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	CP-203B	3 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, 10" to 25', 4" to 61'	Date Start/Finish	6/10/2003-6/11/2003
Hammer Weight/Drop	140 lb / 30"	Hole Diameter (in)	10"

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Depth, ft	S/T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-20				12 18 25 29	▲
		S-21				18 42 50-4"	50+
55		S-22		•Medium sand, few gravel, peat/silt/shell interbeds		14 25 29 33	50+
		S-23		•Fine to medium sand		6 14 20 22 28 25	▲
60				Bottom of boring at 61 feet.			
65							
70							

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 2

...RMINAL 91 TERMINAL 91.GPJ April 14, 2004

CP_W210

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	W-210	1 of 1

Project Name: Terminal 91
Location: Seattle, WA;
Driller/Equipment: Holt Drilling/Hollow stem auger, 4"
Hammer Weight/Drop: 140 lb / 30"
Ground Surface Elevation (ft):
Datum:
Date Start/Finish: 6/10/2003-6/10/2003
Hole Diameter (in): 10"

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Depth, ft	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
	S-1		Loose to medium dense, moist, gray, fine to medium SAND, trace shell fragments (SP)		3 3 3 7 8 14	▲
5	S-2				6 5 4 4	▲
	S-3		•Turns black, strong petroleum-like odor •Sand predominantly fine, wet, shell fragments, strong petroleum-like odor and sheen		1 4 3 4 7 9	▲
10	S-4		•Loose, wet, black		4 4 3 4	▲
	S-5		•Grades coarser with depth, loose to medium dense		3 1 3 4 7 9	▲
			•Trace wood			
15			•Becomes slightly silty, organics at 14.8'			
			Bottom of boring at 16 feet.			
20						

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 3

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

CP_GP01B

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	GP-01B	1 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 22.5'	Date Start/Finish	8/25/2003-8/25/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 22.5'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
				3" Asphalt			
				Medium dense, moist, brown SAND with gravel, trace shell fragments, wood			
5							
		S-1		•Very loose, tan, shell and wood fragments		OH-18"	▲
				Loose, wet, gray-brown silty SAND, trace gravel, shell and wood fragments			
10		S-2		Loose, moist, tan, fine to medium SAND, shell and wood fragments			
		TOC			▼		
		S-3		Loose, wet, gray, silty SAND, trace wood and shell fragments			
				•Bent Shelby tube, poor recovery			
15		S-4		Loose, wet, gray, fine to medium SAND, trace shell and wood fragments		4 2 1	▲
		S-5				1 1-12"	▲
20		S-6				2 1 1	▲
				•Brown, slightly sandy silt layer at 21.5'			
		S-7			14" Hole to 22.5', 9" hole 22.5'-56.5', temporary 10" HSA conductor casing to 22.5' - retracted during seal emplacement	2 2 5	▲

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 5

TERMINAL 91 T...INAL 91.GPJ - March 1?, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	GP-01B	2 of 3

Project Name: Terminal 91
Location: Seattle, WA
Driller/Equipment: Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 22.5'
Hammer Weight/Drop: 140 lb (SPT) & 300 lb (D&M) / 30"

Ground Surface Elevation (ft):
Datum:
Date Start/Finish: 8/25/2003-8/25/2003
Hole Diameter (in): 14" to 22.5'/9" to bottom

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Depth, ft	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot
	S-8		•Medium dense		5 4 7	
	S-9		•Sandy gravel interbed at 28.5'		4 6 8	
30	S-10		Very soft, wet, gray SILT, trace wood and shell fragments		OH-18"	
	S-11		•Gray-brown, sandy, trace shell fragments		4 1 1	
35	S-12				OH-18"	
	S-13				WOH 1 2	
40	S-14		•Olive gray, increasing organics		WOH 1 1	
	S-15		Loose, wet, olive gray to gray, silty SAND, trace shell fragments; sand fine to medium, predominantly medium, black and white sand grains		WOH 3 4	
45	S-16		Medium dense, wet, gray, gravelly SAND; sand fine to coarse, predominantly medium to coarse		4 11 13	
	S-17		Dense, wet, gray, sandy GRAVEL; sand fine to coarse, gravel fine		7 14 30	

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
Po - Porosity
SG - Specific Gravity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 5

TERMINAL 91 TERMINAL 91.GPJ March 17, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	GP-01B	3 of 3

Project Name: Terminal 91
Location: Seattle, WA
Driller/Equipment: Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 22.5'
Hammer Weight/Drop: 140 lb (SPT) & 300 lb (D&M) / 30"
Ground Surface Elevation (ft):
Datum:
Date Start/Finish: 8/25/2003-8/25/2003
Hole Diameter (in): 14" to 22.5'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-18		•No recovery		40 44 47	50+
		S-19		•No recovery		49 0-5"	50+
55		S-20		•Very dense		44 47 50-5"	50+
				Bottom of boring at 56.5 feet.			
60							
65							
70							

Sampler Type (ST):
- No Recovery
- 2" OD Split Spoon
- 3" OD Dames & Moore
- Shelby Tube

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 5

TERMINAL 91 TERMINAL 91.GPJ March 17, 2004

PNO_MW06B

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	MW-6B	1 of 3

Project Name: Terminal 91
Location: Seattle, WA;
Driller/Equipment: Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 25'
Hammer Weight/Drop: 140 lb (SPT) & 300 lb (D&M) / 30"

Ground Surface Elevation (ft):
Datum:
Date Start/Finish: 8/26/2003-8/27/2003
Hole Diameter (in): 14" to 25'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
				3" Asphalt			
				ROAD FILL			
				Sandy GRAVEL with silt Medium dense, damp to moist, gray, gravelly, fine to medium SAND, trace shell fragments			
		S-1				10 6 6	▲
				Brown, silty, fine SAND			
5							
		S-2		Medium dense, damp, sandy GRAVEL, trace silt, trace shells; sand fine to medium		8 6 10	▲
10		S-3		Loose, dark gray, wet, gravelly SAND , trace shell fragments; sand predominantly medium; diesel-like odor		2 2 3	▲
		TOC					
		S-4		•Trace silt, trace organics, trace diesel-like odor, sand fine to medium		2 3 3	▲
15		S-5		•Medium dense, trace shells, diesel-like odor		7 8 9	▲
		S-6		Loose, dark gray, wet, fine to coarse SAND; shell fragments		4 4 5	▲
20		S-7		Medium dense, wet, gray, sandy GRAVEL; sand fine to medium		1 5 11	▲
		S-8		Medium dense, wet, gray, gravelly SAND; sand fine to coarse, predominantly medium to coarse; gravel fine		2 4 10	▲

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 4

TERMINAL 91 TERMINAL 91.GPJ Apr 14, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	MW-6B	2 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 25'	Date Start/Finish	8/26/2003-8/27/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 25'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"
		S-9		Medium dense, wet, gray, sandy GRAVEL, trace silt; sand fine to coarse, predominantly medium to coarse		3, 6, 4
				14" Hole to 25'; 9" hole 25'-59'; temporary 10" HSA conductor casing to 25' - retracted during seal emplacement		
		S-10		•Loose, increasing silt content		2, 3, 4
30		S-11				4, 11, 16
				Dense, wet, gray, slightly gravelly, fine to medium SAND		
		S-12		Dense, wet, gray, sandy GRAVEL; sand fine to coarse, predominantly medium		7, 18, 22
35		S-13		•Light gray, trace silt, increasing gravel content with depth		12, 18, 19
		S-14				9, 20, 23
40		S-15		•Gray, increased silt content with depth, sand fine to coarse		8, 20, 12
		S-16		Dense, wet, tan to gray, slightly silty SAND, trace gravel, trace shell fragments, trace organics; sand fine to medium		9, 12, 15
				Brown-tan sandy gravel interbed 42.5'-43'		
45		S-17		Dense, wet, gray, gravelly SAND, trace silt, shell fragments; sand fine to medium, predominantly medium		15, 16, 18
		S-18		Medium dense, wet, dark gray, sandy GRAVEL, shell fragments; sand fine to coarse, predominantly medium to coarse		6, 10, 18

Blows/Foot: 0 10 20 30 40

Sampler Type (ST):
- No Recovery
- 2" OD Split Spoon
- 3" OD Dames & Moore
- Shelby Tube

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 4

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	MW-6B	3 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 25'	Date Start/Finish	8/26/2003-8/27/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 25'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-19 M 0.9% P 0.1 TOC		Very dense, gray, sand fine to medium		38 43 49	50+
		S-20 TOC		Very dense, wet, gray, fine to medium SAND; predominantly medium		12 28 50-5"	50+
55		S-21		Dense		7 11 26	
		S-22		Medium dense, wet, grayish-brown, slightly silty SAND, trace organics, shell fragments; sand fine to medium, predominantly medium		7 12 15	
				Bottom of boring at 59 feet.			
60							
65							
70							

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 4

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

CP_GP08

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
980014A	GP-08	1 of 1

Project Name: T-91
Location: Washington
Drilling Method: 4" HSA ; Holt Drilling (Mic)
Sampling Method: SPT
Top of PVC Casing Elev. (ft mllw):
Depth to Water (ft BTC):
Start Date: December 15, 2004
Finish Date: December 15, 2004

Depth feet	Well Construction	Sample Drive\Recovery	Blows/ 6"	Sample ID	Mtl. Graphic	Description
1	Flush-mount monument Concrete seal 0'-2'					Asphalt 4.5". Gray-brown, slightly gravelly SAND.
2						Soft, moist, dark brown organic matter
3		18/11	0 3 2	S-1		Loose, gray, slightly gravelly SAND with shell fragments; fine to coarse sand.
4	Hydrated bentonite chips 2'-6'					
5						
6	2" diameter PVC riser pipe					
7	10-20 Colorado sand filter pack 8'-19'					
8		18/14	3 3 2	S-2		
9						Loose, moist to wet, brown, slightly gravelly SAND with shell fragments; fine to coarse sand.
10						
11						
12						
13	10-slot, 2" diameter PVC screen 8'-18'	18/16	3 3 2	S-3		Grades to fine SAND.
14						Loose, wet, gray, slightly gravelly SAND, fine and coarse sand with shell fragments.
15						
16						
17						
18		18/17	5 7 7	S-4		Medium dense, wet, gray SAND with silty, laminated sand, trace shell fragments, grades finer with depth
19						Overdrilled to 19', installed 10' 10-slot 8'-18'.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
Water Level (ATD)
Static Water Level

Logged by: RRH
Approved by: WVG
Figure No. A-

MW_GEOLG T-91.GPJ December 29, 2004

CP- GP09

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
980014A	GP-09	1 of 1

Project Name: T-91
Location: Washington
Drilling Method: 4" HSA ; Holt Drilling (Mic)
Sampling Method: SPT
Top of PVC Casing Elev. (ft mllw):
Depth to Water (ft BTC):
Start Date: December 15, 2004
Finish Date: December 15, 2004

Depth feet	Well Construction	Sample Drive\Recovery	Blows/ 6"	Sample ID	Description
0	Flush-mount monument				2" Asphalt.
					5" Concrete.
1	Concrete seal 0'-2'				Very loose, moist, gray to brown, fine SAND.
2					
3		18/15	1 1 0	S-1	Iron oxide staining
4	Hydrated bentonite chips 2'-6'				
5					
6	2" diameter PVC riser pipe				Medium dense, wet, brown to gray, sandy GRAVEL; trace shell fragments, fine to coarse sand.
7	10-20 Colorado sand filter pack 8'-19'				
8		18/9	5 6 5	S-2	
9					
10					Very loose, wet, brown to gray, gravelly, SAND; fine to coarse sand, trace shell fragments.
11					
12					
13	10-slot, 2" diameter PVC screen 8'-18'	18/9	1 1 1	S-3	
14					Gray silty SAND
15					
16					
17					
18		18/9	2 2 3	S-4	Loose, wet, gray, fine SAND; trace fines.
19					Overdrilled to 19', installed 10' 10-slot 8'-18'.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
Water Level (ATD)
Static Water Level

Logged by: JWC
Approved by: WVG
Figure No. A-

MW_GEOLG T-91.GPJ December 29, 2004

CP_GP10

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
980014A	GP-10	1 of 1

Project Name: T-91
Location: Washington
Drilling Method: 4" HSA ; Holt Drilling (Mic)
Sampling Method: SPT
Top of PVC Casing Elev. (ft mllw):
Depth to Water (ft BTC):
Start Date: December 15, 2004
Finish Date: December 15, 2004

Depth feet	Well Construction	Sample Drive\Recovery	Blows/ 6"	Sample ID	Mtl. Graphic	Description
0	Flush-mount monument					5" Asphalt.
1	Concrete seal 0'-2'					Medium dense, moist, gray to brown, very gravelly SAND; fine to coarse sand.
2						
3		18/9	6 11 11	S-1		
4	Hydrated bentonite chips 2'-6'					Brown, fine to medium sand.
5						
6	2" diameter PVC riser pipe					
7	10-20 Colorado sand filter pack 8'-19'					
8		18/10	13 12 12	S-2		Medium dense, wet, gray-brown, very sandy GRAVEL; medium to coarse sand with trace shell fragments.
9		▼				
10						
11						
12						
13	10-slot, 2" diameter PVC screen 8'-18'	18/4	2 5 7	S-3		Medium dense, wet, gray with trace brown, very gravelly SAND; fine to coarse sand with trace shell fragments, trace fines.
14						
15						
16						
17						
18		18/9	2 4 2	S-4		Loose, wet, gray, gravelly SAND; fine to coarse sand, trace shell fragments, trace fines.
19						Overdrilled to 19', installed 10' 10-slot 8'-18'.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
Static Water Level

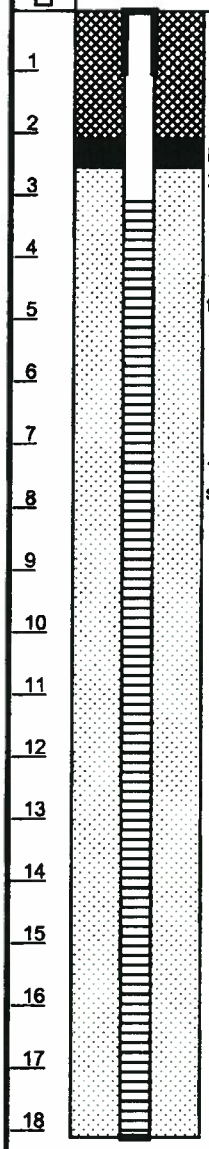
Logged by: JWC
Approved by: WVG
Figure No. A-

MW_GEOLG T-91.GPJ December 29, 2004

CP_GP11

TZF Consultant	Geologic & Monitoring Well Construction Log	
	Well Number **CP_GP11**	Sheet 1 of 1

Project Name Port of Seattle - T-91 Tank Farm Upland Wells
Location Seattle, Washington
Drilling Method 4"ID H.S.A.
Sampling Method SPT
Logged by T. Fitzgerald
Start Date March 17, 2005
Completion Date March 17, 2005



Depth feet	Sample Recovery	Blows / 6"	Geol. Graphic	Description
1				Asphalt to 6-inches
2				(GP) Gravel with sand, gray/brown, 50/50, dry. (auger conveyance).
3				
4				
5				
6		50		(GP/SP) GRAVEL and SAND, gray/brn (10YR52), poorly sorted, rounded gravel to 2-inches, 50% fine to coarse sand, medium dense, dry, trace crushed brick + concrete.
7				
8				▼ increasing sand, wet
9				
10				
11		10 14		(SP) Gravelly SAND, gray (2.5YRN5), 80% fine to coarse sand, about 20% rounded gravel to 1-inch, wet, loose, TPH odor and sheen, trace shell fragments+ white quartz pebbles.
12		23		
13				
14				
15				
16		13 16		(SP) Sand with gravel , gray (2.5YRN5) 90% coarse to medium, rounded gravel to 1-inch, wet, dense, TPH odor, trace shell fragments.
17		21		
18		9		SAA
19		7 4		(ML/SM) Silt with sand (SM) gray (5YRN10), about 50% gray silt, about 50% fine to medium sand, wet, very stiff.

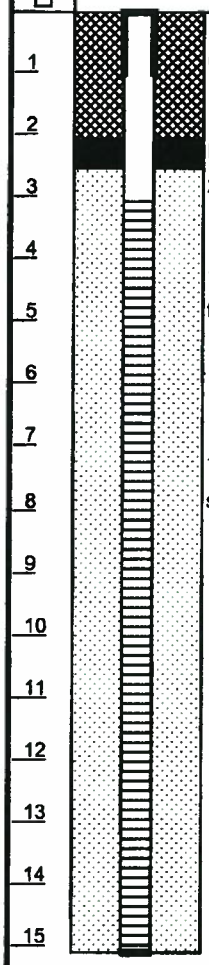
▼ Water level (ATD)

FIGURE B-1

CP_GP12

TZF Consultant	Geologic & Monitoring Well Construction Log	
	Well Number **CP_GP12**	Sheet 1 of 1

Project Name Port of Seattle - T-91 Tank Farm Upland Wells
Location Seattle, Washington
Drilling Method 4"ID H.S.A.
Sampling Method SPT
Logged By T. Fitzgerald
Start Date March 17, 2005
Completion Date March 17, 2005



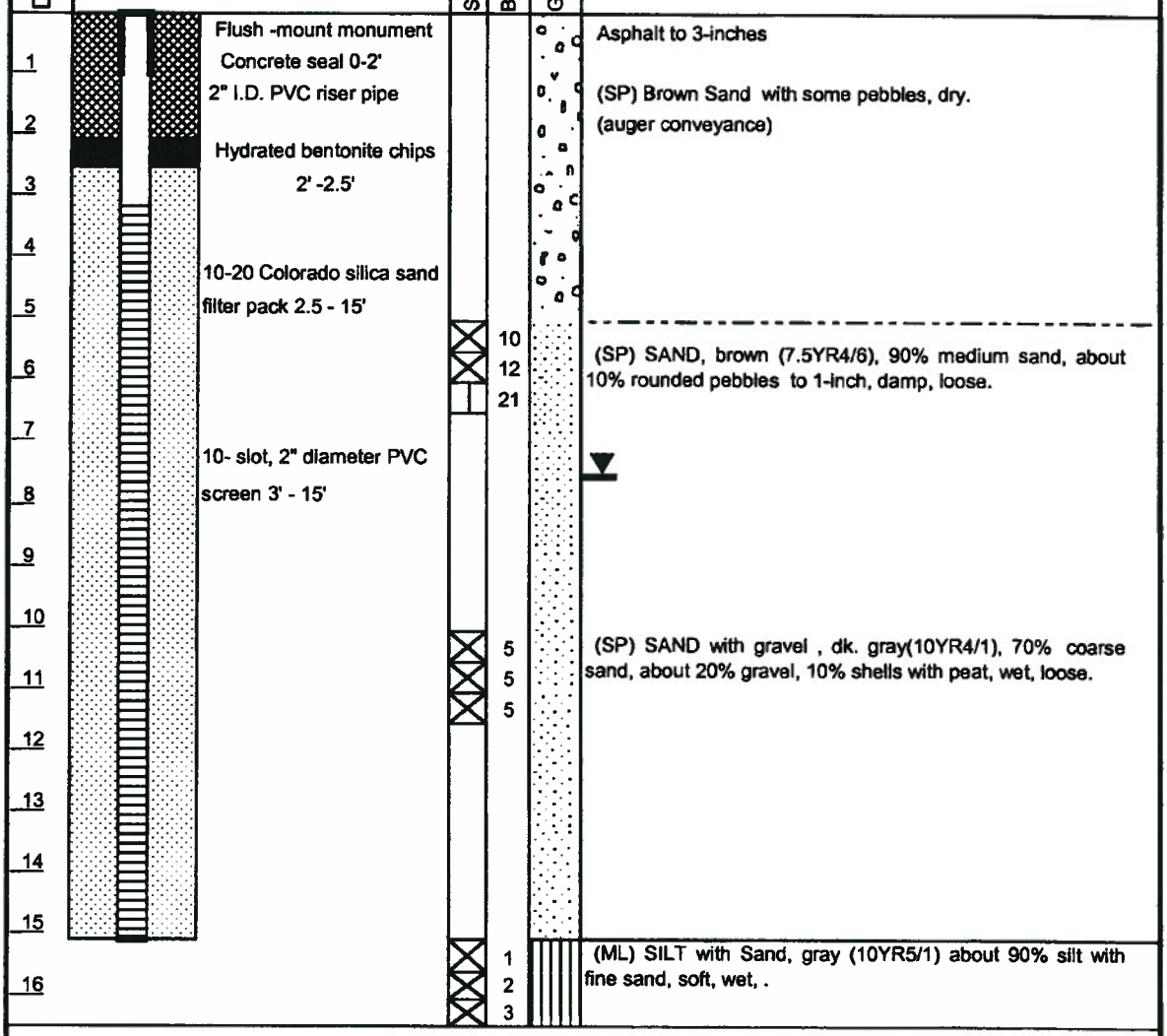
▼ Water Level (ATD)

FIGURE B-2

CP-GP13

TZF Consultant	Geologic & Monitoring Well Construction Log	
	Well Number **CP_GP13**	Sheet 1 of 1

Project Name Port of Seattle - T-91 Tank Farm Upland Wells
Location Seattle, Washington
Drilling Method 4"ID H.S.A
Sampling Method SPT
Logged by T. Fitzgerald
Start Date March 17, 2005
Completion Date March 17, 2005



▼ Water Level (ATD)

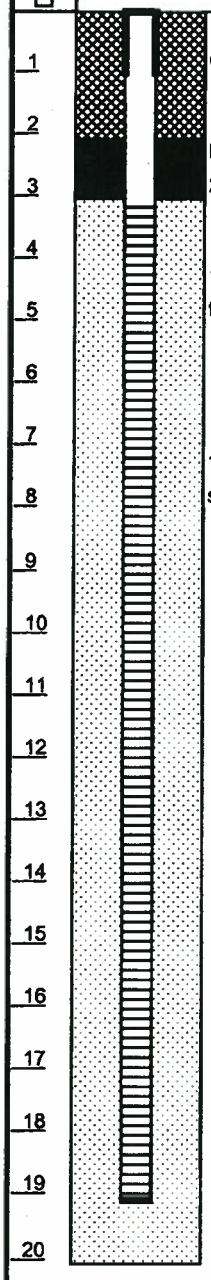
FIGURE B-3

CP_GP14

TZF Consultant	Geologic & Monitoring Well Construction Log	
	Well Number **CP_GP14**	Sheet 1 of 1

Project Name Port of Seattle - T-91 Tank Farm Upland Wells
Location Seattle, Washington
Drilling Method 4" ID H.S.A.
Sampling Method SPT

Logged by T. Fitzgerald
Start Date March 17, 2005
Completion Date March 17, 2005



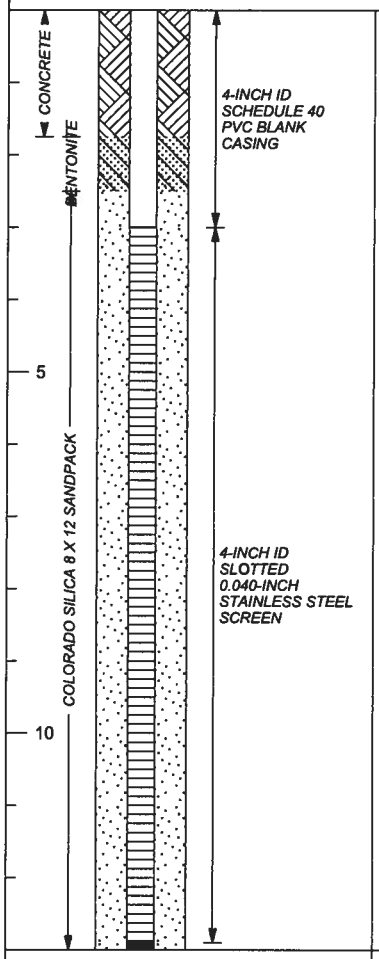
▼ Water Level (ATD)

FIGURE B-4

CP_PR-01

PES Environmental, Inc.
Engineering & Environmental Services

LOG OF CP-PR01



PID (ppm)	BLOWS/6IN	DEPTH (FT)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
					ASPHALT
					GRAVEL BASE COURSE
					CONCRETE
4437	4				**GRAY AND DARK BROWN SAND AND GRAVEL (SP/GP)**, moist, loose, fine sand, fine to medium gravel, trace fines, sheen, hydrocarbon-like odor
	3				
	3				
4620	4				Sand becomes fine to coarse
	6				
	6				
4182	4	5			
	6				
	7				(Shelby tube sampler pushed from 6.2 to 8.5 feet, no lithologic sample for review)
1027	7				**DARK GRAY SAND (SP)**, moist, loose, fine sand, few nonplastic fines, trace shell fragments, product droplets present
	6				
	7				
968	5	10			
	5				
	6				Fines increase to little
1645	5				
	7				
	7				
					Bottom of boring at 13 feet bgs Flush mount well completion
		15			
		20			

POST91-BACKUP POST91.GPJ 10/30/06

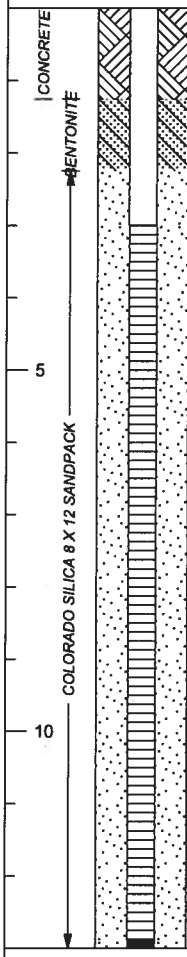
PROJECT	Port of Seattle T-91 LNAPL Study	DIAMETER OF HOLE	12.5 inches
LOCATION	Seattle, Washington	TOTAL DEPTH OF HOLE	13 feet
JOB NUMBER	948.002.01.001		
GEOLOGIST/ENGINEER	Erin McQuillan	DATE STARTED	8/1/05
DRILL RIG	Hollow Stem Auger	DATE COMPLETED	8/1/05

PLATE

CP_PR-02

PES Environmental, Inc.
Engineering & Environmental Services

LOG OF CP-PR02



PID (ppm)	BLOWS/6IN	DEPTH (FT)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
					ASPHALT
					GRAVEL BASE COURSE
					CONCRETE
3627	8				**GRAYISH BROWN SAND AND GRAVEL (SP/GP)**, damp, loose, fine sand, fine to medium gravel, trace fines, hydrocarbon-like odor
	10				
	7				
2980	7				Color becomes black
	12				
	12				
3210	6				Gravel size becomes fine to coarse, product droplets present
	7	5			(Shelby tube sampler pushed from 5.5 to 7.8 feet, no lithologic sample for review)
1204	3				**GRAY SAND (SP)**, moist, loose, fine sand, few shell fragments, trace fine gravel, few fines, hydrocarbon-like odor and sheen
	7				
	7				**GRAY SILTY SAND (SM)**, wet, loose, fine sand, nonplastic fines, few fine gravel, product droplets present
2247	6				
	6				
	5	10			
920	7				**GRAYISH BLACK SAND AND GRAVEL (SP/GP)**, wet, loose, fine to coarse sand, fine to medium gravel, trace fines, product droplets present, hydrocarbon-like odor
	8				
	7				
467	6				
	7				
					Bottom of boring at 13 feet bgs
					Flush mount well completion
		15			
		20			

POST91-BACKUP POST91.GPJ 10/30/06

PROJECT	Port of Seattle T-91 LNAPL Study	DIAMETER OF HOLE	12.5 inches
LOCATION	Seattle, Washington	TOTAL DEPTH OF HOLE	13 feet
JOB NUMBER	948.002.01.001		
GEOLOGIST/ENGINEER	Erin McQuillan	DATE STARTED	8/1/05
DRILL RIG	Hollow Stem Auger	DATE COMPLETED	8/1/05

PLATE

CP_GP03AR

TZF Consultant	Monitoring Well Construction & Boring Log	
	Well Number **GP- 03AR**	Sheet 1 of 1

Project Name: Port of Seattle - T-91 Tank Farm Upland Wells
Location: Pier 91 Seattle, Washington
Driller: Andy Flagan with Cascade Drilling
Sampling Method: 4 " H.S.A. with 3" ID S.S.

Purpose: Replace former MW GP03A
Logged by: T. Fitzgerald
Start Date: 1100H, March 01, 2007.
Completion Date: March 01, 2007

Depth feet	Well Construction	Sample Recovery	Blows / 6"	Geol. Graphic	Subsurface Description
1	Roadway monument				New Asphalt to 5 inches.
2	Concrete seal				Compacted fill - sand with gravel, brown, dry (auger conveyance).
3	2" I.D. PVC riser pipe				
4	Bentonite chips				
5			5 5 6		(SP) SAND with Gravel, medium brn (10YR4/2), poorly sorted, 90% medium to fine sand, 10% rounded gravel to two inches, med. dense, damp.
6					
7	#2/12 Lapis Lustre Well Sand from 4' - 20'				
8					
9					▼
10			15 16 50/2		(SP-GP) Gravelly SAND, dk. gray (10YRN5/1), 70% medium to coarse, 30% rounded gravel to two inches, very dense, wet, TPH odor.
11					
12					
13	10 - slot, 2" diameter pvc well screen 5' - 20'				
14					
15			5 8 6		(SP) SAND, gray (10YRN5/1), 95% mediumsand with trace fine sand and shell fragments, medium dense, wet, (no odor/sheen).
16					
17					
18					
19					
20	4-inch threaded end cap		3 3 4		(SP) SAND, dk. gray (10YRN5/2), 95% medium to coarse, trace pebbles and shells, loose, wet.

Constructed well depth 19.85 ft - toc.

Total auger depth ~ 20.5ft - bgs.

▼ Water level (ATD)

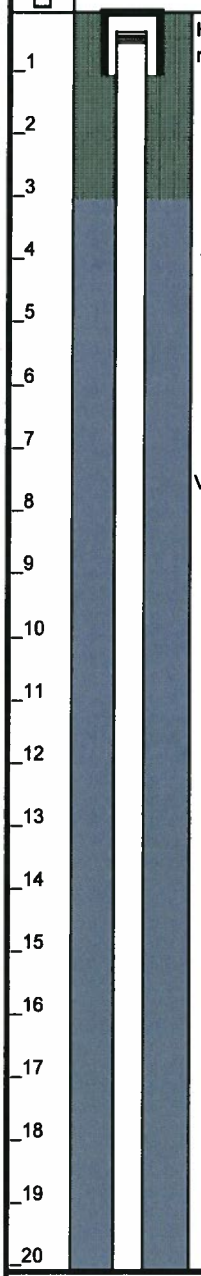
(%) - Percent proportions are field approximations.

FIGURE A-1

CP_GP03BR

TZF Consultant	Monitoring Well Construction & Boring Log	
	Well Number **GP- 03BR**	Sheet 1 of 4

Project Name Port of Seattle - T-91 Tank Farm Upland Wells
Rationale: Replaces former MW_GP03B
Location Pier 91 Seattle, Washington
Logged by T. Fitzgerald
Driller: Andy Flagan with Cascade Drilling
Start Date 0800H March 01, 2007
Sampling Method: 4 "ID H.S.A. with 3" ID Sampler.
Completion Date March 01, 2007



Sample Recovery	Blows / 6"	Geol. Graphic	Subsurface Description
			New construction asphalt to 5-inches
			Compacted fill - sand with gravel, brown, dry (auger conveyance).
	2 3 4		(SP) SAND with Gravel, medium brn (10YR4/2), poorly sorted, 80% medium sand, 20% gravel pebble to angular crushed rock, damp.
			(grading fine)
	2 2 4		(SP) SAND with Gravel, gray brn (10YRN5/1), 80% medium to coarse sand, 10% rounded gravel, 10% shells, loose, wet, TPH odor/sheen.
			(no gravels in conveyance)
	3 4 4		(SP) SAND, gray (10YRN5/1), 100% medium sand, loose, wet, (no odor/sheen).
	3 5 5		(SP) SAND, gray (10YRN5/1), 95% medium to coarse, trace shells, loose, wet.

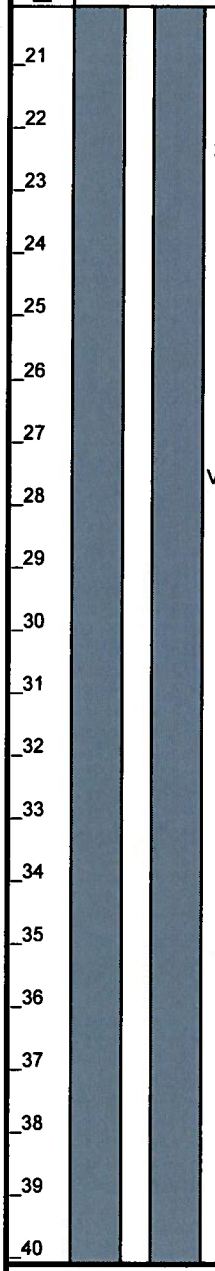
▼ Water level (ATD)

(%) - Percent proportions are field approximations.

FIGURE A-3

TZF Consultant	**Monitoring Well Construction & Boring Log**	
	Well Number **GP- 03BR**	Sheet 2 of 4

Project Name: Port of Seattle - T-91 Tank Farm Upland Wells
Rationale: Replace former MW_GP03B
Location: Pier 91 Seattle, Washington
Logged by: T. Fitzgerald
Driller: Andy Flagan with Cascade Drilling
Start Date 0800H March 01, 2007
Sampling Method: 4 " H.S.A. with 3" ID S.S.
Completion Date: March 01, 2007



Subsurface Description

(SP) SAND with Gravel, gray (10YR5/1), 85% medium, 15% rounded gravel to two inches, loose,wet, trace shell fragments.

(SP-GP) Gravelly SAND, gray (10YRN5/1), 70% medium sand, 30% pebble gravel to one inch, loose, wet, trace shells.

(SP-GP) Gravelly SAND, dk. gray (10YRN5/2), 60% coarse -medium sand, 40% pebble gravel to one inch, loose, wet, trace shells.

(GP) GRAVEL, dk. gray (10YRN5/2), 90% rounded gravel to two inches, medium dense, wet.

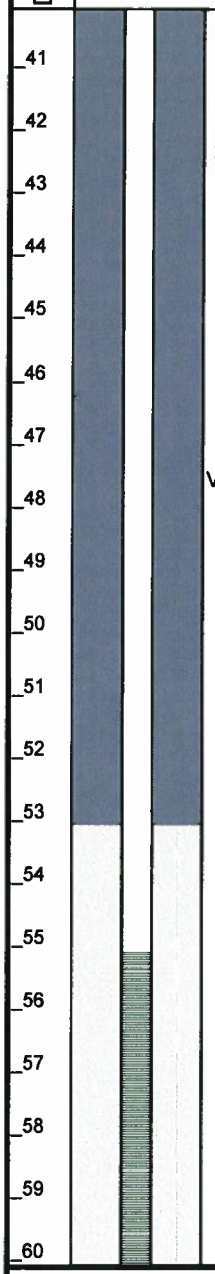
▼ Water level (ATD)

(%) - Percent proportions are field approximations.

FIGURE A-3

TZF Consultant	**Monitoring Well Construction & Boring Log**	
	Well Number **GP- 03BR**	Sheet 3 of 4

Project Name: Port of Seattle - T-91 Tank Farm Upland Wells
Rationale: Replace former MW_GP03B
Location: Pier 91 Seattle, Washington
Logged by: T. Fitzgerald
Driller: Andy Flagan with Cascade Drilling
Start Date 0800H March 01, 2007
Sampling Method: 4 " H.S.A. with 3" ID S.S.
Completion Date: March 01, 2007



Sample Recovery	Blows / 6"	Geol. Graphic	Subsurface Description
X	15 15 15		(SP) SAND, dk. gray (10YR5/1), 100% medium to coarse,dense,wet, trace shell fragments.
X	15 13 20		(SP-GP) GRAVELLY SAND, gray (10YRN5/1), 60% coarse to medium sand, 40% gravels to two inches, dense, wet, trace shells.
X	4 6 7		(SP) SAND w/Gravel, dk. gray (10YRN5/2), 90% coarse -medium sand, 10% pebble gravel to half inch, medium dense, wet.
X	13 12 20		(SP) Sand w/ Gravel, dk. gray (10YRN5/2), 85% med-coarse, 15% gravel to one inch, dense, wet.

▼ Water level (ATD)

(%) - Percent proportions are field approximations.

FIGURE A-3

TZF Consultant	**Monitoring Well Construction & Boring Log**	
	Well Number **GP- 03BR**	Sheet 4 of 4

Project Name: Port of Seattle - T-91 Tank Farm Upland Wells
Rationale: Replace former MW GP03B
Location: Pier 91 Seattle, Washington
Logged by: T. Fitzgerald
Driller: Andy Flagan with Cascade Drilling
Start Date 0800H March 01, 2007
Sampling Method: 4 " H.S.A. with 3" ID S.S.
Completion Date: March 01, 2007

Depth feet	Well Construction	Sample Recovery	Blows / 6"	Geol. Graphic	Subsurface Description
61					
62					
63					
64			11		(SP) SAND with Gravel, dk. gray (10YR4/2), 90% medium, 10% rounded gravel to half inch, med. dense, wet, trace shell fragments.
65	4-inch threaded end cap		12		
			11		
66	Constructed well depth 64.5 ft toc.				Total Boring Depth - 65 feet bgs.
67					
68					
69					
70					
71					
72					
73					
74					
75					
76					
77					
78					
79					
80					

▼ Water level (ATD)

(%) - Percent proportions are field approximations.

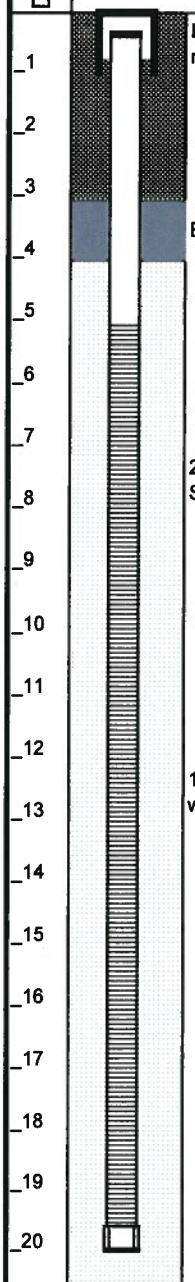
FIGURE A-3

CP_GP04R

TZF Consultant	**Monitoring Well Construction & Boring Log**	
	Well Number **GP- 04R**	Sheet 1 of 1

Project Name: Port of Seattle - T-91 Tank Farm Upland Wells
Location: Pier 91 Seattle, Washington
Driller: Andy Flagan with Cascade Drilling
Sampling Method: 4 " H.S.A. with 3" ID S.S.

Rationale: Replace former MW GP04
Logged by: T. Fitzgerald
Start Date: 1200H March 01, 2007
Completion Date: March 01, 2007



Constructed well depth 19.83 - feet toc.	Total auger depth~ 20.5 ft bgs.
▼ Water level (ATD)	(%) - Percent proportions are field approximations.

FIGURE A-2

CP_PR-03 through CP_PR-13

Table 2
LNAPL Monitoring Well Locations
Port of Seattle Terminal 91 Phase 2 Data Gaps Investigation
Seattle, Washington

PES Environmental, Inc.

Boring	Surveyed Coordinates		Elevations			Well Completion Information							Comments
	Northing	Easting	PVC	Monument	Ground	Well Materials	Monument	Boring Depth	Well Depth	Screen Depth	Filter Pack Depth	Seal Depth	
PR-01	Well inaccessible under a stack of jersey barriers					4" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 8 x 12 sand	Flush	13	13.0	3.2 - 12.8	2.5 - 13	0 - 2.5	Previous PVC elev. survey = 18.84 feet
PR-02	235,222.32	1,258,679.05	17.86	18.16	18.15	4" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 8 x 12 sand	Flush	13	13.0	3.2 - 12.8	2.5 - 13	0 - 2.5	Previous PVC elev. survey = 17.89 feet
PR-03	234,999.20	1,258,724.22	18.40	18.78	18.75	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-1 for lithology
PR-04	235,007.60	1,258,877.93	18.17	18.41	18.38	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-9 for lithology
PR-05	235,133.88	1,258,844.34	18.18	18.58	18.55	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	13.1	3.3 - 12.9	2 - 14	0 - 2	See DG-11 for lithology
PR-06	235,276.45	1,258,590.77	18.45	18.97	18.95	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-18 for lithology
PR-07	235,167.78	1,258,635.35	18.55	18.86	18.81	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	13.0	3.2 - 12.8	2 - 14	0 - 2	See DG-19 for lithology
PR-08	235,228.56	1,258,737.39	17.18	17.46	17.51	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-30 for lithology
PR-09	235,268.97	1,258,774.71	18.24	18.57	18.58	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-34 for lithology
PR-10	235,391.61	1,258,798.61	18.37	18.85	18.86	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	13.2	3.4 - 13.0	2 - 14	0 - 2	See DG-52 for lithology
PR-11	235,283.59	1,258,825.55	18.44	18.91	18.91	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-53 for lithology
PR-12	235,326.55	1,258,639.37	18.36	19.02	18.97	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-57 for lithology
PR-13	235,133.01	1,258,256.72	17.31	17.70	17.68	2" stainless steel, 0.040"-slot screen; Schedule 40 PVC riser; 10 x 20 sand	Flush	14	12.9	3.1 - 12.7	2 - 14	0 - 2	See DG-73 for lithology

Notes:
1. Horizontal datum = Washington State Plane coordinate system (NAD 83, feet).
2. Vertical datum = mean lower low water datum (feet).
3. PVC elevation = top of PVC well casing (north side).
4. Monument elevation = top of steel surface monument (north side).
5. Ground elevations measured less than 2 feet north of each well.
6. Depths in feet relative to ground surface.
7. Flush = flush with grade.
8. All screens constructed of continuous wire-wrapped stainless steel.

PES Environmental, Inc.

Table 3
Soil Descriptions
Port of Seattle Terminal 91 Data Gaps Investigation
Seattle, Washington

Soil Boring Number	Date Drilled	Lithologic Interval (ft bgs)	USCS Soil Type	Soil Description	PID Measurements Depth	PID Measurements Reading	LNAPL Appearance (if LNAPL observed)	Additional Notes
Lease Parcel								
DG-1	5/24/07	2-8	SP	Dark Brown Sand - moist, fine to medium, trace fine gravel; wet at 7', loose. CP_PR-03	3	50	Extensive staining	Boring moved
		8-14	SP	Gray Sand - wet, fine, trace shell fragments, loose	6.5	55	Extensive staining	
DG-2	5/29/07	2-8	SP	Tan Sand - moist, fine; wet at 7.5', loose	3	0		Boring moved
		8-14	SP	Gray Sand - wet, fine, trace medium gravels, trace shell fragments, loose	8	1		
DG-3	5/25/07	4-5	FILL	Coarse broken rock with fine sand and fine gravel	4	23		Boring moved
		5-8	SP	Brown Sand - moist, fine, loose	5	184	Slight staining	
		8-16	SP	Gray Sand - wet, fine, trace shell fragments, loose	8.5	474	Slight staining, strong odor	
DG-4	5/24/07	2-2.7	FILL	Gravel and broken brick fragments	3.5	32	Extensive, thick, sticky	Boring moved
		2.7-14	SP	Black Sand - moist, fine to medium, few fine gravel, trace wood fragments; color becomes gray at 10'	7	42	Extensive, sticky	
DG-5	5/24/07	2-3	GP	Dark Brown Gravel with Sand- moist, fine to medium gravel, fine sand	3	21	Thick, sticky, black	
		3-10	SP	Brown Sand - moist, fine, loose	7	24	Extensive staining/smearing	
		10-14	SP	Gray Sand - wet, fine, trace fines, trace shell fragments	10	5		
DG-6	5/29/07	2-7	SP	Black Sand with Gravel- moist, fine sand, fine gravel	2	15	Extensive, black, sticky, tar-like smearing	
		7-14	SP	Gray Sand - wet, fine, trace shell fragments	6.5	45	Moderate staining/smearing	
DG-7	5/29/07	2-7*	SP	Black Sand with Gravel- moist, fine sand, fine to coarse gravel, trace brick fragments; *No recovery from interval 6-10'	3	28	Thick, sticky, tar-like smearing	
		7-14	SP	Gray Sand - wet, fine, trace shell fragments	10	36		
DG-8	5/22/07	2-6	SP	Dark Gray Sand - moist, fine, few fine gravel, loose	2	7		
		6-7	SP	Gray Sand - moist, fine to medium, some shell fragments				
		7-14	SP	Black Sand - wet, fine, trace fine gravel; color becomes gray at 11', loose	7	8		
DG-9	5/29/07	2-8	SP	Black Sand - moist, fine CP_PR-04	3	23	Very extensive, black, sticky, tar-like	Black, tar-like goo oozing out top of acetate tube
		8-14	SP	Gray Sand - wet, fine	6.5	33	Extensive, black, tar-like liquid covering soil	
DG-10	5/22/07	2-6	SP	Black Sand - moist, fine, some wood fragments	2	58	Stained, soaked	
		6-7	GP	Black Gravel - wet, fine to medium, little fine sand	4	201	Stained	
		7-14	SP	Black Sand - wet, fine, few fines	8	267	Extensive staining	
DG-11	5/29/07	2-8	SP	Black Sand with Gravel - moist, fine sand, little medium gravel CP_PR-05	3	110	Moderate black, sticky, tar-like smearing	
		8-15	SP	Gray Sand - wet, fine, trace shell fragments, loose	8	207	Extensive dark brown, smearing/staining	
DG-12	5/29/07	4-7	SP	Tan Sand - damp, fine, loose	4	25		Boring moved
		7-16	SP	Gray Sand - wet, fine; few shell fragments at 13', loose	8	10		
DG-13	5/24/07	2-4	SP	Dark Brown - moist, fine, few fine gravel	3	35	Extensive staining/smearing, sticky	
		4-11	SP	Tan Sand - moist, loose, fine; color becomes dark gray at 8'	7.5	68	Moderate smearing	
		11-14	SP	Gray Sand - wet, loose, fine, trace fines				
DG-14	5/24/07	3-5	SP	Dark Brown Sand with Gravel - moist, fine to medium sand, fine gravel	4	39	Extensive smearing, sticky	
		5-10	SP	Brown Sand - moist, loose, fine to medium, trace fine gravel	8	70	Moderate smearing	
		10-16	SP	Gray Sand - wet, loose, fine, few shell fragments, trace fines				
DG-15	5/23/07	4-9	SP	Gray Sand - moist, loose, fine to medium, few fine to medium gravel	4	5		Boring moved
		9-12	GP	Gravel with Sand - wet, fine to medium, some medium sand	8	166	Droplets	
		12-16	SP	Gray Sand - wet, fine (trace coarse sand), few fines	9.5	280	Product	
DG-16	5/23/07	2-4	SP	Brown Sand with Gravel - moist, loose, fine, some fine gravel	2.5	20	Extensive smearing	Boring moved
		4-10*	SP	Brown Sand - moist, loose, fine (*No recovery from interval 6'-10')	5.5	104	Extensive smearing	
		10-12.5	SP	Gray Sand - wet, loose, fine to coarse, little fine gravel	12	523		
		12.5-14	GP	Gravel with Sand - wet, fine to medium, medium to coarse sand	13	347		
		14-16	SP	Gray Sand - wet, loose, fine	15	3		
DG-17	5/23/07	3-9.5	SP	Gray Sand - damp, fine to medium, trace medium gravel, trace shell fragments	3	82		Boring moved
		9.5-11	SP	Sand with Gravel - wet, loose, fine to coarse, fine gravel	7	77	Droplets	
		11-15	SP	Gray Sand - wet, fine to coarse, few fine gravel, trace shell fragments	8	282	Droplets	
DG-18	5/29/07	4-8	SP	Brown Sand with Gravel - moist, loose, fine to medium, some medium gravel	4	38	Scattered droplets	Boring moved
		8-12	SP	Gray Sand - wet, loose, fine to coarse, trace fine gravel CP_PR-06	8	71	Scattered droplets	
		12-16	SP	Sand with Gravel - wet, loose, fine to coarse sand, fine to medium gravel				

Table 3
Soil Descriptions
Port of Seattle Terminal 91 Data Gaps Investigation
Seattle, Washington

Soil Boring Number	Date Drilled	Lithologic Interval (ft bgs)	USCS Soil Type	Soil Description	PID Measurements Depth	PID Measurements Reading	LNAPL Appearance (if LNAPL observed)	Additional Notes
DG-19	5/23/07	3.5-10	SP	Tan Sand - damp, loose, fine (becomes gray and wet at 6') CP_PR-07	3.5	1		Boring moved
					7	94	Droplets	
					8.5	390	Droplets	
		10-12	GP	Gravel - wet, fine to coarse, little medium sand				
		12-16	SP	Gray Sand with Gravel - wet, fine to coarse, fine to medium gravel (Limited recovery from 12'-16')				
DG-20	5/25/07	2-6	GP	Gravel with dark borwn Sand - moist, fine to medium gravel,	2	78	Moderate staining	
		6-9	SP	Brown Sand - moist, fine, loose (wet at 7')	7.5	223	Moderate smearing, isolated droplets	
		9-12	SP	Brown Sand with Gravel - wet, fine to coarse, some fine to medium gravel (Limited recovery from 9.5'-13.5')				
		12-17.5	SP	Gray Sand - wet, fine loose				
DG-21	5/23/07	2.5-6.5	SP	Brown Sand with Gravel - moist, fine sand, some fine gravel	2.5	26	Extensive smearing	
		6.5-10.5	SP	Gray Sand - wet, fine, few fine gravel, loose	8	259	Droplets	
		10.5-14.5	SP	Gravel with Sand - wet, fine, fine to coarse sand, loose	11	588	Product	
DG-22	5/23/07	3.5-9	SP	Brown Sand - moist, fine, few medium gravel, few shell fragments, loose (at 5' color becomes gray, gravel decreases to trace; wet at 7')	3.5	46		
					7.5	182	Droplets, smeared	
		9-10.5	SP	Gray Sand - wet, fine to coarse, little fine gravel, few shell fragments				
		10.5-14.5	GP	Gravel - wet, fine to coarse, some medium sand (limited recovery 10.5'-14.5')				
DG-23	5/25/07	3-5	FILL	Broken rock, gravel, sand and shell fragments	3.5	5		Boring moved
		5-10	SP	Dark Brown Sand - moist, fine, loose (wet at 8')	7.5	80	Moderate staining	
					9	602	Moderate staining, strong odor	
		10-15	SP	Gray Sand - wet, fine to medium, few shell fragments, loose				
DG-24	5/25/07	1.5-6	SP	Dark Brown Sand with Gravel - moist, fine sand, some medium gravel	3	38	Moderate, thick, sticky smearing	
		6-8	SP	Brwon Sand - wet, fine to medium, trace fine gravel	7	110	Extensive smearing	
		8-14	SP	Gray Sand - wet, fine, trace shell fragments				
DG-25	5/25/07	3-9		Dark Brown Sand - moist fine to medium, loose (wet at 7')	3.5	61	Moderate, thick, sticky smearing	
					7	330	Moderate, thick, sticky smearing	
		9-18	GP	Gravel with Sand - wet, fine to coarse, fine to coarse sand (limited recovery from 10'-18')				
DG-26	5/25/07	4-14	SP	Dark Gray Sand - moist, fine to medium, few medium gravel (at 5.5' gravel decrasees to trace; wet at 8')	4	262	Scattered droplets	
					8	749	Limited visible product, odor	
					10	1,037	Scattered droplets	
		14-16	GP	Gravel - wet, fine to medium, little medium sand, loose				
DG-27	5/25/07	2-3.5	GP	Gravel with Sand - moist, medium, fine to medium sand	3	58	Extensive, sticky smearing	
		3.5-10	SP	Dark Brown - moist, fine to medium, trace medium gravel	7.5	184	Extensive staining	
		10-14	SP	Gray Sand - wet, fine, trace fines (at 13.3 fines increase to few, wood fragments)				
DG-28	5/31/07	3.5-5	GP	Gravel with Sand - damp, fine to medium gravel, fine to medium sand, loose	3.5	100	Light smearing, scattered droplets	
		5-16	SP	Brown Sand - moist, fine, trace shell fragments, trace fines (wet at 8.5'; at 13.5' fines increase to few)	7.5	303	Moderate smearing/staining	
					10	421	Scattered droplets	
DG-29	5/25/07	2-3.5	GP	Gravel with Sand - damp, fine to medium, medium sand, loose	2	70	Extensive, thick, sticky staining	
		3.5-6	SP	Brown Sand - moist, fine, few fine to medium gravel				
		6-7	SP	Brown Sand - wet, fine to coarse, some fine gravel, losse				
		7-9.5	SP	Brown Sand - wet, fine, trace fine gravel	7.5	468	Moderate smearing	
		9.5-14	SP	Gray Sand - wet, fine, trace shell fragments, loose				
DG-30	5/25/07	1.4-9	SP	Dark Brown Sand - moist, fine to medium, trace medium gravel, loose	1.5	50	Extensive, thick, sticky, tar-like smearing	Boring moved
					7.5	77	Extensive, thick, sticky smearing	
		9-13	SP	Gray Sand - wet, fine, trace fines, loose (at 12' fines increase to few) CP_PR-08				
DG-31	5/25/07	3.5-5	SP	Gray Sand with Gravel - moist, fine to medium sand, fine to medium gravel, loose	4	91	Odor	
		5-14.5	SP	Gray Sand - moist, fine to medium, trace shell fragments, loose (wet at 7')	8	420	Scattered droplets, strong odor	
					10	787	Strong odor	
		14.5-15.5	SM	Gray Silty Sand - wet, fine, little fines, trace shell fragments				
		15.5-16	ML	Gray Silt - wet, soft, medium plascicity, wood fragments				

Table 3
Soil Descriptions
Port of Seattle Terminal 91 Data Gaps Investigation
Seattle, Washington

Soil Boring Number	Date Drilled	Lithologic Interval (ft bgs)	USCS Soil Type	Soil Description	PID Measurements Depth	PID Measurements Reading	LNAPL Appearance (if LNAPL observed)	Additional Notes
DG-32	5/22/07	3-4.5	GP	Black Gravel - moist, fine, angular, little fine sand	3.5	495	Dark staining	
		4.5-7	SP	Black Sand - moist, fine, little fine to medium gravel, loose				
		7-11	SP	Black Sand - wet, fine to coarse, some fine gravel	8	132	Extensive staining	
					9	247	Stained	
		11-15	SP	Gray Sand - wet, fine, trace fines, trace shell fragments				
DG-33	5/22/07	1.5-3.5	GP	Black Gravel - moist, fine, angular, some fine sand	2	26	Dark product staining	
		3.5-6	SP	Gray Sand - moist, fine loose	4	78	Dark product staining	
		6-8	GP	Gravel - wet, fine, little fine sand	7.5	182	Smeared	
		8-14	SP	Dark Gray Sand - wet, fine, few fines, loose	8.5	650	Scattered droplets	
DG-34	5/22/07	8-12	SP	Dark Gray Sand - wet, fine, trace fines, loose (no recovery until 8'	8	555	Scattered droplets	Sample recovery problems; boring re-drilled
DG-34A	5/31/07	4-16	SP	Gray Sand - damp, fine, few to medium to coarse gravel, loose (wet at 8', few shell fragments at 10', few fines at 13') CP_PR-09	4	462	Strong odor (PHC and non-PHC?)	Boring moved
					7.5	362		
DG-35	5/31/07	2.5-4	SP	Sand with Gravel - moist, fine to medium, fine to medium gravel, loose	2.5	51	Extensive, thick, sticky	
		4-14	SP	Dark Brown Sand - moist, fine to medium (7'-8' sand medium to coarse, little fine gravel; 8' sand fine, trace fine gravel				
					8	192	Moderate to extensive smearing/staining	
					9	434	Moderate to extensive smearing/staining	
DG-36	5/24/07	3.5-11	SP	Dark Brown Sand - moist, fine to medium, few fine gravel (at 8' becomes gray and wet)	3.5	137	Extensive, thick, sticky, brown	
					7	282	Extensive, dark brown	
					9.5	272	Scattered droplets, strong odor	Odor PHC and potentially non-PHC
		11-14.5	SP	Gray sand - wet, fine, trace fines, trace shell fragments				
DG-37	5/23/07	3-11	SP	Black Sand - moist fine to medium, few medium gravel (at 8.5' gravel decreases to trace)	3	78		
					4.5	228	Extensive, sticky	
					9	922	Odor only	
		11-16	SP	Gray Sand - wet, fine, trace fines, loose				
DG-38	5/24/07	4-5	GP	Broken rock, gravel and sand - moist, fine gravel, fine to medium sand	4.5	13		
		5-16	SP	Gray Sand - moist, fine, trace shell fragments,loose (wet at 8.5', at 12' fines increase to few	8	49		
DG-39	5/24/07	4-8	SP	Dark Brown Sand with Gravel - moist, fine to medium sand, fine to medium gravel	4.5	1	Light to moderate smearing	
		8-16	SP	Brown Sand - wet, fine, trace fine gravel, loose	8.5	102	Moderate droplets, smearing	
DG-40	5/25/07	4-8	SP	Dark Brown Sand - moist, fine, little black wood fragments	3.5	51		Boring moved, refusal at first attempted location,
		8-12		Black Sand - wet, fine, few fine gravel, loose	8	172	Extensive, dark smearing	bit bouncing on wood?
		12-18	GP	Gravel - wet, fine to medium, loose (limited recovery from 12' to 16')				
		16-18	SP	Gray Sand - wet, fine to medium sand, floose (limited recovery from 16' to 18')				
DG-41	5/22/07	2-5	SP	Dark Brown Sand - damp, fine, few fine gravel,	4	80	Sticky, stained	
		5-10	SP	Gray Sand with Gravel - moist, fine to medium sand, some fine gravel, loose (wet at 6.5')	6	367	Droplets	
					8	357	Strong hydrocarbon-like odor	
		10-14	SP	Gray Sand - wet, fine, trace fines, loose				
DG-42	5/22/07	2.5-3.5	SP	Brown Sand - damp, fine, loose	3	17	Scattered droplets, sticky, tar-like	Refusal
DG-42A	5/29/07	2-6.5	SP	Black Sand - moist, fine	4	82	Extensive, heavy, sticky smearing	Boring moved
					6	39	Extensive, heavy, sticky smearing	
DG-43	5/25/07	5-15	SP	Gray Sand - damp, fine, loose (wet at 9')	5	108	Slight staining, scattered droplets, odor	Refusal in first hole (5/23/07), thick concrete
					9	182	Scattered droplets, sheen	and poor recovery in second hole
DG-44	5/22/07	2-3	SP	Dark Brown Sand - damp, fine, loose	2.5	21	Stained	Refusal
DG-44A	5/31/07	4-13.5	SP	Brown Sand - damp, fine, few fines gravel, loose	4	18	Light smearing	Moved, needs resurveying
					8	177	Scattered droplets	
					10	694	Very strong solvent-like/creosote-like odor	
		13.5-16	GP	Gravel with Sand - wet, medium gravel, medium to coarse sand, loose				
DG-45	5/22/07	2.5-3.5	SP	Brown Sand - damp, fine, loose	3	69		Refusal
DG-45A	5/29/07	3-13	SP	Tan Sand - damp, fine, trace fine gravel (color becomes black at 6', wet at 8')	3	80	Slight smearing	Boring moved
					6	146	Moderate dark brown staining	
					8	88	Slight hydrocarbon-like odor	
		13-15	SP	Black Sand - wet, fine to coarse, few fine gravel				

Table 3
Soil Descriptions
Port of Seattle Terminal 91 Data Gaps Investigation
Seattle, Washington

Soil Boring Number	Date Drilled	Lithologic Interval (ft bgs)	USCS Soil Type	Soil Description	PID Measurements Depth	PID Measurements Reading	LNAPL Appearance (if LNAPL observed)	Additional Notes
DG-46	5/24/07	2-14	SP	Brown Sand with Gravel - moist, fine to medium sand, fine gravel (at 6.5' gravel decreases to trace)	3	28	Moderate staining	
					7.5	75	Moderate smearing	
DG-47	5/22/07							Refusal
DG-47A	5/31/07	2-6	GP	Brown Gravel with Sand - damp, medium gravel, medium sand, loose	2.5	17	Moderate smearing/staining	Boring moved
		6-14	SP	Gray Sand - moist, fine, trace fines, trace fine to medium gravel, loose (wet at 8'; at 11' fines increase to few)	7.5	110	Occasional droplets	
					9.5	294	Very strong solvent-like odor	
DG-48	5/22/07	2.5-3.5	SP	Brown Sand - damp, fine, loose	3	19		Refusal
DG-48A	5/31/07	4-9	SP	Dark Brown Sand - moist, fine to medium, few fine gravel, loose (at 7' gravel decrease to trace; wet at 8')	4	38.3	Moderate to extensive smearing	Boring moved
					7.5	79.3	Scattered droplets	
		9-16	SP	Dark Gray Sand - wet, fine, little shell fragments, trace fines (at 12' fines increase to few)	10	396	Very strong solvent-like odor	
DG-49	5/24/07	2-10		Brown Sand - moist, fine, trace fine gravel, loose	2.5	49	Extensive, sticky smearing	Poor recovery
				No Recovery				
		10-14	SP	Brown Sand with Gravel - wet, fine sand, some fine to medium gravel, loose				
DG-49A	5/31/07	2-10	SP	Brown Sand - moist, fine to medium, little fine gravel (wet at 8.5')	2	76	Moderate staining	Bonng moved
					7	1,125	Scattered droplets, strong solvent-like odor	
		9-14	SP	Gray sand - wet, fine sand, few fines, few shell fragments				
DG-50	5/23/07	1.5-8	SP	Black Sand with Gravel - moist, fine sand, some fine gravel, loose	2.5	80	Sticky, dark, smeared	Boring moved
					5.5	410	Sticky, dark, smeared	
					7	1,608	Heavy, smeared, stained	
		8-11	SP	Black Sand - wet, fine, trace fine gravel, loose				
		11-15	SP	Gray Sand - wet, fine, loose				
DG-51	5/23/07	2-4	SP	Brown Sand with Gravel - moist, fine to medium sand, some fine gravel	3	333	Heavy, sticky, stained	Boring moved
		4-6.5	FILL	Sand and Red Brick Fragments	6.5	3,036	Stained, non-PHC odor	
		6.5-13	SP	Gray Sand - wet, fine, trace gravel, trace shell fragments, loose				
DG-52	5/23/07	2-4	SP	Brown Sand with Gravel - moist, fine to medium, some medium gravel, loose	2.5	285	Heavy, sticky, stained	
		4-6	SP	Tan Sand - moist, fine to medium, little shell fragments, trace fine gravel				
		6-8	SP	Brown Sand - moist/wet, fine, trace fine gravel CP_PR-10	6.5	>9,999	Staining, PHC & non-PHC odors	
		8-13	SP	Gray Sand - wet, fine, trace shell fragments				
DG-53	5/24/07	2-6.5	GP	Gravel with Black Sand - moist/wet, medium gravel, fine to medium sand	2	20	Extensive, thick, sticky, dark	
		6.5-10	SP	Dark Brown Sand - wet, fine to medium, few fine gravel, trace shell gragments CP_PR-11	7.5	375	Extensive smearing	
		10-16	SP	Gray Sand - wet, fine, few fines, loose				
DG-54	5/23/07	2-4	SP	Black Sand with Gravel - moist, little fine medium gravel	3	30	Sticky, stained	Refusal
DG-54A	5/31/07							Refusal; moved, needs resurveying
DG-55	5/23/07	2-5	SP	Black Sand with Gravel - moist, fine, little medium gravel	3.5	29	Sticky, stained	Refusal at first attempted location, on wood?
DG-55A	5/31/07	2-3	GP	Brown Gravel with Sand - moist, medium gravel, fine to medium sand	2.5	30	Moderate, thick, sticky	Boring moved
		3-13	SP	Dark Brown Sand - moist, fine to medium, trace medium gravel, loose (fines increase to few at 11')	8	219	Light to moderate smearing, strong odor	Odor solvent-like
DG-56	5/23/07	2-6	SP	Brown Sand - moist, fine, few fine gravel	2.5	81	Sticky	
		6-14	SP	Gray Sand - wet, fine, trace fines, loose (some shell fragemnts at 11'; trace medium gravel 13'-14')	7	288	Droplets, solvent-like odor	
DG-57	5/24/07	3.5-5	SP	Gray Sand with Gravel - damp, fine sand, some fine to medium gravel, loose	4.5	32		
		5-12	SP	Gray Sand - moist, fine to medium, trace fine gravel, loose CP_PR-12	8	117	Scattered droplets	
		12-16	GP	Gravel with Sand - wet, fine to medium gravel, some fine to coarse sand				
DG-58	5/18/07	1-11	SP	Dark Gray Sand - damp, fine, loose (wet at 8', few fines at 9.5')	2	13		
					6	82	Sticky, heavy	
					10	350	Heavy	
		11-12	GP	Gravel with Black Sand - wet, fine gravel, fine to coarse sand, loose				
DG-59	5/22/07	2-7	SP	Tan Sand - damp fine, trace medium gravel, trace shell fragments, loose (wet at 6.5')	2	1		
					6	21		
		7-10.5	SP	Gray Sand - wet, fine to medium sand, trace medium gravel, trace fines, trace shell fragments	7.5	322		
					10	302	Sheen, scattered droplets	
		10.5-16	GP	Gray Gravel with Sand - wet, fine to coarse sand, fine gravel , very loose				

Table 3
Soil Descriptions
Port of Seattle Terminal 91 Data Gaps Investigation
Seattle, Washington

PES Environmental, Inc.

Soil Boring Number	Date Drilled	Lithologic Interval (ft bgs)	USCS Soil Type	Soil Description	PID Measurements Depth	PID Measurements Reading	LNAPL Appearance (if LNAPL observed)	Additional Notes
DG-60	5/29/07	2-8	SP	Brown Sand - damp, fine, loose	2.5	0		
					7	3		
		8-9	ML	Gray Silt - wet soft, low plasicity				
		9-10	SP	Gray Sand - wet, fine to medium, loose				
		10-12	GP	Gray Gravel with Sand - wet, fine to medium, medium to coarse sand, loose	11	10	Scattered droplets, sheen	
		12-18	SP	Gray Sand - wet, fine, few fines				
DG-61	5/23/07	1-2	SP	Dark Brown Sand with Gravel - damp, fine sand, medium gravel, loose				
		2-8.5	SP	Tan Sand - damp to wet (wet at 6.5'), fine trace fine gravel, few shell fragments (becomes gray at 7')	2	0		
					7	1,227	Scattered droplets	
		8.5-11.5	SP	Gray Sand - wet, fine to coarse, few fine to medium gravel	8.5	915	Moderate droplets	
		11.5-13	GP	Gravel with Sand - wet, fine to medium gravel, some fine to coarse sand				
DG-62	5/18/07	1-4	SP	Tan Sand with Gravel - damp, fine, fine gravel, loose	3	0		Boring moved
		4-11	SP	Dark Gray Sand - moist, fine, trace fine gravel, loose	5	182	Hydrocarbon-like odor	
		11-12	SP	Sand with Gravel - wet, fine to coarse sand, fine gravel, loose				
DG-63	5/18/07	1-10	SP	Tan Sand - damp, fine, trace shell fragments, loose	2	1		Boring moved
					6	282	Droplets	
		10-12	SP	Black Sand with Gravel - wet, fine to coarse sand, fine gravel, loose				
DG-64	5/18/07	1-16	SP	Black Sand - damp to wet (wet at 7'), fine to coarse (coarses with depth), few fine gravel	2	128		Boring moved
					5	127		
					10	200	Droplets	
DG-65	5/18/07	1-2	SP	Dark Brown Sand - damp, fine, loose	1	15		
		2-5	SP	Brown Sand with Gravel - damp, fine sand, fine gravel, loose				
		5-10	SP	Black Sand - moist to wet (wet at 7.5'), fine to medium, few fine gravel, loose	6	100	Hydrocarbon-like odor	
		10-13	SP	Black Sand with Gravel - wet, fine to coarse sand, fine gravel, loose				
		13-16	SP	Black Sand - wet, fine, loose				
AOC 11								
DG-66	5/22/07	1-3	SM	Brown Silty Sand - damp, fine, little non-plastic fines				Refusal in three separate borings
		3-4.5	SP	Tan Sand - damp, fine loose	3	0		
		4.5-6	SM	Brown Sitly Sand - damp, fine, little nonplastic fines, few fine gravel	5.5	1		
DG-66A	5/29/07	0.5-6	FILL	Tan Sand with gravel and broken rock	3	1		
		6-6.5	ML	Brown Sandy Silt - moist to wet, soft, low plascitiy, organic/wood fragments				
		6.5-14	SP	Gray Sand - wet, fine to medium, few fine gravel, few shell fragments	9	1		
DG-67	5/21/07	2-7	SP	Tan Sand - damp, fine, some medium gravel, loose	4	0		
		7-11.5	SP	Gray Sand - moist/wet (wet at 8'), fine to coarse, trace fine gravel, shell fragments, loose	9	0		
		11.5-13	ML	Gray Silt - moist, medium plasicity, soft				
DG-68	5/29/07	2-5	FILL	Sand, gravel, and broken rock	5	50	Moderate smearing	Boring moved
		5-10.5	SP	Brown Sand - moist, fine, trace fine gravel, trace shell fragments	8	43	Moderate smearing	
					9	90	Moderate to extensive smearing	
		10.5-16.5	SP	Gray Sand - wet, fine to coarse, trace fine gravel, loose				
DG-69	5/29/07	1-9.5	SP	Dark Brown Sand - damp, fine, few medium gravel, trace fines, loose	4	1	Scattered droplets	Boring moved
					5	52	Scattered droplets	
					9	91	Scattered droplets	
		9.5-16	SP	Gray Sand - wet, medium to coarse, trace medium gravel, loose				
DG-70	5/21/07	0.5-10	SP	Tan Sand - damp to wet (wet at 8'), fine, few fine gravel, few fines	4	0		
					9	0		
		10-11.5	ML	Gray Silt - moist/wet, medium plasicity, soft, trace fine sand, black wood fragments				
		11.5-14	SP	Gray Sand - wet, fine to medium, trace fine gravel, trace fines, loose				
DG-71	5/21/07	2-10	SM	Brown Silty Sand - damp to wet (wet at 10'), fine sand, few fines	3	0		
					5.5	5		
					9	0		
		10-12	SP	Gray Sand - wet, fine to coarse, little fine gravel, trace fines, loose				

Table 3
Soil Descriptions
Port of Seattle Terminal 91 Data Gaps Investigation
Seattle, Washington

Soil Boring Number	Date Drilled	Lithologic Interval (ft bgs)	USCS Soil Type	Soil Description	PID Measurements Depth	PID Measurements Reading	LNAPL Appearance (if LNAPL observed)	Additional Notes
DG-72	5/21/07	1-7	SP	Tan Sand - damp, fine to medium, some fine gravel, few shell fragments, loose	3.5	0		
		7-16	SP	Gray - wet, fine to medium, few fine gravel, shell fragments, loose	9.5	474		
DG-73	5/21/07	1-9	SP	Tan Sand - damp to wet (wet at 8'), fine, few fine gravel , trace fines, loose	3.5	0		
		9-16	SP	Gray Sand - wet, fine to medium, trace fine gravel	9.5	749		
DG-74	5/21/07	1-10	SP	Brown Sand - damp to wet (wet at 8.5'), fine to medium, few fine gravel, loose	2.5	0		
					6	0		
		10-12	SP	Sand with Gravel - wet, fine to coarse, some fine to medium gravel	10	107	Strong hydrocarbon-like odor	
DG-75	5/22/07	1.5-3	SM	Brown Silty Sand - damp, fine sand, little fines	4	0		
		3-9	SP	Tan Sand - damp, fine, loose	4	0		
		9-16	SP	Dark Gray Sand - wet, fine to medium, some fine to medium gravel, loose	9	141	Scattered droplets	
DG-76	5/21/07	2-12	SP	Gray Sand - damp to wet (wet at 7.5'), fine to medium, little fine to medium gravel, trace fines, loose (sand coarsens at 9')	3.5	0		
					8	0	Hydrocarbon-like odor	
DG-77	5/21/07	1.5-5	SP	Brown Silty Sand - damp, fine, little fines	3	0		
		5-7.5	SP	Tan Sand - moist, fine to medium sand, little fine gravel, little shell fragments (becomes gray at 6')	6	303	Hydrocarbon-like odor	
		7.5-9	SM	Gray Silty Sand - moist, fine sand, some low plasicity fines, little black organic fragments				
		9-12	GP	Gravel with Gray Sand - wet, fine to medium gravel, fine to coarse sand, loose	9	357	Sheen	
DG-78	5/21/07	2-8	SP	Brown Sand - damp, fine to medium, little fine to medium gravel, trace shell fragments	3	0		
					5	65		
		8-12	GP	Gravel with Gray Sand- wet, fine gravel, fine to coarse sand, loose	8	294	Droplets	
DG-79	5/21/07	2-9	SP	Tan Sand - damp, fine some fine to medium gravel, loose (color becomes gray at 6.5', wet at 8')	3.5	0		
					7.5	50		
		9-16	GP	Gravel with Gray Sand - wet, fine to medium gravel, fine to coarse sand,loose (no recovery 12'-16')	10	1,354	Hydrocarbon-like odor	
DG-80	5/21/07	2-5	SM	Brown Silty Sand - damp, fine sand, little fines, few fine gravel, loose	3.5	0		
		5-9	SP	Tan Sand - damp to wet (wet at 8'), fine sand, few fine gravel, trace fines, loose (becomes gray at 7.5')	7	3		
		9-12	SP	Gray Sand - wet, fine to coarse, little to some fine gravel, few shell fragments	9	601		
DG-81	5/21/07	2-12	SP	Brown Sand - damp to wet (wet at 8'), fine to medium, little fine gravel, trace fines, loose (becomes gray at 8', sand fine to coarse from 10')	3.5	0		
					7.5	159		
DG-82	5/21/07	1-4.5	SP	Tan Sand - damp, fine, few fine gravel, few fines, loose	4.5	25		
		4.5-12	SP	Dark Gray Sand - damp, fine to medium, trace fine gravel, few fines	9	248	Scattered droplets	
		12-16	GP	gravel with Gray Sand - wet, fine gravel, fine to to coarse sand, loose				
SWMU 30								
DG-83	5/18/07	0.5-8	SP	Brown Sand with Gravel - damp, fine sand, little medium gravel, loose	4	4		
		8-12	SP	Dark Gray Sand - moist/wet, fine, few fine gravel, trace shell fragments, loose (at 12' few shell framents, trace gravel; at 14' few fines)	8	409	Fine droplets	
DG-84	5/18/07	2-4	GP	Gravel with Sand - damp, fine to medium, fine to medium sand, loose	4	6		
		4-10	SP	Tan Sand with Gravel - damp, fine sand, some fine to medium gravel, loose	8	308		
		10-11	SP	Black Sand with Gravel - wet, fine to coarse, fine gravel, loose				
		11-16	SP	Black Sand - wet, fine, few shell fragments, trace fine gravel (no recvery 12'-16')				
DG-85	5/18/07	0.5-5.5	SP	Tan Sand - damp, fine, little medium gravel, loose	3	37		
		5.5-6	SM	Gray Silty Sand - moist, fine, liitle non-plastic fines				
		6-16	SP	Gray Sand - moist, fine to medium, few shell fragements, loose	8	3		
DG-86	5/18/07	0.5-4	FILL	Gravel, sand and broken rock				
		4-8	SP	Tan Sand with Gravel - damp, fine to medium,some fine gravel, loose	4	7		
		8-16	SP	Black Sand - moist/wet, fine to medium, few fine shell fragments, loose	8	527	Scattered droplets	
DG-87	5/18/07	0.5-2	GP	Gravel with Sand - damp, fine to medium, fine to medium sand, loose				
		2-5.5	SP	Tan Sand - damp, fine, some fine to medium gravel, loose	5	48		
		5.5-6	SM	Gray Silty Sand - wet, fine, some fines				
		6-16	SP	Black Sand with gravel - wet, fine, medium gravel	8	39		
DG-88	5/18/07	0.5-5	GP	Gravel - damp, fine to coarse, some fine to medium sand, loose				
		5-5.5	SM	Gray Silty Sand - moist, fine sand, little fines	5	57		
		6-12	GP	Gravel with Sand - moist, fine to coarse, fine sand	8	100		
		12-16	SP	Gray Sand - wet, fine to medium, few shell fragments, trace fines, loose				

Note: 1. Sampled depth in feet below existing grade.

CP_PR-13

CP_GP07R

TZF Consultant

Monitoring Well Construction & Boring Log

Well Number **GP- 07R** Sheet 1 of 1

Project Name: Port of Seattle - T-91 Tank Farm Upland Wells
Location: Pier 91 Seattle, Washington
Driller: Steve Collet with Cascade Drilling
Sampling Method: 4 " H.S.A. with 3" ID sampler.

Purpose: Replace former MW GP07
Logged by: T. Fitzgerald
Start Date: 0800H, September 19, 2008.
Completion Date: September 19, 2008

Depth feet	Well Construction	Sample Recovery	Blows / 6"	Geol. Graphic	Subsurface Description
1	POS traffic monument				New Asphalt to 6 inches.
2	Concrete seal				Recently emplaced compacted fill - sand with gravel, brown, dry (auger conveyance).
3	2" I.D. PVC riser pipe				
4	Bentonite chips				
5			5 5 6		(SP-GP) Gravelly SAND,Brwn (10YR5/1), ~50% medium to coarse sand, ~50% subrounded gravel to two inches,dense,damp, no odor (Fill).
6					
7					
8	#2/12 Lapis Lustre Well Sand from 4' - 20'				
9					▼
10			13 50/2		(SP/SM) Silty SAND with wood, dk. gray (10YRN5/2), 60% medium to coarse sand, 20% silt, very dense, wet, abundant wood debris (no odor no sheen).
11					
12					
13	10 - slot, 2" diameter pvc well screen 5' - 20'				
14					
15			27 31 32		SAA, poor recovery, Large wood fragment to ten inches, cut by sampler (former piling?).
16					*'Difficult auger drilling due to wood obstruction.'*
17					
18					
19					
20	4-inch threaded end cap		18 20 21		Sand w/gravel (SP) gray,~60% medium to fine sand ,~40% sub rounded gravel to two inches, wet, (poor recovery).

Constructed well depth 19.85ft (toc). Well development by Cascade Drilling.

Total auger depth ~ 20.5ft - bgs.

▼ Water level (ATD)

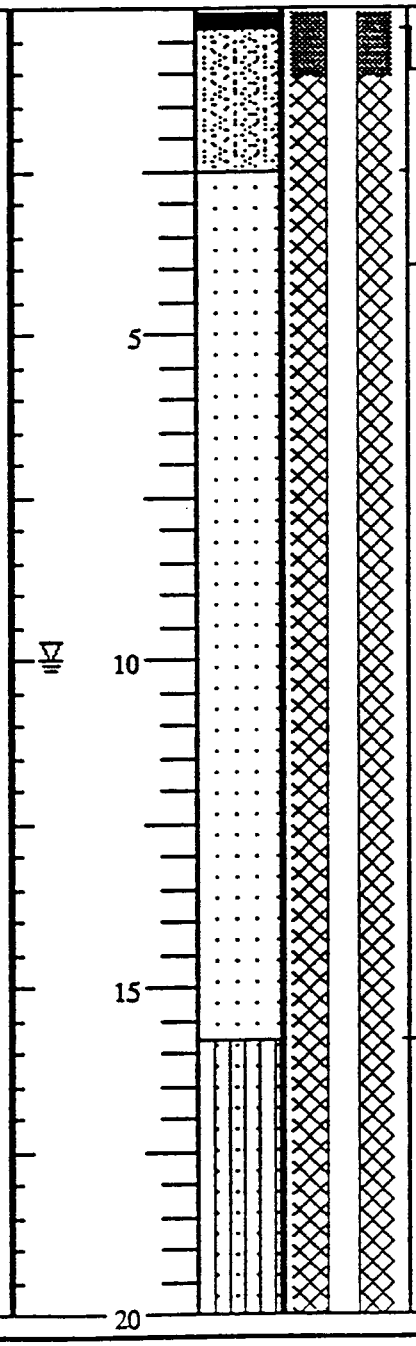
(%) - Percent proportions are field approximations.

FIGURE A-1

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	1 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION



0 - 0.25 foot: ASPHALT. (AS)

0.25 - 2.5 feet: GRAVELLY SAND; brown, fine to medium, 15% subround gravel to 1 inch in diameter. Trace to 5% shell fragments, 0-5% silt, compact, dry. (SW) (FILL)

2.5 - 15.8 feet: SAND; light olive brown to olive, fine to medium, 5-10% subround gravel to 1 inch in diameter, 0-5% shell debris, some banding. Saturated, petroleum odor below 5.5 feet. (SP)

— @ 8.0-9.0 feet: coarse sand layer with strong petroleum odor.

15.8 - 45.0 feet: SILTY SAND; olive, very fine to medium, 5-40% silt, 0-10% wood debris, organic decay - H2S odor. Saturated. Silt decreasing to 5% at 30.0 feet, wood and shell debris increase to 10%. Gravel increases to 20% at 35.0 feet, silt to 15% at 40.0 feet. (SM)

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	2 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
								15.8 - 45.0 feet: SILTY SAND; see previous page for Description.
1	3" SS	5-5-7		25				
2	3" SS	3-17-16		30				
3	3" SS	5-6-8		35				
				40				

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	3 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
4	3" SS	3-3-4						
5	3" SS	7-7-9		45				45.0 - 60.0 feet: SAND; olive, medium, 5-25% subround gravel to 1 1/2 inch in diameter, 3-10% shell debris, gravel increases in size and quantity with depth. (SP)
				50				
				55				
				60				

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors	BORING NO.	CP-108B
LOCATION	Pier 91	PAGE	4 OF 4
DRILLED BY	Tacoma Pump & Drill	REFERENCE ELEV.	4.84'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	62.00'
LOGGED BY	S. Nelson	DATE COMPLETED	1/20/89

SAMPLE NUMBER	SAMPLE TYPE	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
				65				Borehole terminated at 62.0 BGS on 1/20/89.
				70				ADDITIONAL REMARKS: 5) Reference elevation at top of PVC casing, City of Seattle datum. 6) Lithologic description for CP-108-A is the same as CP-108-B to depth of 21.5 feet. Samples were taken with a Dames & Moore sampler and 300 lb. jars.
				75				
				80				

REMARKS

1) Specific Location: Garfield. 2) H.S.Auger = Hollow Stem Auger. 3) SS = Split Spoon sample. 4) Water measurement at 10.0 feet BGS, at 14:00 on 1/26/89. See ADDITIONAL REMARKS at end of Description column.

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	CP-203B	1 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, 10" to 25', 4" to 61'	Date Start/Finish	6/10/2003-6/11/2003
Hammer Weight/Drop	140 lb / 30"	Hole Diameter (in)	10"

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Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
				Loose, moist, brown fine to medium SAND, shell fragments (SP)		1	
		S-1				1	▲
						1	
						4	
						3	
						4	
5		S-2		•Loose to medium dense, wet, trace gravel, wood	▼	9	
						4	
						3	▲
						4	
		S-3		•Gray, no gravel, strong petroleum-like odor and sheen		3	
						3	
						4	
						4	▲
						4	
						3	
10		S-4				3	
				Medium dense, wet, gray SAND to slightly silty SAND (SP-SM)		3	
						2	▲
						2	
		S-5				3	
						4	
						2	
						5	▲
						6	
				•Fine to coarse gravel lens 14' - 14.5'		7	
15		S-6		•Loose, trace organics, trace shell fragments		5	
						4	
						2	▲
						3	
		S-7				2	
						3	
						3	▲
				•Silt content decreasing		5	
						4	
						4	
20		S-8		•Trace silt, fine gravel lenses		5	
						6	▲
						4	
						6	
		S-9		Medium dense, wet, gray SANDY GRAVEL, trace silt, trace wood, trace shells (GP)		5	
						9	
						10	
						8	▲
						6	
						4	

Sampler Type (ST):
- ○ No Recovery
- ■ Shelby Tube
- ▨ 2" OD Split Spoon
- ▮ 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 2

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	CP-203B	2 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, 10" to 25', 4" to 61'	Date Start/Finish	6/10/2003-6/11/2003
Hammer Weight/Drop	140 lb / 30"	Hole Diameter (in)	10"

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Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-10		Medium dense, wet, gray GRAVELLY SAND, trace silt, trace wood, trace shell fragments (SP)		5, 6, 6, 5	
		S-11				5, 7, 9, 14, 15, 15	
30		S-12				6, 7, 11, 12	
				•Decreasing silt content			
		S-13		Very dense, wet, gray, black and white SAND, trace silt, silt interbeds, trace shell fragments (SP)		10, 25, 29, 28, 28, 27	50+
35		S-14		•Medium dense		7, 14, 14, 14	
		S-15		•Wood and shell fragments		7, 9, 15, 20, 20, 22	
				•Dense, gravelly, trace silt			
40		S-16				7, 14, 18, 20	
				•Dark gray, trace shell fragments			
		S-17				9, 8, 12, 15, 25, 29	
				•Very dense			
45		S-18		•Wood and shell interbeds, no gravel		6, 6, 27, 30	
		S-19				7, 14, 22, 20, 29, 35	
				•Peat interbeds			

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
Po - Porosity
SG - Specific Gravity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 2

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

Exploration Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Exploration Number	Sheet
980014	CP-203B	3 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, 10" to 25', 4" to 61'	Date Start/Finish	6/10/2003-6/11/2003
Hammer Weight/Drop	140 lb / 30"	Hole Diameter (in)	10"

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-20				12 18 25 29	▲
		S-21				18 42 50-4"	50+
55		S-22		•Medium sand, few gravel, peat/silt/shell interbeds		14 25 29 33	50+
		S-23		•Fine to medium sand		6 14 20 22 29 25	▲
60				Bottom of boring at 61 feet.			
65							
70							

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
Po - Porosity
SG - Specific Gravity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 2

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

Pacific Northern Geoscience

BORING NUMBER CP205-B SHEET 1 OF 2
PROJECT PIER 91 WELL REPLACEMENT
LOCATION Seattle, Washington
PROJECT NUMBER 95-33258-01
COORDINATES N 235,740.0 E 1,618,603.0
SURFACE ELEVATION 5.53 DATUM Seattle
LOGGED BY WVG

Depth Feet	Lab Sample	Samp. No.	Blow Counts	Rec. %	PID ppm	STRATA	DESCRIPTION	BOREHOLE/WELL CONSTRUCTION DETAIL	ELEVATION FEET
							asphalt	Flush Mount Mounument/Concrete Surface Seal	5
		1	14 16 17	100			SAND (sp); gray to green, fine- to very fine-grained, shell fragments; loose, damp, no odor	9" ID Mild Steel Casing Grouted in place with 10% Bentonite Cement Grout from 0-16.9' (85 Gallons Total)	
5		2	18 25 27	100			as above; trace gravel, saturated at 5.5'		0
		3	18 25 26	100			GRAVELLY SAND (swg); gray-black, medium- to coarse-grained, gravel to 3/4"; loose, wet, slight petroleum odor		
10		4	15 19 20	100			as above; gravel to 1"; wet, no odor		-5
		5	14 15 16	100			as above; slightly silty, gravel to 1/2"; wet, no odor		
15		6	12 14 16	100			as above; gray to black, fining down to very silty sand with gravel at 16'		-10
							SILTY SAND (sm); gray-black, very silty, trace gravel; firm, wet	Medium Bentonite Chips (11 bags)	
		7	12 14 16	100			SILTY SAND (sm); gray, medium- to very fine-grained, slightly to moderately silty; slightly firm, wet	2" ID Schedule 40 PVC Riser from 0-34.5'	
20		8	10 12 13	100			as above; abundant shell fragments; wet, no odor		-15
							GRAVELLY SAND (swg); gray-black, slightly silty; wet, no odor		
		9	25 30 33	100			SANDY GRAVEL (gw); gray to black, gravel to 3", sand fine to very coarse grained; loose, wet, no odor		
25		10	30 32 35	100			as above		-20
		11	18 20 23	100			SANDY SILT (ml); gray-green, moderately plastic; firm, moist to wet, no odor		
		12	18 30 35				SILTY SAND (sm); gray-green, wood fragments; firm, moist to wet		

DRILLING CONTRACTOR Cascade
DRILLING METHOD 10.25" & 4.25"ID HSA
SAMPLING EQUIPMENT Split Spoon
DRILLING STARTED 11/20/95 ENDED 11/21/95

REMARKS Drilling Sequence - Drilled to 26.5' w/ 4 1/4" HSA's. Opened hole to 16.5' w/ 10 1/4" HSA's. Grouted 9" casing at 16.5' and let set for 24 hours. Cleaned out casing and drilled to 44.5' w/ 4 1/4" HSA's

BIGWELL PNG 1/16/98

Pacific Northern Geoscience

BORING NUMBER **CP205-B** SHEET 2 OF 2

PROJECT **PIER 91 WELL REPLACEMENT**

LOCATION **Seattle, Washington**

PROJECT NUMBER **95-33258-01**

COORDINATES **N 235,740.0 E 1,618,603.0**

SURFACE ELEVATION **5.53** DATUM **Seattle** LOGGED BY **WVG**

SAMPLE INFORMATION						STRATA	DESCRIPTION	BOREHOLE/WELL CONSTRUCTION DETAIL	ELEVATION FEET
Depth Feet	Lab Sample	Samp. No.	Blow Counts	Rec. %	PID ppm				
		13	32	100			SILTY SAND (sm); gray, fine- to medium-grained, abundant wood fragments and shells; loose to slightly firm, wet, H2S odor		-25
			33						
		14	36	100					
			38					10/20 Colorado Sand (3.5 bags)	
			40				as above; thin silt-rich horizons; H2S odor		
		15	45	100					
			32						
			40				as above; fine- to very-fine grained; H2S odor		
		16	41	100					
35			40						-30
			42				as above		
		17	47	100					
			20						
			28				as above	2" ID .010" Slot PVC Screen from 34.5-44.5'	
		18	35	100					
			22						
			27				as above		
		19	33	100					
			18						
40			20				as above		-35
		20	20	100					
			22						
			21						
		21	21	100			as above; gray-green, fine grained, very silty; firm, wet, H2S odor		
			24						
			16				SILTY SAND (sm-ml); gray-green, very silty, with thin silt horizons to 1/2", wood fragments; firm (silt layers moderately plastic), moist to wet		
		22	18	100					
			24						
							EOB at 44.75 feet.	2" ID PVC Tail Pipe from 44.5-44.75'	

BIOWELL P... 1/15/98

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	GP-01B	1 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 22.5'	Date Start/Finish	8/25/2003-8/25/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 22.5'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
				3" Asphalt			
				Medium dense, moist, brown SAND with gravel, trace shell fragments, wood			
5							
		S-1		•Very loose, tan, shell and wood fragments		WOH-18"	▲
				Loose, wet, gray-brown silty SAND, trace gravel, shell and wood fragments			
10		S-2		Loose, moist, tan, fine to medium SAND, shell and wood fragments			
		TOC			▼		
		S-3		Loose, wet, gray, silty SAND, trace wood and shell fragments			
				•Bent Shelby tube, poor recovery			
15		S-4		Loose, wet, gray, fine to medium SAND, trace shell and wood fragments		4 2 1	▲
		S-5				1 1-12"	▲
20		S-6				2 1 1	▲
				•Brown, slightly sandy silt layer at 21.5'			
		S-7				2 2 5	▲

14" Hole to 22.5'; 9" hole 22.5'-56.5'; temporary 10" HSA conductor casing to 22.5' - retracted during seal emplacement

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 5

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	GP-01B	2 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 22.5'	Date Start/Finish	8/25/2003-8/25/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 22.5'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
	S-8		•Medium dense		5 4 7	▲
	S-9				4 6 8	▲
			•Sandy gravel interbed at 28.5'			
30	S-10		Very soft, wet, gray SILT, trace wood and shell fragments		7 OH-18"	▲
	S-11		•Gray-brown, sandy, trace shell fragments		4 1 1	▲
35	S-12				7 OH-18"	▲
	S-13				WOH 1 2	▲
40	S-14		•Olive gray, increasing organics		WOH 1 1	▲
	S-15		Loose, wet, olive gray to gray, silty SAND, trace shell fragments; sand fine to medium, predominantly medium, black and white sand grains		WOH 3 4	▲
45	S-16		Medium dense, wet, gray, gravelly SAND; sand fine to coarse, predominantly medium to coarse		4 11 13	▲
	S-17		Dense, wet, gray, sandy GRAVEL; sand fine to coarse, gravel fine		7 14 30	▲

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 5

TERMINAL 91 TERMINAL 91.GPJ March 17, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	GP-01B	3 of 3

Project Name: Terminal 91
Location: Seattle, WA;
Driller/Equipment: Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 22.5'
Hammer Weight/Drop: 140 lb (SPT) & 300 lb (D&M) / 30"

Ground Surface Elevation (ft):
Datum:
Date Start/Finish: 8/25/2003-8/25/2003
Hole Diameter (in): 14" to 22.5'/9" to bottom

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Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-18		•No recovery		40 44 47	50+
		S-19		•No recovery		49 50-5"	50+
55		S-20		•Very dense		44 47 50-5"	50+
				Bottom of boring at 56.5 feet.			
60							
65							
70							

M,D,SG
Po,P,TOC

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 5

TERMINAL 91 TERMINAL 91.GPJ March 17, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	MW-6B	1 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 25'	Date Start/Finish	8/26/2003-8/27/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 25'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
				3" Asphalt			
				ROAD FILL			
				Sandy GRAVEL with silt Medium dense, damp to moist, gray, gravelly, fine to medium SAND, trace shell fragments			
		S-1				10 6 6	▲
				Brown, silty, fine SAND			
5							
		S-2		Medium dense, damp, sandy GRAVEL, trace silt, trace shells; sand fine to medium		8 6 10	▲
		M,D,SG Po,P,TOC					
10		S-3		Loose, dark gray, wet, gravelly SAND , trace shell fragments; sand predominantly medium; diesel-like odor	▼	2 2 3	▲
		TOC					
		S-4		•Trace silt, trace organics, trace diesel-like odor, sand fine to medium		2 3 3	▲
15		S-5		•Medium dense, trace shells, diesel-like odor		7 8 9	▲
		S-6		Loose, dark gray, wet, fine to coarse SAND; shell fragments		4 4 5	▲
20		S-7		Medium dense, wet, gray, sandy GRAVEL; sand fine to medium		1 5 11	▲
		S-8		Medium dense, wet, gray, gravelly SAND; sand fine to coarse, predominantly medium to coarse; gravel fine		2 4 10	▲

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 4

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

Exploration Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Exploration Number	Sheet
980014	MW-6B	2 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 25'	Date Start/Finish	8/26/2003-8/27/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 25'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-9		Medium dense, wet, gray, sandy GRAVEL, trace silt; sand fine to coarse, predominantly medium to coarse		3, 6, 4	
				14" Hole to 25'; 9" hole 25'-59'; temporary 10" HSA conductor casing to 25' - retracted during seal emplacement			
		S-10		•Loose, increasing silt content		2, 3, 4	
30		S-11				4, 11, 16	
				Dense, wet, gray, slightly gravelly, fine to medium SAND			
		S-12		Dense, wet, gray, sandy GRAVEL; sand fine to coarse, predominantly medium		7, 18, 22	
35		S-13		•Light gray, trace silt, increasing gravel content with depth		12, 18, 19	
		S-14				9, 20, 23	
40		S-15		•Gray, increased silt content with depth, sand fine to coarse		8, 20, 12	
		S-16		Dense, wet, tan to gray, slightly silty SAND, trace gravel, trace shell fragments, trace organics; sand fine to medium		9, 12, 15	
				Brown-tan sandy gravel interbed 42.5'-43'			
45		S-17		Dense, wet, gray, gravelly SAND, trace silt, shell fragments; sand fine to medium, predominantly medium		15, 16, 18	
		S-18		Medium dense, wet, dark gray, sandy GRAVEL, shell fragments; sand fine to coarse, predominantly medium to coarse		6, 10, 18	

Sampler Type (ST):
- No Recovery
- 2" OD Split Spoon
- 3" OD Dames & Moore
- Shelby Tube

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 4

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Exploration Log

Project Number	Exploration Number	Sheet
980014	MW-6B	3 of 3

Project Name	Terminal 91	Ground Surface Elevation (ft)	
Location	Seattle, WA;	Datum	
Driller/Equipment	Holt Drilling/Hollow stem auger, temporary 10" HSA conductor casing to 25'	Date Start/Finish	8/26/2003-8/27/2003
Hammer Weight/Drop	140 lb (SPT) & 300 lb (D&M) / 30"	Hole Diameter (in)	14" to 25'/9" to bottom

This log is part of the report prepared by Aspect Consulting, LLC for the named project and should be read together only with that report for complete interpretation. This summary applies only to the location of this exploration and at the time of exploration. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Depth, ft	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Blows/6"	Blows/Foot (0 10 20 30 40)
		S-19 M,D,SG Po,P,TOC		•Very dense, gray, sand fine to medium		38 43 49	50+
		S-20 TOC		Very dense, wet, gray, fine to medium SAND; predominantly medium		12 28 50-5"	50+
55		S-21		•Dense		7 11 26	
		S-22		Medium dense, wet, grayish-brown, slightly silty SAND, trace organics, shell fragments; sand fine to medium, predominantly medium		7 12 15	
				Bottom of boring at 59 feet.			
60							
65							
70							

Sampler Type (ST):
- No Recovery
- Shelby Tube
- 2" OD Split Spoon
- 3" OD Dames & Moore

Lab tests:
TOC - Total Organic Carbon
P - Permeability
M - Moisture
D - Density
SG - Specific Gravity
Po - Porosity
DR - Drainage Rate

WOH = Weight Of Hammer

Logged by: RRH
Approved by: WVG
Figure No. A - 4

TERMINAL 91 TERMINAL 91.GPJ April 14, 2004

APPENDIX B

STANDARD OPERATING GUIDELINES

Standard Operating Guideline
Measuring Groundwater Levels

Introduction

This Standard Operating Guideline (SOG) describes the field procedure typically followed by site field representatives when measuring groundwater levels. Groundwater levels in wells will be measured prior to commencing developing, purging, sampling, and pumping tests.

Equipment

- Electronic water-level monitoring probe or other measuring device
- Decontamination supplies (e.g., buckets, Alconox, distilled water, squirt bottle)
- Field notebook
- Groundwater purge-and-sample form(s) if in conjunction with groundwater sampling
- Keys for locks (if necessary)
- Tools to open well covers (e.g., socket wrench, spanner wrench)
- Disposable gloves (as a minimum), and other protective clothing (as necessary).

Typical Procedure

1. If more than one well will be measured, begin depth measurement in the order in terms of lowest to highest chemical concentrations in the monitoring wells.

2. Remove well caps from all wells prior to initiation of water level measurement activities. This will allow wells to equilibrate, if necessary.

3. If the potential exists for floating product [light non-aqueous phase liquid (LNAPL)] to be present, use an electric oil-water interface probe or oil-sensitive paper to measure depth of the floating product and the electronic depth probe to measure the depth-to-water. Record both depths in field notebook and note the water depth as the "depth with oil layer present." Unless otherwise instructed, always measure depths to floating product layer and groundwater from the top of the northern side of the well casing.

4. When floating product is not present, measure depth-to-water using a pre-cleaned water-level probe from the top of the northern side of the well casing, unless otherwise instructed.

5. Repeat measurements a minimum of three times or have field partner confirm measurement.

6. Record time of day the measurement was taken using military time (e.g., 16:00).

7. Decontaminate water-level and/or oil-water interface probe and line prior to reuse (refer to the Equipment Decontamination SOG).

Standard Operating Guideline
Groundwater Sampling

Introduction

This Standard Operating Guideline (SOG) provides the procedures typically followed by site field representative's personnel during the collection of groundwater samples from monitoring wells. Groundwater sampling from temporary boreholes (e.g., grab groundwater samples collected from direct-push borings) is not addressed by this SOG. This SOG provides guidance on procedures that are generally consistent with standard practices used in environmental sampling. Federal, state and/or local regulatory agencies may require groundwater sampling procedures that differ from those described in this SOG and/or may require additional procedures. As guidance, this SOG does not constitute a specification of requirements for groundwater sampling. Deviations from, and additions to, the procedures described herein may be appropriate based on project-specific sampling objectives, site-specific conditions, and/or regulatory requirements. The user of this SOG should modify the sampling procedures used, as appropriate, to conform to the project-specific requirements and then document such deviations from this SOG in the project-specific documentation of groundwater sampling activities.

This SOG does not address quality assurance/quality control (QA/QC) procedures for groundwater sampling in detail. While some general QA/QC procedures are addressed, project-specific QA/QC procedures should be developed and presented in a quality assurance project plan (QAPP), field sampling and analysis work plan, or other project- or activity-specific document.

This SOG contains the following sections:

- Field Equipment/Material
- Typical Procedures for Monitoring Well Purging and Groundwater Sampling
- Stabilization Criteria for Adequacy of Monitoring Well Purging
- Typical Procedures for Groundwater Sampling Using Passive Diffusion Bags (PDBs)
- Quality Control Guidance
- Investigation-Derived Waste (IDW) Management
- References.

Field Equipment/Materials

Material/equipment typically required for the collection of groundwater samples from monitoring wells may include:

- Electric water-level monitoring probe
- Multi-phase interface monitoring probe

- Bladder pump, peristaltic pump, pre-cleaned, disposable, 2- or 4-inch bailers with disposable cord, inertial pump, submersible pump, passive diffusion bags, or other suitable apparatus for purging the well and sampling
- Flexible discharge tubing [polyethylene (PE), Teflon™, or similar]
- Purge water collection container
- Multi-parameter water quality meter (temperature, pH, specific conductance, redox potential)
- Turbidity meter
- Flow-through cell
- Nitrocellulose filters (if conducting field filtering)
- Sample containers (laboratory-supplied) with appropriate preservatives
- Additional chemical preservatives (if necessary)
- Watch or stopwatch
- Sample labels, pens, field logbook, or other appropriate field forms (e.g., groundwater purge and sample forms, chain-of-custody forms), and access agreements and third-party sample receipts (if warranted)
- Previous purging and sampling data for monitoring wells to be sampled, including water levels, purging parameters, and laboratory analysis results.
- Monitoring well boring and construction log (including wellhead elevation survey and reference point information)
- Personnel and equipment decontamination supplies
- Sample shipping and packaging supplies
- Personal protective equipment as specified in the Health and Safety Plan (HASP).

Typical Procedures for Monitoring Well Purging and Groundwater Sampling

1. **Pre-Purging Data Collection and Purging Equipment Placement.** Record the data and information collected during this procedure on a groundwater purge and sample form. Perform the following prior to groundwater sampling:
   a. Calibrate the multi-parameter water quality meter, prior to beginning sampling and as necessary based on field conditions, in accordance with the instructions in the manufacturer's operation manual. Note that it may be appropriate to keep a written log of the calibration procedures and instrument maintenance with the instrument.
   b. Examine the monitoring well to be sampled and associated protective surface enclosure for any structural damage, poorly fitting caps, and leaks into the inner casing. If notable conditions exist, they should be recorded on the sampling log for the well so that any necessary follow-up corrective actions can be planned and implemented.

c. Record an initial measurement of the depth to water. Calculate the volume of water in the well casing if wetted-casing-volume-based purging is to be used to remove the so-called "stagnant water" from the well prior to sampling. The volume of water in the wetted well casing should be calculated using the formula: $V = (\pi r^2) \times L$ where r is one half of the inner diameter of the well casing/screen and L is the length of wetted casing/screen (calculated by subtracting the depth to water from the total well depth). Total well depth should not be measured at the start of a sampling event (due to the potential to cause turbidity). Measure the total well depth after sample collection. Note that some regulatory agencies require that the calculated "stagnant water" volume include the water contained in the pores space of the wetted portion of the monitoring well filter pack in addition to the casing/screen. If this is a requirement, it should be defined in the project-specific sampling requirements.

d. If light non-aqueous phase liquid (LNAPL) is potentially present, measure the depth and thickness of the LNAPL and the static water level using a multiphase interface monitoring probe. Use one of the following devices for purging:

   (1) Bladder pump: Adjust the pump intake at a depth approximately equal to the middle or just slightly below the middle of the well screen interval or water column unless another position is justified based on site-specific conditions.

   (2) Peristaltic pump: Place the pump intake at a depth equal to the approximate middle or just slightly above the middle of the well screen interval or water column unless another position is justified based on site-specific conditions. Note: If degassing of water is occurring when sampling with a peristaltic pump, alternative types of sampling equipment should be used for volatile organic compound (VOC) or volatile petroleum hydrocarbon (VPH) sample collection.

   (3) Inertial pump: Place the pump intake at a depth approximate to the middle or just slightly below the middle of the well screen interval or water column unless another position is justified based on site-specific conditions. Note: Some studies suggest that the use of inertial pumps for purging and/or sampling may produce a low bias when collecting samples for VOC and VPH analyses. This should be considered along with regulatory requirements when selecting an inertial pump for purging and/or sampling.

   (4) Submersible pump: place the pump intake at a depth approximate to the middle or just slightly below the middle of the well screen interval unless another position is justified based on site-specific conditions.

   (5) Pre-cleaned or disposable bailers. Note: The use of bailers for low-flow purging/sampling is not appropriate.

   (6) Another suitable purging/sampling device may be selected for use depending upon project requirements.

2. **Monitoring Well Purging and Sampling.** When purging of a monitoring well prior to sampling is appropriate and/or required, purge the well using either (a) wetted-casing-volume-based purging or (b) low-flow purging as described in the following sections. If a well exhibits evidence of slow recharge or produces excessively silty water, etc., the well may need to be redeveloped.

a. Wetted-casing-volume-based purging.

(1) Establish a purging rate to pump or bail approximately three wetted-casing volumes of groundwater without dewatering the well.

(2) If using a pump, set-up the discharge tubing, flow-through cell, water quality meter, and purge water collection container. If turbidity is measured, collect the sample for turbidity measurement after groundwater passes through the flow-through cell in the vial provided with the turbidity meter. If using a bailer, maintain a clean plastic container next to the well for collecting observation samples. Begin purging the well.

(3) At the beginning of purging and periodically thereafter, record the following information and water quality parameters/observations on the groundwater purge and sample form. As guidance, field parameters may be measured after one purge volume is removed and every 1/2 purge volume thereafter.
- Date and time
- Purge volume and/or flow rate
- Water depth
- Temperature
- pH
- Specific conductance
- Dissolved oxygen
- Oxidation-reduction potential (ORP)
- Other observations as appropriate (turbidity, color, presence of odors, sheen, etc).

(4) Continue purging until water quality parameters have stabilized (refer to Stabilization Criteria for Adequacy of Monitoring Well Purging below) and/or a minimum of three wetted-casing volumes of water have been removed from the well. If a well purges dry, let it recover to 80 percent of original water column, then sample. If the well takes a very long time to recover (i.e., longer than 2 hours), try to sample the well at the end of day or first thing the next day.

(5) Collect the sample in pre-cleaned sample containers suitable for the laboratory analyses to be performed.

(6) If sampling using a bailer, use a bottom-emptying device or other technique to avoid sample agitation. If the collected water is very turbid, or a bottom-emptying bailer is not used, properly transfer the water from the bailer into the appropriate sample containers. Be careful to avoid agitating the sample. When sampling for VOCs, turn the bottle upside down after filling the container to identify possible headspace. If bubbles are present, top off the sample container or resample.

b. Low-flow purging and sampling.

(1) Place the pump intake at a depth equal to the approximate middle or just slightly above the middle of the well screen interval or water column or otherwise as dictated by well-specific soil stratigraphy and project-specific requirements. For example, it may be appropriate that the pump intake be set opposite to any preferential flow pathways (i.e., zones of higher permeability).

(2) Place an electronic water-level indicator probe in the well, approximately 0.5 to 3 inches below the piezometric surface. If available, a transducer of sufficient accuracy can also be used to measure depth to water when purging.

(3) Connect the pump discharge tube to a flow-through cell housing a water quality parameter probe.

(4) Activate the pump for purging at a flow rate ranging from approximately 0.1 to 0.5 liters per minute (L/min) or other flow rate as dictated by project-specific and/or site-specific requirements. (Note: Some regulatory agencies may require specific flow rates). Determine the flow rate by timing the rate at which the flow-through cell is filled.

(5) During purging, monitor the water level in the well to evaluate potential drawdown. The goal is to minimize drawdown to less than approximately 4 inches. If drawdown is observed (especially rapid drawdown at the beginning of purging), decrease the pumping rate.

(6) Measure water quality parameters at approximately 3- to 5-minute intervals during purging. Continue purging until water quality parameters have stabilized (refer to Stabilization Criteria for Adequacy of Monitoring Well Purging below).

(7) Immediately after purging, collect the sample in pre-cleaned sampled containers suitable for the laboratory analyses to be performed using the same flow rate that was used during purging unless it is necessary to decrease the rate to minimize aeration or turbulent filling of sample containers. If sampling for VOCs or VPH reduce the flow rate to 0.1 L/min or less.

3. **Sampling with LNAPL Present in a Monitoring Well.** Wells containing LNAPL are typically not sampled for dissolved phase constituents in groundwater due to the potential for entrainment of LNAPL in the aqueous sample matrix. If such sampling is required, and purging is not required, make sure the pump intake is placed in the upper 2 feet of water column and collect the samples without purging in a manner that reduces the potential for mixing of the groundwater sample with air or LNAPL. If groundwater sampling is required from wells containing LNAPL for the purposes of characterizing VOCs, and purging is required, purge the well prior to sampling unless or until LNAPL becomes entrained in the sampling apparatus. If LNAPL will likely become entrained in the groundwater, the sample should be collected without purging. If LNAPL becomes entrained in the sampling apparatus then the sampling effort for VOCs should be aborted.

4. **Field Filtering Groundwater Samples.** Groundwater sample filtering and/or preservation should be performed in accordance with the requirements of the analytical method being specified and any other project-specific requirements. For example, samples collected for dissolved metals are typically filtered using a 0.45 µm filter.

5. **Sample Collection Considerations.** When multiple analyses will be performed, collect the samples in order of decreasing sensitivity to volatilization (i.e., VOC samples first and metals last). When sampling for VOCs, turn the sample container upside down after filling to identify possible headspace. If bubbles are present, top off the sample bottle or resample (do not reuse bottles, especially if they have been pre-preserved by the vendor or laboratory). If possible, the pump should not be moved or turned off between purging and sampling; however, the pump may need to be turned off for a very brief period

(as a practical matter) so field personnel can handle samples and minimize the potential for water to splash on the ground surface. The ground surface should be protected from incidental splashing, especially if water from the well would be considered a hazardous waste for disposal purposes.

6. **Monitoring Wells with Slow Recharge.** If a well purges dry, let it recover to 80 percent of original water column, then sample. If the well takes a very long time to recover (i.e., longer than 2 hours), try to sample the well at the end of day or first thing the next day.
7. **Sample Container Filling and Shipping.** Fill the appropriate containers for the analyses to be requested and ensure that the required label information is completely and accurately filled in. Follow sampling packaging, shipping, and chain-of-custody procedures (see applicable SOG).
8. **Decontamination.** Follow personnel and equipment decontamination procedures (see applicable SOG).

Stabilization Criteria for Adequacy of Monitoring Well Purging

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EPA 2001) states that "with respect to groundwater chemistry, an adequate purge is achieved when pH, specific conductance, and temperature of groundwater have stabilized and the turbidity has either stabilized or is below 10 nephelometric turbidity units (NTUs). Wells should be considered stable when the criteria listed in the following table have been met for pH, specific conductance, temperature, and turbidity. Attempts should also be made to stabilize ORP and dissolved oxygen.

Field Parameters	Stabilization Criteria for Three or More Consecutive Readings	Notes
pH	Difference between three or more consecutive readings is within ±0.2 units	–
Temperature	Difference between three or more consecutive readings is constant	–
Specific Conductance	Difference between three or more consecutive readings is within ±3%	–
Turbidity	Difference between three or more consecutive readings is within ±10% or three consecutive readings below 10 NTUs	Generally, turbidity is the last parameter to stabilize. Attempts should be made to achieve stabilization; however, this may not be possible. It should be noted that natural turbidity in groundwater may exceed 10 NTUs. If turbidity is greater than 50 NTU, redevelopment of the well may be warranted.
ORP	Difference between three or more consecutive readings is within ±20mV	Very sensitive. Attempts should be made to achieve stabilization; however, due to parameter sensitivity this may not be possible.
Dissolved Oxygen	Difference between three or more consecutive readings is within ±10% or ±0.2 milligrams per liter (mg/L), whichever is greater	Very sensitive. Attempts should be made to achieve stabilization, especially when collecting samples of VOC analysis; however, due to parameter sensitivity this may not be possible.

Attempts should be made to achieve the stabilization criteria. Because of geochemical heterogeneities in the subsurface environment, stabilization of field parameters during purging may not always be achievable. If field parameter measurements do not indicate stabilization, continued conventional purging may be required until a minimum of three wetted-casing volumes have been removed. During low-flow purging of a well containing a large volume of casing water, it may be practical to discontinue low-flow purging and proceed with sampling if field parameters have not stabilized within a reasonable period. This judgment must be made on a site-specific/project-specific basis.

Typical Procedures for Groundwater Sampling Using Passive Diffusion Bags (PDBs)

Groundwater sampling using water-filled passive diffusion bag (PDB) samplers may be suitable for obtaining samples for VOC analysis. The suggested application of the method is for long-term monitoring of VOCs in groundwater wells at well characterized sites. (Note: The use of PDBs may not be suitable for the assessment of tertiary amyl methyl ether, methyl tert-butly ether, methyl-isobutyl ketone, styrene, and acetone). The effectiveness of the use of a single PDB sampler in a well is dependent on the assumption that there is horizontal flow through the well screen and that the quality of the water in the well screen is representative of the groundwater in the aquifer directly adjacent to the screen. If there are vertical components of intrabore-hole flow, multiple intervals of the formation contributing to flow, or varying concentrations of VOCs vertically within the screened or open interval, then a multiple deployment of PDB samplers within a well may be more appropriate for sampling the well.

Typically PDB samplers should not be used in wells having screened or open intervals longer than10 feet. If PDB samplers are to be used in wells with screened intervals of greater than 10 feet, then they are generally used in conjunction with borehole flow meters or other techniques to characterize vertical variability in hydraulic conductivity and contaminant distribution or used strictly for qualitative reconnaissance purposes. In larger well screens or in wells that may have vertical flow, the use of baffles should be considered.

Following are the procedures for deploying a PDB sampler.

1. **Acquire PDBs.** Obtain the pre-filled PDB samplers from the analytical laboratory. (The PDB samplers are prefilled at the laboratory with laboratory-grade deionized water. Unfilled PDB samplers can be obtained and filled in the field, but this is not recommended.)
2. **Deploy PDBs in Monitoring Wells.** To deploy the PDB sampler in the well:
    a. Measure the well depth and compare the measured depth with the reported depth to the bottom of the well screen from well-construction records. This is to check whether sediment has accumulated in the bottom of the well, whether there is a non-screened section of pipe (sediment sump) below the well screen, and the accuracy of well-construction records.

b. Attach the PDB sampler to a weighted line. (Sufficient weight should be added to counterbalance the buoyancy of the PDB sampler.) (Note: Stainless-steel or Teflon™-coated stainless-steel wire is preferable, but rope can be used if it is of sufficient strength, non-buoyant, and subject to minimal stretching. However, the rope should not be reused due to the potential for cross contamination.) Additionally, to prevent cross-contamination, the weighted lines should not be reused in different wells.

c. To prevent cross-contamination, the PDB samplers should not contact non-aqueous phase liquid (NAPL) during deployment or retrieval.

d. Calculate the distance from the bottom of the well, or top of the sediment in the well, up to the point where the PDB sampler is to be placed.

e. Attach the PDB sampler to the weight or weighted line at the target depth.

   1) For the field-fillable type of PDB sampler, the sampler is equipped with a hanger assembly and weight that can be slid over the sampler body until it rests securely near the bottom of the sampler.

   2) If using a coated stainless-steel wire as a weighted line, make loops at appropriate points to attach the upper and lower ends of PDB sampler.

   3) Where the PDB sampler position varies between sampling events, movable clamps with rings can be used.

   4) When using rope as a weighted line, tie knots or attach clasps at the appropriate depths. Nylon cable ties or stainless-steel clips inserted through the knots can be used to attach the PDB samplers.

f. Lower the weight and weighted line down the well until the weight rests on the bottom of the well and the line above the weight is taut. The PDB samplers should now be positioned at the expected depth. (The depth can be checked by placing a knot or mark on the line at the correct distance from the top knot/loop of the PDB sampler to the top of the well casing and checking to make sure that the mark aligns with the lip of the casing after deployment.)

g. Secure the assembly. (A suggested method is to attach the weighted line to a hook on the inside of the well cap.)

h. Reattach the well cap. The well should be sealed in such a way as to prevent surface-water in-flow into the well.

i. Allow the system to remain undisturbed until the PDB sampler equilibrates. Laboratory and field data suggest that a 2-week equilibration time is probably adequate for most applications. Note: In less permeable formations, longer equilibration times may be required.

3. **Recovering the PDBs.** Following the equilibration time, recover the PDB sampler from the monitoring well.

   a. Remove the PDB samplers from the well by using the attached line. The PDB samplers should not be exposed to heat or agitated.

b. Examine the surface of the PDB sampler for evidence of algae, iron, or other coatings and for tears in the membrane. Note the observations in a sampling field book. If there are tears in the membrane, the sample should be rejected. If there is evidence that the PDB sampler exhibits a coating, this should be noted in the report.

c. Detach and remove the PDB sampler from the weighted line. Remove the excess liquid from the exterior of the bag to minimize the potential for cross contamination.

4. **Sample Container Filling and Shipping.** Transfer the water from the PDB sampler to sample container. This is typically accomplished by carefully cutting a small hole in the bag and directing the flow into the sample container. Some commercially available PDB samplers provide a discharge device that can be inserted into the sampler. When transferring the sample to the sample container, minimize agitation. Ensure that the required label information is completely and accurately filled in. Follow sampling packaging, shipping, and chain-of-custody procedures (see applicable SOG).

5. **Decontamination.** Follow personnel and equipment decontamination procedures (see applicable SOG).

Quality Control Guidance

Follow the quality control requirements specified in the Quality Assurance Project Plan (QAPP), project-specific field sampling and analysis work plan, and/or project-specific regulatory requirements, as applicable. The following may be used as guidelines.

1. Approximately one duplicate sample should be obtained for each sampling event or for each batch of samples (a batch is typically defined as 20 samples). Collect duplicate samples immediately after the original samples are collected. Purging is not performed between original sample collection and collection of duplicate samples. Original and duplicate samples are collected sequentially, without appreciable delay between collection cycles. Duplicate samples are to be submitted to the laboratory blind (i.e., not identified as a duplicate sample).

2. Typically, at least one type of field blank sample (rinsate or transfer) should be collected per day of water sampling. All field blank samples are to be collected, preserved, labeled, and treated like any other sample. Field blank samples are to be sent blind to the laboratory (i.e., not identified as a field blank). Record in the field notebook the collection of any blank sample (rinsate, transfer, trip). The types of field blank samples are discussed below.

   a. Rinsate blank samples. If rinsate field blank samples are required, prepare the sample by pouring deionized water over, around, and through the various reusable sampling implements contacting a natural sample. Rinsate blanks need not be collected when dedicated sampling equipment is used for purging and sampling the well. Rinsate blank samples are to be analyzed for the same parameters as the environmental samples.

b. Transfer blank samples. Transfer blank samples are routinely prepared when no rinsate blank samples are collected. (The purpose of a transfer blank sample is to monitor for entrainment of contaminants into the sample from existing atmospheric conditions at the sampling location during the sample collection process.) A transfer blank sample is prepared by filling a sample container(s) with distilled or deionized water at a given sampling location. Transfer blank samples are to be analyzed for the same parameters as the environmental samples.

c. Trip blank samples. Trip blank samples are submitted for VOC analysis to monitor for possible sampling contamination during shipment as volatile organic samples are susceptible to contamination by diffusion of organic contaminants through the Teflon™-faced silicone rubber septum of the sample vial. Trip blank samples are prepared by the laboratory by filling VOA vials from organic-free water and shipped with field sample containers. Trip blank samples accompany the sample bottles through collection and shipment to the laboratory and are stored with the samples. It is suggested that a trip blank sample be included in each cooler of samples submitted for VOC analysis.

Investigation-Derived Waste (IDW) Management

Purge water is to be contained onsite in an appropriate labeled container for disposition by the client unless other project-specific procedures are defined. Other investigation-derived wastes, such as personal protective equipment, are to be properly handled and disposed. Preferably, personal protective equipment (PPE) IDW should also be containerized and left onsite for disposal by the client. As a matter of practice, any waste, or potential waste, generated onsite, should remain onsite. Refer to the IDW SOG.

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Standard Operating Guideline
Equipment Decontamination

Introduction

This Standard Operating Guideline (SOG) describes field procedures typically followed by site field representative's personnel during the decontamination of sampling and monitoring equipment. Proper decontamination procedures minimize the potential for cross-contamination among sampling points on a single site or between separate sites.

Equipment

- Two or three containers (e.g., 5-gallon buckets, or 5- or 10-gallon plastic tubs) for dip rinsing, washing, and collection of rinse water.
- Two or three utility brushes or test tube brushes for removal of visible contamination. A test tube brush (or similar) can be stapled to the end of a dowel and used to clean the inside of a bailer.
- Non-phosphate Alconox, Liquinox, or trisodiumphosphate (TSP) to be mixed with potable or distilled water.
- Rinse solutions, such as methyl alcohol (methanol), dilute nitric acid (0.1 molar), deionized or distilled water, and/or tap water. Deionized water is preferable to distilled water, because the deionization process typically results in greater removal of organic compounds.
- Multi-gallon storage containers filled with potable water to be used for rinsing or washing.
- Spray bottles, squirt bottles, or garden sprayers to apply rinse liquid. A separate bottle should be used for each liquid.
- Solvex or neoprene gloves that extend, as a minimum, halfway up the forearm. In cooler weather, it is advisable to use different resistant chemicals neoprene gloves that provide better insulation against cold temperatures.
- Paper towels to wipe off gross contamination.
- Garbage bags, or other plastic bags, and aluminum foil to wrap clean sampling equipment after decontamination, to store sampling equipment, and/or to dispose of decontamination debris.
- Sample bottles for rinsate blanks. For these blanks, Laboratory Type II (millipore) water should be used. Purified water from the selected analytical laboratory is recommended. This water is often filtered and boiled to remove impurities.
- Department of Transportation (DOT)-approved container (e.g., 55-gallon drum) to store contaminated wash and rinse water. Contained decontamination should be labeled appropriately.

Procedures

In most cases, the following procedures are adequate to remove contamination.

1. Pre-clean sampling equipment. If there is gross contamination on equipment, wipe it off with paper towels and/or rinse it off with water. Additional internal decontamination may be possible by circulation of water or cleaning solutions.
2. Wash all parts of equipment with detergent water and scrub with brushes. Take equipment apart when appropriate to remove visible contamination.
3. Rinse equipment by dipping in rinse solution, spraying, or pouring solution over it. Dip rinsing can introduce contaminants into solution. Spraying might not allow a thorough rinsing of the equipment, but it is a more efficient rinsing method because less rinse solution is used. Appropriate rinsing solutions are specified in the project sampling and analysis plan. Some typical solutions are indicated in the equipment section of this SOG.
   a. Methanol (used to remove organic compounds)
   b. Dilute acids (used to remove metals and other cations)
   c. Tap water
   d. Deionized/distilled water.
4. Rinse the sampler with generous amounts of deionized water. Pouring water over the sampler is best, although spraying or using a squirt bottle to apply rinse water might be adequate if you are trying to minimize waste.
5. Prepare rinsate blanks. To ensure proper decontamination, submit a rinsate blank for analysis. It is best to do this just before sampling. The blank should be analyzed for the same chemicals the samples are being checked for and for the chemical used to decontaminate equipment, if appropriate.

   To prepare a rinsate blank, pour millipore analyte-free water through or into the sampler. Collect the rinsate water in a clean bottle. Pour the collected rinsate water into the appropriate sample container(s). It is advisable to prepare one rinsate blank every day in the field. Use water specifically for blank preparation.
6. Wipe sampling equipment with a paper towel or allow it to air dry.
7. Place samplers in clean plastic bags or sealed containers, or wrap them in aluminum foil for storage in an undisturbed location that is free of contamination.

Investigation-Derived Residuals

For details of handling investigation-derived residuals refer to the project sampling and analysis plan.

Special Notes

- To reduce the potential for cross-contamination, samples should be collected so that the least contaminated stations areas are sampled first. Subsequent sampling should be completed in the order of increasing contamination. Areas that typically have lower levels of contamination include those upgradient of source, background areas, and the periphery of the contaminated area.

- Prepare rinsate blanks. To ensure proper decontamination, submit a rinsate blank for analysis. It is best to do this just before sampling. The blank should be analyzed for the same chemicals the samples are being checked for and for the chemical used to decontaminate equipment, if appropriate.
- To prepare a rinsate blank, pour analyte-free water through or into the sampler. Pour the collected rinsate water into the appropriate sample container(s). It is advisable to prepare one rinsate blank every day in the field. Use water specifically for blank preparation.
- Monitoring instruments that come into contact with sampled materials must be decontaminated, along with sampling devices. They should be washed, or at least rinsed, before monitoring other sampling sites.
- As determined from analysis of rinsate blanks, decontamination using soap and water is adequate in removing detectable quantities of contaminants. This type of decontamination has been compared to laboratory procedures for decontaminating sampling bottles. Using methanol as a rinse does help in cases of contamination with organic compounds.

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Data Quality Standard Operating Guidelines
Environmental Data Collection

Introduction

This Standard Operating Guideline (SOG) describes recommended procedures to be followed by site field representatives when collecting environmental data. The guideline is divided into pre-field procedures and field procedures for ease of use.

Pre-Field Procedures

The following procedures represent the minimal effort appropriate for most environmental data collection projects. Refer to project-specific plans for additional data collection procedures.

1. Review the work plan or sampling plan prior to initiating fieldwork, and discuss any questions with project manager or field leader.
2. Review the Health and Safety Plan.
3. Set up subcontract with analytical laboratory for type and quantity of analyses, documentation and delivery format, both hard copy and electronic data deliverables (EDDs) and turnaround time requirements. Establish contacts at the laboratory, field and home office (Project Manager or person responsible) for all communications.
4. Notify the analytical laboratory of the upcoming fieldwork and advise about the following:
    a. Number of samples per medium
    b. Analyses needed
    c. Dates of sample delivery, coordinate for Saturday pick-up if necessary
    d. Means of delivery (e.g., courier, FedEx)
    e. Turnaround time required
    f. Level of quality control (QC) reporting required
    g. Delivery format, for both hard copy and EDDs. (If EDDs will be uploaded into a database, refer to the Database Use Data Quality SOG.)
5. Order the sample containers from the laboratory. Determine whether field personnel will preserve the samples in the field or if pre-preserved sample containers will be provided. It is preferable to order containers with appropriate preservatives.
6. Arrange for delivery or pickup of sample containers.
7. Request the laboratory fax or email you chain-of-custody forms and laboratory receipt documents immediately after receiving the samples.

8. Check the chain-of-custody form to verify the correct samples were collected and correct analyses were requested. Double check the laboratory receipt documents to verify there are no typographical errors for samples.

   If changes are required, request change in writing, via email; do not request over the phone. Request the laboratory include all change request documentation in the laboratory summary report.

Field Procedures

1. At the beginning of each field day, identify planned work and document field conditions in the field notes.
2. Hold tailgate safety meeting and have all present sign the form.
3. Complete sample identification labels for each sampling container using an indelible pen. Use the sample identification protocol described in the work plan or sampling plan. It is recommended that pre-printed labels be created at the office prior to going to the field site, if possible.
4. Complete the chain-of-custody form, accounting for each sample. Verify that sample identifications, sampling times, and requested analyses on the chain-of-custody form match the sample identifications, sampling times, and requested analyses on the sample labels.
5. Verify that the appropriate QC samples (field duplicate samples, trip blanks samples, etc.) required in the work plan or sampling plan were collected. If applicable, document blind duplicate parents in field notes, and if using a database, supply a summary table of the parent and duplicate samples to your database coordinator.
6. Verify, where applicable, that the appropriate sample volume was collected to enable the analytical laboratory to perform QC analyses (e.g., matrix spike and matrix spike duplicate analysis). (For example, if a water sample is being analyzed for polynuclear aromatic hydrocarbons, 1 liter of sample is required for the analysis, and another 2 liters are required for the matrix spike and matrix spike duplicate analyses.)
7. Collect, preserve, and transport samples to the analytical laboratory in accordance with the work plan or sampling plan.
8. Provide adequate ice in coolers, so the coolers arrive at the laboratory at a temperature of 4 degrees Celsius (C) ± 2 degrees C.
9. Keep in contact with the project manager or other team member to report any problems, unusual observations, etc.
10. Verify samples were received by the analytical laboratory and the laboratory understands the chain-of-custody and requested analyses prior to beginning analyses.
11. If samples are sent by overnight delivery, be sure to include the tracking number and time released to the delivery service on the chain-of-custody form.

Standard Operating Guideline
Sample Packaging and Shipping

Introduction

This Standard Operating Guideline (SOG) presents methods for shipping non-hazardous materials, including most environmental samples via United Parcel Service (UPS), Federal Express, and Greyhound. Many local laboratories offer courier service as well.

Equipment

- Coolers or ice chests
- Sorbent material
- Bubble-wrap
- Strapping tape
- Labels and pens
- Chain-of-Custody forms
- Chain-of-Custody seals
- UPS, Federal Express, or Greyhound manifests.

Samples shipped to each analytical laboratory can be sent by UPS or Federal Express on a next-day basis unless other arrangements are made. Greyhound bus service should only be used if there is direct service (e.g., Sacramento or Bakersfield to San Francisco). Ice chests, used to refrigerate perishable items, can be used to convey non-hazardous samples to the analytical laboratory.

Absorbent pads should be placed in the bottom of the shipping container to absorb liquids in the event of sample container breakage. Transportation regulations require absorbent capacity of the material to equal the amount of liquid being shipped; each pad absorbs approximately 1 quart of liquid. Liquid samples in glass jars or bottles should also be wrapped in plastic bubble wrap. A small amount of air space is desirable in filled plastic containers. This often prevents the cap of the container from coming off should the container undergo compression. Volatile organics analysis (VOA) vials should be packed in sponge holders. Additionally, exposure of filled VOA vials to other types of sample containers, by placement in the same shipping container, is not recommended. Various non-VOA sample containers are solvent-rinsed, which may contaminate the VOA vials before or after sample collection. Therefore, a separate shipping container for VOA vials is recommended. An equal weight of ice substitute should be used to keep the samples below 4 degrees Celsius (C) for the duration of the shipment (up to 48 hours). Care in choosing a method of sample chilling should be observed so that the collected samples are not physically or chemically damaged. Re-usable blue ice blocks, block ice, ice cubes, or dry-ice are suitable for keeping samples chilled. Labels of samples may get wet. Use of waterproof pens and labels is desirable for identification of sample containers. Use of clear tape to cover each affixed sample label is helpful in ensuring sample identification. Strong adhesive tape should be used to band the coolers closed. Additionally, it is recommended that the drain plug be covered with adhesive tape to prevent any liquid from escaping.

Specific requirements for packaging materials may apply if the samples being shipped are known to be hazardous materials as defined in 49 CFR 171.8 (samples are not considered hazardous waste and, therefore, manifest requirements do not apply). UPS holds shippers responsible for damage occurring in the event of accidents when a hazardous material is shipped as a non-hazardous material. Samples that obviously are hazardous materials should, therefore, be shipped as such, and samples that most likely are not hazardous materials should be shipped in coolers. Guidelines for shipping hazardous materials by UPS are provided in the *Guide for Shipping Hazardous Materials* available from UPS. Specific labels for shipping of hazardous materials are available.

Chain-of-custody documentation should accompany shipments of samples to the analytical laboratory. Often, the chain-of-custody document contains an analytical request section that may be completed following sample collection. Chronological listing of collected samples is desirable. A copy of the completed chain-of-custody form should be retained in the event that the original form is lost or destroyed.

It should be noted that samples retained by the analytical laboratory, which are not chosen for analysis, may be assessed a fee for disposal. Often a disposal fee is assigned to a sample, typically soil, that has been retained beyond standard analytical holding periods. Therefore, consultation with project management is recommended to determine which samples may be of interest. Contacting the selected analytical laboratory regarding disposal policies is also recommended. Arrangements may be made with the analytical laboratory for return of the unanalyzed samples for later disposal to the area of origin.

Standard Operating Guideline
Well Construction and Development

Introduction

This Standard Operating Guideline (SOG) describes procedures used by the onsite field Consultants personnel for well construction and development following completion of boring and soil sampling procedures (described in Standard Operating Guideline, Boring, and Subsurface Soil Sampling).

Well Construction Materials

- 2-inch or 4-inch Schedule 40 PVC blank casing
- 2-inch or 4-inch Schedule 40 PVC slotted casing, of appropriate slot size
- 2-inch or 4-inch Schedule 40 PVC threaded and slip caps
- 2-inch or 4-inch Schedule 40 stainless steel blank casing
- 2-inch or 4-inch Schedule 40 stainless steel wire wrapped casing, of appropriate slot size
- 2-inch or 4-inch stainless steel threaded and slip caps
- Stainless steel well centralizers
- 12-inch x 0.25-inch mild steel isolation casing with welded centralizers
- Hasp-locking standpipes
- Ground-level traffic-rated watertight well housing enclosure
- Locking expansion plugs
- Combination or key lock
- Filter pack sand (refer to Standard Operating Guideline, Design of Filter Packs and Selection of Well Screens for Monitoring Wells)
- Type I or II Portland cement
- Concrete
- Bentonite powder
- 0.25-inch bentonite pellets or chips.

Well Development Equipment

- 2-inch or 4-inch-diameter vented surge block
- 1-inch dedicated PVC hose for monitoring well development and purging
- Centrifugal surface pump
- Submersible pump (4-inch-diameter wells or larger)
- 55-gallon DOT-approved drums

- Teflon, stainless steel or PVC bailer
- Teflon-coated bailer retrieval wire
- Airlift pump with foot valve and compressor
- Bladder pump (2-inch diameter wells only)

Typical Procedure

1. Following completion of selected borings, install the monitoring well casing through the center of the hollow stem auger, drive casing, or open boring. The monitoring well consists of a PVC Schedule 40 slotted well casing of appropriate diameter and a blank casing with a threaded bottom cap and a slip or threaded top cap or watertight expansion plug. The casing string must be held in tension during initial installation.
2. Place clean, well graded sand around the slotted section of the monitoring well to serve as the filter pack. The grade of sand is chosen on the basis of aquifer units encountered (refer to Standard Operating Guideline, Design of Filter Packs and Selection of Well Screens for Monitoring Wells). The filter pack is emplaced as the auger or temporary casing is removed from the boring.
3. Ensure that filter pack sand for the well extends to approximately 3 feet above the top of the screened interval.
4. If required in the well construction permit, notify the appropriate inspector prior to placing the well seal.
5. Place a 2- to 3-foot-thick bentonite pellet seal above the sand pack, as the auger and/or casing is removed from the boring. If the seal is placed above the water table, the bentonite pellets must be hydrated with potable water prior to placement of the annular seal.
6. Fill the remainder of the annulus between the well casing and the borehole wall with cement/bentonite grout (with approximately 5 percent bentonite), or a high-solids bentonite slurry (11 to 13 pounds per gallon), to a depth of approximately 1 foot below ground surface. If the water level is higher than the seal, use a tremie pipe to place the grout.
7. Install either a threaded cap or a locking watertight expansion plug on the monitoring well. Place a steel hasp-locking well housing over the top of the well and cement it into the annulus of the boring.
8. Place a traffic-rated precast concrete or steel well enclosure approximately 1 to 2 inches above grade, and cement it into place with concrete. Have a concrete apron constructed around the well housing enclosure to facilitate runoff.
9. For aboveground completion, ensure that the well casing extends approximately 3 feet above ground surface. An 8-inch-diameter hasp-locking steel well housing surrounds the well casing. Traffic bollards can be installed around the well housing as necessary.
10. Repeat Steps 1 through 9 for all monitoring wells at site.
11. Following the curing of the grout (approximately 24 hours), each monitoring well is developed. Prior to development activities, measure the depth in each well to static water level and total casing depth.

12. Also prior to well development, if applicable, check the water interface of each monitoring well for the presence of floating product (NAPL). Use a clear bailer or color indicator paste for the inspection.
13. If a monitoring well has a water level of less than 25 feet, it may be developed by using a centrifugal surface pump with dedicated 1-inch I.D. clear flex suction hose, placed with the hose intake placed temporarily at all levels of the screened interval. If the well is greater than 25 feet deep, a submersible pump or airlift pump with air filter is used for development. In either case, a surge block of appropriate size can be moved up and down inside the screened section of the well casing to create a surging action that hydraulically stresses the filter pack.
14. During development of each well, ensure that field parameters and observations are recorded on a Kennedy/Jenks Consultants purge and sample form (attached). Information to be recorded includes, but is not limited to, the following items:
    a. Depth to water
    b. Development time and volume
    c. Development (flow) rate
    d. pH, temperature, specific conductivity, and turbidity
    e. Other observations, as appropriate (e.g., color, presence of odors, or sheen).
15. Develop each monitoring well until water of relatively low turbidity is removed from the casing.
16. When development of each well is discontinued, record the following field parameters/observations:
    a. Depth to water
    b. Temperature
    c. pH
    d. Specific conductance
    e. Turbidity
    f. Color

Investigation-Derived Wastes

Place groundwater produced by well development in appropriately labeled containers for disposition by the client.

Groundwater Purge and Sample Form Date: _____

PROJECT NAME: _____ WELL NUMBER: _____

PROJECT NUMBER: _____ PERSONNEL: _____

STATIC WATER LEVEL (FT): _____ MEASURING POINT DESCRIPTION: _____

WATER LEVEL MEASUREMENT METHOD: _____ PURGE METHOD: _____

TIME START PURGE: _____ PURGE DEPTH (FT) _____

TIME END PURGE: _____ _____

TIME SAMPLED: _____

COMMENTS: _____

WELL VOLUME CALCULATION (FILL IN BEFORE PURGING)	TOTAL DEPTH (FT)	-	DEPTH TO WATER (FT)	=	WATER COLUMN (FT)	X	MULTIPLIER FOR CASING DIAMETER (IN)			=	CASING VOLUME (GAL)
							2	4	6		
							0.16	0.64	1.44		

TIME							
VOLUME PURGED (GAL)							
PURGE RATE (GPM)							
TEMPERATURE (°C)							
pH							
SPECIFIC CONDUCTIVITY (micromhos/cm) (uncorrected)							
DISSOLVED OXYGEN (mg/L)							
eH(MV)Pt-AgCl ref.							
TURBIDITY/COLOR							
ODOR							
DEPTH OF PURGE INTAKE (FT)							
DEPTH TO WATER DURING PURGE (FT)							
NUMBER OF CASING VOLUMES REMOVED							
DEWATERED?							

Groundwater Purge and Sample Form

Date: _____

PROJECT NAME: _____ WELL NUMBER: _____

PROJECT NUMBER: _____ PERSONNEL: _____

SAMPLE DATA:

TIME SAMPLED: _____ COMMENTS: _____

DEPTH SAMPLED (FT): _____ _____

SAMPLING EQUIPMENT: _____ _____

SAMPLE NO.	NO. OF CONTAIN-ERS	CON-TAINER TYPE	PRESER-VATIVE	FIELD FILTRA-TION	VOLUME FILLED (ml or L)	TURBIDITY	COLOR	SHIPPED UNDER CHAIN-OF-CUS-TODY AT 4°C?	ANALYSIS REQUEST (METHOD)	COMMENTS

PURGE WATER DISPOSAL NOTES:

TOTAL DISCHARGE (GAL): _____ COMMENTS: _____

DISPOSAL METHOD: _____ _____

DRUM DESIGNATION(S)/VOLUME PER (GAL): _____

WELL HEAD CONDITIONS CHECKLIST (CIRCLE YES OR NO - IF NO, ADD COMMENTS):

WELL SECURITY DEVICES OK (BOLLARDS, CHRISTY LID, CASING LID AND LOCK)?: YES NO

INSIDE OF WELL HEAD AND OUTER CASING DRY?: YES NO

WELL CASING OK?: YES NO

COMMENTS: _____

_____

GENERAL:

WEATHER CONDITIONS: _____

TEMPERATURE (SPECIFY °C OR °F): _____

PROBLEMS ENCOUNTERED DURING PURGING OR SAMPLING? _____

_____

_____

cc: Project Manager: _____
Job File: _____
Other: _____

Standard Operating Guideline
Handling and Disposal of Investigation-Derived Waste

Introduction

Environmental site investigations usually result in generation of some regulated waste, particularly if the project involves drilling and construction of monitoring wells. Any potentially hazardous or dangerous material that is generated during a site investigation must be handled and disposed of in accordance with applicable regulations. This guideline provides a procedure to be used for dealing with investigation-derived wastes that have the potential of being classified as hazardous or dangerous, including soil cuttings, well development water, and decontamination water.

Equipment

- DOT-approved packaging (typically DOT 17E or 17H drums)
- Funnel
- Bushing wrench
- 15/16-inch socket wrench
- Shovel
- Appropriate markers (spray paint, paint pen)
- Plastic sheeting
- Drip pans
- Pallets.

Typical Procedures

Preparing Containers

1. Place each container on a pallet if it is to be moved with a fork lift after it is full.
2. Place plastic sheeting under containers for soil and drip pans under containers used to hold water.
3. Ensure that packaging materials are compatible with the wastes to be stored in them. Bung-type drums should be used to contain liquids. If a liquid is corrosive, a plastic or polymer drum should be used.
4. Solids should be placed in open-top drums. Liners are placed in the drums if the solid material is corrosive or contains free liquids. Gaskets are also used on open-top drums.

Storing Wastes

1. As waste materials are generated, place them directly into storage containers.
2. Do not fill storage drums completely. Provide sufficient outage so that the containers will not be overfull if their contents expand.
3. After filling a storage drum, seal it securely, using a bung wrench or socket wrench, for a bung-type or open-top drum, respectively.
4. Label drums or other packages containing hazardous or dangerous materials and mark them for storage or shipment. To comply with marking and labeling requirements, affix a properly filled out yellow hazardous waste marker and a DOT hazard class label to each waste container. Do not mark drums with on-site field representatives name. All waste belongs to the client. Mark accumulation start date.
5. During an ongoing investigation, use a paint marker to mark the contents, station number, date, and quantity of material on each drum or other container. Do not mix investigation-derived wastes with one another or with other materials. Do not place items such as Tyvek, gloves, equipment, or trash into drums containing soils or liquids, and do not mix water and soil. Disposable protective clothing, trash, soil, and water materials should be disposed of in separate containers.
6. Upon completion of field work, or the portion of the project that generates wastes, notify the client as to the location, number, contents, and waste type of waste containers. Remind the client of the obligation to dispose of wastes in a timely manner and in accordance with applicable regulations.

Regulations

49 CFR 100-177, *Federal Transportation of Hazardous Materials Regulations.*

EPA Region X, Technical Assistance Team. 1984. *Manual for Sampling, Packaging, and Shipping Hazardous Materials*. Seattle, WA: EPA.

APPENDIX C

FIELD FORMS

PES Environmental, Inc.
Engineering & Environmental Services

PAGE OF	
DATE:	
PROJECT:	
JOB No:	
PROJECT MANAGER:	
RECORDED BY:	

DAILY FIELD REPORT

TIME	DESCRIPTION, COMMENTS, NOTES, ETC.

ATTACHMENTS: ☐ NO ☐ YES

DESCRIPTION: SIGNATURE

PES Environmental, Inc.
Engineering & Environmental Services

PAGE OF

DATE:

FREE PRODUCT FORM

PROJECT:

JOB No:

FIELD PERSONNEL:

RECORDED BY:

MEASURING INSTRUMENT:

☐ STEEL TAPE/BAR WITH PASTE ☐ ELECTRIC INTERFACE PROBE

☐ OTHER-TYPE: _____

INSTRUMENT SERIAL No. _____

DATUM: ☐ MEAN SEA LEVEL _____

☐ OTHER - DESCRIBE _____

PRODUCT THICKNESS MEASUREMENT

WELL I.D.	TIME	REFERENCE ELEVATION (Feet)	DEPTH TO PRODUCT (Feet)			DEPTH TO WATER (Feet)			ELEVATION FOR TOP OF PRODUCT (feet)	PRODUCT THICKNESS (feet)
			1st	2nd	3rd	1st	2nd	3rd		

PRODUCT SAMPLING

SAMPLING METHOD: _____

☐ BAILER - TYPE: _____ ☐ GRAB - TYPE: _____

☐ OTHER - TYPE: _____

SAMPLE DISTRIBUTION: SAMPLE SERIES: _____

SAMPLE NO.	VOLUME/CONT.	ANALYSIS REQUESTED	PRESERVATIVES	LABORATORY	COMMENTS

PES Environmental, Inc.
Engineering & Environmental Services

PAGE OF
DATE:

WATER LEVEL DATA FORM

PROJECT:	
JOB No:	
FIELD PERSONNEL:	
RECORDED BY:	

MEASURING INSTRUMENT:

☐ STEEL TAPE ☐ OTHER-TYPE ____________

☐ ELECTRONIC SOUNDER SERIAL No.

DATUM: ☐ MEAN SEA LEVEL ☐ OTHER - DESCRIBE

WELL I.D.	TIME	REFERENCE ELEVATION (Feet)	DEPTH TO WATER (Feet)			WATER LEVEL ELEVATION (Feet)	COMMENTS (well condition, odor, presence of product, etc.)
			1st	2nd	3rd		

PES Environmental, Inc.

Engineering & Environmental Services

Page:	of
Date/Time:	
Project Name:	
Job No:	
Recorded By:	
Sampled By:	

GROUNDWATER SAMPLING FORM

Well Type:	☐ Monitoring	☐ Extraction	☐ Other		Well No:
Well Material:	☐ PVC	☐ Stainless Steel	☐ Other		

WELL PURGING

PURGE VOLUME

Casing Diameter (D in inches)

☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other _____

Total Depth of Casing (TD in feet below top of casing): _____

Water-Level Depth (WL in feet below top of casing): _____

Pump rate: approximately _____ mL/minute

PURGING METHOD

☐ Bailer - type: _____

☐ Submersible ☐ Centrifugal ☐ Bladder

☐ Peristaltic - Type: _____

PUMP INTAKE SETTING

☐ Bottom ☐ Top ☐ Middle: _____

Depth in feet (BTOC): _____

Screen interval feet (BTOC) from _____ to _____

FIELD PARAMETER MEASUREMENTS

START TIME: _____ STOP TIME: _____ TOTAL GALLONS REMOVED: _____

Time	Gallons Removed	pH	Conductivity (µmhos/cm)	Temperature (ºC)	DTW (feet bgs)	ORP (mV)	DO (mg/L)	Observations (color, well condition, odor, cloudiness, etc.)

Notes:

WELL SAMPLING

☐ Bailer ☐ Peristalic

Sample No.	Time	Volume	Analyses	Bottle Type	Preservative

QUALITY CONTROL SAMPLES

Duplicate Sample No.	Time	Volume	Analyses	Bottle Type	Preservative
Field Blank Sample No.	**Time**	**Volume**	**Analyses**	**Bottle Type**	**Preservative**

PES ENVIRONMENTAL
DAILY SAFETY MEETING CHECKLIST

Project Name: _____ Date: _____

Project Number: _____ Presented by: _____

Check the Topics/Information Reviewed:

- ☐ Safety glasses, hard hat, safety boots
- ☐ Site safety plan review and location
- ☐ Equipment and machinery familiarization
- ☐ Employee right-to-know/MSDS location
- ☐ Open pits, excavations, and site hazards
- ☐ Vehicle safety and driving/road conditions
- ☐ Portable tool safety and awareness
- ☐ Overhead utility locations and clearance
- ☐ First aid, safety, and PPE location
- ☐ Sharp object, rebar, and scrap metal hazards
- ☐ Safety is everyone's responsibility
- ☐ Latex gloves inner/nitrile gloves outer
- ☐ Excavation/trenching inspections/documentation
- ☐ Full-face respirators with proper cartridges
- ☐ Upgrade to level ___ at: PID(___eV)>___ppm
- ☐ Work stoppage at: PID(___eV) >___ppm, %LEL>10%
- ☐ Slips, trips, and falls
- ☐ Directions to hospital
- ☐ Anticipated visitors
- ☐ Electrical ground fault
- ☐ Public safety and fences
- ☐ Excavator swing and loading
- ☐ Orderly site and housekeeping
- ☐ Smoking in designated areas
- ☐ Leather gloves for protection
- ☐ Effects of the night before
- ☐ Vibration related injuries
- ☐ Fire extinguisher locations
- ☐ Eye wash station locations
- ☐ Decontamination procedures
- ☐ Daily work scope
- ☐ Emergency protocol
- ☐ Parking and laydown
- ☐ Hot work permits
- ☐ Strains and sprains
- ☐ Noise hazards
- ☐ No horseplay
- ☐ Heat and cold stress
- ☐ Backing up hazards
- ☐ Accidents are costly
- ☐ Dust and vapor control
- ☐ Refueling procedures
- ☐ Confined space entry
- ☐ Flying debris hazards

Discussion/Comments/Follow-up Actions: _____

NAME	SIGNATURE	COMPANY

Instructions:

- Conduct a daily safety meeting prior to beginning each day's site activities.
- Complete form, obtain signatures, and file with the Daily Summary.
- Follow up on any noted items and document resolution of any action items.

PES Environmental, Inc.

Engineering & Environmental Services

WELL DEVELOPMENT FORM

Page:	of
Date/Time:	
Project Name:	
Job No:	
Recorded By:	
Sampled By:	

Well Type: _____

Well Material: ☐ PVC ☐ Stainless Steel ☐ Other

Well ID:

WELL PURGING

PURGE VOLUME

Casing Diameter (D in inches)

☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other _____

Total Depth of Casing (ft. below TOC) (Pre-DV): _____

Total Depth of Casing (ft. below TOC) (Post-DV): _____

Water-Level Depth (feet below TOC): _____

PURGING METHOD

☐ Bailer - type: _____

☐ Submersible ☐ Centrifugal ☐ Bladder

☐ Other - Type: _____

PUMP INTAKE SETTING

☐ Near Bottom ☐ Near Top ☐ Other: _____

Depth in feet (BTOC): _____

Screen interval feet (BTOC) from _____ to _____

Est.Target Development Volume: 3x Borehole [sat.screen only] + water added during drilling

FIELD PARAMETERS MEASUREMENT

Time	Total Gallons Removed	Flow Rate (GPM)	Depth to Water (fbgs)	Pump Intake (fbgs)	Turbidity		Observations (color, well condition, odor, cloudiness, etc.)

---------- > STOP TIME: _____ ---------- > TOTAL GALLONS REMOVED _____

APPENDIX D

QUALITY ASSURANCE PROJECT PLAN

PES Environmental, Inc.
Engineering & Environmental Services

A Report Prepared for:

Port of Seattle
P.O. Box 1209
Seattle, Washington 98111

QUALITY ASSURANCE PROJECT PLAN
TERMINAL 91 SITE
TANK FARM AFFECTED AREA
2001 WEST GARFIELD STREET
SEATTLE, WASHINGTON

JULY 11, 2013

948.007.05

1215 Fourth Avenue • Suite 1350 • Seattle, Washington 98161 • Tel (206) 529-3980 • Fax (206) 529-3985

TABLE OF CONTENTS

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) is being submitted as an appendix to the Compliance Monitoring Plan (CMP) for the Port of Seattle's (Port) Terminal 91 Tank Farm Affected Area (TFAA) located in Seattle, Washington. These documents have been developed pursuant to Agreed Order No. DE-8938 (AO) between the Port and the Washington State Department of Ecology (Ecology, 2012). This QAPP has been modified by PES from the original, which was prepared by Kennedy/Jenks Consultants (KJC, 2010) as part of the previous 2010 Groundwater Monitoring Plan (GMP). The 2010 GMP and associated QAPP were approved by the Washington State Department of Ecology (Ecology) on October 14, 2010.

This QAPP was prepared in accordance with guidelines presented in the U.S. Environmental Protection Agency's (EPA) *Guidance for Quality Assurance Project Plans* (EPA 2002a). The content of this QAPP is consistent with *EPA Requirements for Quality Assurance Project Plans* (EPA 2001), and the ten elements of QAPPs described in the *Uniform Federal Policy for QA Project Plans* (EPA, 2005) have been taken into consideration in preparation of this document.

This QAPP is organized by the following four elements as specified in EPA 2002a and 2001:

1. Project Management – Section 2
2. Data Generation and Acquisition – Section 3
3. Assessment and Oversight – Section 4
4. Data Validation and Usability – Section 5

2.0 PROJECT MANAGEMENT

The project management section addresses the basic area of project management, including the project history and objectives, and the roles and responsibilities of the project personnel. The first three sub-elements of project management (Title and Approval Sheet, Table of Contents, and Distribution List) are presented in the beginning of this QAPP. The remaining elements under project management are discussed in this section.

2.1 Project/Task Organization

The organization of key personnel for the TFAA is shown on Figure 1.

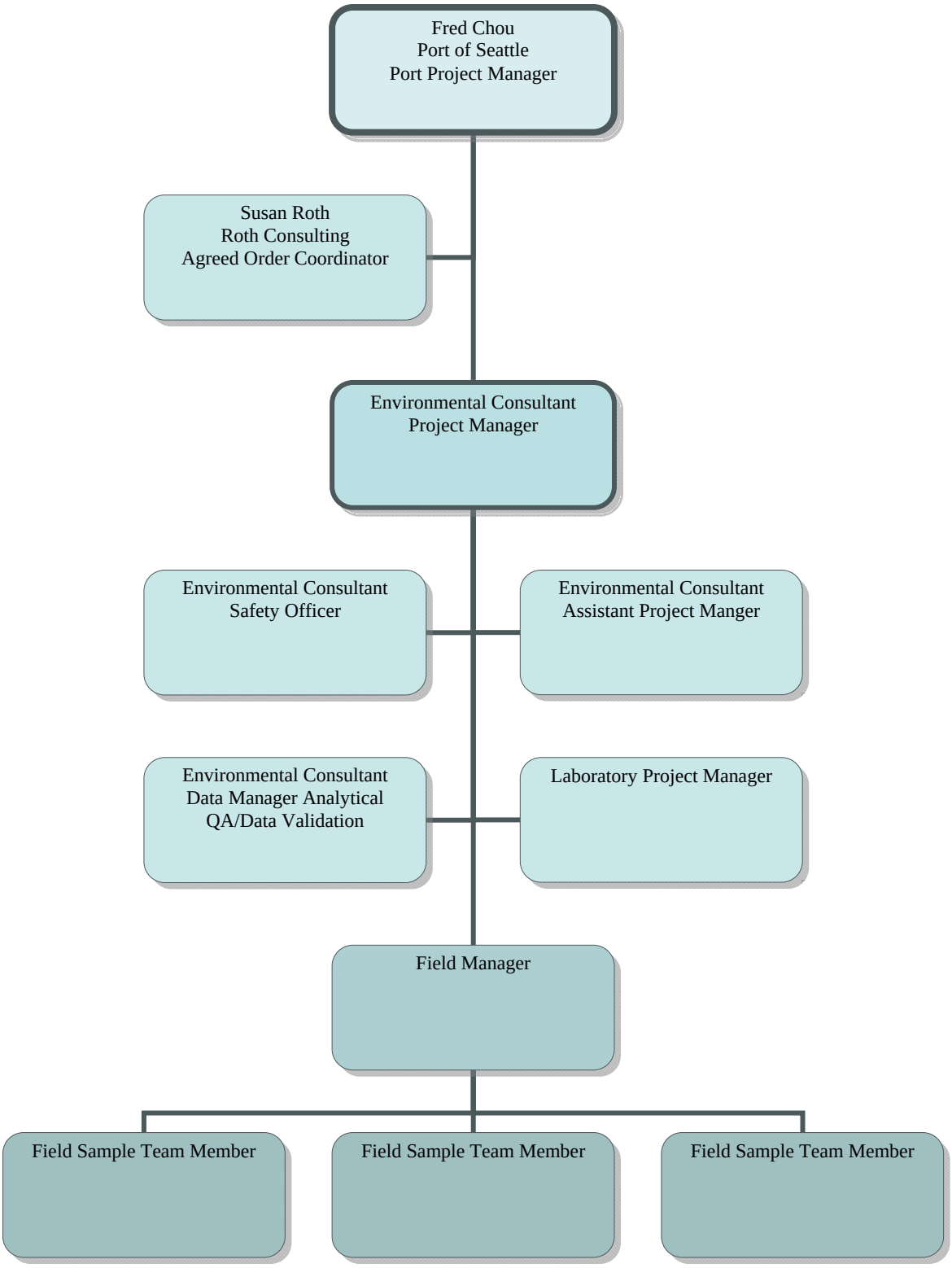

Figure 1: Organization of Key Personnel

2.2 Problem Definition and Background

The purpose of this QAPP is to provide EPA and or Ecology-approved methods and procedures for conducting the tasks that are outlined in the CMP at the TFAA in accordance with Model Toxics Control Act (MTCA) and the 2012 Agreed Order No. DE-8938 (Ecology, 2012). The overall QAPP objective for measurement data is to provide data of known and acceptable quality.

Further details of the background and objectives of the project are provided in the CMP.

2.3 Project/Task Description

The tasks to be completed at the TFAA are specified in the CMP, including the rationale, sampling locations, sample types, and sample analytes.

2.4 Quality Objectives and Criteria

QA objectives are prescribed to provide reliability and accuracy of measurement data and apply to all aspects of sample handling, analysis, data management, and reporting. This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

2.4.1 Data Quality Objectives Process

EPA's data quality objectives (DQOs) process (EPA, 2000) was considered in developing the sampling program for the TFAA.

2.4.2 Data Quality Indicators

Performance criteria are expressed in terms of data quality indicators. The principle indictors of data quality are precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity. These data quality indicators are discussed below.

2.4.2.1 Precision

Precision is an appraisal of the reproducibility of a set of measurements. Precision can be better defined as the variability of a group of measurements compared to their average value. Variability for environmental monitoring programs contains both an analytical component and a field component.

Analytical precision will be evaluated by the analyses of matrix spike duplicate and laboratory duplicate samples, which can be mathematically expressed as the relative percent difference (RPD) between duplicate sample analyses. RPD is calculated using the following equation:

$$RPD = \frac{(S - D)}{\left(\frac{(S + D)}{2}\right)} * 100$$

Where:

RPD = Relative percent difference
S = First sample value
D = Second (duplicate) sample value

Matrix spike duplicate and laboratory duplicate samples, where applicable, will be analyzed at a frequency of one per batch (which typically consists of up to 20 samples) for each sample matrix received. Field duplicate samples will be submitted to the laboratory as a means to determine field variability.

Precision quantities will be calculated for analyses with detection limits of the same order of magnitude and with detected concentrations greater than or equal to five times the detection limits. In instances where no criteria have been established (e.g., field duplicates), RPD project goals are less than 35 percent for well-homogenized soil samples and less than 25 percent for water samples.

2.4.2.2 Bias and Accuracy

Bias is the systematic or persistent distortion of a measurement process that causes error in one direction. Accuracy refers to how close a measurement is to the true value. Bias and accuracy will be evaluated by the analysis of matrix spike samples and laboratory control sample and can be mathematically expressed as the percent recovery of an analyte that has been used to fortify a field sample at a known concentration prior to analysis. The percent recovery (R) for a matrix spike sample is calculated as follows:

$$R = \frac{(SSR - SR)}{SA} * 100$$

Where:

SSR = Spiked sample result
SR = Sample result
SA = Spike added

The following calculation is used to determine percent recovery for a laboratory control sample or reference material:

$$R = \frac{RM}{RC} * 100$$

Where:

RM = Reference material result
RC = Known reference concentration

Field blank samples and method blank samples will also be used to evaluate bias of the data. Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Analytes detected in field or method blank samples will be evaluated as potential indicators of bias.

2.4.2.3 Representativeness

Representativeness concerns 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. Sampling locations were selected on both a systematic and biased sampling basis in an attempt to spatially cover the site and to obtain more data in areas where historical data and other information indicate the highest contaminant concentrations. Sampling locations and methods for selection of those sampling locations are presented in Section 8 of the CMP.

2.4.2.4 Comparability

Comparability is a qualitative QA criterion that expresses the confidence in the ability to compare one data set with another. Comparability among data sets is achieved through the use of similar sampling procedures and analytical methods. Sampling procedures will be performed as referenced in the SAP. Analytical procedures will be conducted according to guidelines contained in standard EPA methods as discussed in Section 3.4. Standard operating guidelines (SOGs) for collecting samples and recording field measurements were developed in accordance with EPA-accepted methods.

2.4.2.5 Completeness

Completeness describes the percentage of measurements that meet QA acceptance criteria for the requested determinations. Measurement of completeness (C) can be defined as the ratio of acceptable measurements obtained to the total number of planned measurements for an activity. Percent completeness is defined as:

$$C = \frac{M_a}{M_t} * 100$$

Where:

M_a = Number of acceptable data per target QC limits
M_t = Total number of data points.

The goal for completeness is 100 percent, but lower levels of completeness may be considered acceptable.

2.4.2.6 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest. The method detection limit (MDL) is the defined as the statistically calculated minimum amount that can be measured with 99 percent confidence that the reported value is greater than zero. MDLs are specified in the

individual methods and are developed by the laboratory for each analyte of interest representing the aqueous and solid matrices within the capability of an analytical method. The method reporting limit (MRL) is the lowest value to which the laboratory will report an unqualified quantitative result for an analyte. The MRL is always greater than the statistically determined MDL.

Analyte concentrations for this investigation will be reported to the MDL. Analytes detected at concentrations between the MRL and the MDL will be reported with a J qualifier to indicate that the value is an estimate (i.e., the analyte concentration is below the calibration range). The MDL will be adjusted by the laboratory, as necessary, to reflect sample dilution or matrix interferences.

2.5 Special Training/Certification

Prior to conducting sampling activities, field personnel are responsible for reviewing the protocol and performing safety briefings.

The Safety Officer is responsible for ensuring personnel receive the necessary safety training. Records of training are documented and are maintained with the Safety Officer and in the individual's personnel file.

Laboratory analyses will be performed by a Washington State accredited laboratory. Laboratory activities will be performed by qualified personnel. Each staff member must have the combination of experience and education needed to demonstrate the required knowledge for his or her position. The laboratory training requirements will be presented in project laboratories' quality assurance plans.

2.6 Documentation and Records

Records will be maintained documenting activities performed and data generated during the project. As it is the Project Manager's responsibility for ensuring project performance, the Project Manager will be responsible for maintaining these records with assistance from the Data Manager and the Laboratory Project Manager. The Project Manager is also responsible for ensuring that the final CMP, QAPP, and the site Health and Safety Plan (HASP), and any revisions or amendments to any of these documents are provided to the project personnel listed on the distribution list at the beginning of this QAPP.

Paper records will be placed in the project file and maintained throughout the duration of the project.

Electronic files will be maintained by the project consultant. Contents of the server will be backed up on a magnetic tape daily.

The types of documents that will be generated during the project are discussed below.

2.6.1 Field Documentation

Field logbooks and sampling forms (e.g., groundwater sampling forms) will be used to record data obtained during the various project tasks. Other types of field records that will be generated and maintained include photographs, chain-of-custody forms, and sample receipt records. The Field Sample Team Leader will be responsible for maintaining these forms. Field data obtained from personnel other than the specified project consultant (e.g., survey data) will be forwarded to the Environmental Consultant Project Manager for incorporation into project databases and the project file.

Field logbooks and/or field forms containing field measurements and notes will be manually entered into the project database. Data will be checked for errors. Field logbooks and/or field forms will then be archived in the Environmental Consultant project files.

2.6.2 Laboratory Documentation

Records related to sample analysis will be documented by the laboratory. The project laboratory will be required to submit data that are supported by sufficient backup information and QA results to enable reviewers to determine the quality of the data. The laboratory will be required to submit the data in both electronic format and hard copy. The hard copy data packages from the project laboratory will include the following information, where applicable:

- A case narrative discussing analytical procedures and any difficulties that were encountered;
- Environmental sample results (including dates of extraction/preparation and analysis);
- Method blank data results (e.g., reagent blanks);
- Matrix spike/matrix spike duplicate results (including concentrations of spiking compounds, percent recoveries, and control limits);
- Laboratory duplicate results, relative percent differences, and control limits;
- Original sample chain-of-custody/analysis request forms; and
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions.

The analytical laboratory will routinely archive raw laboratory data, including initial and continuing calibration data, chromatograms, and quantitation reports for at least 5 years.

Electronic analytical data provided by the project laboratory will be submitted in Excel format and will be loaded into the project database. Electronic data will be checked for errors before being incorporated into appropriate databases and verified against hard copy results.

2.6.3 Other Project Records

Other project records that will be generated during the sampling are discussed below.

- QA Reports. Upon completion of the data validation, QA reports will be prepared. Any limitations with regards to the usability of the data will be discussed in these reports. The

QA reports will be submitted to the Project Manager and included with the sampling report.

- Audit Reports. Findings of any audits conducted during the project will be documented in an audit report. The audit report will describe any problems encountered and corrective actions taken. System and performance audit reports will be used as necessary to document the review or audit of field sampling and laboratory operations.

- Quarterly Project Status Reports. These reports will be prepared by the Project Manager and submitted to the Port.

3.0 DATA GENERATION AND ACQUISITION

This section discusses the aspects of data generation and acquisition to ensure that appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and are properly documented.

3.1 Sampling Process Design

The overall sampling strategy, including the sample media, sample type, sample locations, and number of samples to be collected, is presented in the CMP.

3.2 Sampling Methods

Sample collection, location, and field measurement procedures are described in the CMP.

Sample analyses, matrices, method numbers, containers and sample size requirement, preservation methods, and holding times associated with the analyses to be performed will be confirmed with the project laboratory prior to the sampling event. All sample containers will be provided by the analytical laboratory. For those analyses requiring preservation, the laboratory will provide "pre-preserved" sample containers with the appropriate preservative.

3.3 Sample Handling and Custody

Samples will be placed in appropriate sample containers, properly preserved and stored, and traceable from the time of sample collection until sample data are received. Written records (e.g., chain-of-custody and field sampling forms, logbooks) will exist for each sample throughout sample collection, transport, storage, and analytical activities.

3.3.1 Sample Containers, Preservatives, and Holding Times

Sample analyses, matrices, method numbers, containers, preservation methods, and holding times associated with the analyses to be performed will be confirmed with the project laboratory prior to the sampling event.

3.3.2 Sample Custody

The key aspect of documenting sample custody is recordkeeping. Field logbooks and/or field forms will be maintained to document the collection of every sample. At the time of sampling, the appropriate sample container will be selected, and the sample number for each sample will be recorded on the sample log form by the sampler. Any QC samples collected at this time will also be noted in the field logbook and/or field forms.

Sample labels will be filled out with waterproof ink at the time of sample collection. Sample containers will be labeled with the following information:

- Source;
- Sample location or sample identification;

- Sample depth (if appropriate);
- Analytes;
- Preservative; and
- Sampling date and time.

The containers will be immediately placed in a cooler with ice for temporary sample storage during collection and transportation to the laboratory. At the end of each day, and prior to the transfer of the samples off-site, chain-of-custody analysis request forms will be completed. The chain-of-custody form will indicate the sample identification, sample type, date and time of collection, the specific analyses requested for that sample, and the signature of the sample collector. When more than one form is needed, the forms will be sequentially numbered.

Samples will be transmitted to the laboratory with the completed chain-of-custody analysis request forms. Original chain-of-custody forms will remain with the sample during storage and analysis and will be forwarded with the data packages.

3.3.3 Sample Identification

The sample identification system that will be used to label samples collected during the project is described below.

The sample identification will consist of the following components:

- Sample location/well identification;
- Sample date; and
- Sample modifiers (as necessary).

For example, a groundwater sample collected from monitoring well CP-104A-120113 denotes a sample collected in December 1, 2013; Sample numbers associated with field duplicates and field blanks will include a generic (distinct from any wells that are being sampled) number (e.g., D-100) and four digit date identification, as described above.

QC samples will be identified using the same rationale as above but will be appended with a code applicable to the type of QC sample.

3.3.4 Sample Packaging and Storage

Prior to shipment, sample containers will be securely packed inside plastic coolers. Each sample container will be wrapped with bubble wrap or Styrofoam packing and placed on absorbent pads or other suitable packing material that has been placed in the bottom of the cooler. Ice will be placed in the cooler to keep samples cold. Packing material will be added to fill the cooler completely and secure sample containers in an upright position.

The original chain-of-custody analysis request form(s) will be enclosed in plastic and placed inside the cooler. A custody seal will be adhered to one side of the cooler then placed over the lid and adhered to the other side so that the custody seal must be broken to open the cooler. To

prevent damage to the seal during shipping, tape will be placed over the seal for protection. Use of custody seals will help ensure that samples are not tampered with after collection.

3.3.5 Laboratory Documentation System

The sample custodian at the analytical laboratory will sign the chain-of-custody analysis request form upon receipt of the samples and note the condition of each sample received upon entry of all samples into the laboratory logbook. The custody seals on coolers will also be inspected. Custody seals will not be required if the sampler transports sample to laboratory. Any discrepancies will be reported to the project consultant.

3.4 Analytical Methods

Analytical methods and procedures outlined in EPA's *Test Methods for Evaluating Solid Waste* (EPA 1986 as amended), *Methods for Chemical Analysis of Water and Waste* (EPA 1983), *Standard Methods for the Examination of Water and Wastewater*, 20th Edition [American Public Health Association (APHA), et al. 1999], and *Analytical Methods for Petroleum Hydrocarbons* [Washington State Department of Ecology (Ecology) 1997] will be implemented to provide consistent results of known and documented quality and to ensure that data are accurate, precise, comparable, and legally defensible.

Groundwater samples will be analyzed for the following:

- Volatile organic compounds (VOCs) (benzene, toluene, ethybenzene, xylenes [BTEX]) using EPA Method 8260B.
- Total petroleum hydrocarbons (TPH) as gasoline-range hydrocarbons by Washington State Method Northwest Total Petroleum Hydrocarbons as Gasoline (NWTPH-Gx)
- TPH as diesel-range and heavier oil-range hydrocarbons by Washington State Method Northwest Total Petroleum Hydrocarbons as Diesel and Oil Extended (NWTPH-Dx), using the acid and silica gel cleanup method.

3.5 Quality Control

QC check samples will be assessed for both field and laboratory operations to ensure overall precision/bias and accuracy throughout the project. Field QC samples will include field duplicate and blank samples. The frequency of field QC check samples is discussed below. Laboratory QC parameters, criteria, and frequency are specified in the analytical procedures referenced in Section 3.5.2. Comparison of QC samples against established criteria is performed during the data validation process described in Section 5.

3.5.1 Field Quality Control Samples

3.5.1.1 Field Duplicate Samples

Field duplicate samples are designed to monitor overall sampling and analytical precision. One field duplicate sample will be collected for approximately every 20 project samples and analyzed

for the parameters specified in Section 3.2. Field duplicates will be treated as a separate sample from the originals (assigned unique sample number) and not identified to the laboratory as a duplicate sample.

Field duplicate samples will be collected, preserved, labeled, and treated like any other sample. They will be sent "blind" (i.e., not identified as a duplicate) to the laboratory. The field duplicate sample will be documented as such in the field logbook and/or field forms.

3.5.1.2 Blank Samples

At least one type of blank sample (equipment or trip) will be collected for each groundwater sampling event. Because disposable (i.e., non-reusable) equipment will be used for collecting samples, a single equipment blank will be collected. Trip blank samples will be submitted daily whenever a groundwater sample is being analyzed for VOCs. Blank samples will be collected, preserved, labeled, and treated like any other sample. The type of blank sample will be noted in the field logbook and/or field forms.

- Equipment Blank Samples. Equipment blank samples are collected to identify potential contamination from the sample collection equipment and to identify potential cross-contamination between sampling locations. One equipment blank sample will be collected during each sampling event. The equipment blank sample is collected by rinsing the sampling equipment with distilled or deionized water and placing the collected water in an appropriate container with preservative, as necessary. Equipment blank samples will be analyzed for the same parameters as the environmental samples.

- Trip Blank Samples. Volatile organic samples are susceptible to contamination by diffusion of organic contaminants through the sample vials. Therefore, trip blank samples will be submitted to monitor for possible sample contamination during shipment. Trip blank samples will be prepared by the analytical laboratory by filling volatile organic analyte (VOA) vials with organic-free water and shipping the blank samples with the clean sample containers. Trip blank samples will accompany the sample containers through collection and shipment to the laboratory and will be stored with any collected samples at all times. Trip blank samples will be submitted for VOC analysis on a daily basis whenever a water sample is being analyzed for VOCs.

3.5.2 Internal Laboratory QC Evaluation Criteria

Each EPA analytical method includes a description of QC procedures and QC requirements that must be adhered to. Control limits and, in many cases, requirements for corrective action are described in the methods. QC procedures will be completed by the laboratory as required in each method.

The frequency of analysis for laboratory control samples, matrix spike samples, matrix spike duplicates or laboratory duplicates, and method blanks will be one for every 20 samples or one per batch, whichever is more frequent. Surrogate spikes and internal standards will be added to samples as required by the method. Performance-based criteria presented in the method will be used to establish the acceptability of the data or the need for reanalysis of the samples.

During data validation (see Section 5), analytical results will be evaluated against the quality objectives noted in the individual analytical methods.

3.5.3 Sample Data Tracking System

Sample data must pass a series of requirements to verify that proper chain-of-custody documentation procedures have been followed. The Project Manager will verify that the following conditions have been met:

- Samples collected are properly documented in field logbooks and/or field forms;
- Chain-of-custody analysis request forms and field forms are complete and accurate; and
- Correct number of blanks and duplicates were collected.

3.6 Instrument/Equipment Testing, Inspection, and Maintenance

Preventive maintenance of equipment is essential if project resources are to provide accurate results and are to be used cost-effectively. Preventive maintenance will take two forms: (1) implementation of a schedule of preventive maintenance activities to minimize downtime and ensure accuracy of measurement systems; and (2) availability of critical spare parts and backup systems and equipment.

Qualified operators will perform routine inspections and maintenance for field instruments in accordance with manufacturers' recommendations. Field equipment will be inspected prior to the start of sampling activities. Maintenance activities, if performed, will be documented in the field logbook and/or field forms. Company owned or rental sampling equipment will be used during the project. As the type of field equipment that will be used for this project is standard (i.e., used frequently in environmental sampling), replacement parts are readily available. The Field Sample Team Leader will be responsible for maintaining the field equipment.

The laboratory's QA Plan discusses preventive maintenance for the laboratory's equipment and instruments. Maintenance and inspection records are documented in laboratory logbooks.

3.7 Instrument/Equipment Calibration and Frequency

Field instruments will be operated, calibrated, and maintained by qualified personnel according to manufacturer's guidelines and recommendations. At a minimum, instruments will be calibrated before use each day or more frequently as necessary. Calibration records will be recorded in the field logbook and/or field forms.

Laboratory instruments will be calibrated and maintained in accordance with the requirements of EPA (EPA 1983; 1986), APHA (1999), and Ecology (1997) and normal operating standards associated with good laboratory practices. Calibration procedures are also specified in the laboratory's QA Plan. Calibration records are documented in laboratory logbooks.

3.8 Inspection/Acceptance of Supplies and Consumables

Typical supplies used for sampling such as calibration standards for field equipment, tubing for groundwater sampling, safety supplies, etc., are purchased in bulk prior to the start of sampling. The Field Sample Team Leader will be responsible for purchasing and inspecting these sampling supplies prior to the start of sampling activities.

All sample containers will be provided by the analytical laboratory. For those analyses requiring preservation, the laboratory will provide pre-preserved sample containers with the appropriate preservative as specified in the applicable analytical method.

Materials/reagents of appropriate purity and quality and suitably cleaned laboratory equipment will be used in the laboratory analyses process. Laboratory supplies will be obtained from reputable suppliers with appropriate documentation or certification, where warranted.

3.9 Non-Direct Measurements

Non-direct measurements are not anticipated to be collected at this time. If non-direct measurements are obtained during field activities, they will be cited and the indicated purpose of the data provided.

3.10 Data Management

Both field and laboratory data will be collected during the project. Data obtained during sample collection will be manually entered into field logbooks and/or field forms. Data from these sources (such as sample location name and coordinates, water levels, and field parameters) will be manually entered into the project database or other appropriate program. Entries of these data will be reviewed by a second individual.

The laboratory will provide analytical data in both electronic and paper form. Electronic data will meet the requirements of the Port Environmental Management Information System (EMIS) and will be downloaded into the project database for verification of format and content. Any work product prepared from field activity and sampling data, such as reports, tables, figures, boring logs, etc., will be verified by another/second individual. After data validation and addition of validation qualifiers, qualified analytical data will be provided to the Port in the EMIS format and submitted electronically into Ecology's EIM database.

All paper generated records will be placed in the project file and maintained throughout the duration of the project.

4.0 ASSESSMENT AND OVERSIGHT

This section discusses the activities that will be performed for assessing the effectiveness of the implementation of the project and associated QA/QC activities.

4.1 Assessments and Response Actions

The type and frequency of assessments that will be conducted during the sampling are described below. Assessments of both field and laboratory operations will be conducted as discussed below.

4.1.1 Field Operations

A readiness review will be conducted prior to initiation of field sampling to ensure that all necessary preparations have been made for efficient and effective completion of the project field work. The Project Manager will verify that all field equipment has been assembled for the field work and that all subcontractors have been scheduled. Any deficiencies noted during this readiness review will be corrected prior to initiation of field activities.

A readiness review will also be completed of the analytical data prior to the distribution of the final data to the project team members or others. The Data Manager will verify that all results have been received from the laboratory and that data assessment and validation have been completed. The Data Manager will notify the data users when the data are ready for use.

4.1.2 Laboratory Operations

4.1.2.1 Performance Evaluation Audits

Performance evaluation audits are an independent means of establishing the quality of measurement data by analysis of samples provided specifically for the evaluation.

During a performance evaluation audit, the performance of the laboratory technicians and the instrumentation or analytical systems on which they work are evaluated. A performance evaluation audit is accomplished by providing performance evaluation samples containing specific pollutants (in appropriate matrices) whose identities and/or concentrations are unknown to the technician. The laboratory participates in both internal and external performance testing to examine the overall laboratory performance, as well as to qualify for various federal, state, and independent certification programs. Laboratories are required to perform at least two performance test studies each year per program using approved performance test samples to comply with National Environmental Laboratory Accreditation Program (NELAP) requirements.

The laboratory will be responsible for implementing corrective action for analytical procedures. If QC data are unacceptable, the cause will be determined and corrected. Corrective actions that affect the integrity of the project analytical data will require re-analysis of the affected sample or qualifying of these data in the final data report. If corrective actions are warranted by the laboratory, the Laboratory Project Manager will document the corrective action(s) and forward this information to the Project Manager.

System and Technical Laboratory Audits

System and technical audits are performed by the Laboratory QA Manager according to a predetermined schedule and when requested by laboratory management. PES may conduct a laboratory audit at the request of the Project Manager should corrective actions be needed during the project. This audit will be project-specific and will focus only on the performance of the laboratory for this project. A laboratory audit report will be prepared and submitted to the Laboratory Project Manager and Project Manager.

4.2 Reports to Management

Results of any field and laboratory audits, corrective action reports, and performance evaluations will be placed in PES' project file.

The QA reports will be submitted with the sampling report(s). Any deficiencies in the laboratory's abilities to meet QC criteria will be included in the report(s).

5.0 DATA VALIDATION AND USABILITY

This section discusses the QA activities that will occur after the data collection or generation phase of the project is completed. Implementation of these actions ensures that the data conform to the specified criteria, therefore, achieving the project objectives.

5.1 Data Review, Verification, and Validation

Field and laboratory data generated during the project will be reviewed, verified, and validated. Field data entered into the database will be verified. Errors identified during the verification of data will be corrected prior to release of the final data.

The laboratory is responsible for verifying analytical results prior to the submittal of the data to the Data Manager. Initially, all analytical data generated by the laboratory are verified by the laboratory. During the analysis process, the analyst and the Laboratory QA Manager verify the results have met various performance-based control limits (e.g., surrogate recoveries and continuing calibration). Non-conformance of various method QC requirements and control limits warrants the re-analysis and/or re-extraction of a sample.

Once the laboratory has released the data, it will be reviewed by the PES Data Manager. The Data Manager will review the data package to verify that all samples are accounted for. The Data Manager will verify and validate the data based on the quality objectives specified in this QAPP and performance-based criteria specified in the analytical methods in accordance with EPA's *Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review* (EPA, 1999; 2004). If data do not meet required criteria, they will be qualified as specified under the action portion of each requirement of the functional guidelines.

For analytical data where no validation guidelines exists (e.g., nitrate), the same objectives, criteria, validation procedures, and actions will be used.

5.2 Verification and Validation Procedures

During implementation of the project, the Field Sample Team Leader will be responsible for overseeing field measurements and data recording. The laboratory will forward chain-of-custody forms to the Data Manager upon receipt of samples. The Data Manager will review the chain-of-custody forms to verify correct sampling analyses are being performed and all samples specified are collected.

In addition, data verification and validation will be conducted to assess the laboratory's performance in meeting the qualify objectives identified in the QAPP (e.g., detection limits and control limits) and performance-based criteria specified in the analytical methods. Data validation is a process in which data are reviewed and evaluated by supervisory personnel within the laboratory, and the Data Manager.

The laboratory is responsible for ensuring that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results are within the acceptable limits. The Project Data Manager is responsible for ensuring that all analyses performed by the

laboratories are correct, properly documented, and complete, and that they satisfy the project DQOs specified in this QAPP.

Data review and validation of the analytical chemistry data will be conducted by PES. A minimum of 20 percent of the data, but no fewer than one sample delivery group, will undergo full (Stage 3 or 4) data validation using *EPA's Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review* (EPA 1999; 2004).

Two levels of data validation will be applied during this project: Full (EPA Stage 3 or 4, depending on method type), and summary (EPA Stage 2B). Stage 4 validation includes review of the data package for compliance with documentation and quality control criteria for all the following items, plus recalculations of instrument calibration curves, sample, and QC results. Stage 2B validation includes a review of all the following items, but without recalculation, transcription, or compound identification checks. The QC elements that will be evaluated during data validation include:

- Package completeness;
- Verification of electronic data deliverable (EDD) against hardcopy (10 percent verification);
- Holding times from extraction to analysis;
- Blank results (method, field, instrument);
- Spike recoveries;
- Reference material recoveries (SRM®, CRM, and laboratory generated), if analyzed;
- Laboratory duplicate results;
- Reported detection limits; and
- Compound identification (from raw data).

At the onset of the project, packages will be chosen for full (Stage 3 or 4) validation. As the project proceeds and the quality of the data is verified and documented, the level of validation will decrease. At a minimum, all data packages will receive summary (Stage 2B) validation. Additional packages for full (Stage 3 or 4) validation will then be chosen based on sample or data priorities, potential quality issues, revised laboratory methods, or at the request of the agency or data users. Over the course of the project, it is expected that a minimum of 20 percent of the packages will receive full (Stage 4) validation.

Validation qualifiers and reason codes will be assigned to individual data points as a result of the validation. These validation qualifiers will not replace laboratory flags or footnotes, but will be added to the EDD that is submitted to the Port for upload to the EMIS database. Validation qualifiers inform the data user whether or not the data meet all project measurement quality objectives (MQOs). Both laboratory flags and validation qualifiers will be maintained in the EMIS database.

All discrepancies and requests for additional, corrected data will be discussed with the laboratories prior to issuing the final data validation report. All contacts with the laboratories will be documented in communication records.

If data do not meet the project quality objectives and required criteria, they will be flagged with data qualifiers as specified under the action portion of each requirement of the functional guidelines (EPA, 1999; 2002b). Upon completion of the data validation, a validation report will be prepared summarizing the findings and addressing whether the QC requirements for each analysis have been met. Any limitations to the usability of the data will also be discussed in these reports. These validation reports will be submitted to the Project Manager and included with the sampling report.

5.3 Reconciliation with User Requirements

Data quality assessment will be conducted by the Project Manager and Data Manager in consultation with EPA guidelines. The results of the validation will be reviewed, and cases where the projects DQOs were not met will be identified. The usability of the data will be determined in terms of the magnitude of the DQO exceedance, as well as the importance of the data with respect to other historical data sets.

Data will be presented in the database with the appropriate data qualifier(s) and validation label that indicates the level of review. The data users will consider the effect of any inaccuracy or imprecision of the qualified data in their evaluations of the data.

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