SITE CHARACTERIZATION WORK PLAN

Prior Plant #4 - ESP
310 SE Stephens St.
Portland, Oregon 97214

Oregon DEQ ECSI No. 1010

Prepared for:

Farhad Ghafarzade
310 SE Stephens St.
Portland, Oregon 97214

Prepared by:

PNG ENVIRONMENTAL, INC.

Project Number 1257-01
April 25, 2024

TABLE OF CONTENTS

SECTION PAGE

FIGURES

APPENDICES

1 INTRODUCTION

PNG Environmental, Inc. (PNG) has prepared this work plan for investigation of the former East Side Plating (ESP) Plant #4 property in Portland, Oregon (Figures 1 and 2). Multiple investigations were completed in 2022 and 2023 to provide a preliminary assessment of soil, groundwater, soil vapor, and indoor air quality at the facility. Based on results of these initial investigation activities, the former Plant 4 facility entered the DEQ Voluntary Cleanup Program (VCP). During subsequent discussions with DEQ following their review of the existing data, DEQ stated that further action is needed to address data gaps and assess the potential risks on the former Plant 4 facility prior to issuance of a No Further Action (NFA) determination. Specifically, DEQ is requesting investigation of soil gas, indoor air quality, and groundwater to evaluate potentially contaminated media at the site. These data will support delineation of the nature and extent of contamination at the site, support updating the conceptual site model, and allow assessment of potential risks to human health and the environment.

2 BACKGROUND

2.1 FACILITY DESCRIPTION AND OPERATION

The 0.61-acre facility located at 310 SE Stephens Street contains one building (former Plant #4) comprised of three interconnected sub-buildings/structures (Figures 1 and 2). The property is zoned IG1 General Industrial. All adjacent properties are also zoned General Industrial, within the Central Eastside Industrial District (CEID). The building occupancy is currently in flux, with new tenants getting established. Appendix A shows site features and the building's layout in 1995. A detailed summary of site history is available in the Preliminary Assessment (Hahn 1995).

In the 1920s and 1930s, the site was occupied by several dwellings and two livestock liveries. Beginning in 1946, East Side Plating owned the facility until the recent property transfer in 2023. The facility operated six plating lines (a chrome plating line, two zinc barrel lines, a prototype dye and plating line, a hand-barrel plating line, and a hand zinc rack line), a strip line for reclaiming metals, and a polish shop. The polish shop, formerly located in the northeast corner of the building (Appendix A), included a parts degreaser that originally utilized 1,1,1-trichloroethane (TCA) and then transitioned to trichloroethene (TCE). According to discussions with the former owners, degreaser operations were moved to an alternate facility and no longer operated at former Plant #4 by the mid to late-1980s.

ESP plating lines generated process wastewaters that were historically disposed directly to the city sanitary sewer. In 1980, the City of Portland billed ESP for the replacement of a 40-foot section of concrete sewer piping located along SE Third Avenue near the intersection with SE Harrison Street that had corroded. At that time, ESP constructed a wastewater treatment facility in the southern portion of the building and discontinued discharge of untreated process wastewater. The wastewater treatment system, constructed in 1980, processed approximately 1,880,000 gallons of wastewater per year and subsequently discharged to the sanitary sewer. Sludge was shipped off-site. Additional pollution control infrastructure (e.g., floor sumps, chrome treatment system, cyanide destruction system, holding tanks) were also installed between 1978 and 1981.

Despite the fact that an EPA Preliminary Assessment prepared in 1984 indicated that the city sewer line outside of former Plant #4 had been replaced at least four times between 1950 and 1980, the City of Portland records show the line was only replaced once (in 1980). This records review conclusion was also confirmed by the former owner (Hahn 1995). There is no record of any other sewer replacement project in the vicinity of the facility related to former Plant #4 operations.

Prior to the property's transfer in 2023, the building was emptied of all equipment related to prior metal plating activities.

2.2 PHYSICAL SETTING AND GEOLOGY

The former Plant #4 facility is located within the Portland Basin, a structural basin in the Pacific Northwest filled with continental sedimentary rocks of late Miocene to Pleistocene age. The Portland Basin is a northwest-southeast trending basin covering southwest Washington and northwest Oregon, including Portland, and is about 20 miles wide and 45 miles long.

Soils in the vicinity of the ESP facility have been mapped as Channel facies (Pleistocene). Channel facies are catastrophic (i.e., Missoula) flood deposits that are complexly interlayered and variable silts, sands, and gravels deposited in major floodways. The thickness of these flood deposits is approximately 100 feet.

Underlying these soils in the vicinity of the facility is the Troutdale sand and gravel aquifer, which consists of volcanoclastic conglomerates derived from the Cascade Range. The thickness of the Troutdale aquifer near the facility may be up to 200 feet. Beneath the Troutdale aquifer are Tertiary rocks generally consisting of volcanic basalts.

Soil borings were completed in 2022 and 2023 within the building footprint and adjacent to the north, east, and south (PNG 2022, PNG 2023a). Boring logs are included in Appendix B. Observed soils were predominately silts and silt with sand, transitioning to sandy gravel at approximately 10 to 13 feet below ground surface (bgs), followed by sand to the termination depth of 55 feet bgs.

2.3 HYDROGEOLOGY

The water table observed in the 2022 and 2023 soil borings was generally encountered between 45 to 50 feet bgs (PNG 2022, PNG 2023a). Similarly, historic water level measurements obtained from the on-site industrial well indicated groundwater at 53 feet bgs (Hahn 1995).

A Phase II Environmental Site Assessment was completed at the property immediately adjacent to the south of the former Plant #4 building (Evren 2015). Groundwater was encountered during that assessment at 42 feet bgs.

Based on regional studies, groundwater flow is expected to be generally to the west/northwest, toward the Willamette River.

2.4 REGULATORY FRAMEWORK

Oregon’s environmental cleanup rules (Oregon Administrative Rules [OAR] 340-122) establish the standards and procedures to be used to assure protection of the present and future public health, safety and welfare, and the environment in the event of a release or threat of a release of a hazardous substance. In the event of a release of a hazardous substance, remedial actions shall be implemented to achieve one of the following:

- Acceptable risk levels defined in OAR 340-122-0115, as demonstrated by a residual risk assessment.
- Numeric cleanup standards developed as part of an approved generic remedy identified or developed by the Department under OAR 340-122-0047, if applicable.
- For areas where hazardous substances occur naturally (e.g., metals, etc.), the background level of the hazardous substances, if higher than those levels specified above.

Acceptable risk levels may be evaluated through conducting a site-specific risk assessment that calculates exposure point concentrations (EPCs) for specific exposure-pathway receptor-scenarios, or responsible parties (RPs) may use generic for hazardous substances under DEQ’s Risk-Based Decision Making (RBDM) guideline to streamline the risk assessment process. In terms of the latter, DEQ has compiled default risk-based screening reference levels (DEQ 2017) for common exposure-pathway receptor-scenarios that may be utilized in lieu of site-specific risk calculations (OAR 340-122-0115). In particular, the pre-calculated risk-based concentration (RBC) represents the concentration of a contaminant of interest (COI) in the impacted medium (e.g., soil, groundwater, or air) that potentially represents an unacceptable risk level.

2.4.1 DEQ Risk Based-Concentrations

DEQ first developed RBDM guidance in 2003 for comparing COI concentrations to default RBCs for applicable human health exposure scenarios. These RBCs eventually replaced Environmental Protection Agency (EPA) Preliminary Remediation Goals (PRGs) as screening criteria in human health risk assessments. Published RBC tables are updated periodically by DEQ; with the most recent update relevant to ESP published in 2018 (DEQ 2018).

In the 2009 revision to its RBC tables, DEQ included newly-developed soil gas and indoor air RBCs for residential, urban, and occupational settings. DEQ also published final guidance for vapor intrusion assessments (DEQ 2010), and issued air and soil vapor RBC values which have also been revised over time. In September 2017, DEQ updated their guidance as Risk-Based Decision Making for the Remediation of Contaminated Sites to reflect a broader spectrum of contaminated sites (DEQ 2017). The last DEQ RBC table revision was in May 2018 (DEQ 2018).

Recently in June 2023, DEQ released a set of tables that provide new RBCs for vapor intrusion pathways (DEQ 2023). These new RBCs for residential and commercial exposure scenarios are intended to be more consistent with EPA's Vapor Intrusion Screening Level (VISL) calculations and values. In March 2024, DEQ released a draft Guidance for Assessing and Remediating Vapor Intrusion into Buildings which incorporates the June 2023 RBCs. This draft guidance is intended to replace the previous guidance for vapor intrusion assessments.

The published RBCs represent a conservative default concentration of a chemical in an impacted medium (e.g., soil, groundwater, or air). When chemical concentrations on a site exceed the RBC, unacceptable human health impacts are possible. For carcinogens, the regulatory standard is represented by an excess cancer risk of one in one million ($1x10^{-6}$); for non-carcinogens, this is represented by a Hazard Index of 1. RBC exceedances typically trigger further investigation and potentially a human health risk assessment. Therefore, RBCs can be applied at sites as generic, conservative cleanup standards and are routinely used by DEQ to determine if a site requires additional action. Site specific parameters used in the equations to develop the RBCs are often adjusted to match actual conditions in developing site-specific cleanup levels. As such, DEQ reserves the right to disallow the use of generic RBCs at sites that may not fit generic RBC default conditions, such as at sites with widespread contamination.

There are several exposure pathways by which a receptor may be exposed to a chemical, including incidental ingestion, inhalation, and dermal contact with the affected medium. The current and reasonably anticipated future use of properties in the Locality of Facility (LOF) are the primary criterion for determining whether a certain exposure pathway is likely to be of concern.

The property is zoned IG1 General Industrial. Adjacent properties are also zoned General Industrial, within the Central Eastside Industrial District (CEID). The current and expected future land use is expected to remain industrial. The City of Portland supplies drinking water to all properties in the vicinity of the facility. Based on a previously conducted survey of water well logs filed with Oregon Water Resources Division (OWRD), groundwater in the area of the former Plant #4 is used primarily for industrial purposes (Hahn 1995). Within the area of the facility, groundwater has generally been encountered at depths of between 42 and 53 feet bgs. Investigation of the facility in August 2022 and February 2023 encountered groundwater between 45 and 50 feet bgs in eight borings. At these depths, current receptors are unlikely to be exposed to groundwater as long as the facility and surrounding properties continue to have access to City-supplied drinking water.

2.5 PREVIOUS ON-SITE INVESTIGATION SUMMARY

Two previous focused investigations were completed in August 2022 and February/March 2023. These two investigations consisted of focused soil, groundwater, and soil vapor sampling. In addition, an ambient air (indoor and outdoor) sampling event was conducted in August 2023. These investigations were conducted to document environmental conditions at and adjacent to the facility. Sampling locations chosen were intended to provide overall coverage throughout the facility. The sampling locations were also based on a combination of building use (potentially worst-case areas such as in the vicinity of the former plating lines, wastewater treatment system, or solvent use areas) and adequate access for drilling equipment.

2.5.1 Nature and Extent of Contamination

Details of recent (2022-2023) investigation results are available in multiple technical memorandums (PNG 2022, PNG2023a, PNG 2023b). Data tables are also included in Appendix C. Sample locations are shown on Figure 2. During soil boring installations, continuous soil core samples were evaluated in the field for indications of environmental contamination (i.e., odor, discoloration). In total, 14 soil borings were completed with 74 soil samples collected from all borings combined. In addition, a groundwater grab sample was collected at eight of the boring locations. Groundwater was encountered between 45 to 50 feet below ground surface (bgs). Shallow (five feet bgs) soil vapor was collected from the five boring locations outside of the former Plant 4 building (B-10 through B-14). In addition, sub-slab soil gas was collected from a network of 13 cross-slab vapor pins inside the building. Vapor pins were installed such that they were distributed throughout the entire building, with particular consideration given to coverage in former operational areas. Lastly, a single ambient air monitoring event collected samples from five indoor locations and one outdoor location.

Below is a summary of constituents detected during the sampling activities.

- Detections in soil include:
    - Metals – Arsenic, cadmium, chromium, copper, nickel, silver, zinc
    - Total Petroleum Hydrocarbons – diesel (DRO) and oil (RRO)
- Detections in groundwater include:
    - Volatile Organic Compounds – PCE, TCE, cis-1,2-DCE, 1,1-DCE
    - Metals – Arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, thallium, zinc
    - PFAS – PFBS, PFHxA, HFPO-DA, PFHpA, PFHxS, PFOA, PFOS
- Detections in soil gas include:
    - Total Petroleum Hydrocarbons – gasoline (GRO)
    - Volatile Organic Compounds – TCE, ethylbenzene, xylene, multiple other VOCs at low levels

- Detections in indoor/outdoor air include:
    - Volatile Organic Compounds – low levels of several VOCs including TCE, PCE, ethylbenzene, chloromethane, benzene, 1,2-DCA.

Soil

Soils were analyzed for multiple constituents including metals, VOCs, and hydrocarbons.

Several metals (arsenic, cadmium, chromium, copper, nickel, silver, and zinc) were detected in soil from borings within the building footprint at concentrations that exceed Portland Basin regional default concentrations established by DEQ. Conversely, in soil samples from borings completed outside of the building footprint, only two metals (cadmium and nickel) were detected at concentrations that exceed Portland Basin regional default background concentrations. Although metals have been detected in soils above Portland Basin regional default background levels both inside and outside of the building, none of the detected metals concentrations, except arsenic, exceed occupational risk-based concentration (RBC) screening levels established by DEQ. The RBC for arsenic in soil is lower than regional default background concentrations.

Fifty of the 74 samples collected were analyzed for TPH. Where analyzed, gasoline (GRO) was not detected in any of the soil samples. Diesel (DRO) and oil (RRO) were only detected in two of the 50 samples (B-10 at 5 feet bgs and B-14 at 10 feet bgs). No TPH concentrations exceed the DEQ occupational or construction worker RBCs, except for the TPH RRO concentration detected in the soil sample from B-10 located in Stephens St. offsite to the north of the former Plant #4 (5,040 mg/kg compared to the construction worker RBC of 4,600 mg/kg).

VOCs were not detected in the 30 soil samples analyzed, except for relatively low concentrations (generally part per billion level) detected in eight samples: Boring B-12 from 15 feet bgs and three deep samples from below the groundwater table at about 50 feet bgs (boring locations B-12, 13, 14). No VOCs were detected at concentrations that exceeded an occupational RBC established by DEQ. As previously mentioned, the facility and all adjacent properties are zoned general industrial. This building is within the Central Eastside Industrial District and occupational use of the property is not expected to change in the future.

Groundwater

Various concentrations of total (unfiltered) metals (arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, thallium, and zinc) were detected in the groundwater grab samples collected from the temporary well points during the 2022 and 2023 sampling events. Generally, detections of metals in groundwater were at relatively low concentrations. The push probe methodology for collecting screening-level groundwater samples will typically result in more turbid samples containing suspended and colloidal material that may contain naturally occurring metals (sourced from suspended soil in the water sample) and may not be representative of the true quality of groundwater. As such, dissolved (filtered) metals in groundwater samples were also collected. The results of filtered sample analysis only detected a small subset of the aforementioned metals (copper, nickel, and thallium) and at much lower concentrations and frequency. None of the detected metal concentrations exceed occupational RBCs.

The groundwater grab samples were also analyzed for VOCs and PFAS compounds. PCE and TCE were detected in nearly every groundwater sample collected. TCE concentrations detected in groundwater samples collected on the former Plant #4 property are all less than 13 ug/L. TCE concentrations from borings B-10 and B-11, offsite to the north of former Plant #4, were higher than onsite with concentrations of 26 and 24 ug/L. Some of the detected TCE concentrations in groundwater grab samples exceed DEQ's occupational RBC for ingestion/inhalation from tap water of 3.3 ug/L. However, municipal drinking water is available in this City of Portland area and ingestion/inhalation of tap water derived from groundwater in the vicinity of this facility is not considered likely.

Similarly, six PFAS compounds were also detected at low part per trillion concentrations in every groundwater sample collected. The observation of these VOC and PFAS compounds at low levels in all groundwater samples collected to the north, west and south of Plant #4 suggests a more regional groundwater quality condition.

Soil Gas

Soil gas was collected from shallow soil borings located outside of the building footprint, as well as from cross-slab vapor pins within the former Plant #4 building.

TPH as GRO was detected at several locations, both from soil borings and vapor pins. None of the detected concentrations exceed the former DEQ occupational RBC for vapor intrusion into buildings, however, one sample at SG-6 exceeds the new (June 2023/March 2024) commercial RBC.

TCE concentrations in soil gas at nearly every vapor pin location and one of the soil borings exceeds the new commercial RBC of 100 ug/m^3, with the highest concentration detected at SG-9 (34,900 ug/m^3). PCE concentrations in soil gas at two locations (SG-6 and SG-7) also exceed the new commercial RBC of 1,600 ug/m^3. In addition, ethylbenzene concentrations in soil gas collected from borings B-10 and B-11, located to the north of the facility in SE Stephens Street, exceed the commercial RBC of 160 ug/m^3. Ethylbenzene concentrations collected from vapor pins inside the building footprint were all well below the commercial RBC.

Indoor Air

In August 2023, five indoor air quality samples were collected throughout the northeastern portion of the former Plant #4 facility. Sample locations were selected to represent areas of the building with generally greater VOC concentrations in previously collected sub-slab soil vapor samples. One outdoor air quality sample was collected in outdoor air simultaneous to the indoor air sampling event. Although seven VOCs were detected in indoor air during the August 2023 sampling event, all VOCs detected were reported at relatively low levels and none exceed DEQ's commercial RBCs for air. Similarly, only five VOCs were detected in outdoor air, and all detected concentrations were well below DEQ commercial RBCs for air. TCE, which was detected in every indoor sample at concentrations ranging from 0.26 to 1.2 ug/m^3, was not detected in the outdoor air sample.

3 OBJECTIVES

Initial investigations were completed in 2022 and 2023 to provide a preliminary assessment of soil, groundwater, soil vapor, and indoor air quality at the facility. During subsequent discussions with DEQ after review of the existing data, DEQ stated that further action is needed to address data gaps and characterize the nature and extent of contamination at the site. As such, the objectives of the 2024 investigation activities are intended to address data gaps identified by DEQ, as follows:

- Determine groundwater flow direction.
- Characterize the nature and extent of groundwater contamination on site.
- Characterize soil vapor quality under and adjacent to the building. In particular, characterize areas of current and previous operations that involved the use of chemicals such as metals, paints, and solvents.
- Gather information to complete the conceptual site model (CSM), such as;
    - Identification of contaminated media
    - Identification of potential human and ecological receptors
    - Identification of potential pathways between identified contamination and receptors
- Gather information to support evaluation of potential current and future risk to human health receptors.

4 FOCUSED INVESTIGATION PLAN

The focused investigation activities described in this work plan are designed to address the data gaps identified by DEQ and the objectives outlined in Section 3.

Investigation activities will involve expansion and sampling of a soil gas monitoring network, cross-slab differential pressure monitoring, and ambient air sampling to assess soil gas conditions and to assess potential risk associated with potential vapor intrusion. This data will also be evaluated to determine if additional monitoring of soil gas is necessary.

Additional on-site investigation activities will include the installation, development, and sampling of monitoring wells. This activity will address data gaps in groundwater flow and groundwater quality across the site. Any modifications to the planned characterizations below will be completed in consultation with DEQ as described in Section 5.

4.1 PRE-INVESTIGATION ACTIVITIES

Prior to beginning any on-site work, the following tasks will be completed.

Health and Safety Plan

PNG will update the site-specific Health and Safety Plan (HASP). The HASP is developed in accordance with rules established by the Occupational Safety and Health Administration (OSHA). The purpose of this written plan is to establish procedures and practices for PNG employees, as well as subcontractors, aimed at minimizing potential exposure, accidents, and physical injuries that may occur during onsite activities. The HASP will specifically address known or suspected hazards at the site. The HASP will also provide contingency arrangements for emergency situations.

Underground Utilities

In preparation for subsurface activities, underground utilities in the vicinity will be researched in advance. In particular, PNG will research details of the sanitary sewer segment (diameter, depth, etc.) on SE Third Avenue adjacent to the facility that was replaced in 1980, and the segment on SE Stephens Street to the north that was recently repaired in 2022. Monitoring wells MW-1, -2, -3 and -4 are located near these sewer lines, as shown on Figure 3.

Underground utilities will be located in the vicinity of proposed vapor pins and monitoring wells. Underground utilities will be located through a combination of one-call and private utility locate subcontractors. Utilities that run across planned installation locations will be identified. If one of the proposed vapor pin or monitoring well locations is too close to an existing underground utility for that feature to be safely installed the vapor pin or well location will be modified as necessary. Once all proposed locations have been cleared for utilities, installation locations can be finalized.

4.2 INVESTIGATION ACTIVITIES

4.2.1 Sub-Slab Soil Gas Characterization

The soil gas characterization was developed to be consistent with DEQ's vapor intrusion guidance (DEQ 2010). PNG proposes to expand the existing semi-permanent soil gas vapor pin sampling network. The previous vapor pins (SG-1 through SG-13) were installed during previous investigation efforts in 2022. The expanded network will consist of the existing 13 sub-slab soil gas vapor pins and five new vapor pins; all five new vapor pins are located around the perimeter of the former Plant #4 building (Figure 3). The proposed vapor pin locations have been chosen to provide coverage across the property. Vapor pins are multi-functional, and will be used for sub-slab soil gas sampling as well as future cross-slab differential pressure monitoring.

All soil gas samples will be analyzed for VOCs by U.S. Environmental Protection Agency (EPA) Method TO-15. All soil gas analysis will be completed on a normal turnaround basis.

Cross-Slab Differential Pressure Monitoring

As part of sub-slab vapor monitoring events, PNG will conduct a direct measurement of cross-slab differential pressure and separately measure outdoor barometric pressure to assess differential pressure. The cross-slab differential pressure data collection will utilize CLK-Zephyr II+ data logging micro-monometers, or similar devices, at five vapor pin locations. The micro-manometer is auto-zeroing and has a pressure differential sensitivity to 0.001 inches of water. The auto-zeroing feature allows for highly accurate differential pressure logging over time. Cross-slab differential pressure data will be electronically recorded at one-minute intervals throughout the collection time. The meters will be installed at vapor pins SG-5, -6, -9, -10, and -13. The differential pressure meters will be left in place for approximately 24 hours. Cross-slab differential pressure monitoring will be completed at least one day prior to collection of sub-slab soil vapor samples.

4.2.2 Groundwater Characterization

PNG proposes to install eight groundwater monitoring wells (Figure 2). The proposed groundwater monitoring well locations were selected to cover the perimeter of the property on all sides, where accessible. In addition, three interior boring locations will be observed, within the northern half of the building, where the greatest soil vapor impact has been seen during previous investigations. No monitoring wells are planned for the eastern side of the property due to limited access and worker safety concerns. This network of monitoring wells will allow for the characterization of groundwater flow in the vicinity of Plant #4. Based on regional trends, groundwater flow is expected to be to the west/northwest toward the Willamette River.

Continuous soil cores will be screened in the field (e.g., odor, color, and PID readings). These groundwater monitoring wells will be constructed with 15-foot, 2-inch diameter, 0.010-inch slotted, pre-packed schedule 40 PVC well screens to a depth of approximately 55 to 60 feet, consistent with OWRD standards and depth-to-water observations in previously completed soil borings. The wells will be fitted with locking caps and finished with flush-mount surface monuments. These wells will be developed and sampled to evaluate groundwater quality across the site.

Following development, eight groundwater samples will be collected (one from each monitoring well plus one duplicate sample). Groundwater samples will be analyzed for gasoline and diesel-extended range total petroleum hydrocarbons (TPH) by NW Methods TPH-Gx and TPH-Dx, volatile organic compounds (VOCs) by EPA Method 8260D, and total and dissolved priority pollutant metals by EPA Methods 6010/7470/7471. Groundwater samples will also be analyzed for PFAS compounds by Draft Method 1633. All groundwater analysis will be completed on a normal turnaround basis.

Following installation of the seven monitoring wells, a licensed surveyor will establish elevations for the new monuments and well casings. Elevations will be recorded to within an accuracy of 0.01 feet vertically and 0.1 feet horizontally. Relevant physical features (e.g., building corners, catch basins, etc.) will also be surveyed in order to compile an accurate map of the site as deemed appropriate. However, legal property boundaries will not be surveyed.

4.2.3 Deep Soil Vapor Characterization

In order to profile the vertical distribution of VOCs in soil vapor, PNG proposes collecting a series of deeper soil vapor samples. Samples will be collected from approximately 10 and 20 feet bgs at each of the eight push-probe boring locations. In combination with the shallow sub-slab soil gas samples collected from the vapor pin network, these deep soil vapor samples will help characterize the soil vapor both laterally and vertically.

Consistent with the sub-slab soil gas samples, all deep soil vapor samples will be analyzed for VOCs by U.S. Environmental Protection Agency (EPA) Method TO-15. All soil gas analysis will be completed on a normal turnaround basis.

4.2.4 Ambient Air Sampling

PNG proposes to conduct an ambient air sampling event which consists of sample collection from nine indoor locations and one outdoor location. The indoor locations will be the same as locations sampled during the 2023 event (IA-1 through IA-5) plus four additional locations (IA-7 through IA-10) in the southern half of the building to provide additional coverage within all rooms of the building (Figure 3). During the 2023 sampling event, the one outdoor sample, IA-6, was collected from a location along the north wall of the building (this location has now been remaned IA-6 North). In future sampling events, an alternate outdoor sample location, IA-6 South, located along the southern wall of the building and away from the subsurface area of the building with elevated levels of VOCs in soil gas will be used instead (Figure 3). Previously, samples were collected over approximately 24 hours using laboratory-provided six-liter summa canisters and flow controllers. At DEQ's request, this sampling event will be conducted over approximately 11 days to provide a larger time weighted average of conditions. Samples will be collected using Radiello 130 passive diffusion samplers and the laboratory-provided sampling procedure.

All ambient air samples will be analyzed for VOCs by Modified U.S. Environmental Protection Agency (EPA) Method TO-17. All air analysis will be completed on a normal turnaround basis.

4.3 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance and Quality Control (QA/QC) for the work to be performed under this work plan will be conducted as necessary to provide confidence in the characterization for the site. QA/QC samples will include field duplicate and trip blank samples as appropriate. Field and trip blank results may indicate possible contamination introduced by field or laboratory procedures, and field duplicates indicate overall precision in both field and laboratory procedures. QA/QC samples will be collected as part of the soil and groundwater sampling, in accordance with PNG's SOP (Appendix D).

Field duplicates will not be identified as duplicates on the sample labels or chain-of-custody forms, but will be identified as duplicates on the field forms and sample logs. The field duplicate will be analyzed for the same parameters as the investigative sample. At a minimum, one field duplicate for each sample matrix will be sampled and analyzed for every 20 samples collected.

Trip blanks are water samples prepared by the laboratory by filling a water sample container with laboratory grade distilled, deionized water. Trip blanks will accompany the sample containers to and from the event, but at no time will they be opened or exposed to the atmosphere. One trip blank will be transported for each sampling event.

Analytical results from the blanks and duplicates will facilitate data quality control checks. A data validation evaluation will be conducted to verify the accuracy and precision of the resultant chemical data. The evaluation includes a check of the following:

- Data completeness
- Holding times and preservation
- Blanks
- System monitoring compounds (surrogates)
- Laboratory control samples
- Matrix spike/matrix spike duplicates

Based on the results of this data validation evaluation, a more detailed evaluation of other data in the context of the project objectives may be warranted. Additional data validation may be conducted, as appropriate, to ensure data is of an acceptable quality for the intended site characterization purposes.

4.4 INVESTIGATIVE DERIVED WASTE DISPOSAL

All soil and groundwater investigative-derived waste (IDW) media will be containerized in suitable containment and secured on-site for future disposal. It is estimated that two 55-gallon drums of IDW soil and three 55-gallon drums of IDW water will be generated to support monitoring well installation, development, and sampling. All IDW soil and groundwater will be characterized and managed in accordance with applicable rules based on characterization analytical testing results.

4.5 FIELD PROCEDURES AND PNG STANDARD OPERATING PROCEDURES

Field procedures for soil gas, groundwater, and air sampling, groundwater monitoring well installation, vapor pin installation, and IDW disposal will be completed in accordance with the attached standard operating procedures (SOPs) (Appendix D).

5 WORK PLAN ADDENDUM PROCEDURE

If additional work activities beyond the scope of this Work Plan are necessary, they will be described in addendum form and submitted to DEQ for approval prior to initiation. Some modifications or optimization of the field investigation activities described in this work plan may need to be made while in the field in consultation with DEQ. In most cases, modifications will be made in consultation with DEQ and are anticipated to be managed via telephone communication and documented in a follow-up summary electronic mail.

6 REPORTING

A detailed investigation report will be prepared to document all soil, groundwater, and soil gas sampling, and investigative-derived waste management. The report will include a brief description of the site work activities and any variations from the work plan, and interpretation and significance of the results. In addition, the report will discuss the conceptual model, current and future land use, current and future beneficial use of water, and potential migration pathways and receptors. The results of all data collected will be provided in tabular format with figures depicting sample locations and analytical testing results. Laboratory analytical testing reports and IDW disposal documentation will be included in appendices.

7 PROJECT SCHEDULE

At this time work is anticipated to be initiated within thirty (30) days following DEQ approval of this work plan. Contingent on contractor and vendor availability, the activities outlined in this work plan are estimated to require four to six months to complete.

8 LIMITATIONS

PNG has prepared this work plan for use by Plant 4, LLC and Farhad Ghafarzade. This work plan may be made available to future property owners and to regulatory agencies. This work plan is not intended for use by others and the information contained herein is not applicable to other sites.

Our interpretation of subsurface conditions is based on field observations and chemical analytical data. Areas with contamination may exist in portions of the site that were not explored or analyzed.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices and laws, rules, and regulations at the time that the report was prepared. No other conditions, express or implied, should be understood.

PNG Environmental, Inc.

Samantha Biles, P.E.
Environmental Engineer

Brad Berggren, P.E., R.G.
Senior Engineer

REGISTERED
OREGON
BRAD J. BERGGREN
G1921
GEOLOGIST

Expires 4/30/24

9 REFERENCES

DEQ. 2010 (March 25). *Guidance for Assessing and Remediating Vapor Intrusion in Buildings.* Oregon Department of Environmental Quality.

DEQ. 2017 (October 2). *Risk-Based Decision Making for the Remediation of Contaminated Sites.* Oregon Department of Environmental Quality.

DEQ. 2018 (May). *Risk-Based Concentrations for Individual Chemicals.* Oregon Department of Environmental Quality.

DEQ. 2023 (June). *Tables of Vapor Intrusion RBCs Based on EPA VISL Calculations*. Oregon Department of Environmental Quality.

DEQ. 2024 (March). *Guidance for Assessing and Remediating Vapor Intrusion into Buildings.* Oregon Department of Environmental Quality.

Hahn. 1995 (June 29). *Preliminary Assessment*. Hahn and Associates, Inc.

Evren. 2015 (July 7). *Phase II Environmental Site Assessment*. Evren Northwest, Inc.

PNG. 2022 (October 26). *Focused Soil, Groundwater, and Soil Vapor Investigation Technical Memorandum*. PNG Environmental, Inc.

PNG. 2023a (May 5). 2022/2023 *Focused Soil, Groundwater, and Soil Vapor Investigation Technical Memorandum*. PNG Environmental, Inc.

PNG. 2023b (August 30). *Indoor and Outdoor Ambient Air Sampling Technical Memorandum*. PNG Environmental, Inc.

FIGURES

NOTE: USGS, PORTLAND QUADRANGLE
OREGON-WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)

I:\Autocad Files\PNG-Autocad\1257-01 ESP-Plant #4\2024\Feb 2024\1257-01_BM-021324.dwg

PNG ENVIRONMENTAL, INC.
6665 SW Hampton St., Ste. 101 TEL (503) 620-2387
Tigard, OR 97223 FAX (503) 620-2977

DATE: 2-25-24
FILE NAME: 1257-01
DRAWN BY: JJT
APPROVED BY: SV

PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

VICINITY MAP

Project No. 1257-01
Figure No. 1

LEGEND

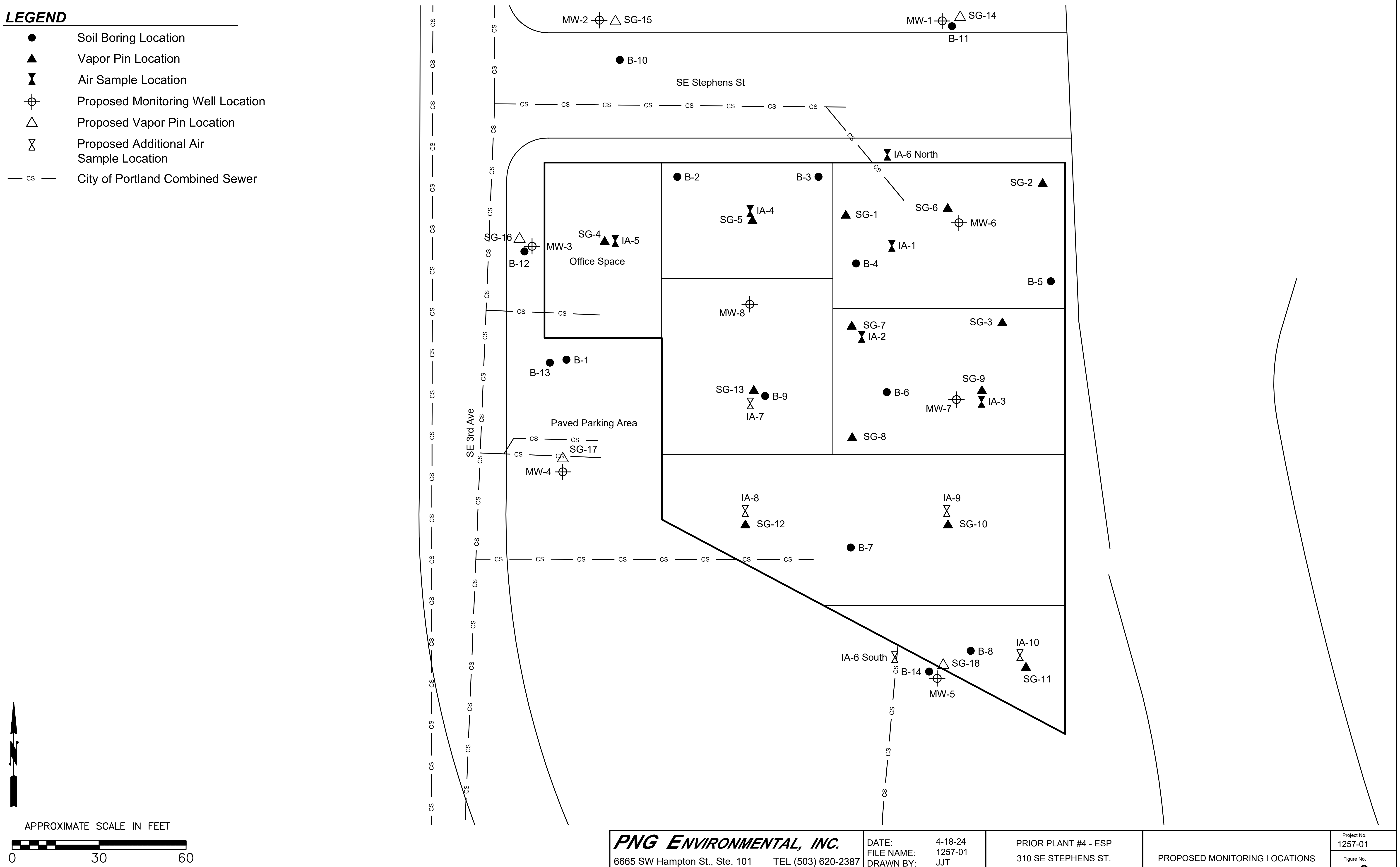
- ● Soil Boring Location
- ▲ Vapor Pin Location
- ⧗ Air Sample Location
- ⌖ Proposed Monitoring Well Location
- △ Proposed Vapor Pin Location
- ⧖ Proposed Additional Air Sample Location

APPROXIMATE SCALE IN FEET

0 30 60

PNG ENVIRONMENTAL, INC. 6665 SW Hampton St., Ste. 101 Tigard, OR 97223	TEL (503) 620-2387 FAX (503) 620-2977	DATE: 4-18-24 FILE NAME: 1257-01 DRAWN BY: JJT APPROVED BY: SV	PRIOR PLANT #4 - ESP 310 SE STEPHENS ST. PORTLAND, OR.	SITE FEATURES	Project No. 1257-01 Figure No. 2

I:\Autocad Files\PNG-Autocad\1257-01 ESP-Plant #4\2024\Feb 2024\1257-01_BM-021324.dwg



PNG ENVIRONMENTAL, INC.
6665 SW Hampton St., Ste. 101
Tigard, OR 97223
TEL (503) 620-2387
FAX (503) 620-2977

DATE:	4-18-24
FILE NAME:	1257-01
DRAWN BY:	JJT
APPROVED BY:	SV

PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

PROPOSED MONITORING LOCATIONS

Project No.
1257-01

Figure No.
3

I:\Autocad Files\PNG-Autocad\1257-01 ESP-Plant #4\2024\Feb 2024\1257-01_BM-021324.dwg

APPENDIX A
Historic (1995) Facility Layout

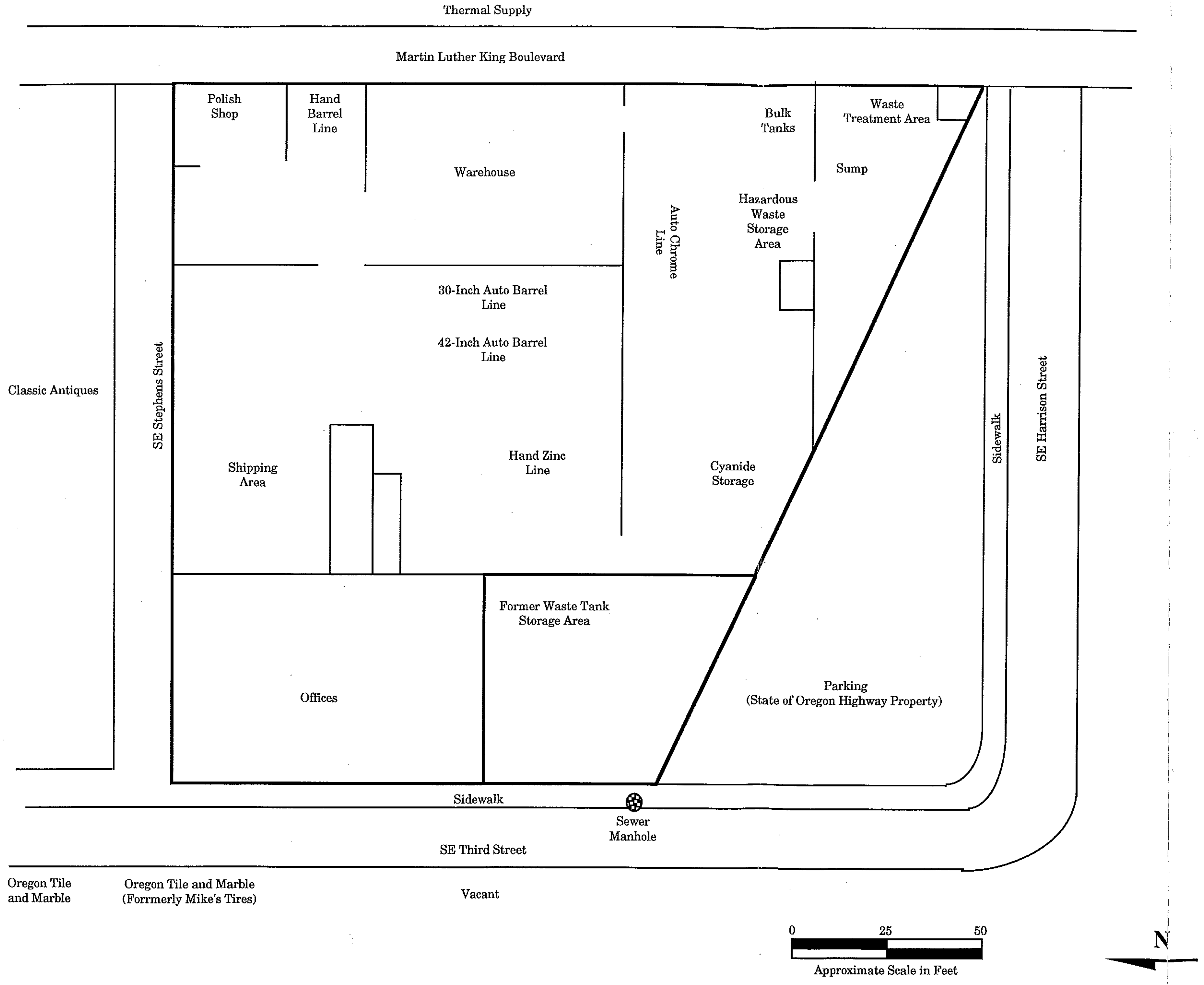


Figure 2

Site Map

Preliminary Assessment
East Side Plating, Inc.
310 SE Stephens Street
Portland, Oregon

HAHN AND ASSOCIATES, INC.

ENVIRONMENTAL MANAGEMENT
434 NW SIXTH AVENUE, SUITE 203
PORTLAND, OREGON 97209
(503) 796-0717

April 1995

Project #2755

APPENDIX B
PNG Boring Logs

BORING / WELL LOG

ID B - 1

PNG Environmental, Inc.

Page 1 of 3

Project Number: 1197-03		**Boring Start (Date / Time):** 08/22/2022 0800	
Project Name: East Side Plating Plant #4		**Boring End (Date / Time):** 08/22/2022 1145	
Location: 310 SE Stephens St, Portland, OR		**Contractor:** Cascade Drilling	
Logger: Jay Greifer		**Equipment:** Geo-Probe 7720DT	

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
						Asphalt 2.5" w/ trace gravel
		0			1	
B1/1.5	809	0				Silt w/ trace sand - Reddish Brown, Dry
		0			2	low Plastic, v. stiff - NOOSD
		0			3	
		0			4	
		0			5	
						Silt w/ sand - AA NOOSD
		0			6	
		0			7	
		0			8	
		0			9	@ 9' Very Moist (not wet)
		0			10	@ 9.5 = 3" Zone w/ Angular Gravel 1/8→1" Dia Dry
		0			11	Silt w sand AA NOOSD
		0			12	
		0			13	Sandy Gravel - Brown, Dry - Med. Grain Sand
		0			14	1/8 → 1 1/2" Gravel - Angular + rounded NOOSD
B1/14.5	0822	0				
		0			15	
		0				
					16	Sandy Gravel - AA - NOOSD
		0				
					17	
		0				
					18	
		0				
					19	
					20	

1-2 & 14-15 RPM/ GW all

BORING / WELL LOG

ID B-1

PNG Environmental, Inc.

Page 2 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/22/2022
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/22/2022
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						**USCS Description:**
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			21	Sandy Gravel - AA - NOOSD
		0			22	
		0			23	Sand - Med grain - Brown, Loose, NOOSD Damp => Dry
		0			24	
		0	↓		25	
		0			26	Sand - AA - NOOSD
		0			27	
		0			28	
		0			29	
		0	↓		30	
		0			31	Sand - AA - NOOSD
		0			32	
		0			33	
		0			34	@ 34' ∇
		0	↓		35	Sand w/ Gravel = 1/8 => 1" Dia. Rounded & angular - Hard Sand = Med Grain, Damp only - NOOSD
		0			36	
		0			37	Sand w/ Gravel AA - Dry - Dense - NOOSD
		0			38	
		0			39	Sand - As Previous - Dry - NOOSD
		0	↓		40	

BORING / WELL LOG

ID B - 1

PNG Environmental, Inc.

Page 3 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/22/2022
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/22/2022
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			41	Sandy Gravel ~~AA~~ as previous - Damp → Dry - No OSD
		0			42	
		0			43	Sand - Lt Brown, Med Grain (Fine Grain 44.-45.) Damp → Moist No OSD
		0			44	
		0			45	
		0			46	Sand - AA - No OSD ▽ 45.2 in TWP
		0			47	Wet ≈ 47' Set 3/4" 0.010 Slot Screen
		0			48	
		0			49	
		0			50	Abandoned 3/8" BC, Asphalt Patch to grade 2 Bags
					51	
					52	
					53	
					54	
					55	
					56	
					57	
					58	
					59	
					60	

BORING / WELL LOG

ID B-2

PNG Environmental, Inc.

Page 1 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/22/2022 /1238
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/22/2022 /1529
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling ~~125~~
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

B2/1.5

Sample Information

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			1	Concrete Floor 5" + 2" Pea Gravel Bed
B2/1.5	1244	0 0			2	Silt w/ trace Sand - Reddish Brown, Dry Semi Plastic, Semi Stiff - NOOSD
		0			3	
		0			4	
		0			5	
		0			6	Silt w/ Sand - AA - NOOSD
		0			7	
		0			8	
		0			9	Very moist @ 9' - (NOT WET)
		0			10	@ 9.75' Gravel w/ Sand 1/8→1" angular & rounded 3" ZONE
		0			11	Silt w/ Sand - As Previous - softer, damp, NOOSD
		0			12	
		0			13	
		0			14	Sandy Gravel, Gray/Brown, Dry, Med/Coarse Sand 1/8-1" Gravel, angular & rounded, NOOSD, Dry
B2/14.5	1258	0			15	
		0			16	Low Recovery - Push Rock in shoe 16-20 Sandy Gravel AA - NO OSD
					17	
					18	
					19	
					20	

BORING / WELL LOG

ID B-2

PNG Environmental, Inc.

Page 2 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/ 22/2022
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/ 22/2022
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						**USCS Description:**
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			21	Sandy Gravel -AA- NO OSD, Dry
		0			22	Sand - Med Grain, ~~Olv~~ olive gray, loose, Dry NO OSD
		0			23	
		0			24	
		0			25	
		0			26	
		0			27	Sand - AA - Dry - NO OSD
		0			28	
		0			29	
		0			30	Sandy Gravel w/ Some Silt ≈1/8→1/4+" Gravel Fine grain Sand. Dry NO OSD
		0			31	
		0.1			32	Sandy Gravel w/ Some Silt AA - NO OSD
		0			33	
		0			34	Sand - Med Grain - olive gray/Brown color
		0			35	Med dense. dry→Damp NO OSD
		0			36	Sand - AA - trace rounded gravel ≈ #4 1/4" rocks - mostly sand core
		0			37	NO OSD
		0			38	
		0			39	
		0			40	

BORING / WELL LOG

ID B-2

PNG Environmental, Inc.

Page 3 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/ 22/2022
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/ 22/2022
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						**USCS Description:**
Sample ID	**Time**	**PID (ppm)**	**Recovery**	**Water**	**Depth (ft)**	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			41	Sand- Fine → Med Grain - Light / Dark Brown Dry → Damp, - no OSD
		0			42	
		0			43	
		0			44	
		0			45	
		0.1			46	Sand- AA wet @ 47'
		0			47	Set 3/4" PVC 0.010 screen 45-50'
		0		▽	48	47.37 in TWP ▽ ABD w/ 3/8" BC, concrete to grade 2 Bags
		0			49	
		0			50	
					51	
					52	
					53	
					54	
					55	
					56	
					57	
					58	
					59	
					60	

BORING / WELL LOG

ID B 3

PNG Environmental, Inc.

Page 1 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/22/2022 1531
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/23/2022 0829
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			1	Concrete Floor 5½"
B3/1.5	1537	0.1			2	Silt w/ trace Sand - Reddish Brown, Dry Semi Plastic, Semi Stiff - NO OSD
		0.1			3	
		0			4	
		0			5	
		0			6	Silt w/ Sand - AA - NO OSD
		0			7	
		0			8	
		0			9	
		0			10	> 9.8' Gravel w/ Sand, Almost Moist, Brown (1" ⇒ 1/8 gravel) NO OSD
		0.1			11	Silt w/ Sand - As previous
		0.1			12	
		0.1			13	Sandy Gravel, Gray/Brown, Dry, Med Grain Sand 1/8 ⇒ 1+" Gravel, angular + rounded, Dry, NO OSD
		0.1			14	
B3/14.5	1549	0			15	
		0			16	
		0.1			17	Sandy Gravel - AA - Dry - NO OSD
		0.1			18	
		0			19	
		0			20	

BORING / WELL LOG

ID B-3

PNG Environmental, Inc.

Page 2 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/22/2022
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/23/2022 0829
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information / **USCS Description:**

Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description
		0.1			21	Sandy Gravel As Above - NO OSD Dry
		0.1			22	
		0.1			23	
		0.1			24	Sand - Med Grain, Olive gray, loose, Dry NO OSD
		0.1			25	
		0.1			26	
		0			27	
		0			28	Sand - AA - NO OSD
		0			29	
		0			30	
		0.1			31	Sandy Gravel w/ trace Silt; 1/8 → 1+" rock, Fine → Med Grain Sand, Dry. NO OSD
		0.0			32	
		0.1			33	Sand As Previous - Dry - NO OSD
		0.1			34	
		0			35	
		0.2			36	Sandy Gravel - Slough - NO OSD, Dry
		0.2			37	Sand - AA - NO OSD, Dry
		0.1			38	
		0			39	
		0			40	

BORING / WELL LOG

ID B-3

PNG Environmental, Inc.

Page 3 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	08/22/2022
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/23/2022 0829
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0.1			41	Sand- Fine→Med Gray- Brown Dry→Damp NO OGD
		0.1			42	
		0			43	
		0			44	
		0.1			45	
		0			46	Sand-AA, wet @ 48 set 3/4" PVC Scrn 50-45'
		0			47	
		0.1			48	
		0.1			49	
		0.1			50	08-23-22 @ 0740 GW samples collected
					51	ABD w/ 3/8" BC. Concrete to grade
					52	2 1/2 Bags
					53	
					54	
					55	
					56	
					57	
					58	
					59	
					60	

BORING / WELL LOG

ID B - 4

PNG Environmental, Inc.

Page 1 of 1

Project Number:	1197-03	**Boring Start (Date / Time):**	08/23/2022 0856
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/23/2022 0927
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information | **USCS Description:**

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			1	Concrete Slab- 5"
B4/1.5	0910	0 0			2	Silt w/ trace Sand - Reddish Brown, Soft Dry ⇒ Damp, Semi-Plastic, NOOSD
		0			3	
		0			4	
		0			5	
		0			6	Silt w/ Sand - AA - NOOSD
		0.1			7	
		0.1			8	
		0.1			9	
		0			10	⇒ trace gravel noted 9.75 ⇒ 9.5' NOOSD - ok
		0			11	— Sandy Gravel w/ trace Silt, Dry, Med Grain Sand 1/8 ⇒ 1+" gravels, angular rounded - NOOSD
		0			12	
		0			13	
		0			14	
B4/14.5	0921	0 0			15	ABD w/ 3/8" BL & line to grade
					16	
					17	
					18	
					19	
					20	

1.5 & 14.5 PP, Gx, Dx, VOC

BORING / WELL LOG

ID B-5

PNG Environmental, Inc.

Page 1 of 1

Project Number:	1197-03	**Boring Start (Date / Time):**	08/23/2022 1015 core
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/23/2022 1052
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
						Concrete floor ≈ 5"
		0			1	
B5/1.5	1037	0				Silt w/ trace Sand, Reddish Brown, Soft Dry, Non plastic, NOOSD
		0			2	
		0			3	
		0			4	
						Silt - Reddish brown, Semi Plastic, Dry Med Stiff - NOOSD
		0			5	
		0			6	
						Silt - AA - NOOSD
		0			7	
		0			8	Silt w/ trace Sand - As previous + moist NOOSD
		0			9	- @ 9' = 1" Gravel layer, Angular, Hard, Dry - NOOSD
						3 silt w/ trace sand, as previous - NOOSD
		0			10	~~silty~~ jf Sandy Silt w/ Gravel, Damp Brown NOOSD
		0			11	Silty Sand w/ Gravel, Dry → Damp - Reddish Brown, Gray Gravel 1/8"-1" Dia Rounded + angular NOOSD
		0			12	
		0			13	
		0			14	
B5/14.5	1050	0 0				
					15	ABD w/ 3/8" B
					16	
					17	
					18	
					19	
					20	

1-2 PPM VOC
14-15 PPM

NOTE: Low Clearance, cut hole in Ceiling for Mast.

BORING / WELL LOG

ID B-6

PNG Environmental, Inc.

Page 1 of 1

Project Number:	1197-03	**Boring Start (Date / Time):**	08/23/2022 1054
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/23/2022 1113
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			1	Concrete Floor 6" Gravel
B6/1.5	1058	0				
		0			2	Silt w/ trace Sand - Brown, Soft => Med Stiff Dry Semi Plastic NO OSD
		0			3	
		0			4	
		0			5	3 2½" Gravel Zone 3 Silt w/ trace Sand - AP
		0			6	> Silt w/ Sand & Gravel, Dry NOOSD
		0			7	Sandy Silt - Brown, Damp, non Plastic Med Stiff, NOOSD
		0			8	
		0			9	
		0			10	
		0			11	Silty Sandy Gravel, Dense, Brown/Gray Dry "1/8-1+" Gravel
		0			12	
		0			13	
		0			14	
B6/14.5	1109	0				
		0			15	
					16	
					17	ABD w/ 3/8" BC
					18	
					19	
					20	

BORING / WELL LOG

ID B - 7

PNG Environmental, Inc.

Page 1 of 1

Project Number: 1197-03		**Boring Start (Date / Time):** 08/23 /2022 1224	
Project Name: East Side Plating Plant #4		**Boring End (Date / Time):** 08/23/2022 1240	
Location: 310 SE Stephens St, Portland, OR		**Contractor:** Cascade Drilling	
Logger: Jay Greifer		**Equipment:** Geo-Probe	

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0.1			1	Concrete slab - on concrete slab - (14" Total)
B7/1.5	1229	0.1			2	Fine Sand w/ trace silt - Brown, dry loose - NOESD
		0.1			3	
		0			4	
		0			5	Silt w/ trace sand. Brown, moist, semi plastic NOESD
		0			6	
		0.1			7	Silty Sandy Gravel - Brown, 1/8→1" gravel Med→Fine grain sand. Dry NOESD
		0			8	
		0			9	Sand w/ some Gravel. Brown, Med grain Sand Dry NOESD
		0.1			10	trace silt @ 9.5' NOESD
		0			11	
		0			12	Sand w/ Gravel AA - NOESD Dry→Damp only
		0.1			13	
		0.1			14	ABD w/ 3/8" BC
B7/14.5	1236	0			15	
					16	
					17	
					18	
					19	
					20	

1-2 PP VOC
14-15 PP

BORING / WELL LOG

ID B-8

PNG Environmental, Inc.

Page 1 of 1

Project Number:	1197-03	**Boring Start (Date / Time):**	08/23/2022 1241
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/ /2022, 1257
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
						Concrete Floor 5"
		0			1	
B8/1.5	1246	0				Sand w/ some silt - Sand = Fine. Damp = Dry
		0			2	brown. Orange Brick noted @ 1' bg
		0			3	
		0			4	
		0			5	Silt w/ trace sand, Very Moist, Brown, Soft non plastic NOOSD
		0			6	~~Silt w/~~ 8' Silty Sand w/ Gravel, Brown
		0			7	damp. Rounded & angular gravel. Med → Fine Sands - NOOSD
		0			8	
		0			9	Silt w/ trace sand: Moist, Fine sand - Soft - NOOSD
		0			10	Sandy Gravel - Brown, Damp/dry, hard, 1/8→1" gravel. NOOSD angular + rounded rock
		0			11	
		0			12	Sandy Gravel - AA - NOOSD
		0			13	
		0			14	
B8/14.5	@ 1255	0				
		0			15	
					16	ABD w/ 3/8" BC
					17	
					18	
					19	
					20	

JJ

BORING / WELL LOG

ID B-9 NINE

PNG Environmental, Inc.

Page 1 of 1

Project Number:	1197-03	**Boring Start (Date / Time):**	08/23/2022 1455
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	08/23/2022
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe – 420

Sample Information | **USCS Description:** 0→Hand Auger 7720DT

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations	
		0.1			1	Concrete Floor - Poor Condition Weathered Concrete	420
B9/1.5	1509	0.2 0.2			2	Silt w/ trace Sand, Fine grain sands, olive gray Non plastic	420
		0.1			3	Silt w/ trace sand (less sand & more dense) otherwise - AA - NO OSD	420 HA
		0			4	Silt w/ trace Sand AA - NO OSD	
		0			5	Sandy Silt w/ Gravel, Dry, Hard, NO OSD	
		0			6		7720
		0			7	Gravelly Sand w/ trace Silt, Med→Fine grain sand, 1/8→1 1/2" Gravel, Dry, Hard NO OSD	
		0			8		
		0			9		
		0			10		
					11	Gravely Sand w/ Silt AA - NO OSD	
		0.3			12		
		0			13	ABD w/ 3/8" BC	
		0			14		
B9/14.5	1702	0			15		
					16		
					17		
					18		
					19		
					20		

NOTE- B-7 in pit. 38" ↓ floor ~~elev~~ Elevation

BORING / WELL LOG

ID B-10

Page 1 of 3

PNG Environmental, Inc.

Project Number:	1197-03	**Boring Start (Date / Time):**	02/21/2023 0946
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/21/2023 1700
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe 7720DT

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
					1	Asphalt - SE Stephens St. 6"
					2	Silt w/ trace sand - Reddish Brown, Dry → Moist Low Plastic, Med Stiff NOOSD
		0			3	
		0			4	
B10/5	1145	0			5	Set PRT - Soil Gas @ 5' Trace Gravel @ 4.5
					6	Silt w/ trace Gravel, R-Brown, Damp, Semi Plastic - NOOSD Silt w/ trace Sand " " "
		0			7	
		0			8	
		0			9	← Sand Zone
B10/10	1149	0			10	Silty Gravel & Sand - Brown ≤ 1/2" Gravel 1→1/8" Subangular NOOSD
					11	
					12	
		0			13	Silty Gravel & Sand AA - Damp
		0			14	
B10/15	1154	0			15	~~SP Sand - Brown - Med-Lrg Grain Dry - Damp~~ ~~NO~~ JG
					16	Silty Gravel & Sand - AA Damp
		0			17	
		0			18	
		0			19	
B10/20	1200	0			20	SP Sand - Brown, Med - Lrg Grain Sand - Dry - Damp, Loose NOOSD

W - SE Stephens St

BORING / WELL LOG

ID B-10

Page 2 of 3

PNG Environmental, Inc.

Project Number: 1197-03
Project Name: East Side Plating Plant #4
Location: 310 SE Stephens St, Portland, OR
Logger: Jay Greifer

Boring Start (Date / Time): 02/21/2023 0916
Boring End (Date / Time): 02/21/2023 1700
Contractor: Cascade Drilling
Equipment: Geo-Probe

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			21	Sandy Gravel - Brown, Dry → Damp, Rounded & sub-angular gravel, Med Grain Sand Loose - no OSD
		0			22	
		0			23	
		0			24	
B-10/25	1209	0			25	
		0			26	Sandy Gravel AA no OSD
		0			27	
		[illegible]			28	Sand - Brown, Med Grain, Damp - no OSD
		0			29	Gravel w Sand 1+" Moist - no OSD
B10-30	1224	0			30	
		0			31	Gravel w/ Sand - AA no OSD
		0			32	
		0			33	Sand - Brown, Med Grain, Damp - no OSD
		0			34	
B10-35	1242	0			35	
		0			36	Sand AA - (+ more Gravel) no OSD
		0			37	
		0			38	
		0			39	
B10/40	1301	0			40	

BORING / WELL LOG

ID B - 10

Page 3 of 3

PNG Environmental, Inc.

Project Number:	1197-03	**Boring Start (Date / Time):**	02/21/2023 0946
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/21/2023 1700
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
						~~Cont Attach in Sample~~ JG ok
		0			41	Sand w/ some Gravel, Brown, Dry ⇒ dry, Rounded Gravels – NOOSD
		0			42	Sand – Med Grain, Dry – NOOSD
		0			43	
		0			44	Sample Saved (AA) from Hole. ok
B10/45	1334	0			45	Sand- Med Gr, ~~Brown~~, Dry-Moist, NOOSD
		0		▽	46	Slough (Sand & Gravel) ▽ 46.0 in TWP
		0			47	Sand – Med Grain, Brown, Med Dense – Loose
		0			48	Small Wet Zone @ 48'
		0			49	
B10/50	1404	0			50	Drill to 55, Not enough water @ 50 to set TWP
		0			51	Sand-AA-Wet.
		0			52	
		0			53	
		0			54	Set 5' PVC 0.010 slot Screen 55-50 3/4"
—		0			55	
					56	Abandoned w/ 3/8" Bent. chips/6" Conc./6" asphalt patch
					57	Completed!
					58	
					59	
					60	

BORING / WELL LOG

ID B-10

PNG Environmental, Inc.

Page 1 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/21/2023 0946
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/21/2023 1700
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe 7720DT

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
					1	Asphalt - SE Stephens St. 6"
					2	Silt w/ trace Sand - Reddish Brown, Dry → Moist Low Plastic, Low Stiff NOOSD
		0			3	
		0			4	
B10/5	1145	0			5	Set PRT - Soil Gas @ 5' Trace Gravel 4.5
					6	Silt w/ trace Gravel, R-Brown, Damp, Semi Plastic - NOOSD Silt w/ trace Sand " " "
		0			7	
		0			8	
		0			9	Sand Zone
B10/10	1149	0			10	Silty Gravel & Sand - Brown ± 1/2" Gravel 1→1/8" Subangular NOOSD
					11	
					12	
		0			13	Silty Gravel & Sand AA - Damp
		0			14	
B10/15	1154	0			15	~~SP Sand - Brown - Medium Grain Dry Damp~~ ~~NO~~ JG
					16	Silty Gravel & Sand - AA Damp
		0			17	
		0			18	
		0			19	
B10/20	1200	0			20	SP Sand - Brown, Med. Lg Grain Sand - Dry → Damp, Loose NOOSD

W - SE Stephens St

BORING / WELL LOG

ID B-10

Page 2 of 3

PNG Environmental, Inc.

Project Number: 1197-03		**Boring Start (Date / Time):** 02/21/2023 0916	
Project Name: East Side Plating Plant #4		**Boring End (Date / Time):** 02/21/2023 1700	
Location: 310 SE Stephens St, Portland, OR		**Contractor:** Cascade Drilling	
Logger: Jay Greifer		**Equipment:** Geo-Probe	

Sample Information

USCS Description:

Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description
		0			21	Sandy Gravel - Brown, Dry - Damp. Rounded 2 sub-angular gravel, Med Grain Sand Loose ~ no OSD
		0			22	
		0			23	
		0			24	
B-10/25	1209	0			25	
		0			26	Sandy Gravel AA no OSD
		0			27	
		[illegible]			28	Sand · Brown, Med Grain, Damp - no OSD
		0			29	Gravel w Sand 1+" Moist - no OSD
B10-30	1224	0			30	
		0			31	Gravel w/ Sand - AA - no OSD
		0			32	
		0			33	Sand - Brown, Med Grain, Damp - no OSD
		0			34	
B10-35	1242	0			35	
		0			36	Sand - AA - (+ more Gravel) no OSD.
		0			37	
		0			38	
		0			39	
B10/40	1301	0			40	

BORING / WELL LOG

ID B-10

PNG Environmental, Inc.

Page 3 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/21/2023 0946
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/21/2023 1700
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			41	~~Cont Attach to Graphic~~ JG ok Sand w/ some Gravel, Brown, damp-dry, Rounded Gravels – NOOSD
		0			42	
		0			43	Sand – Med Grain, Dry – NOOSD
		0			44	
B10/45	1334	0			45	Sample Taken (AT) from Hole. ok Sand- Med Gr, ~~Brown~~, Dry-Moist, NOOSD
		0		▽	46	Slough (Sands Loose) ▽ 46.0 in TWP
		0			47	
		0			48	Sand – Med Grain, Brown, Med Dense – Loose Small Wet Zone @ 48'
		0			49	
B10/50	1404	0			50	Drill to 55, Not enough water @ 50 to set TWP
		0			51	Sand-AA-Wet.
		0			52	
		0			53	
		0			54	
—		0			55	Set 5' PVC 0.010 slot screen 55-50 3/4"
					56	abandoned w/ 3/8" Bentonite / 6" conc / 6" asphalt patch Completed!
					57	
					58	
					59	
					60	

ID B - 11

BORING / WELL LOG

Page 1 of 3

PNG Environmental, Inc.

Project Number:	1197-03	**Boring Start (Date / Time):**	02/22/2023 0815
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/22/2023 1300
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe 7720DT

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			1	Open soil area btwn Roadway & Sidewalk Silt w/ trace sand Reddish Brown. Dry-moist No OSD
		0			2	Semi plastic, Semi stiff
		0			3	
		0			4	
B11/5	0834	0			5	
		0			6	AA - increased moisture - No OSD
		0			7	
		0			8	
		0			9	- Gravels w/ Sand & Silt, Gray - Subangular
B11/10	0839	0			10	Dry Dense. No OSD
					11	
					12	Gravelly Silty Sand, Brown, Well Graded
		0			13	No OSD
		0			14	
B11/15	0844	0			15	
					16	Gravely Silty Sand - AA No OSD
		0 0			17	
		0			18	
		0			19	
B11/20	0848	0			20	

E - SE Stephens St

ID B-11

BORING / WELL LOG

Page 2 of 3

PNG Environmental, Inc.

Project Number:	1197-03	**Boring Start (Date / Time):**	02/22/2023
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/22/2023
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
						Gravelly Silty Sand - AA - NO OSD
					21	
		0			22	
		0			23	
		0			24	
B11/25	0856	0			25	
						Gravelly Silty Sand - AA
		0			26	SP - Sand - Med Grain. Dense, Damp NO OSD
		0			27	
		0			28	
		0			29	
B11/30	0907	0			30	
					31	
					32	Gravelly Slough SP - SAND - AA - NO OSD
		0			33	
		0			34	
B11/35	0924	0			35	
					36	Above stuck in core - [illegible]
					37	
					38	
					39	
B11/40					40	

BORING / WELL LOG

ID B - 11

PNG Environmental, Inc.

Page 3 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/22/2023
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/22/2023
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						**USCS Description:**
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
B11/40.5	1011	0			41	Sandy Gravel - Moist, Brown, Well Graded, NO OSD
		0			42	
		0			43	Sand - Brown, Moist, Med Grain, Damp-Dry NO OSD
		0			44	
B11/45	1012	0			45	
		0			46	Sand A.A - NO OSD Wet but not saturated. Drill to 55 set Temp
		0			47	
		0			48	
		0			49	
B11/50	1024	0			50	Slow recovery - Wet Tubes @ 55' Set 3/4" PVC 0.010 slot screen
					51	
					52	
					53	
		0			54	
		0			55	ABD w/ 3/8" BC to grade (new sand at top)
					56	
					57	
					58	
					59	
					60	

SE 3rd

BORING / WELL LOG

ID B-12

Page 1 of 3

PNG Environmental, Inc.

Project Number:	1197-03	**Boring Start (Date / Time):**	02/27/2023 1305
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/27/2023 1056
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
						Concrete Sidewalk SE 3rd Ave 6"4"
		0			1	Silt w/ trace sand - Medium Brown
		0			2	Damp-Dry, Non plastic, Non stiff, NOOSD
		0			3	
		0			4	Set Soil Gas Tip 5' bgs
B12/5	0840	0			5	
		0			6	Silt w/ trace Sand AA
		0			7	
		0			8	
		0			9	Silty Gravel w/ Sand - Brown, Well Graded
B12/10	916	0			10	Poorly Sorted, Damp - NOOSD
					11	
					12	
		0			13	Silty Sand & Gravel -AA- NOOSD
		0			14	Sand w/ some Silt, Brown, Loose, Damp NOOSD
B12/15	0821	0			15	
					16	Slough
					17	
		0			18	Silty Sandy Gravel, Brown, Dense W.G., Damp-Dry NOOSD
		0			19	
B12/20	0837	0			20	

HCID + VOC @ 5'

PP Met 5, 10

BORING / WELL LOG

ID B-12

Page 2 of 3

PNG Environmental, Inc.

Project Number:	1197-03	**Boring Start (Date / Time):**	02/ 22/2023 1305
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/ ~~27~~/2023 1056
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			21	Sand - Brown - loose, Med/Large, Well Graded Damp - NOOSD
		0			22	
		0			23	
		0			24	
B12/25	0835	0			25	
		0			26	Sand - AA - NOOSD
		0			27	
		0			28	
		0			29	
B12/30	0845	0			30	
					31	Sand - AA - NOOSD
		0			32	
		0			33	
		0			34	
B12/35	0853	0			35	
		0			36	SAND - AA - NOOSD
		0			37	Sandy Gravel w/ trace Silt - Brown Dry - Rounded Subangular Gravels, NOOSD
		0			38	
		0			39	
B12/40	0915	0			40	

BORING / WELL LOG

ID B-12

Page ______ of ______

PNG Environmental, Inc.

Project Number:	1197-03	**Boring Start (Date / Time):**	02/22/2023 1305
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/27/2023 1056
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						USCS Description:
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
						Sand-Brown, loose, well graded damp
		0			41	Med grain
		0			42	
						Sandy Gravel w/trace silt - As previous - NOOSD
		0			43	
		0			44	Sand-Brown, loose, Med grain - AP - NOOSD
B12/45	0928	0			45	
					46	
						SAND-AA- Damp only [illegible] 50'
		0			47	
		0			48	
		0			49	
B12/50	0932	0			50	
		0			51	Sand-AA- wet - NOOSD
		0			52	≥ 5% trace gravel noted NOOSD
		0			53	Set 3/4" 0.010 slot PVC screen
		0			54	50-55' TWP.
X		0			55	ABD w/ 3/8" BC 55→2'
					56	2→0' concrete to grade
					57	
					58	
					59	
					60	

BORING / WELL LOG

ID B-13

PNG Environmental, Inc.

Page 1 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/27/2023 1103
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/27/2023
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						**USCS Description:**
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			1	Asphalt
		0			2	Silt w/ Trace Sand, Reddish Brown, Dry Sub Plastic - Sub Stiff - NOOSD
		0			3	
		0			4	
13/5	1106	0			5	
		0			6	Silt w/ Trace Sand - AA - NOOSD
		0			7	
		0			8	
		0			9	Increased moisture @ 8'
13/10	1111	0			10	> Small Gravel Zone - NO OSD
					11	Sandy Gravel w/ trace Silt Brown, Dense Damp
		0			12	
		0			13	
		0			14	
13/15	1120	0			15	
		0			16	Sandy Gravel - AA - NOOSD
		0			17	
		0			18	
		0			19	
13/20	1123	0			20	

4' E of Orig B-1) (see soil gas boring / hole)

BORING / WELL LOG

ID B-13

PNG Environmental, Inc.

Page 2 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/27/2023 1103
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/27/2023
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information						**USCS Description:**
Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			21	Sandy Gravels - AA - NOOSD
		0			22	
		0			23	Sand - Med Grain, Brown, Loose Damp → Dry, NOOSD
		0			24	
B13/25	1127	0			25	
		0			26	
		0			27	Sand - AA - NOOSD
		0			28	
		0			29	
B13/30	1135	0			30	
		0			31	Sand AA - NOOSD
		0			32	
		0			33	
		0			34	
B13/35	1150	0			35	
					36	Slough
		0			37	Sand w/ Gravel - Rounded + angular gravel, Med → Coarse grain sand, Brown, Damp, NOOSD
		0			38	Sand - Med grain, Brown, Damp → Dry NOOSD
		0			39	
B13/40	1205	0			40	

BORING / WELL LOG

ID B - 13

PNG Environmental, Inc.

Page 3 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/27/2023 1103
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/27/2023
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description: Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
		0			41	Sand-AA-NOOSD-Damp only
		0			42	
		0			43	
		0			44	
B 13/45	1222	0			45	trace sand slough
		0			46	Sand-AA - wet zone ~~45-50~~ +/- JG 47-49 NOOSD
		0			47	
		0			48	
		0			49	
B 13/50	1237	0			50	[Pull rods + sampler (w/ Pull cap) slipped down hole, move 1' back, clean & advance push to 50, core 50-55] ABD rods
					51	
					52	Set TWP 50-55
					53	
					54	Sand-AA wet Set TWP 55-50 3/4" 0.010 slot PVC screen
—					55	
					56	
					57	
					58	
					59	
					60	

BORING / WELL LOG

ID B - 14

PNG Environmental, Inc.

Page 1 of 3

Project Number: 1197-03		**Boring Start (Date / Time):** 02/27/2023	1548
Project Name: East Side Plating Plant #4		**Boring End (Date / Time):** 02/28/2023	1000
Location: 310 SE Stephens St, Portland, OR		**Contractor:** Cascade Drilling	
Logger: Jay Greifer		**Equipment:** Geo-Probe	

Sample Information						**USCS Description:** Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations
Sample ID	**Time**	**PID (ppm)**	**Recovery**	**Water**	**Depth (ft)**	
					1	Gravel cover / Soil
					2	
		0			3	Silt w/ Sand & Gravel - Brown, Moist, NOOSD
		0			4	
B 14/5	1553	0			5	Sand - Brown, Med Grain - Loose Very Moist - NOOSD
					6	
					7	
					8	Low recovery
		0			9	Sandy Gravel w/ Silt, Brown, dry → damp dense NOOSD
B 14/10	1603	0			10	
					11	
					12	Sandy Gravel w/ Silt AA - NOOSD
		0			13	
		0			14	
B 14/15	1608	0			15	
		0			16	Sandy Gravel w/ Silt AA - NOOSD
		0			17	
		0			18	Gravelly Sand, Lt brown, Med Grain Med Dense - Damp → Dry - NOOSD
		0			19	
B 14/20	1611	0			20	

BORING / WELL LOG

ID B-14

PNG Environmental, Inc.

Page 2 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/~~27~~ 27/2023 1548
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/28/2023 ≈1000
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information

USCS Description:

Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description
		0			21	Gravelly Sand AA - NO OSD
		0			22	Sand - SP - Med to Coarse Grain - Dry NOOSD
		0			23	
		0			24	
B14/25	1025	0			25	
		0			26	
		0			27	Sand - AA - NO OSD
		0			28	
					29	
B14/30	1637 JG	~~1637~~ 0			30	
		0			31	Gravelly Sand - AP (20-22') NOOSD
		0			32	
		0			33	Sand - SP - AP (22-30) NOOSD
		0			34	
B14/35	1647	0			35	(slough)
		0			36	Sand - AA - NOOSD
		0			37	
		0			38	
		0			39	
B14/40	1709	0			40	

BORING / WELL LOG

ID B-14

PNG Environmental, Inc.

Page 3 of 3

Project Number:	1197-03	**Boring Start (Date / Time):**	02/27/2023 1548
Project Name:	East Side Plating Plant #4	**Boring End (Date / Time):**	02/28/2023 1000
Location:	310 SE Stephens St, Portland, OR	**Contractor:**	Cascade Drilling
Logger:	Jay Greifer	**Equipment:**	Geo-Probe

Sample Information / **USCS Description:**

Group name, group symbol, grain size percentage, (angularity optional), color, moisture, consistency/density, plasticity, other observations, environmental observations

Sample ID	Time	PID (ppm)	Recovery	Water	Depth (ft)	USCS Description
		0			41	
		0			42	Sand AA - NOOSD
		0			43	
		0			44	
B 14/45	1723	0			45	
					46	45-50 no recovery
					47	
					48	
					49	
					50	
B 14/50G	0815	0 0			51	Sand AA - Wet - NOOSD
		0			52	Installed TWP 1/4" sch40 PVC 0.010 slot screen 55-50'
		0			53	
		0			54	
14—		0			55	abd w/ 3/8" BC to grade
					56	
					57	
					58	
					59	
					60	

02-28-23 JB

APPENDIX C
Data Tables from Previous Reports

Table 1
Soil Analytical Results - Total Metals (mg/kg)
East Side Plating Plant #4
Portland, Oregon

Sample ID	Sample Date	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
B1/1.5	08/22/2022	4.0 U	13	3.3 U	1.3 U	26	31	15	0.053 U	23	3.3 U	0.67 U	2.7 U	81
B1/14.5	08/22/2022	3.3 U	3.0	2.7 U	1.1 U	31	25	2.9	0.028 U	17	2.7 U	0.54 U	2.2 U	57
B2/1.5	08/22/2022	4.0 U	13	3.3 U	1.3 U	40	28	14	0.053 U	20	3.3 U	0.67 U	2.7 U	80
B2/14.5	08/22/2022	3.3 U	2.7	2.8 U	1.1 U	16	27	4.4	0.044 U	16	2.8 U	0.55 U	2.2 U	60
B3/1.5	08/22/2022	3.7 U	9.5	3.1 U	1.2 U	26	17	11	0.049 U	16	3.1 U	0.61 U	2.4 U	74
B3/14.5	08/22/2022	3.2 U	2.3	2.7 U	1.1 U	9.6	22	2.8	0.043 U	14	2.7 U	0.54 U	2.2 U	50
B4/1.5	08/23/2022	4.3 U	12	3.5 U	52	171	30	14	0.057 U	29	3.5 U	0.71 U	2.8 U	102
B4/14.5	08/23/2022	3.6 U	1.7	3.0 U	1.2 U	9.3	20	2.7	0.048 U	11	3.0 U	0.59 U	2.4 U	51
B5/1.5	08/23/2022	3.9 U	14	3.2 U	4.9	26	12,000	18	0.052 U	421	3.2 U	0.65 U	2.6 U	94
B5/14.5	08/23/2022	3.4 U	3.1	2.8 U	1.1 U	11	27	3.0	0.045 U	11	2.8 U	0.56 U	2.2 U	52
B6/1.5	08/23/2022	3.9 U	6.8	3.3 U	55	26	143	73	0.12	5,890	3.3 U	0.93	2.6 U	3,280 U
B6/14.5	08/23/2022	3.2 U	1.7	2.7 U	19	14	22	2.1 U	0.043 U	242	2.7 U	0.53 U	2.1 U	42
B7/1.5	08/23/2022	3.4 UJ	4.5	2.8 U	1.1 U	28	23 J	4.4 J	0.045 U	61 J	2.8 U	0.56 U	2.2 UJ	58 J
B7/14.5	08/23/2022	3.4 U	2.0	2.8 U	1.1 U	26	24	2.7	0.045 U	14	2.8 U	0.56 U	2.2 U	46
B8/1.5	08/23/2022	4.1 U	4.6	3.4 U	1.4 U	18	19	5.5	0.054 U	62	3.4 U	0.68 U	2.7 U	60
B8/14.5	08/23/2022	3.3 U	1.7	2.7 U	1.1 U	8.4	17	3.0	0.043 U	42	2.7 U	0.54 U	2.2 U	50
B9/1.5	08/23/2022	4.1 U	16	3.4 U	1.4 U	392	25	59	0.055 U	9.7	3.4 U	1.2	2.7 U	249
B9/14.5	08/23/2022	3.2 U	3.1	2.7 U	9.4	14	20	2.9	0.043 U	84	2.7 U	0.53 U	2.1 U	178
B12/5	02/27/2023	4.1 U	7.9	3.4 U	1.4 U	20	22	13	0.054 U	18	3.4 U	0.68 U	2.7 U	73
B12/10	02/27/2023	3.3 U	1.9	2.8 U	1.1 U	10	16	3.7	0.044 U	14	2.8 U	0.55 U	2.2 U	50
B13/5	02/27/2023	4.1 U	8.5	3.4 U	26	19	24	13	0.055 U	29	3.4 U	0.68 U	2.7 U	75
B13/10	02/27/2023	4.0 U	4.8	3.3 U	1.3 U	19	20	6.7	0.053 U	24	3.3 U	0.66 U	2.6 U	65
B14/5	02/27/2023	3.8 U	4.5	3.2 U	1.8	32	22	6.8	0.051 U	106	3.2 U	0.64 U	2.6 U	83
B14/10	02/27/2023	3.2 U	2.4	2.7 U	2.4	30	29	4.5	0.043 U	31	2.7 U	0.54 U	2.2 U	54
DEQ RBC Screening Level Criteria for Soil[a]														
Ingestion, Dermal Contact, and Inhalation														
Occupational		NA	1.9	2,300	1,100	>Max	47,000	800	350	22,000	NA	5,800	NA	NA
Construction Worker		NA	15	700	350	530,000	14,000	800	110	7,000	NA	1,800	NA	NA
Excavation Worker		NA	420	19,000	9,700	>Max	390,000	800	2,900	190,000	NA	49,000	NA	NA
Volatilization to Outdoor Air														
Occupational		NA	NV	NV	NV	NV	NV	NV	NV	NV	NA	NV	NA	NA
Vapor Intrusion into Buildings														
Occupational		NA	NV	NV	NV	NV	NV	NV	NV	NV	NA	NV	NA	NA
Default Background Concentrations[b]														
Portland Basin		0.56	8.8	2.0	0.63	76	34	79	0.23	47	0.71	0.82	5.2	180

Note:

[a] Oregon Department of Environmental Quality (DEQ) Generic Risk-based concentrations (revised May 2018).

[b] DEQ, Background Levels of Metals in Soils for Cleanups Fact Sheet, Table 1 (updated January 25, 2018)

Metals analyzed by EPA Method 6020B

Mercury analyzed by EPA Method 7471B

mg/kg = milligrams per kilogram

J = Data Validation Qualifier. The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample. See the data validation report for additional information.

U = Undetected at method reporting limit shown

NA = Not applicable

>Max indicates the DEQ regards this concentration as not being "physically possible" since the constituent RBC exceeds likely free-phase levels

NV = This chemical is considered "nonvolatile" for purposes of the exposure calculations.

Table 2
Soil Analytical Results - Fuels and Volatile Organic Compounds (mg/kg)
East Side Plating Plant #4
Portland, Oregon

Location	Sample Date	GRO	DRO	RRO	PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	Vinyl Chloride	1,1,1-TCA	1,1,2-TCA	1,1-DCA	Benzene	Ethylbenzene	Toluene	Total Xylenes	Naphthalene
B4/1.5	08/23/2022	6.8 U	5.7 U	14 U	0.0068 U	0.0034	0.0068 U	0.014 U	0.0068 U	0.0068 U	0.0068 U	0.0068 U	0.0068 U	0.0027 U	0.0068 U	0.014 U	0.018 U	0.034 U
B4/14.5	08/23/2022	5.2 U	4.8 U	12 U	0.0052 U	0.0021 U	0.0052 U	0.010 U	0.0052 U	0.0052 U	0.0052 U	0.0052 U	0.0052 U	0.0021 U	0.0052 U	0.010 U	0.014 U	0.026 U
B5/1.5	08/23/2022	-	-	-	0.0057 U	0.0023 U	0.0057 U	0.012 U	0.0057 U	0.0057 U	0.0057 U	0.0057 U	0.0057 U	0.0023 U	0.0057 U	0.012 U	0.015 U	0.029 U
B6/1.5	08/23/2022	-	-	-	0.34	4.0	0.031	0.0097 U	0.0049 U	0.0049 U	0.0070	0.0049 U	0.0049 U	0.0019 U	0.0076	0.0097 U	0.038	0.024 U
B7/1.5	08/23/2022	-	-	-	0.0052 U	0.0021 U	0.0052 U	0.010 U	0.0052 U	0.0052 U	0.0052 U	0.0052 U	0.0052 U	0.0021 U	0.0052 U	0.010 U	0.014 U	0.026 U
B8/1.5	08/23/2022	-	-	-	0.0065 U	0.0050	0.0065 U	0.013 U	0.0065 U	0.0065 U	0.0065 U	0.0065 U	0.0065 U	0.0026 U	0.0065 U	0.013 U	0.017 U	0.033 U
B9/1.5	08/23/2022	-	-	-	0.0078 U	0.0031 U	0.0078 U	0.016 U	0.0078 U	0.0078 U	0.0078 U	0.0078 U	0.0078 U	0.0031 U	0.0078 U	0.016 U	0.020 U	0.039 UJ
B10/5	02/21/2023	54 U	713	5,040	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/10	02/21/2023	5.2 U	5.2 U	13 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/15	02/21/2023	4.3 U	4.3 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/20	02/21/2023	4.2 U	4.2 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/25	02/21/2023	4.5 U	4.5 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/30	02/21/2023	4.4 U	4.4 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/35	02/21/2023	4.5 U	4.5 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/40	02/21/2023	4.6 U	4.6 U	12 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/45	02/21/2023	4.9 U	4.9 U	12 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B10/50	02/21/2023	5.0 U	5.0 U	13 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/5	02/22/2023	5.6 U	5.6 U	14 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/10	02/22/2023	4.5 U	4.5 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/15	02/22/2023	4.8 U	4.8 U	12 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/20	02/22/2023	4.9 U	4.9 U	12 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/25	02/22/2023	4.6 U	4.6 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/30	02/22/2023	4.4 U	4.4 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/35	02/22/2023	5.3 U	5.3 U	13 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/40.5	02/22/2023	4.8 U	4.8 U	12 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/45	02/22/2023	4.4 U	4.4 U	11 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B11/50	02/22/2023	5.3 U	5.3 U	13 U	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B12/5	02/27/2023	5.4 U	5.4 U	14 U	0.0053 U	0.0021 U	0.0053 U	0.011 U	0.0053 U	0.0053 U	0.0053 U	0.0053 U	0.0053 U	0.0021 U	0.0053 U	0.011 U	0.014 U	0.027 U
B12/10	02/27/2023	4.4 U	4.4 U	11 U	0.0030 U	0.0012 U	0.0030 U	0.0060 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0012 U	0.0030 U	0.0060 U	0.0078 U	0.015 U
B12/15	02/27/2023	4.4 U	4.4 U	11 U	0.0030 U	0.0013	0.0030 U	0.0060 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0012 U	0.0030 U	0.0060 U	0.0078 U	0.015 U
B12/20	02/27/2023	4.6 U	4.6 U	12 U	0.0036 U	0.0014 U	0.0036 U	0.0071 U	0.0036 U	0.0036 U	0.0036 U	0.0036 U	0.0036 U	0.0014 U	0.0036 U	0.0071 U	0.0093 U	0.018 U
B12/25	02/27/2023	4.2 U	4.2 U	11 U	0.0031 U	0.0012 U	0.0031 U	0.0062 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0012 U	0.0031 U	0.0062 U	0.0080 U	0.015 U
B12/30	02/27/2023	4.2 U	4.2 U	11 U	0.0031 U	0.0012 U	0.0031 U	0.0062 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0012 U	0.0031 U	0.0062 U	0.0081 U	0.016 U
B12/35	02/27/2023	4.3 U	4.3 U	11 U	0.0028 U	0.0011 U	0.0028 U	0.0057 U	0.0028 U	0.0028 U	0.0028 U	0.0028 U	0.0028 U	0.0011 U	0.0028 U	0.0057 U	0.0074 U	0.014 U
B12/40	02/27/2023	4.2 U	4.2 U	11 U	0.0029 U	0.0012 U	0.0029 U	0.0059 U	0.0029 U	0.0029 U	0.0029 U	0.0029 U	0.0029 U	0.0012 U	0.0029 U	0.0059 U	0.0076 U	0.015 U
B12/45	02/27/2023	4.5 U	4.5 U	11 U	0.0031 U	0.0017	0.0031 U	0.0062 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0012 U	0.0031 U	0.0062 U	0.0081 U	0.016 U
B12/50	02/27/2023	4.5 U	4.5 U	11 U	0.0043	0.0032	0.0032 U	0.0063 U	0.0032 U	0.0032 U	0.0032 U	0.0032 U	0.0032 U	0.0013 U	0.0032 U	0.0063 U	0.0082 U	0.016 U
B13/5	02/27/2023	5.5 U	5.5 U	14 U	0.0044 U	0.0018 U	0.0044 U	0.0089 U	0.0044 U	0.0044 U	0.0044 U	0.0044 U	0.0044 U	0.0018 U	0.0044 U	0.0089 U	0.012 U	0.022 U
B13/10	02/27/2023	5.3 U	5.3 U	13 U	0.0043 U	0.0017 U	0.0043 U	0.0086 U	0.0043 U	0.0043 U	0.0043 U	0.0043 U	0.0043 U	0.0017 U	0.0043 U	0.0086 U	0.011 U	0.021 U
B13/15	02/27/2023	4.3 U	4.3 U	11 U	0.0030 U	0.0012 U	0.0030 U	0.0060 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0012 U	0.0030 U	0.0060 U	0.0078 U	0.015 U
B13/20	02/27/2023	4.5 U	4.5 U	11 U	0.0032 U	0.0013 U	0.0032 U	0.0064 U	0.0032 U	0.0032 U	0.0032 U	0.0032 U	0.0032 U	0.0013 U	0.0032 U	0.0064 U	0.0083 U	0.016 U
B13/25	02/27/2023	4.2 U	4.2 U	11 U	0.0030 U	0.0012 U	0.0030 U	0.0060 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0012 U	0.0030 U	0.0060 U	0.0078 U	0.015 U
B13/30	02/27/2023	4.3 U	4.3 U	11 U	0.0039 U	0.0016 U	0.0039 U	0.0078 U	0.0039 U	0.0039 U	0.0039 U	0.0039 U	0.0039 U	0.0016 U	0.0039 U	0.0078 U	0.010 U	0.020 U
B13/35	02/27/2023	5.0 U	5.0 U	13 U	0.0038 U	0.0015 U	0.0038 U	0.0075 U	0.0038 U	0.0038 U	0.0038 U	0.0038 U	0.0038 U	0.0015 U	0.0038 U	0.0075 U	0.0098 U	0.019 U
B13/40	02/27/2023	4.2 U	4.2 U	11 U	0.0029 U	0.0012 U	0.0029 U	0.0059 U	0.0029 U	0.0029 U	0.0029 U	0.0029 U	0.0029 U	0.0012 U	0.0029 U	0.0059 U	0.0077 U	0.015 U
B13/45	02/27/2023	5.2 U	5.2 U	13 U	0.0040 U	0.0016 U	0.0040 U	0.0079 U	0.0040 U	0.0040 U	0.0040 U	0.0040 U	0.0040 U	0.0016 U	0.0040 U	0.0079 U	0.010 U	0.020 U
B13/50	02/27/2023	4.9 U	4.9 U	12 U	0.0038 U	0.0022	0.0038 U	0.0076 U	0.0038 U	0.0038 U	0.0038 U	0.0038 U	0.0038 U	0.0015 U	0.0038 U	0.0076 U	0.0098 U	0.019 U
B14/5	02/27/2023	5.1 U	5.1 U	13 U	0.0041 U	0.0016 U	0.0041 U	0.0082 U	0.0041 U	0.0041 U	0.0041 U	0.0041 U	0.0041 U	0.0016 U	0.0041 U	0.0082 U	0.011 U	0.020 U
B14/10	02/27/2023	4.3 U	21	79	0.0030 U	0.0012 U	0.0030 U	0.0059 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0012 U	0.0030 U	0.0059 U	0.0077 U	0.015 U
B14/15	02/27/2023	4.3 U	4.3 U	11 U	0.0029 U	0.0012 U	0.0029 U	0.0058 U	0.0029 U	0.0029 U	0.0029 U	0.0029 U	0.0029 U	0.0012 U	0.0029 U	0.0058 U	0.0075 U	0.015 U
B14/20	02/27/2023	4.4 U	4.4 U	11 U	0.0030 U	0.0012 U	0.0030 U	0.0061 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0030 U	0.0012 U	0.0030 U	0.0061 U	0.0079 U	0.015 U
B14/25	02/27/2023	4.5 U	4.5 UJ	11 U	0.0036 U	0.0014 U	0.0036 U	0.0072 U	0.0036 U	0.0036 U	0.0036 U	0.0036 U	0.0036 U	0.0014 U	0.0036 U	0.0072 U	0.0093 U	0.018 U
B14/30	02/27/2023	4.3 U	4.3 U	11 U	0.0031 U	0.0012 U	0.0031 U	0.0062 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0031 U	0.0012 U	0.0031 U	0.0062 U	0.0081 U	0.016 U
B14/35	02/27/2023	5.0 U	5.0 U	12 U	0.0037 U	0.0015 U	0.0037 U	0.0075 U	0.0037 U	0.0037 U	0.0037 U	0.0037 U	0.0037 U	0.0015 U	0.0037 U	0.0075 U	0.0097 U	0.019 U
B14/40	02/27/2023	4.4 U	4.4 U	11 U	0.0039 U	0.0016 U	0.0039 U	0.0078 U	0.0039 U	0.0039 U	0.0039 U	0.0039 U	0.0039 U	0.0016 U	0.0039 U	0.0078 U	0.010 U	0.020 U

Table 2
Soil Analytical Results - Fuels and Volatile Organic Compounds (mg/kg)
East Side Plating Plant #4
Portland, Oregon

Location	Sample Date	GRO	DRO	RRO	PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	Vinyl Chloride	1,1,1-TCA	1,1,2-TCA	1,1-DCA	Benzene	Ethylbenzene	Toluene	Total Xylenes	Naphthalene
B14/45	02/27/2023	5.3 U	5.3 U	13 U	0.0042 U	0.0017 U	0.0042 U	0.0085 U	0.0042 U	0.0042 U	0.0042 U	0.0042 U	0.0042 U	0.0017 U	0.0042 U	0.0085 U	0.011 U	0.021 U
B14/50.5	02/28/2023	5.1 U	5.1 U	13 U	0.0065	0.0016 U	0.0041 U	0.0082 U	0.0041 U	0.0041 U	0.0041 U	0.0041 U	0.0041 U	0.0016 U	0.0041 U	0.0082 U	0.011 U	0.021 U
DEQ RBC Screening Level Criteria for Soil[a]																		
Ingestion, Dermal Contact, and Inhalation																		
Occupational		20,000	14,000	14,000	1,000	51	2,300	23,000	29,000	4.4	870,000	26	260	37	150	88,000	25,000	23
Construction Worker		9,700	4,600	4,600	1,800	130	710	7,100	13,000	34	470,000	54	3,200	380	1,700	28,000	20,000	580
Excavation Worker		>Max	>Max	>Max	50,000	3,700	20,000	200,000	370,000	950	>Max	1,500	89,000	11,000	49,000	770,000	560,000	16,000
Volatilization to Outdoor Air																		
Occupational		69,000	>Max	>Max	>Csat	96	>Max	>Max	>Csat	89	>Csat	24	240	50	160	>Csat	>Csat	83
Vapor Intrusion into Buildings																		
Occupational		>Max	>Max	>Max	36	2.3	>Max	>Max	630	2.2	>Csat	4.2	5.9	2.1	17	>Csat	>Csat	83
Leaching to Groundwater																		
Occupational		130	>Max	>Max	1.9	0.087	4.5	51	32	0.010	880	0.029	0.20	0.10	0.90	490	100	0.34

Notes:

[a] Oregon Department of Environmental Quality (DEQ) Generic Risk-based Concentrations (RBCs) (revised May 2018)

Volatile organic compounds (VOCs) analyzed by EPA Method 8260D

Gasoline range organics (GRO) analyzed by Method NWTPH-Gx

Diesel and Oil range organics (DRO and RRO) analyzed by Method NWTPH-Dx

DCA = Dichloroethane

DCE = Dichloroethene

PCE = Tetrachloroethene

TCA = Trichloroethane

TCE = Trichloroethene

mg/kg = Milligrams per kilogram

U = Undetected at method reporting limit shown

J = Data Validation Qualifier. The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample. See the data validation report for additional information.

\- = Not analyzed for this parameter

NA = Not applicable

>Max indicates the DEQ regards this concentration as not being "physically possible" since the constituent RBC exceeds likely free-phase levels

>Csat = This soil RBC exceeds the limit of three-phase equilibrium partitioning. Refer to "ChemData" page of the RBDM for the corresponding value of Csat. Soil concentrations in excess of Csat indicate that free product might be present. See Section B.2.1.4 for additional information.

Table 3
Groundwater Analytical Results - Total and Dissolved Metals and Cyanide (ug/L)
East Side Plating Plant #4
Portland, Oregon

Sample ID	Sample Date	Total Antimony	Dissolved Antimony	Total Arsenic	Dissolved Arsenic	Total Beryllium	Dissolved Beryllium	Total Cadmium	Dissolved Cadmium	Hexavalent Chromium	Total Chromium	Dissolved Chromium	Total Copper	Dissolved Copper	Total Lead	Dissolved Lead	Total Mercury	Dissolved Mercury	Total Nickel	Dissolved Nickel
B-1	08/22/2022	4.0 U	4.0 U	2.0 U	2.0 U	2.0 U	2.0 U	1.0 U	1.0 U	2.3	3.2	3.4	5.0 U	5.0 U	2.0 U	2.0 U	2.0 U	0.20 U	4.2	4.0
B-2	08/22/2022	4.0 U	4.0 U	2.0 U	2.0 U	2.0 U	2.0 U	1.0 U	1.0 U	0.53	2.0 U	2.0 U	7.7	7.2	2.0 U	2.0 U	0.20 U	0.20 U	17	16
B-3	08/23/2022	4.0 U	4.0 U	2.0 U	2.0 U	2.0 U	2.0 U	1.0 U	1.0 U	0.50 U	2.0 U	2.0 U	18	16	2.0 U	2.0 U	0.20 U	0.20 U	13	13
B-10	02/21/2023	4.0 U	4.0 U	10	2.0 U	8.8	2.0 U	3.7 J	1.0 U	-	140	2.0 U	175	5.0 U	14	2.0 U	2.0 U	0.20 U	175	5.0
B-11	02/22/2023	4.0 U	4.0 U	6.8 J	2.0 U	4.5	2.0 U	6.9	1.0 U	-	46	2.0 U	110 J	5.0 U	21	2.0 U	2.0 U	0.20 U	84 J	3.2
B-12	02/27/2023	40 U	4.0 U	152	2.0 U	25	2.0 U	10 U	1.0 U	-	903	2.0 U	862	5.0 U	268	2.0 U	2.0 U	0.20 U	742	4.2
B-13	02/27/2023	40 U	4.0 U	85	2.0 U	20 U	2.0 U	10 U	1.0 U	-	630	2.0 U	529	6.6	163	2.0 U	2.0 U	0.20 U	455	4.5
B-14	02/28/2023	40 U	4.0 U	69	2.0 U	20 U	2.0 U	10 U	1.0 U	-	151	2.0 U	228	5.0 U	106	2.0 U	2.0 U	0.20 U	699	98
Volatilization to Outdoor Air																				
Occupational		NA	NA	NA	NA	NA	NA	NA	NA	NV	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vapor Intrusion into Buildings																				
Occupational		NA	NA	NA	NA	NA	NA	NA	NA	NV	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW in an Excavation																				
Construction/Excavation		NA	NA	6,300	6,300	270,000	270,000	130,000	130,000	9,400	>S / 9,400	>S / 9,400	5,400,000	5,400,000	>S	>S	>S	>S	>S	>S

Table 3
Groundwater Analytical Results - Total and Dissolved Metals and Cyanide (ug/L)
East Side Plating Plant #4
Portland, Oregon

Sample ID	Sample Date	Total Selenium	Dissolved Selenium	Total Silver	Dissolved Silver	Total Thallium	Dissolved Thallium	Total Zinc	Dissolved Zinc	Total Cyanide
B-1	08/22/2022	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	25 U	25 U	5.0 U
B-2	08/22/2022	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	25 U	25 U	5.0 U
B-3	08/23/2022	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	25 U	25 U	5.0 U
B-10	02/21/2023	6.6	2.0 U	2.0 U	2.0 U	2.0 U	4.5	353	25 U	-
B-11	02/22/2023	3.6 J	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	341	25 U	-
B-12	02/27/2023	20 U	2.0 U	20 U	2.0 U	20 U	2.0 U	2,080	25 U	-
B-13	02/27/2023	20 U	2.0 U	20 U	2.0 U	20 U	2.0 U	1,300	25 U	-
B-14	02/28/2023	20 U	2.0 U	20 U	2.0 U	20 U	2.0 U	580	25 U	-
Volatilization to Outdoor Air										
Occupational		NA	NA	NA	NA	NA	NA	NA	NA	NV
Vapor Intrusion into Buildings										
Occupational		NA	NA	NA	NA	NA	NA	NA	NA	NV
GW in an Excavation										
Construction/Excavation		NA	NA	1,100,000	1,100,000	NA	NA	NA	NA	81,000

Table 3
Groundwater Analytical Results - Total and Dissolved Metals and Cyanide (ug/L)
East Side Plating Plant #4
Portland, Oregon

Note:

[a] Oregon Department of Environmental Quality (DEQ) Generic Risk-Based Concentrations (revised May 2018)

Metals by EPA Method 6020B

Hexavalent Chromium by Method SM3500Cr C-2011

Mercury by EPA Method 7470A

Cyanide by Method SM 4500CN E-2011

ug/L = Micrograms per Liter

U = Undetected at method reporting limit shown

J = Data Validation Qualifier. The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample. See data validation report for additional information.

\- = Not analyzed for this parameter

NA = Not applicable

NV = This chemical is considered "nonvolatile" for purposes of the exposure calculations.

>S = This groundwater RBC exceeds the solubility limit. Refer to Appendix D of the RBDM for the corresponding value of S. Groundwater concentrations in excess of S indicate that free product may be present. See Section B.2.1.4 for additional information.

Table 4
Groundwater Analytical Results - Volatile Organic Compounds (ug/L)
East Side Plating Plant #4
Portland, Oregon

Location	Sample Date	GRO	DRO	RRO	PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	Vinyl Chloride	1,1,1-TCA	1,1,2-TCA	1,1-DCA	Benzene	Ethylbenzene	Toluene	Total Xylenes	Naphthalene
B-1	08/22/2022	100 U	142	424	0.50 U	2.1	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.5 U	2.5 UJ
B-2	08/22/2022	100 U	111 U[1]	278 U[1]	4.1	12	1.2	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.5 U	2.5 UJ
B-3	08/23/2022	100 U	188 [1]	295 U[1]	5.1	13	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.5 U	2.5 U
B-10	02/21/2023	100 U	100 U	250 U	1.2	26	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.5 U	2.5 U
B-11	02/22/2023	100 U	100 U	250 U	1.2	34	0.52	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.5 U	2.5 U
B-12	02/27/2023	200 U	100 U	250 U	1.0 U	3.9	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	3.0 U	5.0 U
B-13	02/27/2023	100 U	111 U	278 U	1.6	3.0	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.5 U	2.5 U
B-14	02/28/2023	100 U	111 U[1]	278 U[1]	2.7	1.1	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.69	0.50 U	2.5	2.5 U
DEQ RBC Screening Level Criteria for Groundwater[a]																		
Ingestion/Inhalation from Tapwater																		
Occupational		450	430	430	48	3.3	260	2,600	1,400	0.49	37,000	1.3	13	2.1	6.4	6,300	830	0.72
Volatilization to Outdoor Air																		
Occupational		>S	>S	>S	>S	20,000	>S	>S	2,400,000	5,900	>S	21,000	68,000	14,000	43,000	>S	>S	16,000
Vapor Intrusion into Buildings																		
Occupational		>S	>S	>S	48,000	3,700	>S	>S	360,000	880	>S	11,000	14,000	2,800	8,200	>S	>S	11,000
GW in an Excavation																		
Construction/Excavation		14,000	>S	>S	5,600	430	18,000	180,000	44,000	960	1,100,000	49	10,000	1,800	4,500	220,000	23,000	500
EPA Vapor Intrusion Screening Levels[b]																		
Commercial		NA	NA	NA	24.2	2.18	105	45.7	82.1	2.45	3,110	2.6	33.4	6.93	15.2	8,070	162	20.1

Notes:

[a] Oregon Department of Environmental Quality (DEQ) Generic Risk-Based Concentrations (RBCs) (revised May 2018)

[b] Environmental Protection Agency (EPA), Vapor Intrusion Screening Level (VISL) Calculator.

[1] Laboratory Qualifier. An aliquot for anaysis was taken from the original container received due to the level of sediment present in the sample. Rinsing of the original container for inclusion in the sample extraction was not performed.

Volatile organic compounds (VOCs) analyzed by EPA Method 8260D
Gasoline Range Organics (GRO) analyzed by Method NWTPH-Gx
Diesel and Residual Range Organics (DRO and RRO) analyzed by Method NWTPH-Dx
ug/L = Micrograms per Liter
DCA = Dichloroethane
DCE = Dichloroethene
PCE = Tetrachloroethene
TCA = Trichloroethane
TCE = Trichloroethene
U = Undetected at method reporting limit shown
J = Data Validation Qualifier. The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
- = Not analyzed for this parameter
NA = Not applicable or Not available
>S = This groundwater RBC exceeds the solubility limit. Refer to Appendix D of the RBDM for the corresponding value of S. Groundwater concentrations in excess of S indicate that free product may be present. See Section B.2.1.4 for additional information.

Table 5
Groundwater Analytical Results - Per- and Polyfluoroalkyl Substances (PFAS) (ng/L)
East Side Plating Plant #4
Portland, Oregon

Sample ID	Sample Date	PFBS	PFHxA	HFPO-DA	PFHpA	ADONA	PFHxS	PFOA	PFNA	PFOS	9C1-PF3ONS	PFDA	MeFOSAA	EtFOSAA	PFUnA	11Cl-PF3OUdS	PFDoA	PFTrDA	PFTeDA
B-1	08/22/2022	13	23	2.0 U	3.0	2.0 U	10	16	2.0 U	573	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
B-2	08/22/2022	21	15	2.0 U	3.2	2.0 U	26	5.6 J	2.0 U	61	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
B-3	08/23/2022	6.5	9.1	2.0 U	4.2	2.0 U	21	11	2.0 U	78	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 UJ
B-10	02/21/2023	5.9	8.4	1.9 U	5.3	1.9 U	20	16	1.9 U	80	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U
B-11	02/22/2023	6.6	9.3	1.9 U	5.1	1.9 U	17	16	3.0	107	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U
B-12	02/27/2023	3.5	4.5	1.8 U	2.9	1.8 U	8.0	8.1	1.8 U	28	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U
B-13	02/27/2023	4.0	3.4	1.9 U	2.1	1.9 U	5.6	4.3	1.9 U	16	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U
B-14	02/28/2023	3.8	6.7	1.9 U	3.8	1.9 U	7.0	8.0	1.9 U	22	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U
EPA Regional Screening Levels[1]																			
Carcinogenic		-	-	-	-	-	-	1,100	-	-	-	-	-	-	-	-	-	-	
Noncarcinogenic		6,000	-	60	-	-	390	60	59	40	-	-	-	-	-	-	-	-	

Notes:

[1] Environmental Protection Agency (EPA) Regional Screening Level (RSL) Resident Soil to GW Table, May 2022.

PFAS analyzed by PFAS Isotope Dilution (Modified Method 537, Vista Analytical Laboratory).

PFBS = Perfluorbutanesulfonic acid
PFHxA = Perfluorohexanoic acid
HFPO-DA = Hexafluoropropylene oxide dimer acid
PFHpA = Perfluoroheptanoic acid
ADONA = 4,8-dioxa-3H-perfluorononanoic acid
PFHxS = Perfluorohexanesulfonoic acid
PFOA = Perfluorooctanoic acid
PFNA = Perfluorononanaoic acid
PFOS = Perfluorooctanesulfonic acid
9C1-PF3ONS = 9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid
PFDA = Perfluorodecanoic acid
MeFOSAA = N-Methylperfluoro-1-octanesulfonamido acetic acid
EtFOSAA = N-Ethyperfluoro-1-octanesulfonamido acetic acid
PFUnA = Perfluoroundecanoic acid
11Cl-PF3OUds = 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid
PFDoA = Perfluorododecanoic acid
PFTrDA = Perfluorotridecanoic acid
PFTeDA = Perfluorotetradecanoic acid
ug/L = Micrograms per Liter
J = Data Validation Qualifier. The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
U = Undetected at method reporting limit shown

Table 6

Air Analytical Results - Volatile Organic Compounds (ug/m^3)

East Side Plating Plant #4
Portland, Oregon

Sample Location	Date	Benzene	Ethylbenzene	PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	1,1-DCA	Vinyl Chloride	Chloroethane	Chloromethane
Indoor Locations												
IA-1	08/12/2023	0.20 U	0.95	0.42 U	0.80	0.25 U	0.25 U	0.25 U	0.25 U	0.16 U	0.33 U	0.43
IA-2	08/12/2023	0.29	3.6	0.33	1.2	0.079 U	0.079 U	0.079 U	0.080 U	0.051 U	0.11 U	1.6
IA-3	08/12/2023	0.18 U	2.5	0.39 U	0.34	0.23 U	0.23 U	0.23 U	0.23 U	0.15 U	0.30 U	0.67
IA-4	08/12/2023	0.22	0.82	0.15	0.32	0.079 U	0.079 U	0.079 U	0.080 U	0.051 U	0.11 U	1.9
IA-5	08/12/2023	0.21	1.2	0.14 U	0.26	0.079 U	0.079 U	0.079 U	0.080 U	0.051 U	0.11 U	2.0
Outdoor Locations												
IA-6	08/12/2023	0.24	0.24	0.19	0.11 U	0.079 U	0.079 U	0.079 U	0.080 U	0.051 U	0.11 U	1.2
DEQ RBC Screening Level Criteria for Soil Gas[a]												
Vapor Intrusion Into Buildings												
Commercial (June 2023)		52	160	1,600	100	5,800	5,800	29,000	260	93	580,000	13,000
DEQ RBC Screening Level Criteria for Air[a]												
Inhalation												
Commercial (June 2023)		1.6	4.9	47	3	180	180	880	7.7	2.8	18,000	390

Table 6

Air Analytical Results - Volatile Organic Compounds (ug/m^3)

East Side Plating Plant #4
Portland, Oregon

Sample Location	Date	Chloroform	1,1,1-TCA	Carbon Tetrachloride	1,2-DCA	1,1,2,2-TCA	1,2-Dibromoethane	1,4-Dichlorobenzene	1,2-Dichloropropane	Vinyl Acetate
Indoor Locations										
IA-1	08/12/2023	0.30 U	0.34 U	0.39 U	0.25 U	0.43 U	0.48 U	0.37 U	0.43 U	0.22 U
IA-2	08/12/2023	0.097 U	0.11 U	0.55	0.084	0.14 U	0.15 U	0.12 U	0.14 U	0.070 U
IA-3	08/12/2023	0.28 U	0.31 U	0.36 U	0.23 U	0.40 U	0.44 U	0.35 U	0.40 U	0.20 U
IA-4	08/12/2023	0.097 U	0.11 U	0.55	0.090	0.14 U	0.15 U	0.12 U	0.14 U	0.070 U
IA-5	08/12/2023	0.097 U	0.11 U	0.58	0.087	0.14 U	0.15 U	0.12 U	0.14 U	0.070 U
Outdoor Locations										
IA-6	08/12/2023	0.097 U	0.11 U	0.57	0.081 U	0.14 U	0.15 U	0.12 U	0.14 U	0.070 U
DEQ RBC Screening Level Criteria for Soil Gas[a]										
Vapor Intrusion Into Buildings										
Commercial (June 2023)		18	730,000	68	16	7.1	0.68	37	110	29,000
DEQ RBC Screening Level Criteria for Air[a]										
Inhalation										
Commercial (June 2023)		0.53	22,000	2	0.47	0.21	0.02	1.1	3.3	880

Table 6
Air Analytical Results - Volatile Organic Compounds (ug/m^3)
East Side Plating Plant #4
Portland, Oregon

Notes:

[a] Oregon Department of Environmental Quality (DEQ) Generic Risk-based concentrations (revised May 2018). An update to guidance and RBCs for volatilization to indoor air pathways based on EPA Vapor Intrusion Screening Levels was released June 2023.

Volatile organic compounds (VOCs) analyzed by Modified TO-15 SIM

ug/m^3 = Micrograms per cubic meter

DCA = Dichloroethane

DCE = Dichloroethene

PCE = Tetrachloroethene

TCA = Trichloroethane

TCE = Trichloroethene

TMB = Trimethylbenzene

U = Undetected at method reporting limit shown

Table 7
Soil Vapor Analytical Results - Volatile Organic Compounds (ug/m^3)
East Side Plating Plant #4
Portland, Oregon

Location	Date	Gasoline	Benzene	Toluene	Ethylbenzene	Total Xylenes	PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	1,1-DCA	Vinyl Chloride	Freon 12	Chloromethane
SG-1	08/31/2022	-	1.7	17	7.6	47	5,590	3,740	1.1	0.79 U	0.79 U	1.1	0.51 U	2.3	0.41 U
SG-2	08/31/2022	-	1.1	20	8.8	51	957	1,610	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	2.1	0.41 U
SG-3	08/31/2022	-	0.83	20	9.8	60	434	1,080	0.79 U	1.7	0.79 U	2.0	0.51 U	2.3	0.41 U
B-10	02/21/2023	8,180	34	186	715	3,330	165	45	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	0.99 U	0.86
B-11	02/22/2023	4,590	27	127	228	1,070	285	1,130	86	2.7	0.79 U	0.80 U	0.51 U	2.0	0.98
B-12	02/22/2023	826 U	1.4	11	9.0	48	5.7	9.0	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	2.4	0.81
B-13	02/27/2023	1,170 J	14	105	54	233	1.4 U	2.4	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	2.4	1.6
B-14	02/27/2023	826 U	5.1	35	29	135	18	12	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	2.5	0.41 U
SG-4	03/02/2023	1,280 J	0.64 U	1.9 U	3.1	12	686	308	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	0.99 U	0.41 U
SG-5	03/02/2023	1,690 J	0.64 U	1.9 U	1.9	8.1	1,060	1,820	4.5	0.79 U	0.79 U	0.80 U	0.51 U	2.2	0.41 U
SG-6	03/02/2023	826,000 U	0.99	1.9 U	2.6	9.5	35,800	23,800	112	16	3.4	16	0.51 U	2.2	0.41 U
SG-7	03/02/2023	14,200	4.3	1.9 U	3.1	17	5,210	26,400	1,240	113	6.3	19	0.51 U	2.1	0.41 U
SG-8	03/02/2023	4,670	0.64 U	1.9 U	2.1	7.4	1,430	6,000	10	9.4	1.7	19	0.51 U	2.2	0.41 U
SG-9	03/02/2023	12,400	1.6	1.9 U	1.0	4.7	443	34,900	54	8.2	7.7	73	0.51 U	2.1	0.43
SG-10	03/02/2023	1,250 J	0.64 U	2.7	2.6	11	930	304	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	1.9	0.41 U
SG-11	03/02/2023	826 U	0.64 U	1.9 U	2.2	9.8	40	58	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	1.7	0.41 U
SG-12	03/02/2023	3,260	0.64 U	1.9	3.3	15	259	342	0.79 U	0.79 U	0.79 U	0.80 U	0.51 U	2.1	0.41 U
SG-13	03/02/2023	1,620 J	0.64 U	7.5	3.7	16	1,370	377	1.4	1.1	1.4	1.9	0.51 U	2.2	0.41 U
DEQ RBC Screening Level Criteria for Soil Gas[a]															
Vapor Intrusion Into Buildings															
Commercial (June 2023)		40,000	52	730,000	160	15,000	1,600	100	5,800	5,800	29,000	260	93	15,000	13,000
DEQ RBC Screening Level Criteria for Air[a]															
Inhalation															
Commercial (June 2023)		1,200	1.6	22,000	4.9	440	47	3	180	180	880	7.7	2.8	440	390

Table 7
Soil Vapor Analytical Results - Volatile Organic Compounds (ug/m^3)
East Side Plating Plant #4
Portland, Oregon

Location	Date	Chloroform	1,1,1-TCA	Carbon Tetrachloride	1,3-Butadiene	Freon 11	Ethanol	Acetone	2-Propanol	Carbon Disulfide	Methylene Chloride	n-Hexane	2-Butanone	Cyclohexane	1,4-Dioxane
SG-1	08/31/2022	75	94	1.3 U	4.4 U	1.5	13	5.4	3.1 U	0.62 U	0.69 U	2.2 U	3.7 U	0.69 U	0.72 U
SG-2	08/31/2022	0.97 U	85	1.3 U	4.4 U	1.5	136	12	3.1 U	0.62 U	0.69 U	2.2 U	6.6	0.69 U	0.72 U
SG-3	08/31/2022	15	40	1.3 U	4.4 U	1.6	76	15	3.8	0.99	1.1	2.2 U	6.6	0.69 U	1.4
B-10	02/21/2023	0.97 U	1.1 U	1.3 U	13	1.1 U	219 J	103	22	0.62 U	0.69 U	124	40	43	0.72 U
B-11	02/22/2023	0.97 U	1.1 U	1.3 U	4.4 U	1.1 U	70	105	14	0.78	0.69 U	70	27	28	0.72 U
B-12	02/22/2023	13	1.1 U	1.3 U	4.4 U	1.4	18	48	15	0.62 U	0.69 U	2.2 U	10	0.90	0.72 U
B-13	02/27/2023	0.97 U	1.1 U	1.3 U	4.4 U	1.3	49	36	13	1.0	1.3	13	7.1	1.9	0.72 U
B-14	02/27/2023	22	1.4	1.3 U	4.4 U	6.7	17	25	4.0	0.62 U	0.69 U	5.5	4.3	0.69 U	0.72 U
SG-4	03/02/2023	22	5.0	1.3 U	4.4 U	2.3	10	3.0 U	3.1 U	0.62 U	0.69 U	2.2 U	3.7 U	0.69 U	0.72 U
SG-5	03/02/2023	3.5	65	1.3 U	4.4 U	1.2	5.5	3.0 U	3.3	0.62 U	0.69 U	2.2 U	3.7 U	0.69 U	0.72 U
SG-6	03/02/2023	47	32	1.3 U	4.4 U	1.4	2.6	3.0 U	3.1 U	0.62 U	0.69 U	2.2 U	3.7 U	0.69 U	0.72 U
SG-7	03/02/2023	57	134	1.3 U	4.4 U	3.4	63	16	8.8	0.62 U	0.69 U	2.2 U	3.7 U	0.77	0.72 U
SG-8	03/02/2023	236	11	1.3 U	4.4 U	4.8	3.4	4.3	3.1 U	0.62 U	4.9	2.2 U	3.7 U	0.69 U	0.72 U
SG-9	03/02/2023	34	45	1.3 U	4.4 U	1.4	22	5.9	3.1 U	0.62 U	3.4	2.2 U	3.7 U	2.2	0.72 U
SG-10	03/02/2023	2.0	7.1	1.3 U	4.4 U	3.2	38	34	12	0.62 U	2.8	2.2 U	7.2	0.69 U	0.72 U
SG-11	03/02/2023	0.97 U	1.1 U	1.3 U	4.4 U	1.7	2.4 U	3.0 U	3.1 U	0.62 U	0.69 U	2.2 U	3.7 U	0.69 U	0.72 U
SG-12	03/02/2023	9.4	8.8	1.3 U	4.4 U	7.1	25	46	8.8	0.62 U	0.69 U	2.2 U	9.3	0.69 U	0.72 U
SG-13	03/02/2023	128	10	1.3 U	4.4 U	3.9	89	28	6.4	0.62 U	0.69 U	12	3.9	1.2	0.72 U
DEQ RBC Screening Level Criteria for Soil Gas[a]															
Vapor Intrusion Into Buildings															
Commercial (June 2023)		18	730,000	68	14	NITI	NITI	NITI	29,000	100,000	41,000	100,000	730,000	880,000	82
DEQ RBC Screening Level Criteria for Air[a]															
Inhalation															
Commercial (June 2023)		0.53	22,000	2	0.41	NITI	NA	NITI	880	3,100	1,200	3,100	22,000	26,000	2.5

Table 7
Soil Vapor Analytical Results - Volatile Organic Compounds (ug/m^3)
East Side Plating Plant #4
Portland, Oregon

Location	Date	Tetrahydrofuran	4-Methyl-2-pentanone	Cumene	4-Ethyltoluene	1,3,5-TMB	1,2,4-TMB	1,3-Dichlorobenzene
SG-1	08/31/2022	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	2.5	1.2 U
SG-2	08/31/2022	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	2.9	1.2 U
SG-3	08/31/2022	0.59 U	5.1 U	0.98 U	0.98 U	1.0	3.6	1.2 U
B-10	02/21/2023	0.59 U	7.5	0.98 U	83	31	99	1.2 U
B-11	02/22/2023	0.59 U	5.1 U	0.98 U	38	14	48	1.2 U
B-12	02/22/2023	0.59 U	5.1 U	0.98 U	6.9	3.8	14	1.2 U
B-13	02/27/2023	0.59 U	5.1 U	3.0	8.4	8.4	23	1.2 U
B-14	02/27/2023	0.59 U	5.1 U	1.6	5.2	4.6	15	1.2 U
SG-4	03/02/2023	0.59 U	5.1 U	0.98 U	1.5	1.2	5.3	1.2 U
SG-5	03/02/2023	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	1.7	1.2 U
SG-6	03/02/2023	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	3.7	1.2 U
SG-7	03/02/2023	0.59 U	5.1 U	0.98 U	0.99	3.1	0.98 U	1.2 U
SG-8	03/02/2023	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	2.4	1.2 U
SG-9	03/02/2023	0.78	5.1 U	0.98 U	0.98 U	0.98 U	0.98 U	1.2 U
SG-10	03/02/2023	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	3.4	1.2 U
SG-11	03/02/2023	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	1.1	1.2 U
SG-12	03/02/2023	0.59 U	10	0.98 U	0.98 U	0.98 U	2.5	1.2 U
SG-13	03/02/2023	0.59 U	5.1 U	0.98 U	0.98 U	0.98 U	1.3	1.2 U
DEQ RBC Screening Level Criteria for Soil Gas[a]								
Vapor Intrusion Into Buildings								
Commercial (June 2023)		290,000	440,000	58,000	NA	8,800	8,800	NITI
DEQ RBC Screening Level Criteria for Air[a]								
Inhalation								
Commercial (June 2023)		8,800	13,000	1,800	NA	260	260	NITI

Table 7
Soil Vapor Analytical Results - Volatile Organic Compounds (ug/m^3)
East Side Plating Plant #4
Portland, Oregon

Notes:

[a] Oregon Department of Environmental Quality (DEQ) Generic Risk-based concentrations (revised May 2018). An update to guidance and RBCs for volatilization to indoor air pathways based on EPA Vapor Intrusion Screening Levels was released June 2023.

Volatile organic compounds (VOCs) analyzed by Modified TO-15/TO-15 SIM
ug/m^3 = Micrograms per cubic meter
2-Propanol = Isopropanol
DCA = Dichloroethane
DCE = Dichloroethene
PCE = Tetrachloroethene
TCA = Trichloroethane
TCE = Trichloroethene
TMB = Trimethylbenzene
Freon 12 = Dichlorodifluoromethane
Freon 11 = Trichlorofluoromethane
U = Undetected at method reporting limit shown
J = Data Validation Qualifier. The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample. See Data Validation report for more information.
NA = Not Available
NITI = No inhalation Toxicity
- = Not applicable or not analyzed for this parameter

APPENDIX D
PNG Standard Operating Procedures

STANDARD OPERATING PROCEDURE
LOW-FLOW PERISTALTIC PUMP GROUNDWATER SAMPLING
SOP 207

This standard operating procedure (SOP) is designed to assist the user in taking representative groundwater samples from wells. Groundwater samples will be collected using low-flow (minimal drawdown) purging and sampling methods as discussed in U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504, July 1996 by Puls, R.W. and M.J. Barcelona - “Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells.”

The field sampler’s objective is to purge and sample the well so that the water that is discharged from the pump, and subsequently collected, is representative of the formation water from the aquifer’s identified zone of interest.

This SOP is applied when the wells to be sampled are not equipped with dedicated down well equipment.

INITIAL PUMP FLOW TEST PROCEDURES

Measure and record the Static Water Level (SWL) on field data sheet following the procedures outlined in SOP 10.

If possible, the optimum flow rate for each well will be established during well development/redevelopment or in advance of the actual sampling event. The appropriate tubing type (Teflon, HDPE, PVC, polyethylene, etc…) should be preselected based on the analytes of interest.

The mid-point of the saturated screen length is used by convention as the location of the tubing intake (i.e. if total well depth is 30 ft below grade surface (bgs) and well is screened from 20-30 ft with a SWL of less than 20 ft., base of tubing should be lowered to 25 ft.). If the head in the well is within the screened interval tubing intake should be placed at ½ of the static well head (i.e. for previous example SWL is at 22 ft. bgs, tubing intake should be placed at 26 ft bgs as 30-22 = 8ft of head in well, 30 – (8*½) = 26 ft.).

Site specific work plans may change the location of sample intake depth in order to sample from the highest yielding zone within the screened interval. In wells with a fully saturated screen length over 10 feet, testing should be performed if possible during development to determine highest water yielding zone within screened interval.

After tubing installation and confirmation that the SWL has returned to its original level (as determined prior to tubing installation), the peristaltic pump should be started at a discharge rate less than 0.5 liters per minute (0.13 gal/min) without any In-Line Flow Cell connected. The water level in the well casing must be monitored continuously for any change from the original measurement. If significant drawdown is observed, the pump’s flow rate should be incrementally reduced until the SWL drawdown ceases and stabilizes. Total drawdown from the initial (static) water level should not exceed 0.3 feet. In any case, the water level in the well should not be lowered below the top of the screen/intake zone of the well.

Once the specific well’s optimum flow rate, without an In-Line Flow Cell connected, has been determined and documented, connect the In-Line Flow Cell system (if available) to be used to the well discharge and determine the control settings required to achieve the well’s determined optimum flow rate with the In-Line Flow Cell connected (due to the system’s back-pressure, the flow rate will be decreased by ten to 20 percent).

PURGE AND SAMPLING EVENTS

Prior to the initiation of purging a well, the Static Water Level will be measured and documented. The peristaltic pump will be started utilizing its documented control settings and its flow rate will be confirmed by volumetric discharge measurement with the In-Line Flow Cell connected. If necessary, any minor modifications to the control settings to achieve the well's optimum flow rate will be documented on the gauging sheet. When the optimum pump flow rate has been established, the SWL drawdown has stabilized within the required range, and at least one pump system volume (down well extraction tubing, pump head tubing, and discharge tubing volume) has been purged, begin taking field measurements for pH, temperature (T), conductivity (Ec), oxygen reduction potential (ORP), dissolved oxygen (DO), and turbidity (TU) using an in-line flow cell or if unavailable individual water quality meters. All water chemistry field measurements will be documented on the gauging sheet. Measurements should be taken every three to five minutes until stabilization has been achieved. Stabilization is achieved after all parameters have stabilized for three consecutive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or dissolved oxygen. Three consecutive measurements indicating stability should be within:

Temperature	± 3 percent of reading (minimum of ± 0.2 C).
pH	± 0.1 units, minimum.
Conductance	± 3 percent of reading.
Dissolved Oxygen	± 10 percent of reading.
Redox (ORP)	± 10 mV.
Turbidity	± 10 percent NTU or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation).

When water quality parameters have stabilized, and there has been no change in the stabilized SWL (i.e., no continuous drawdown), sampling collection may begin.

EQUIPMENT LIST

The following equipment is needed to conduct low flow purging and sampling:

- Portable peristaltic pump equipped with a flow controller set to operate at the specific well's documented optimum flow rate.
- Disposable down well sampling tubing of sufficient length to intake groundwater at the target sampling depth for each well.
- In-Line Flow Cell and meter(s) with connection fittings and tubing to measure water quality.
- Water quality meters as backup in-case of in-line flow cell malfunction.
- Water Level Probe or installed dedicated water level measurement system.
- Photoionization detector (PID).
- Sample containers appropriate for the analytical requirements.
- Field measurement documentation forms.
- 300 to 500 milliliter graduated cylinder or measuring cup.
- Five gallon bucket(s) for containerizing purge water.
- Wristwatch with second hand or stopwatch.
- Sufficient cleaning and decontamination supplies if portable Water Level Probe is utilized.

PROCEDURE

- Calibrate all field instruments at the start of each day's deployment per the instrument manufacturer's instructions. Record calibration data.
- Drive to the first well scheduled to be sampled (typically the least contaminated). Make notes in the field log book describing the well condition and activity in the vicinity of the well. Decontaminate the portable water gauging probe by washing with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Remove the wellhead cover and take a measurement of the well vapor space with a PID. Record the measurement on the gauging and sampling sheet.
- Measure the depth to water from the surveyed reference mark on the wellhead and record the measurement on the gauging and sampling sheet. Lock the water level meter in place so that the level can be monitored during purging and sampling. When placing the probe in the well, take precautions to not disturb or agitate the water.
- Insert a sufficient length of disposable sampling tubing into the well casing to insure that the tip of the tubing is located within the appropriate sampling depth within the well screen.
- Insert a new length of flexible silicone tubing into the peristaltic pump head fixture.
- Connect the down well sampling tubing to the silicone tubing in the peristaltic pump head fixture.
- Connect a new length of disposable pump discharge tubing to the silicone tubing in the peristaltic pump head fixture and secure to drain the flow-rate test purge water into the purge water collection container.
- Start the peristaltic pump. Set the pump controller settings to the documented settings for the specific well. Confirm the flow rate is equal to the well's established optimum flow rate. Modify as necessary (documenting any required modifications).
- Monitor the water level and confirm that the SWL drawdown has stabilized within the well's allowable limits.
- Remove the pump discharge tubing.
- Connect the pump discharge tubing to the In-Line flow cells "IN" fitting.
- Connect the Flow Cell's "OUT" line and secure to drain the purge water into the purge water collection container.
- After a single pump-system's volume (down well sampling tubing, pump head silicone tubing, and discharge tubing volume) has been adequately purged, read, and record water quality field measurements every three to five minutes until all parameters have stabilized within their allowable ranges for at least three consecutive measurements. When stabilization has been achieved, sample collection may begin.
- Disconnect the flow cell, and it's tubing, from the pump discharge line before collecting samples. Decrease the pump rate to 100 milliliters per minute or less by lowering the pump controller's setting prior to collecting samples for volatiles. Refer to the task instructions for the correct order and procedures for filling sample containers. Place the samples in a cooler with enough ice to keep them at 4 degrees Centigrade.
- Once samples for volatiles have been collected, re-establish pump flow rate to the original purge flow rate by inputting the documented controller settings for the well without the In-Line Flow Cell connected, and collect remaining samples.

- When all sample containers have been filled, make a final measurement of the well's Static Water Level and record the measurement on the gauging and sampling sheet. Measure the Total Depth of the well and record the measurement, as well.
- Measure and record total purge volume collected. Consolidate generated purge water.
- Remove and decontaminate the Portable Water Level Probe with phosphate-free detergent, rinsing with potable water and rinsing with deionized water.
- Disconnect and dispose of each length of down well sampling tubing, silicone pump head tubing, and pump discharge tubing.
- Secure the peristaltic pump in the portable pump carrying case.
- Secure the wellhead cover and secure with its lock. Move equipment to next well to be sampled.
- At the end of each day, post calibrate all field instruments and record the measurements.
- Clean and decontaminate the In-Line Flow Cell with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Photocopies of all completed forms should be made each day. The copies should be retained on site. The original forms will be kept in the PNG Environmental project file.

GROUNDWATER
SAMPLE COLLECTION FORM

Well ID no___________________________ Project name_________________________
Sample no.__________________________ Project no.____________________________
Date______/___/_____________________ Collector______________________________

Well Information
Monument condition ☐ Good ☐ Needs repair_____________________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured _______ ppm ☐ Odor_____________
Elevation mark ☐ Yes ☐ Added ☐ Other _________________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other ____________

Purge Data
Total well depth_____________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product_____________ft Pump/Tubing Intake Depth_______________ft
Depth to water______________ft
Casing volume _____________ft (H_2O) X ___________gpf = ________ X 3 = _____________
Casing volumes 3/4”=0.02 gpf 1”=0.04 gpf 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf
Bladder Pumps: ¼” Tubing purge: 5.3mL/ft + 100mL; 3/8” Tubing purge: 9.5 mL/ft + 500mL

Purge Method
Pump type ☐ Peristaltic ☐ Bladder ☐ Submersible ☐ Other____________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other _____
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other _____
Purge start time_____________Purge stop time_____________Purge rate_________________
Refill Timer Setting______ Discharge Timer Setting ______ Pressure Setting______ Flow Rate .

Field Parameters
Meter used ☐ HYDAC Ξ QED Flow Cell ☐ Hanna ☐ Other___________

Gallons / mL	pH	Temp (F)	Conductivity	ORP	DO mg/L	Turbidity	Comments

Sampling Device
Bailer ☐ Disposable ☐ Stainless ☐ Teflon ☐ Other ___________________
Filter Type_________ Size________ (micron) Bailer cord used ☐ Monofillament

Bottles Filled Time_________

Number	Type			Preservative					Filtration	
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No

Comments:

Sampler’s Signature_________________________________Date_________/___/_________

STANDARD OPERATING PROCEDURE
SUB-SLAB VAPOR SAMPLE COLLECTION
SOP 300

This Standard Operating Procedure (SOP) describes the method for sub-slab vapor sample collection from both temporary and permanently installed soil vapor probes (implants). Soil gas probe installation/construction methods are detailed in SOP 21. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present. In certain instances where specific chemicals of concern (e.g. diesel or semi-volatile organic compounds) are being investigated or lower method reporting limits are desired, an alternate sampling methodology (EPA TO-17) may be utilized. In these instances installation of the sampling point will follow the same procedure as described in this SOP but alternate sampling media (adsorbent tubes) will be required as specified in the alternate sampling methodology section of this SOP.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT/MATERIALS

- Tubing: ⅛-inch or ¼-inch outer diameter (OD) inert, impermeable tubing such as nylon (Nylaflow®), Teflon® tubing, or stainless steel.
- Sample Containers: Stainless steel Summa canisters (one-liter Summa canisters are preferred; however, the site specific work plan may justify another appropriate size), syringe, or tedlar bag.
- Monitoring and sampling equipment may include the following: Certified flow controllers (if flow controllers are used, ensure flow controllers are dedicated to the canister/sample location), stainless steel t-fitting, stainless-steel particulate filter, photoionization detector (PID), low flow vacuum pump, vacuum gauge, portable weather station, and/or barometric pressure data loggers. In the event that EPA TO-17 sampling methodology is required adsorbent tubes, low flow rate pumps or high flow rate pumps with low flow adapters and constant pressure controllers will be substituted (see alternate sampling methodology section of this SOP).
- Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, and valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves. Tracer gas should be laboratory grade and the grade noted on the sample form (e.g. 100% pure helium by volume).

COLLECTION PROTOCOL

Since sub-slab sampling is from very shallow depths (typically two to six-inches below surface), minimum purge volumes and low volume samples are preferred to minimize potential breakthrough from the surface. Regardless of sample depth, a 30 minute flow controller (minimum) should be used. Tracer/leak gas (helium is preferred) will be used to ensure breakthrough does not occur. Note that if sub-slab and deeper subsurface soil gas samples are to be collected, they should be collected from separate boring locations in order to maintain a proper seal. Constructing nested sampling points is possible, but breakthrough is more likely and nested construction is not preferred. If possible, shallow samples should be collected prior to deeper samples to ensure surface seal.

Syringe Grab Samples

If only syringe samples are to be collected, connect syringe to probe tubing using the T-valve. If the syringe is connected directly to the probe implant, no purging is required. If a connecting tube is used between the syringe and the implant, purge out one to two dead-volumes of the connecting tubing (approximately one cubic centimeter per foot (cc/ft) for ⅛-inch OD tubing and five cc/ft for ¼-inch OD tubing). Leave syringe connected to implant the tubing. Sample by extracting soil gas via the syringe plunger.

Summa Canisters

Inspect the laboratory-provided Summa canister for damage prior to use. Do not use a canister that has visible damage.

Using a wrench, remove the brass cap above the valve on the top of the Summa canister. Measure and record the initial vacuum of Summa canister. If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.

Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.

The canister will then be fitted with the laboratory-provided steel filter. The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to a T-connector with an in-line vacuum gauge and vacuum tight flow valves at each end. All valves should be closed on the T connector at this time. The valve connected to the sampling train is referred to as the sampling valve. The vacuum pump (truck-mounted or otherwise) is then attached to the second end of the T with the valve closed (referred to as the purge valve).

Lastly, the sample tubing is threaded through the leak-check shroud and connected to the sub-slab sampling point and the third closed valve on the T-connector. The leak-check shroud should then be sealed against the slab surface (see “Leak Check – Probe Point Surface Seal” below).

Leaking Checking - Apparatus

The method described below shall be used to check for leaks in the lines and fittings of the above ground sampling apparatus:

- After the sampling system is set up, double check all valves are closed.
- Open the purge valve (the valve connecting the purge pump to the apparatus, all other valves remain closed), turn on the purge pump, and apply approximately ten inches of vacuum into the T-connector and valves. Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus (T-connector and valves) over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system train that must be remedied.
- If necessary, recheck the system to verify that there is no leakage as described above.
- Document the date and time the leak check(s) were performed on the sampling form. Ensure all valves remain closed.

Leaking Checking – Probe Point Surface Seal

In addition checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work. The helium tracer gas method is listed in ITRC's "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" dated January 2007 (ITRC 2007), and as described below. The ITRC guidance from which the text below is derived is consistent with California Environmental Protection Agency and Oregon Department of Environmental Quality guidance (CalEPA 2005 and 2010; DEQ 2010).

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus (previously described above).
- Place the enclosure shroud flush with the ground surface, placing hydrated bentonite around the shroud to seal the shroud around the sample point.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).
- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow at 200 milliliter per minute (ml/min) or less; let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 5%, this indicates leakage; check/tighten all seals and fittings and repeat procedure. The helium exhaust line should also be monitored so that additional helium can be added to the shroud during sampling if needed.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 5%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 5%, leakage is indicated and the sub-slab abandoned.
- Record helium monitoring measurements in field notes.

Soil Gas Purging Procedures

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage. Flow rates should not exceed 200 ml/min. Purge vapors will be monitored using a PID for the presence of volatile organic compounds.

Slowly open the vacuum pump purge valve and purge three volumes of vapor from the dead space (volume of tubing and sand pack combined), then close the purge valve. Tubing volume can be estimated at 44 milliliters per foot (mm/ft) of 0.25-inch inner diameter (ID) tubing. For the sand pack volume calculation it is important to note that 1 cubic inch is equivalent to 16.387 milliliters. The sand pack volume can be calculated as shown:

Sand pack volume = $(\Phi * \pi * r_1^2 * L_1) - (\pi * r_2^2 * L_2)$

Where Φ = sand pack porosity, typically estimated at 30%

r_1 = radius of sand pack

L_1 = length of sand pack

r_2 = outer radius of tubing (half of outer diameter)

L_2 = length of tubing within the sand pack

Care will be taken not to purge an excessive volume, or at an excessive rate, so as to minimize the chances of inducing leakage from the surface. The pump will also be monitored for signs that it is laboring, a possible indication of a clogged probe or tubing.

During purging, check for leaks as described in the section on leak checks above. Record PID measurements of purge vapors on the field form. At the conclusion of purging, immediately close the purge valve and then shut off the purge pump.

Soil Gas Sample Collection Procedures - Grab Sampling

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. A portable weather station equipped with a data logger is preferred to log site-specific conditions over the duration of sampling. However, if a weather station cannot be set-up on site, record atmospheric data from the closest weather station.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve. The canister's valve should be closed when the vacuum gauge shows a vacuum of 5 inches of mercury (in Hg) (pressure of -5 in Hg). The sample valve should then be closed.

Ensure the canister valve is tightly closed. The sample train should be immediately disassembled by removing the steel particulate filter, and the Summa canister. Immediately cap the Summa canister fitting. The final vacuum reading from the canister should be recorded on the chain of custody, sample collection form, and canister identification tag. If the final canister vacuum is less than 0.1 in Hg (more than -0.1 in Hg of pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected.

Soil vapor samples will be shipped to a certified laboratory for analysis.

Sampling Procedures using a flow controller

The sampling procedure is the same as above except that a laboratory certified in-line flow controller for a pre-specified sampling time (i.e. 30 minutes) will be used. The flow controller fits between the laboratory provided steel particulate filter and the Summa canister. The entire sample train (laboratory-provided steel particulate filter, flow-controller, and summa canister) should be pre-assembled prior to connecting to the sampling valve.

Other Collection Notes

For larger canisters (greater than one liter), sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize potential for vacuum extraction of contaminants from the soil phase. If large volume canisters are used (three or more liters) without a flow controller to ensure the flow rate remains below 200 ml/min, a purge volume test may be required to ensure sample dilution from other zones is not occurring.

FIELD RECORDS

The field technician maintains a log sheet summarizing:

- Sample Location.
- Sample Identification.
- Date and time of sample collection.
- Sampling depth.
- Tubing type, length, and volume.
- Purge Data (i.e. pump used, volume, PID screening information, purge start and stop time, purge vacuum reading).
- Weather conditions.
- Sampling methods and devices.
- Volume of sampling device.
- Sampling start and end date/time.
- Vacuum of canisters before and after samples collected.
- Apparent moisture content (dry, moist, or saturated, etc.) of the sampling zone.
- Chain of custody protocols and records used to track samples from sampling point to analysis.
- Other notes as applicable to site specific observations, sampling issues and mitigation of problems encountered.

ALTERNATIVE EPA METHOD TO-17 SAMPLING PROCEDURE

This alternate sampling methodology is consistent with EPA Compendium Method TO-17: *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes* (EPA 1999) and the established protocols of the PNG preferred laboratory (Air Toxics Ltd.) for the collection and analysis of samples by this method. This method replaces earlier sorbent-based EPA Methods TO-1 and TO-2 and provides an alternative to canister-based EPA Method TO-15 discussed in the Collection Protocol above. The target compound list is the same as TO-15 (i.e. subsets of the 97 VOCs listed as hazardous air pollutants in the Clean Air Act Amendments of 1990). However, TO-17 can collect VOCs over a wider volatility range than TO-15, by using a tube with multiple sorbents packed in increasing sorbent strength. Both single and multi-bed sorbent tubes are described in TO-17. Tube selection and the number and type of sorbents that will be packed into the tubes and conditioned by the laboratory are dependent on the COCs and desired reporting limit. Although the EPA Method TO-17 suggests replicate or distributed pair samples with sampling volumes of one and four liters, there is considerable mention of calculating a safe sampling volume (SSV). The SSV will minimize the potential for breakthrough on the sorbent tube and support the generation of valid analytical results. The sampling volume that is selected should include consideration of both the desired final reporting limit and the SSV of the sorbent being used. Further, when applied to the circumstances presented in this SOP, the methodology must be further modified to account for the greater concentrations of target COCs in soil gas than ambient air. In addition, because soil gas samples are typically for characterization purposes, the replicate or distributed pair sampling methodology should only be applied where field QA/QC samples are considered necessary.

SORBENT TUBE SELECTION

The approach to sorbent tube selection considering both reporting limits and sorbent SSVs is described in the following steps. This evaluation should be discussed with the analytical laboratory prior to ordering sorbent tubes for a given site investigation or sampling event.

- **Determine the Final Reporting Limit of the Target Compound –** This will be dependent on the COCs that are being investigated and their respective risk-based concentrations (RBCs) or preliminary remediation goals (PRGs) that are applicable at the site.
- **Determine the Method Reporting Limit –** The analytical laboratory will provide the mass value for each of the COCs that are being investigated based on the analytical method selected and the sensitivity of the instrumentation. The method reporting limit may vary for each of the target COCs.
- **Calculate the Sampling Volume –** The target sampling volume must be calculated to determine the volume of soil gas that must be drawn through the sorbent tube in order to achieve the desired final reporting limit for the target COCs. The target sampling volume is calculated by dividing the laboratory provided reporting limit for the target COC by the RBC or PRG of the COC then multiplying by 1000 liters. For example if the target COC was benzene at a residential site. The laboratory provided method reporting limit is 0.01 micrograms (ug) and the residential soil gas RBC in Oregon is 62 ug/m^3. Dividing 0.01 by 62 and multiplying by 1000 L/m^3 yields 0.16 L for a minimum sampling volume to achieve the target final reporting limit.
- **Calculate Minimum Flow Rate –** The minimum flow rate for the sampling pump and sorbent tube must be calculated to determine the sampling velocity for a specified time interval. Using the example above, if a minimum sampling volume of 0.16 L is required and the specified sampling interval is 5 minutes, the minimum flow rate would be determined by dividing 0.16 L by 5 minutes. This would yield a minimum flow rate of approximately 0.032 L/minute.
- **Compare the Sampling Volume to the SSV –** To determine whether or not sorbent tube breakthrough is likely for the target COC it is necessary to compare the minimum sampling volume calculated for the target COC with the SSV for the selected sorbent tube for the target COC. The SSVs for target COCs and suitable sorbents for those COCs are presented in Appendix 1 of the EPA Compendium Method TO-17 (EPA 1999). For example TO-17 Appendix 1 indicates that for benzene a SSV of up to 26 L can be collected using a Type 3 (CarboTrap 300) multi-sorbent tube. The target sampling volume determined above (0.16 L) could therefore be accommodated by the SSV of the tube and no breakthrough would be expected at the target sampling volume for a method reporting limit concentration.
- **Calculate if Overloading of Sorbent Tube is Possible –** Having determined if breakthrough is possible due to sampling volume, the likely concentration of the target COC in the soil gas sample must also be considered. For the target sampling volume desired, the maximum concentration of the target COC that could be accommodated by the SSV of the tube must also be evaluated. Again using the above example, if a minimum sampling volume of 0.16 L is required in order to achieve a final reporting limit lower than the RBC (62 ug/m^3), a tube which has an SSV of 26 L could contain a sample with a concentration equivalent to the SSV (26 L) divided by the minimum sampling volume (0.16 L) and multiplied by the RBC (62 ug/m^3) which would equate to 10,075 ug/m^3. Samples collected with sorbent tubes in known source areas would therefore require lower target sampling volumes (achieved through lower flow rates for the same duration or the same flow rate for a shorter duration) because it would not be necessary to achieve the lower reporting

limit but quantification of the concentration without saturation of the sorbent tube is desired.

SORBENT TUBE SAMPLING PROCEDURE

This approach to sorbent tube sampling assumes that sub-slab sampling point installation was performed in accordance with SOP-21 and leak checking and purging as described in the Collection Protocol above has been completed prior to the initiation of the following steps:

- **Pre-Sampling Flow Calibration –** Prior to sorbent tube sample collection the sampling pump that will be used during sample collection must be calibrated. In order to calibrate the pump connect a "set-up" tube provided by the lab to the Tygon tubing connected to the pump. If using a higher flow pump a low flow holder and constant pressure controller may be necessary to lower the flow rate. Adjust pump settings or restrict the flow using the low flow holder to the desired flow rate and record it on the field data sheet.
- **Sorbent Tube Connection –** After pump calibration, replace the "set-up" tube with the sample tube. Remove the sorbent tube from the laboratory provided sample container; then remove the foil wrapping, and both end plugs from the tube. Again using the Tygon tubing, connect the sampling pump to the outlet of the sample tube/low flow holder. Attach the sorbent tube inlet to the union fitting using a Swagelok nut. In the same manner attach the union to the Swagelok nut on the tubing from the sub-slab sampling point.
- **Sample Collection –** To begin sample collection start the sample pump and record the start time. After the desired duration, stop the pump and record the end time.
- **Sorbent Tube Removal –** Disconnect the sorbent tube from the Tygon tubing and union fitting and replace the end plugs on both ends of the sample tube. Record the sample ID, the tube ID, the collection date and time on the field data sheet and the laboratory chain-of-custody form. Wrap the tube in foil then replace in the laboratory provided sample container. Place the sample container in a cooler with blue ice.
- **Post Sampling Flow Calibration –** When completed with sample collection, reattach the "set-up" tube to the pump/low flow holder and measure the post sampling flow rate. Record the post-sampling flow rate on the field data sheet. The post-sampling flow rate should be within 10% of the pre-sampling flow rate.
- **Calculate Sampling Volume –** Calculate the average of the pre- and post-sampling flow rates then determine the total sampling volume by multiplying the average flow rate by the sample collection time duration. Record the sampling volume on the field data sheet and the laboratory chain-of-custody form.

REFERENCES

Cal EPA. *2005 (February 7 rev.). Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.* Department of Toxic Substances Control, Interim Final. California Environmental Protection Agency.

Cal EPA. 2010 (March). *Advisory – Active Soil Gas Investigation (Draft).* California Environmental Protection Agency.

DEQ. 2010 (March 25). *Guidance for Assessing and Remediating Vapor Intrusion in Buildings.* Oregon Department of Environmental Quality.

EPA 1999 (January). *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes.* United States Environmental Protection Agency.

ITRC. 2007 (January). *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline,* Interstate Technology & Regulatory Council

STANDARD OPERATING PROCEDURE
SOIL GAS (VAPOR) MONITORING AND SAMPLING
SOP 302

This standard operating procedure (SOP) describes procedures for performing soil gas (vapor) monitoring and sampling using direct-push drilling technology. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT

Soil gas monitoring and sampling will be performed using direct push sampling equipment. The direct push probe will be advanced using either a truck- or track-mounted Geoprobe rig, or for limited access areas, using portable methods such as rotary hammer drill (rotohammer).

Coring/probe installation equipment which may be used includes the following: a rotohammer or truck-mounted Geoprobe rig, ½-inch to 2-inch diameter concrete coring drill bit, cloth (for dust suppression during drilling), Geoprobe drill rods, ¼-inch diameter tubing (nylon, stainless steel, or Teflon®), fine-grained (20-40) silica sand, granular bentonite grout or alternative, and possibly cement in cases where the formation has a very low permeability.

Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, three-way valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves.

Monitoring/sampling equipment which may be used includes the following: Summa canister (may be a one-liter or six-liter Summa canister with valve), certified flow controller, steel filter, three-way valve, extra miscellaneous valves, photo ionization detector (PID), low flow vacuum pump, vacuum gauge, barometer/thermometer/wind speed indicator.

CORING/PROBE INSTALLATION PROCEDURES

Prior to drilling or coring, an attempt will be made to locate utility lines and if inside a building, to determine whether or not the building has an existing vapor barrier or a tensioned slab.

When samples are collected beneath buildings, a minimum of one sample will be collected from beneath each building. In addition, one duplicate sample will be collected. If possible, the samples will be located in the central portion of the slab, away from the floor slab/perimeter foundation junction, where dilution is more likely to occur.

In each sample location, a small diameter (½-inch to one-inch) hole will be drilled in the foundation using a rotohammer, truck-mounted Geoprobe rig, or concrete corer. When drilling the hole, no water should be used and care should be taken not to puncture the surface of soil underneath. If dust prevention is necessary, cover the location with a cloth or towel and drill through a pre-cut small hole in the cloth.

The probes are typically advanced to a depth of five feet below ground surface (bgs), however, other site-specific depths or multiple depths for vertical soil gas profiling may be targeted by the work plan. At target depth, the probe rod will be withdrawn approximately three to six inches to disengage the expendable probe tip and minimize the terminal void space volume. New, dedicated disposable nylon, stainless steel, or Teflon® tubing would then be fitted with a barbed steel end nut, pushed into the base of the probe rod, and threaded onto a downhole terminal fitting sealed with an o-ring to prevent vapor short-circuiting to the surface through the rod annulus.

The area immediately around the probe rods shall be grouted using hydrated bentonite grout (if temporary installation) or cement (if permanent installation). Wait 30 minutes prior to sampling for bentonite or cement to congeal. VOC-free modeling clay may also be used to seal around the probe rods to prevent vapor short-circuiting to the surface.

Procedures for leak checking, soil gas purging, and sampling are described in the section below.

Following the completion of sampling, the soil boreholes will be filled with hydrated granular or powdered bentonite grout. If a building slab or pavement is present, the hole(s) will be patched with cement and finished flush with the surface.

SYSTEM SETUP

Inspect the laboratory-provided Summa canister for damage prior to use. Do not use a canister that has visible damage.

Using a wrench, remove the brass cap above the valve on the top of the Summa canister. Measure and record the initial vacuum of Summa canister. If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.

Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.

The canister will then be fitted with the laboratory-provided steel filter. The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to a T-connector with an in-line vacuum gauge and vacuum tight flow valves (Swagelok) at each end. All valves should be closed on the T-connector at this time. The valve connected to the sampling train is referred to as the sampling valve. The vacuum pump (truck-mounted or otherwise) is then attached to the second end of the T with the valve closed (referred to as the purge valve).

Lastly, the sample tubing is threaded through the leak-check shroud and connected to the soil gas sampling point and the third closed valve on the T-connector. The leak-check shroud should then be sealed against the surface (see “Leak Check – Probe Point Surface Seal” below).

LEAK CHECKING - APPARATUS

The method described below shall be used to check for leaks in the lines and fittings of the above-ground sampling apparatus:

After the sampling system is set up, make sure all valves are closed.

Open the purge valve (the valve connecting the purge pump to the apparatus, all other valves remain closed), turn on the purge pump, and apply approximately ten inches of vacuum into the T-connector and valves. Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus (T-connector and valves) over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system train that must be remedied.

If necessary, recheck the system to verify that there is no leakage as described above.

Document the date and time the leak check(s) were performed. Close all valves.

LEAK CHECKING – PROBE POINT SURFACE SEAL

In addition checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work. The helium tracer gas method is listed in ITRC's "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" dated January 2007 (ITRC 2007), and as described below. The ITRC guidance from which the text below is derived is consistent with California Environmental Protection Agency and Oregon Department of Environmental Quality guidance (CalEPA 2005 and 2010; DEQ 2010).

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus (previously described above).
- Place the enclosure flush with the ground surface, placing hydrated bentonite around the shroud to seal the shroud around the sample point.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).
- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow to approximately 200 milliliters/minute (ml/min); let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 5%, this indicates leakage; check/tighten all seals and fittings and repeat procedure. The helium exhaust line should also be monitored so that additional helium can be added to the shroud during sampling if needed.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 5%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 5%, leakage is indicated and the probe hole abandoned.
- Record helium monitoring measurements in field notes.

SOIL GAS PURGING PROCEDURES

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage. Flow rates should not exceed 200 ml/min.

Purge vapors will be monitored using a PID for the presence of volatile organic compounds.

Slowly open the vacuum pump purge valve and purge three tubing volumes of vapor from the line, then close the purge valve. Based on a volume of approximately 0.044 liters per foot of ¼-inch ID tubing, and assuming five feet of tubing above ground, this would yield a total purge volume of 1.32 liters for a five-foot probe depth (ten total feet of tubing), and a total purge volume of 1.98 liters for a ten-foot probe depth (15 total feet of tubing).

During purging, check for leaks as described in the section on leak checks above. Record PID measurements of purge vapors on the field form. Oxygen and carbon dioxide concentrations may be monitored in the soil gas stream if desired by the work plan. At the conclusion of purging, immediately close the purge valve and then shut off the purge pump.

SOIL GAS SAMPLING PROCEDURES

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. A portable weather station equipped with a data logger is preferred to log site-specific conditions over the duration of sampling. However, if a weather station cannot be set-up on site, record atmospheric data from the closest weather station.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve. The canister's valve should be closed when the vacuum gauge shows a vacuum of 5 inches of mercury (in Hg) (pressure of -5 in Hg). The sample valve should then be closed.

Ensure the canister valve is tightly closed. The sample train should be immediately disassembled by removing the steel particulate filter, flow controller, and the Summa canister. Immediately cap the Summa canister fitting. The final vacuum reading from the canister should be recorded on the chain of custody, sample collection form, and canister identification tag. If the final canister vacuum is less than 0.1 in Hg (more than -0.1 in Hg of pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected.

Soil vapor samples will be shipped to a certified laboratory for analysis.

FIELD RECORDS

The field technician maintains a log sheet summarizing:

- Sample Location.
- Sample Identification.
- Date and time of sample collection.
- Sampling depth.
- Tubing type, length, and volume.
- Purge Data (i.e. pump used, volume, PID screening information, purge start and stop time, purge vacuum reading).
- Weather conditions.
- Sampling methods and devices.

- Volume of sampling device.
- Sampling start and end date/time.
- Vacuum of canisters before and after samples collected.
- Apparent moisture content (dry, moist, or saturated, etc.) of the sampling zone.
- Chain of custody protocols and records used to track samples from sampling point to analysis.
- Other notes as applicable to site specific observations, sampling issues and mitigation of problems encountered.

ALTERNATIVE EPA METHOD TO-17 SAMPLING PROCEDURE

This alternate sampling methodology is consistent with EPA Compendium Method TO-17: *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes* (EPA 1999) and the established protocols of the PNG preferred laboratory (Air Toxics Ltd.) for the collection and analysis of samples by this method. This method replaces earlier sorbent-based EPA Methods TO-1 and TO-2 and provides an alternative to canister-based EPA Method TO-15 discussed in the Collection Protocol above. The target compound list is the same as TO-15 (i.e. subsets of the 97 VOCs listed as hazardous air pollutants in the Clean Air Act Amendments of 1990). However, TO-17 can collect VOCs over a wider volatility range than TO-15, by using a tube with multiple sorbents packed in increasing sorbent strength. Both single and multi-bed sorbent tubes are described in TO-17. Tube selection and the number and type of sorbents that will be packed into the tubes and conditioned by the laboratory are dependent on the COCs and desired reporting limit. Although the EPA Method TO-17 suggests replicate or distributed pair samples with sampling volumes of one and four liters, there is considerable mention of calculating a safe sampling volume (SSV). The SSV will minimize the potential for breakthrough on the sorbent tube and support the generation of valid analytical results. The sampling volume that is selected should include consideration of both the desired final reporting limit and the SSV of the sorbent being used. Further, when applied to the circumstances presented in this SOP, the methodology must be further modified to account for the greater concentrations of target COCs in soil gas than ambient air. In addition, because soil gas samples are typically for characterization purposes, the replicate or distributed pair sampling methodology should only be applied where field QA/QC samples are considered necessary.

Sorbent Tube Selection

The approach to sorbent tube selection considering both reporting limits and sorbent SSVs is described in the following steps. This evaluation should be discussed with the analytical laboratory prior to ordering sorbent tubes for a given site investigation or sampling event.

- **Determine the Final Reporting Limit of the Target Compound –** This will be dependent on the COCs that are being investigated and their respective risk-based concentrations (RBCs) or preliminary remediation goals (PRGs) that are applicable at the site.
- **Determine the Method Reporting Limit –** The analytical laboratory will provide the mass value for each of the COCs that are being investigated based on the analytical method selected and the sensitivity of the instrumentation. The method reporting limit may vary for each of the target COCs.

- **Calculate the Sampling Volume –** The target sampling volume must be calculated to determine the volume of soil gas that must be drawn through the sorbent tube in order to achieve the desired final reporting limit for the target COCs. The target sampling volume is calculated by dividing the laboratory provided reporting limit for the target COC by the RBC or PRG of the COC then multiplying by 1000 liters. For example if the target COC was benzene at a residential site. The laboratory provided method reporting limit is 0.01 micrograms (ug) and the residential soil gas RBC in Oregon is 62 ug/m^3. Dividing 0.01 by 62 and multiplying by 1000 L/m^3 yields 0.16 L for a minimum sampling volume to achieve the target final reporting limit.
- **Calculate Minimum Flow Rate –** The minimum flow rate for the sampling pump and sorbent tube must be calculated to determine the sampling velocity for a specified time interval. Using the example above, if a minimum sampling volume of 0.16 L is required and the specified sampling interval is 5 minutes, the minimum flow rate would be determined by dividing 0.16 L by 5 minutes. This would yield a minimum flow rate of approximately 0.032 L/minute.
- **Compare the Sampling Volume to the SSV –** To determine whether or not sorbent tube breakthrough is likely for the target COC it is necessary to compare the minimum sampling volume calculated for the target COC with the SSV for the selected sorbent tube for the target COC. The SSVs for target COCs and suitable sorbents for those COCs are presented in Appendix 1 of the EPA Compendium Method TO-17 (EPA 1999). For example TO-17 Appendix 1 indicates that for benzene a SSV of up to 26 L can be collected using a Type 3 (CarboTrap 300) multi-sorbent tube. The target sampling volume determined above (0.52 L) could therefore be accommodated by the SSV of the tube and no breakthrough would be expected at the target sampling volume for a method reporting limit concentration.
- **Calculate if Overloading of Sorbent Tube is Possible –** Having determined if breakthrough is possible due to sampling volume, the likely concentration of the target COC in the soil gas sample must also be considered. For the target sampling volume desired, the maximum concentration of the target COC that could be accommodated by the SSV of the tube must also be evaluated. Again using the above example, if a minimum sampling volume of 0.16 L is required in order to achieve a final reporting limit lower than the RBC (62 ug/m^3), a tube which has an SSV of 26 L could contain a sample with a concentration equivalent to the SSV (26 L) divided by the minimum sampling volume (0.16 L) and multiplied by the RBC (62 ug/m^3) which would equate to 10,075 ug/m^3. Samples collected with sorbent tubes in known source areas would therefore require lower target sampling volumes (achieved through lower flow rates for the same duration or the same flow rate for a shorter duration) because it would not be necessary to achieve the lower reporting limit but quantification of the concentration without saturation of the sorbent tube is desired.

Sorbent Tube Sampling procedure

This approach to sorbent tube sampling assumes that probe installation, leak checking, and purging as described in the Collection Protocol above has been completed prior to the initiation of the following steps:

- **Pre-Sampling Flow Calibration –** Prior to sorbent tube sample collection the sampling pump that will be used during sample collection must be calibrated. In order to calibrate the pump connect a “set-up” tube provided by the lab to the Tygon tubing connected to the pump. If using a higher flow pump a low flow holder and constant pressure controller may be necessary to lower the flow rate. Adjust pump settings or restrict the flow using the low flow holder to the desired flow rate and record it on the field data sheet.

- **Sorbent Tube Connection –** After pump calibration, replace the "set-up" tube with the sample tube. Remove the sorbent tube from the laboratory provided sample container; then remove the foil wrapping, and both end plugs from the tube. Again using the Tygon tubing, connect the sampling pump to the outlet of the sample tube/low flow holder. Attach the sorbent tube inlet to the union fitting using a Swagelok nut. In the same manner attach the union to the Swagelok nut on the tubing from the sub-slab sampling point.
- **Sample Collection –** To begin sample collection start the sample pump and record the start time. After the desired duration, stop the pump and record the end time.
- **Sorbent Tube Removal –** Disconnect the sorbent tube from the Tygon tubing and union fitting and replace the end plugs on both ends of the sample tube. Record the sample ID, the tube ID, the collection date and time on the field data sheet and the laboratory chain-of-custody form. Wrap the tube in foil then replace in the laboratory provided sample container. Place the sample container in a cooler with blue ice.
- **Post Sampling Flow Calibration –** When completed with sample collection, reattach the "set-up" tube to the pump/low flow holder and measure the post sampling flow rate. Record the post-sampling flow rate on the field data sheet. The post-sampling flow rate should be within 10% of the pre-sampling flow rate.
- **Calculate Sampling Volume –** Calculate the average of the pre- and post-sampling flow rates then determine the total sampling volume by multiplying the average flow rate by the sample collection time duration. Record the sampling volume on the field data sheet and the laboratory chain-of-custody form.

REFERENCES

Cal EPA. *2005 (February 7 rev.). Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.* Department of Toxic Substances Control, Interim Final. California Environmental Protection Agency.

Cal EPA. 2010 (March). *Advisory – Active Soil Gas Investigation (Draft).* California Environmental Protection Agency.

DEQ. 2010 (March 25). *Guidance for Assessing and Remediating Vapor Intrusion in Buildings.* Oregon Department of Environmental Quality.

EPA 1999 (January). *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes.* United States Environmental Protection Agency.

ITRC, 2007 (January). *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline,* Interstate Technology & Regulatory Council

STANDARD OPERATING PROCEDURE
LOW-FLOW PERISTALTIC PUMP GROUNDWATER SAMPLING
SOP 207

This standard operating procedure (SOP) is designed to assist the user in taking representative groundwater samples from wells. Groundwater samples will be collected using low-flow (minimal drawdown) purging and sampling methods as discussed in U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504, July 1996 by Puls, R.W. and M.J. Barcelona - "Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells."

The field sampler's objective is to purge and sample the well so that the water that is discharged from the pump, and subsequently collected, is representative of the formation water from the aquifer's identified zone of interest.

This SOP is applied when the wells to be sampled are not equipped with dedicated down well equipment.

INITIAL PUMP FLOW TEST PROCEDURES

Measure and record the Static Water Level (SWL) on field data sheet following the procedures outlined in SOP 10.

If possible, the optimum flow rate for each well will be established during well development/redevelopment or in advance of the actual sampling event. The appropriate tubing type (Teflon, HDPE, PVC, polyethylene, etc…) should be preselected based on the analytes of interest.

The mid-point of the saturated screen length is used by convention as the location of the tubing intake (i.e. if total well depth is 30 ft below grade surface (bgs) and well is screened from 20-30 ft with a SWL of less than 20 ft., base of tubing should be lowered to 25 ft.). If the head in the well is within the screened interval tubing intake should be placed at ½ of the static well head (i.e. for previous example SWL is at 22 ft. bgs, tubing intake should be placed at 26 ft bgs as 30-22 = 8ft of head in well, 30 – (8*½) = 26 ft.).

Site specific work plans may change the location of sample intake depth in order to sample from the highest yielding zone within the screened interval. In wells with a fully saturated screen length over 10 feet, testing should be performed if possible during development to determine highest water yielding zone within screened interval.

After tubing installation and confirmation that the SWL has returned to its original level (as determined prior to tubing installation), the peristaltic pump should be started at a discharge rate less than 0.5 liters per minute (0.13 gal/min) without any In-Line Flow Cell connected. The water level in the well casing must be monitored continuously for any change from the original measurement. If significant drawdown is observed, the pump's flow rate should be incrementally reduced until the SWL drawdown ceases and stabilizes. Total drawdown from the initial (static) water level should not exceed 0.3 feet. In any case, the water level in the well should not be lowered below the top of the screen/intake zone of the well.

Once the specific well's optimum flow rate, without an In-Line Flow Cell connected, has been determined and documented, connect the In-Line Flow Cell system (if available) to be used to the well discharge and determine the control settings required to achieve the well's determined optimum flow rate with the In-Line Flow Cell connected (due to the system's back-pressure, the flow rate will be decreased by ten to 20 percent).

PURGE AND SAMPLING EVENTS

Prior to the initiation of purging a well, the Static Water Level will be measured and documented. The peristaltic pump will be started utilizing its documented control settings and its flow rate will be confirmed by volumetric discharge measurement with the In-Line Flow Cell connected. If necessary, any minor modifications to the control settings to achieve the well's optimum flow rate will be documented on the gauging sheet. When the optimum pump flow rate has been established, the SWL drawdown has stabilized within the required range, and at least one pump system volume (down well extraction tubing, pump head tubing, and discharge tubing volume) has been purged, begin taking field measurements for pH, temperature (T), conductivity (Ec), oxygen reduction potential (ORP), dissolved oxygen (DO), and turbidity (TU) using an in-line flow cell or if unavailable individual water quality meters. All water chemistry field measurements will be documented on the gauging sheet. Measurements should be taken every three to five minutes until stabilization has been achieved. Stabilization is achieved after all parameters have stabilized for three consecutive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or dissolved oxygen. Three consecutive measurements indicating stability should be within:

Temperature	± 3 percent of reading (minimum of ± 0.2 C).
pH	± 0.1 units, minimum.
Conductance	± 3 percent of reading.
Dissolved Oxygen	± 10 percent of reading.
Redox (ORP)	± 10 mV.
Turbidity	± 10 percent NTU or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation).

When water quality parameters have stabilized, and there has been no change in the stabilized SWL (i.e., no continuous drawdown), sampling collection may begin.

EQUIPMENT LIST

The following equipment is needed to conduct low flow purging and sampling:

- Portable peristaltic pump equipped with a flow controller set to operate at the specific well's documented optimum flow rate.
- Disposable down well sampling tubing of sufficient length to intake groundwater at the target sampling depth for each well.
- In-Line Flow Cell and meter(s) with connection fittings and tubing to measure water quality.
- Water quality meters as backup in-case of in-line flow cell malfunction.
- Water Level Probe or installed dedicated water level measurement system.
- Photoionization detector (PID).
- Sample containers appropriate for the analytical requirements.
- Field measurement documentation forms.
- 300 to 500 milliliter graduated cylinder or measuring cup.
- Five gallon bucket(s) for containerizing purge water.
- Wristwatch with second hand or stopwatch.
- Sufficient cleaning and decontamination supplies if portable Water Level Probe is utilized.

PROCEDURE

- Calibrate all field instruments at the start of each day's deployment per the instrument manufacturer's instructions. Record calibration data.
- Drive to the first well scheduled to be sampled (typically the least contaminated). Make notes in the field log book describing the well condition and activity in the vicinity of the well. Decontaminate the portable water gauging probe by washing with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Remove the wellhead cover and take a measurement of the well vapor space with a PID. Record the measurement on the gauging and sampling sheet.
- Measure the depth to water from the surveyed reference mark on the wellhead and record the measurement on the gauging and sampling sheet. Lock the water level meter in place so that the level can be monitored during purging and sampling. When placing the probe in the well, take precautions to not disturb or agitate the water.
- Insert a sufficient length of disposable sampling tubing into the well casing to insure that the tip of the tubing is located within the appropriate sampling depth within the well screen.
- Insert a new length of flexible silicone tubing into the peristaltic pump head fixture.
- Connect the down well sampling tubing to the silicone tubing in the peristaltic pump head fixture.
- Connect a new length of disposable pump discharge tubing to the silicone tubing in the peristaltic pump head fixture and secure to drain the flow-rate test purge water into the purge water collection container.
- Start the peristaltic pump. Set the pump controller settings to the documented settings for the specific well. Confirm the flow rate is equal to the well's established optimum flow rate. Modify as necessary (documenting any required modifications).
- Monitor the water level and confirm that the SWL drawdown has stabilized within the well's allowable limits.
- Remove the pump discharge tubing.
- Connect the pump discharge tubing to the In-Line flow cells "IN" fitting.
- Connect the Flow Cell's "OUT" line and secure to drain the purge water into the purge water collection container.
- After a single pump-system's volume (down well sampling tubing, pump head silicone tubing, and discharge tubing volume) has been adequately purged, read, and record water quality field measurements every three to five minutes until all parameters have stabilized within their allowable ranges for at least three consecutive measurements. When stabilization has been achieved, sample collection may begin.
- Disconnect the flow cell, and it's tubing, from the pump discharge line before collecting samples. Decrease the pump rate to 100 milliliters per minute or less by lowering the pump controller's setting prior to collecting samples for volatiles. Refer to the task instructions for the correct order and procedures for filling sample containers. Place the samples in a cooler with enough ice to keep them at 4 degrees Centigrade.
- Once samples for volatiles have been collected, re-establish pump flow rate to the original purge flow rate by inputting the documented controller settings for the well without the In-Line Flow Cell connected, and collect remaining samples.

- When all sample containers have been filled, make a final measurement of the well's Static Water Level and record the measurement on the gauging and sampling sheet. Measure the Total Depth of the well and record the measurement, as well.
- Measure and record total purge volume collected. Consolidate generated purge water.
- Remove and decontaminate the Portable Water Level Probe with phosphate-free detergent, rinsing with potable water and rinsing with deionized water.
- Disconnect and dispose of each length of down well sampling tubing, silicone pump head tubing, and pump discharge tubing.
- Secure the peristaltic pump in the portable pump carrying case.
- Secure the wellhead cover and secure with its lock. Move equipment to next well to be sampled.
- At the end of each day, post calibrate all field instruments and record the measurements.
- Clean and decontaminate the In-Line Flow Cell with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Photocopies of all completed forms should be made each day. The copies should be retained on site. The original forms will be kept in the PNG Environmental project file.

GROUNDWATER
SAMPLE COLLECTION FORM

Well ID no____________________________ Project name__________________________
Sample no.___________________________ Project no.____________________________
Date______/___/______________________ Collector_______________________________

Well Information

Monument condition ☐ Good ☐ Needs repair________________________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured _______ ppm ☐ Odor_____________
Elevation mark ☐ Yes ☐ Added ☐ Other _________________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other ____________

Purge Data

Total well depth______________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product_____________ft Pump/Tubing Intake Depth________________ft
Depth to water_______________ft
Casing volume ______________ft (H_2O) X ___________gpf = ________ X 3 = ______________
Casing volumes 3/4”=0.02 gpf 1”=0.04 gpf 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf
Bladder Pumps: ¼” Tubing purge: 5.3mL/ft + 100mL; ⅜” Tubing purge: 9.5 mL/ft + 500mL

Purge Method

Pump type ☐ Peristaltic ☐ Bladder ☐ Submersible ☐ Other_____________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other ______
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other _____
Purge start time______________Purge stop time______________Purge rate_________________
Refill Timer Setting______ Discharge Timer Setting ______ Pressure Setting______ Flow Rate .

Field Parameters

Meter used ☐ HYDAC Ξ QED Flow Cell ☐ Hanna ☐ Other____________

Gallons / mL	pH	Temp (F)	Conductivity	ORP	DO mg/L	Turbidity	Comments

Sampling Device

Bailer ☐ Disposable ☐ Stainless ☐ Teflon ☐ Other ____________________
Filter Type__________ Size________ (micron) Bailer cord used ☐ Monofillament

Bottles Filled Time_________

NumberType Preservative Filtration
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No

Comments:

Sampler’s Signature____________________________________Date__________/___/__________

STANDARD OPERATING PROCEDURE
SUB-SLAB VAPOR SAMPLE COLLECTION
SOP 300

This Standard Operating Procedure (SOP) describes the method for sub-slab vapor sample collection from both temporary and permanently installed soil vapor probes (implants). Soil gas probe installation/construction methods are detailed in SOP 21. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present. In certain instances where specific chemicals of concern (e.g. diesel or semi-volatile organic compounds) are being investigated or lower method reporting limits are desired, an alternate sampling methodology (EPA TO-17) may be utilized. In these instances installation of the sampling point will follow the same procedure as described in this SOP but alternate sampling media (adsorbent tubes) will be required as specified in the alternate sampling methodology section of this SOP.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT/MATERIALS

- Tubing: ⅛-inch or ¼-inch outer diameter (OD) inert, impermeable tubing such as nylon (Nylaflow®), Teflon® tubing, or stainless steel.
- Sample Containers: Stainless steel Summa canisters (one-liter Summa canisters are preferred; however, the site specific work plan may justify another appropriate size), syringe, or tedlar bag.
- Monitoring and sampling equipment may include the following: Certified flow controllers (if flow controllers are used, ensure flow controllers are dedicated to the canister/sample location), stainless steel t-fitting, stainless-steel particulate filter, photoionization detector (PID), low flow vacuum pump, vacuum gauge, portable weather station, and/or barometric pressure data loggers. In the event that EPA TO-17 sampling methodology is required adsorbent tubes, low flow rate pumps or high flow rate pumps with low flow adapters and constant pressure controllers will be substituted (see alternate sampling methodology section of this SOP).
- Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, and valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves. Tracer gas should be laboratory grade and the grade noted on the sample form (e.g. 100% pure helium by volume).

COLLECTION PROTOCOL

Since sub-slab sampling is from very shallow depths (typically two to six-inches below surface), minimum purge volumes and low volume samples are preferred to minimize potential breakthrough from the surface. Regardless of sample depth, a 30 minute flow controller (minimum) should be used. Tracer/leak gas (helium is preferred) will be used to ensure breakthrough does not occur. Note that if sub-slab and deeper subsurface soil gas samples are to be collected, they should be collected from separate boring locations in order to maintain a proper seal. Constructing nested sampling points is possible, but breakthrough is more likely and nested construction is not preferred. If possible, shallow samples should be collected prior to deeper samples to ensure surface seal.

Syringe Grab Samples

If only syringe samples are to be collected, connect syringe to probe tubing using the T-valve. If the syringe is connected directly to the probe implant, no purging is required. If a connecting tube is used between the syringe and the implant, purge out one to two dead-volumes of the connecting tubing (approximately one cubic centimeter per foot (cc/ft) for ⅛-inch OD tubing and five cc/ft for ¼-inch OD tubing). Leave syringe connected to implant the tubing. Sample by extracting soil gas via the syringe plunger.

Summa Canisters

Inspect the laboratory-provided Summa canister for damage prior to use. Do not use a canister that has visible damage.

Using a wrench, remove the brass cap above the valve on the top of the Summa canister. Measure and record the initial vacuum of Summa canister. If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.

Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.

The canister will then be fitted with the laboratory-provided steel filter. The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to a T-connector with an in-line vacuum gauge and vacuum tight flow valves at each end. All valves should be closed on the T connector at this time. The valve connected to the sampling train is referred to as the sampling valve. The vacuum pump (truck-mounted or otherwise) is then attached to the second end of the T with the valve closed (referred to as the purge valve).

Lastly, the sample tubing is threaded through the leak-check shroud and connected to the sub-slab sampling point and the third closed valve on the T-connector. The leak-check shroud should then be sealed against the slab surface (see “Leak Check – Probe Point Surface Seal” below).

Leaking Checking - Apparatus

The method described below shall be used to check for leaks in the lines and fittings of the above ground sampling apparatus:

- After the sampling system is set up, double check all valves are closed.
- Open the purge valve (the valve connecting the purge pump to the apparatus, all other valves remain closed), turn on the purge pump, and apply approximately ten inches of vacuum into the T-connector and valves. Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus (T-connector and valves) over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system train that must be remedied.
- If necessary, recheck the system to verify that there is no leakage as described above.
- Document the date and time the leak check(s) were performed on the sampling form. Ensure all valves remain closed.

Leaking Checking – Probe Point Surface Seal

In addition checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work. The helium tracer gas method is listed in ITRC's "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" dated January 2007 (ITRC 2007), and as described below. The ITRC guidance from which the text below is derived is consistent with California Environmental Protection Agency and Oregon Department of Environmental Quality guidance (CalEPA 2005 and 2010; DEQ 2010).

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus (previously described above).
- Place the enclosure shroud flush with the ground surface, placing hydrated bentonite around the shroud to seal the shroud around the sample point.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).
- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow at 200 milliliter per minute (ml/min) or less; let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 5%, this indicates leakage; check/tighten all seals and fittings and repeat procedure. The helium exhaust line should also be monitored so that additional helium can be added to the shroud during sampling if needed.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 5%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 5%, leakage is indicated and the sub-slab abandoned.
- Record helium monitoring measurements in field notes.

Soil Gas Purging Procedures

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage. Flow rates should not exceed 200 ml/min. Purge vapors will be monitored using a PID for the presence of volatile organic compounds.

Slowly open the vacuum pump purge valve and purge three volumes of vapor from the dead space (volume of tubing and sand pack combined), then close the purge valve. Tubing volume can be estimated at 44 milliliters per foot (mm/ft) of 0.25-inch inner diameter (ID) tubing. For the sand pack volume calculation it is important to note that 1 cubic inch is equivalent to 16.387 milliliters. The sand pack volume can be calculated as shown:

Sand pack volume = $(\Phi * \pi * r_1^2 * L_1) - (\pi * r_2^2 * L_2)$

Where Φ = sand pack porosity, typically estimated at 30%

r_1 = radius of sand pack

L_1 = length of sand pack

r_2 = outer radius of tubing (half of outer diameter)

L_2 = length of tubing within the sand pack

Care will be taken not to purge an excessive volume, or at an excessive rate, so as to minimize the chances of inducing leakage from the surface. The pump will also be monitored for signs that it is laboring, a possible indication of a clogged probe or tubing.

During purging, check for leaks as described in the section on leak checks above. Record PID measurements of purge vapors on the field form. At the conclusion of purging, immediately close the purge valve and then shut off the purge pump.

Soil Gas Sample Collection Procedures - Grab Sampling

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. A portable weather station equipped with a data logger is preferred to log site-specific conditions over the duration of sampling. However, if a weather station cannot be set-up on site, record atmospheric data from the closest weather station.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve. The canister's valve should be closed when the vacuum gauge shows a vacuum of 5 inches of mercury (in Hg) (pressure of -5 in Hg). The sample valve should then be closed.

Ensure the canister valve is tightly closed. The sample train should be immediately disassembled by removing the steel particulate filter, and the Summa canister. Immediately cap the Summa canister fitting. The final vacuum reading from the canister should be recorded on the chain of custody, sample collection form, and canister identification tag. If the final canister vacuum is less than 0.1 in Hg (more than -0.1 in Hg of pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected.

Soil vapor samples will be shipped to a certified laboratory for analysis.

Sampling Procedures using a flow controller

The sampling procedure is the same as above except that a laboratory certified in-line flow controller for a pre-specified sampling time (i.e. 30 minutes) will be used. The flow controller fits between the laboratory provided steel particulate filter and the Summa canister. The entire sample train (laboratory-provided steel particulate filter, flow-controller, and summa canister) should be pre-assembled prior to connecting to the sampling valve.

Other Collection Notes

For larger canisters (greater than one liter), sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize potential for vacuum extraction of contaminants from the soil phase. If large volume canisters are used (three or more liters) without a flow controller to ensure the flow rate remains below 200 ml/min, a purge volume test may be required to ensure sample dilution from other zones is not occurring.

FIELD RECORDS

The field technician maintains a log sheet summarizing:

- Sample Location.
- Sample Identification.
- Date and time of sample collection.
- Sampling depth.
- Tubing type, length, and volume.
- Purge Data (i.e. pump used, volume, PID screening information, purge start and stop time, purge vacuum reading).
- Weather conditions.
- Sampling methods and devices.
- Volume of sampling device.
- Sampling start and end date/time.
- Vacuum of canisters before and after samples collected.
- Apparent moisture content (dry, moist, or saturated, etc.) of the sampling zone.
- Chain of custody protocols and records used to track samples from sampling point to analysis.
- Other notes as applicable to site specific observations, sampling issues and mitigation of problems encountered.

ALTERNATIVE EPA METHOD TO-17 SAMPLING PROCEDURE

This alternate sampling methodology is consistent with EPA Compendium Method TO-17: *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes* (EPA 1999) and the established protocols of the PNG preferred laboratory (Air Toxics Ltd.) for the collection and analysis of samples by this method. This method replaces earlier sorbent-based EPA Methods TO-1 and TO-2 and provides an alternative to canister-based EPA Method TO-15 discussed in the Collection Protocol above. The target compound list is the same as TO-15 (i.e. subsets of the 97 VOCs listed as hazardous air pollutants in the Clean Air Act Amendments of 1990). However, TO-17 can collect VOCs over a wider volatility range than TO-15, by using a tube with multiple sorbents packed in increasing sorbent strength. Both single and multi-bed sorbent tubes are described in TO-17. Tube selection and the number and type of sorbents that will be packed into the tubes and conditioned by the laboratory are dependent on the COCs and desired reporting limit. Although the EPA Method TO-17 suggests replicate or distributed pair samples with sampling volumes of one and four liters, there is considerable mention of calculating a safe sampling volume (SSV). The SSV will minimize the potential for breakthrough on the sorbent tube and support the generation of valid analytical results. The sampling volume that is selected should include consideration of both the desired final reporting limit and the SSV of the sorbent being used. Further, when applied to the circumstances presented in this SOP, the methodology must be further modified to account for the greater concentrations of target COCs in soil gas than ambient air. In addition, because soil gas samples are typically for characterization purposes, the replicate or distributed pair sampling methodology should only be applied where field QA/QC samples are considered necessary.

SORBENT TUBE SELECTION

The approach to sorbent tube selection considering both reporting limits and sorbent SSVs is described in the following steps. This evaluation should be discussed with the analytical laboratory prior to ordering sorbent tubes for a given site investigation or sampling event.

- **Determine the Final Reporting Limit of the Target Compound –** This will be dependent on the COCs that are being investigated and their respective risk-based concentrations (RBCs) or preliminary remediation goals (PRGs) that are applicable at the site.
- **Determine the Method Reporting Limit –** The analytical laboratory will provide the mass value for each of the COCs that are being investigated based on the analytical method selected and the sensitivity of the instrumentation. The method reporting limit may vary for each of the target COCs.
- **Calculate the Sampling Volume –** The target sampling volume must be calculated to determine the volume of soil gas that must be drawn through the sorbent tube in order to achieve the desired final reporting limit for the target COCs. The target sampling volume is calculated by dividing the laboratory provided reporting limit for the target COC by the RBC or PRG of the COC then multiplying by 1000 liters. For example if the target COC was benzene at a residential site. The laboratory provided method reporting limit is 0.01 micrograms (ug) and the residential soil gas RBC in Oregon is 62 ug/m^3. Dividing 0.01 by 62 and multiplying by 1000 L/m^3 yields 0.16 L for a minimum sampling volume to achieve the target final reporting limit.
- **Calculate Minimum Flow Rate –** The minimum flow rate for the sampling pump and sorbent tube must be calculated to determine the sampling velocity for a specified time interval. Using the example above, if a minimum sampling volume of 0.16 L is required and the specified sampling interval is 5 minutes, the minimum flow rate would be determined by dividing 0.16 L by 5 minutes. This would yield a minimum flow rate of approximately 0.032 L/minute.
- **Compare the Sampling Volume to the SSV –** To determine whether or not sorbent tube breakthrough is likely for the target COC it is necessary to compare the minimum sampling volume calculated for the target COC with the SSV for the selected sorbent tube for the target COC. The SSVs for target COCs and suitable sorbents for those COCs are presented in Appendix 1 of the EPA Compendium Method TO-17 (EPA 1999). For example TO-17 Appendix 1 indicates that for benzene a SSV of up to 26 L can be collected using a Type 3 (CarboTrap 300) multi-sorbent tube. The target sampling volume determined above (0.16 L) could therefore be accommodated by the SSV of the tube and no breakthrough would be expected at the target sampling volume for a method reporting limit concentration.
- **Calculate if Overloading of Sorbent Tube is Possible –** Having determined if breakthrough is possible due to sampling volume, the likely concentration of the target COC in the soil gas sample must also be considered. For the target sampling volume desired, the maximum concentration of the target COC that could be accommodated by the SSV of the tube must also be evaluated. Again using the above example, if a minimum sampling volume of 0.16 L is required in order to achieve a final reporting limit lower than the RBC (62 ug/m^3), a tube which has an SSV of 26 L could contain a sample with a concentration equivalent to the SSV (26 L) divided by the minimum sampling volume (0.16 L) and multiplied by the RBC (62 ug/m^3) which would equate to 10,075 ug/m^3. Samples collected with sorbent tubes in known source areas would therefore require lower target sampling volumes (achieved through lower flow rates for the same duration or the same flow rate for a shorter duration) because it would not be necessary to achieve the lower reporting

limit but quantification of the concentration without saturation of the sorbent tube is desired.

SORBENT TUBE SAMPLING PROCEDURE

This approach to sorbent tube sampling assumes that sub-slab sampling point installation was performed in accordance with SOP-21 and leak checking and purging as described in the Collection Protocol above has been completed prior to the initiation of the following steps:

- **Pre-Sampling Flow Calibration –** Prior to sorbent tube sample collection the sampling pump that will be used during sample collection must be calibrated. In order to calibrate the pump connect a “set-up” tube provided by the lab to the Tygon tubing connected to the pump. If using a higher flow pump a low flow holder and constant pressure controller may be necessary to lower the flow rate. Adjust pump settings or restrict the flow using the low flow holder to the desired flow rate and record it on the field data sheet.
- **Sorbent Tube Connection –** After pump calibration, replace the “set-up” tube with the sample tube. Remove the sorbent tube from the laboratory provided sample container; then remove the foil wrapping, and both end plugs from the tube. Again using the Tygon tubing, connect the sampling pump to the outlet of the sample tube/low flow holder. Attach the sorbent tube inlet to the union fitting using a Swagelok nut. In the same manner attach the union to the Swagelok nut on the tubing from the sub-slab sampling point.
- **Sample Collection –** To begin sample collection start the sample pump and record the start time. After the desired duration, stop the pump and record the end time.
- **Sorbent Tube Removal –** Disconnect the sorbent tube from the Tygon tubing and union fitting and replace the end plugs on both ends of the sample tube. Record the sample ID, the tube ID, the collection date and time on the field data sheet and the laboratory chain-of-custody form. Wrap the tube in foil then replace in the laboratory provided sample container. Place the sample container in a cooler with blue ice.
- **Post Sampling Flow Calibration –** When completed with sample collection, reattach the “set-up” tube to the pump/low flow holder and measure the post sampling flow rate. Record the post-sampling flow rate on the field data sheet. The post-sampling flow rate should be within 10% of the pre-sampling flow rate.
- **Calculate Sampling Volume –** Calculate the average of the pre- and post-sampling flow rates then determine the total sampling volume by multiplying the average flow rate by the sample collection time duration. Record the sampling volume on the field data sheet and the laboratory chain-of-custody form.

REFERENCES

Cal EPA. *2005 (February 7 rev.). Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.* Department of Toxic Substances Control, Interim Final. California Environmental Protection Agency.

Cal EPA. 2010 (March). *Advisory – Active Soil Gas Investigation (Draft).* California Environmental Protection Agency.

DEQ. 2010 (March 25). *Guidance for Assessing and Remediating Vapor Intrusion in Buildings.* Oregon Department of Environmental Quality.

EPA 1999 (January). *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes.* United States Environmental Protection Agency.

ITRC. 2007 (January). *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline,* Interstate Technology & Regulatory Council

STANDARD OPERATING PROCEDURE
SOIL GAS (VAPOR) MONITORING AND SAMPLING
SOP 302

This standard operating procedure (SOP) describes procedures for performing soil gas (vapor) monitoring and sampling using direct-push drilling technology. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT

Soil gas monitoring and sampling will be performed using direct push sampling equipment. The direct push probe will be advanced using either a truck- or track-mounted Geoprobe rig, or for limited access areas, using portable methods such as rotary hammer drill (rotohammer).

Coring/probe installation equipment which may be used includes the following: a rotohammer or truck-mounted Geoprobe rig, ½-inch to 2-inch diameter concrete coring drill bit, cloth (for dust suppression during drilling), Geoprobe drill rods, ¼-inch diameter tubing (nylon, stainless steel, or Teflon®), fine-grained (20-40) silica sand, granular bentonite grout or alternative, and possibly cement in cases where the formation has a very low permeability.

Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, three-way valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves.

Monitoring/sampling equipment which may be used includes the following: Summa canister (may be a one-liter or six-liter Summa canister with valve), certified flow controller, steel filter, three-way valve, extra miscellaneous valves, photo ionization detector (PID), low flow vacuum pump, vacuum gauge, barometer/thermometer/wind speed indicator.

CORING/PROBE INSTALLATION PROCEDURES

Prior to drilling or coring, an attempt will be made to locate utility lines and if inside a building, to determine whether or not the building has an existing vapor barrier or a tensioned slab.

When samples are collected beneath buildings, a minimum of one sample will be collected from beneath each building. In addition, one duplicate sample will be collected. If possible, the samples will be located in the central portion of the slab, away from the floor slab/perimeter foundation junction, where dilution is more likely to occur.

In each sample location, a small diameter (½-inch to one-inch) hole will be drilled in the foundation using a rotohammer, truck-mounted Geoprobe rig, or concrete corer. When drilling the hole, no water should be used and care should be taken not to puncture the surface of soil underneath. If dust prevention is necessary, cover the location with a cloth or towel and drill through a pre-cut small hole in the cloth.

The probes are typically advanced to a depth of five feet below ground surface (bgs), however, other site-specific depths or multiple depths for vertical soil gas profiling may be targeted by the work plan. At target depth, the probe rod will be withdrawn approximately three to six inches to disengage the expendable probe tip and minimize the terminal void space volume. New, dedicated disposable nylon, stainless steel, or Teflon® tubing would then be fitted with a barbed steel end nut, pushed into the base of the probe rod, and threaded onto a downhole terminal fitting sealed with an o-ring to prevent vapor short-circuiting to the surface through the rod annulus.

The area immediately around the probe rods shall be grouted using hydrated bentonite grout (if temporary installation) or cement (if permanent installation). Wait 30 minutes prior to sampling for bentonite or cement to congeal. VOC-free modeling clay may also be used to seal around the probe rods to prevent vapor short-circuiting to the surface.

Procedures for leak checking, soil gas purging, and sampling are described in the section below.

Following the completion of sampling, the soil boreholes will be filled with hydrated granular or powdered bentonite grout. If a building slab or pavement is present, the hole(s) will be patched with cement and finished flush with the surface.

SYSTEM SETUP

Inspect the laboratory-provided Summa canister for damage prior to use. Do not use a canister that has visible damage.

Using a wrench, remove the brass cap above the valve on the top of the Summa canister. Measure and record the initial vacuum of Summa canister. If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.

Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.

The canister will then be fitted with the laboratory-provided steel filter. The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to a T-connector with an in-line vacuum gauge and vacuum tight flow valves (Swagelok) at each end. All valves should be closed on the T-connector at this time. The valve connected to the sampling train is referred to as the sampling valve. The vacuum pump (truck-mounted or otherwise) is then attached to the second end of the T with the valve closed (referred to as the purge valve).

Lastly, the sample tubing is threaded through the leak-check shroud and connected to the soil gas sampling point and the third closed valve on the T-connector. The leak-check shroud should then be sealed against the surface (see “Leak Check – Probe Point Surface Seal” below).

LEAK CHECKING - APPARATUS

The method described below shall be used to check for leaks in the lines and fittings of the above-ground sampling apparatus:

After the sampling system is set up, make sure all valves are closed.

Open the purge valve (the valve connecting the purge pump to the apparatus, all other valves remain closed), turn on the purge pump, and apply approximately ten inches of vacuum into the T-connector and valves. Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus (T-connector and valves) over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system train that must be remedied.

If necessary, recheck the system to verify that there is no leakage as described above.

Document the date and time the leak check(s) were performed. Close all valves.

LEAK CHECKING – PROBE POINT SURFACE SEAL

In addition checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work. The helium tracer gas method is listed in ITRC's "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" dated January 2007 (ITRC 2007), and as described below. The ITRC guidance from which the text below is derived is consistent with California Environmental Protection Agency and Oregon Department of Environmental Quality guidance (CalEPA 2005 and 2010; DEQ 2010).

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus (previously described above).
- Place the enclosure flush with the ground surface, placing hydrated bentonite around the shroud to seal the shroud around the sample point.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).
- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow to approximately 200 milliliters/minute (ml/min); let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 5%, this indicates leakage; check/tighten all seals and fittings and repeat procedure. The helium exhaust line should also be monitored so that additional helium can be added to the shroud during sampling if needed.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 5%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 5%, leakage is indicated and the probe hole abandoned.
- Record helium monitoring measurements in field notes.

SOIL GAS PURGING PROCEDURES

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage. Flow rates should not exceed 200 ml/min.

Purge vapors will be monitored using a PID for the presence of volatile organic compounds.

Slowly open the vacuum pump purge valve and purge three tubing volumes of vapor from the line, then close the purge valve. Based on a volume of approximately 0.044 liters per foot of ¼-inch ID tubing, and assuming five feet of tubing above ground, this would yield a total purge volume of 1.32 liters for a five-foot probe depth (ten total feet of tubing), and a total purge volume of 1.98 liters for a ten-foot probe depth (15 total feet of tubing).

During purging, check for leaks as described in the section on leak checks above. Record PID measurements of purge vapors on the field form. Oxygen and carbon dioxide concentrations may be monitored in the soil gas stream if desired by the work plan. At the conclusion of purging, immediately close the purge valve and then shut off the purge pump.

SOIL GAS SAMPLING PROCEDURES

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. A portable weather station equipped with a data logger is preferred to log site-specific conditions over the duration of sampling. However, if a weather station cannot be set-up on site, record atmospheric data from the closest weather station.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve. The canister's valve should be closed when the vacuum gauge shows a vacuum of 5 inches of mercury (in Hg) (pressure of -5 in Hg). The sample valve should then be closed.

Ensure the canister valve is tightly closed. The sample train should be immediately disassembled by removing the steel particulate filter, flow controller, and the Summa canister. Immediately cap the Summa canister fitting. The final vacuum reading from the canister should be recorded on the chain of custody, sample collection form, and canister identification tag. If the final canister vacuum is less than 0.1 in Hg (more than -0.1 in Hg of pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected.

Soil vapor samples will be shipped to a certified laboratory for analysis.

FIELD RECORDS

The field technician maintains a log sheet summarizing:

- Sample Location.
- Sample Identification.
- Date and time of sample collection.
- Sampling depth.
- Tubing type, length, and volume.
- Purge Data (i.e. pump used, volume, PID screening information, purge start and stop time, purge vacuum reading).
- Weather conditions.
- Sampling methods and devices.

- Volume of sampling device.
- Sampling start and end date/time.
- Vacuum of canisters before and after samples collected.
- Apparent moisture content (dry, moist, or saturated, etc.) of the sampling zone.
- Chain of custody protocols and records used to track samples from sampling point to analysis.
- Other notes as applicable to site specific observations, sampling issues and mitigation of problems encountered.

ALTERNATIVE EPA METHOD TO-17 SAMPLING PROCEDURE

This alternate sampling methodology is consistent with EPA Compendium Method TO-17: *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes* (EPA 1999) and the established protocols of the PNG preferred laboratory (Air Toxics Ltd.) for the collection and analysis of samples by this method. This method replaces earlier sorbent-based EPA Methods TO-1 and TO-2 and provides an alternative to canister-based EPA Method TO-15 discussed in the Collection Protocol above. The target compound list is the same as TO-15 (i.e. subsets of the 97 VOCs listed as hazardous air pollutants in the Clean Air Act Amendments of 1990). However, TO-17 can collect VOCs over a wider volatility range than TO-15, by using a tube with multiple sorbents packed in increasing sorbent strength. Both single and multi-bed sorbent tubes are described in TO-17. Tube selection and the number and type of sorbents that will be packed into the tubes and conditioned by the laboratory are dependent on the COCs and desired reporting limit. Although the EPA Method TO-17 suggests replicate or distributed pair samples with sampling volumes of one and four liters, there is considerable mention of calculating a safe sampling volume (SSV). The SSV will minimize the potential for breakthrough on the sorbent tube and support the generation of valid analytical results. The sampling volume that is selected should include consideration of both the desired final reporting limit and the SSV of the sorbent being used. Further, when applied to the circumstances presented in this SOP, the methodology must be further modified to account for the greater concentrations of target COCs in soil gas than ambient air. In addition, because soil gas samples are typically for characterization purposes, the replicate or distributed pair sampling methodology should only be applied where field QA/QC samples are considered necessary.

Sorbent Tube Selection

The approach to sorbent tube selection considering both reporting limits and sorbent SSVs is described in the following steps. This evaluation should be discussed with the analytical laboratory prior to ordering sorbent tubes for a given site investigation or sampling event.

- **Determine the Final Reporting Limit of the Target Compound –** This will be dependent on the COCs that are being investigated and their respective risk-based concentrations (RBCs) or preliminary remediation goals (PRGs) that are applicable at the site.
- **Determine the Method Reporting Limit –** The analytical laboratory will provide the mass value for each of the COCs that are being investigated based on the analytical method selected and the sensitivity of the instrumentation. The method reporting limit may vary for each of the target COCs.

- **Calculate the Sampling Volume –** The target sampling volume must be calculated to determine the volume of soil gas that must be drawn through the sorbent tube in order to achieve the desired final reporting limit for the target COCs. The target sampling volume is calculated by dividing the laboratory provided reporting limit for the target COC by the RBC or PRG of the COC then multiplying by 1000 liters. For example if the target COC was benzene at a residential site. The laboratory provided method reporting limit is 0.01 micrograms (ug) and the residential soil gas RBC in Oregon is 62 ug/m^3. Dividing 0.01 by 62 and multiplying by 1000 L/m^3 yields 0.16 L for a minimum sampling volume to achieve the target final reporting limit.
- **Calculate Minimum Flow Rate –** The minimum flow rate for the sampling pump and sorbent tube must be calculated to determine the sampling velocity for a specified time interval. Using the example above, if a minimum sampling volume of 0.16 L is required and the specified sampling interval is 5 minutes, the minimum flow rate would be determined by dividing 0.16 L by 5 minutes. This would yield a minimum flow rate of approximately 0.032 L/minute.
- **Compare the Sampling Volume to the SSV –** To determine whether or not sorbent tube breakthrough is likely for the target COC it is necessary to compare the minimum sampling volume calculated for the target COC with the SSV for the selected sorbent tube for the target COC. The SSVs for target COCs and suitable sorbents for those COCs are presented in Appendix 1 of the EPA Compendium Method TO-17 (EPA 1999). For example TO-17 Appendix 1 indicates that for benzene a SSV of up to 26 L can be collected using a Type 3 (CarboTrap 300) multi-sorbent tube. The target sampling volume determined above (0.52 L) could therefore be accommodated by the SSV of the tube and no breakthrough would be expected at the target sampling volume for a method reporting limit concentration.
- **Calculate if Overloading of Sorbent Tube is Possible –** Having determined if breakthrough is possible due to sampling volume, the likely concentration of the target COC in the soil gas sample must also be considered. For the target sampling volume desired, the maximum concentration of the target COC that could be accommodated by the SSV of the tube must also be evaluated. Again using the above example, if a minimum sampling volume of 0.16 L is required in order to achieve a final reporting limit lower than the RBC (62 ug/m^3), a tube which has an SSV of 26 L could contain a sample with a concentration equivalent to the SSV (26 L) divided by the minimum sampling volume (0.16 L) and multiplied by the RBC (62 ug/m^3) which would equate to 10,075 ug/m^3. Samples collected with sorbent tubes in known source areas would therefore require lower target sampling volumes (achieved through lower flow rates for the same duration or the same flow rate for a shorter duration) because it would not be necessary to achieve the lower reporting limit but quantification of the concentration without saturation of the sorbent tube is desired.

Sorbent Tube Sampling procedure

This approach to sorbent tube sampling assumes that probe installation, leak checking, and purging as described in the Collection Protocol above has been completed prior to the initiation of the following steps:

- **Pre-Sampling Flow Calibration –** Prior to sorbent tube sample collection the sampling pump that will be used during sample collection must be calibrated. In order to calibrate the pump connect a “set-up” tube provided by the lab to the Tygon tubing connected to the pump. If using a higher flow pump a low flow holder and constant pressure controller may be necessary to lower the flow rate. Adjust pump settings or restrict the flow using the low flow holder to the desired flow rate and record it on the field data sheet.

- **Sorbent Tube Connection –** After pump calibration, replace the "set-up" tube with the sample tube. Remove the sorbent tube from the laboratory provided sample container; then remove the foil wrapping, and both end plugs from the tube. Again using the Tygon tubing, connect the sampling pump to the outlet of the sample tube/low flow holder. Attach the sorbent tube inlet to the union fitting using a Swagelok nut. In the same manner attach the union to the Swagelok nut on the tubing from the sub-slab sampling point.
- **Sample Collection –** To begin sample collection start the sample pump and record the start time. After the desired duration, stop the pump and record the end time.
- **Sorbent Tube Removal –** Disconnect the sorbent tube from the Tygon tubing and union fitting and replace the end plugs on both ends of the sample tube. Record the sample ID, the tube ID, the collection date and time on the field data sheet and the laboratory chain-of-custody form. Wrap the tube in foil then replace in the laboratory provided sample container. Place the sample container in a cooler with blue ice.
- **Post Sampling Flow Calibration –** When completed with sample collection, reattach the "set-up" tube to the pump/low flow holder and measure the post sampling flow rate. Record the post-sampling flow rate on the field data sheet. The post-sampling flow rate should be within 10% of the pre-sampling flow rate.
- **Calculate Sampling Volume –** Calculate the average of the pre- and post-sampling flow rates then determine the total sampling volume by multiplying the average flow rate by the sample collection time duration. Record the sampling volume on the field data sheet and the laboratory chain-of-custody form.

REFERENCES

Cal EPA. *2005 (February 7 rev.). Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.* Department of Toxic Substances Control, Interim Final. California Environmental Protection Agency.

Cal EPA. 2010 (March). *Advisory – Active Soil Gas Investigation (Draft).* California Environmental Protection Agency.

DEQ. 2010 (March 25). *Guidance for Assessing and Remediating Vapor Intrusion in Buildings.* Oregon Department of Environmental Quality.

EPA 1999 (January). *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes.* United States Environmental Protection Agency.

ITRC, 2007 (January). *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline,* Interstate Technology & Regulatory Council