Data Gaps Analysis and Work Plan

Spic 'N Span Cleaners Site
652 S Dearborn Street
Seattle, Washington
King County Assessor's Parcel 5247802485

Prepared for:
Seattle Chinatown International District Preservation and Development Authority (SCIDpda)
409 Maynard Avenue S, P2
Seattle, WA 98104

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PBS
214 E GALER STREET
SUITE 300
SEATTLE, WA 98102
206.233.9639 MAIN
866.727.0140 FAX
PBSUSA.COM

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1.0 INTRODUCTION

PBS Engineering and Environmental, Inc. (PBS) is pleased to submit this analysis of data gaps and subsequent work plan to the Washington State Department of Ecology (Ecology) on behalf of the Seattle Chinatown International District Preservation and Development Authority (SCIDpda). The purpose of the analysis is to identify potential data gaps in the site characterization of the Spic N Span Cleaners Site located at 652 S Dearborn Street in Seattle, Washington (Site). Identification of data gaps is based on review of previous environmental investigation and extensive interim remedial actions completed at the Site to date. The purpose of the work plan portion of the document is to propose additional environmental investigation activities to address identified data gaps in collaboration with Ecology.

The Site is currently listed on Ecology's Confirmed and Suspected Contaminated Sites List (CSCSL) under Facility Site Identification (FSID) 54766547 and Contaminated Site Identification (CSID) 3502. The Site is enrolled in the Voluntary Cleanup Program by the current owner of King County Assessor's parcel 5247802485 (the property) under VCP Project Number NW2564. SCIDpda intends to purchase the property from the current owner. Prior to purchase of the property, SCIDpda intends to enter into a Prospective Purchaser Consent Decree (PPCD) with Ecology to pursue cleanup and regulatory closure of the Site. SCIDpda, its environmental counsel and PBS attended a meeting with Ecology and the current owner of the property on March 30, 2023 to discuss the PPCD and potential steps moving forward to reach regulatory closure at the Site.

During the March 30, 2023 meeting, Ecology indicated that it would be beneficial if they could review a summary report of interim remedial actions completed and analytical data collected at the Site since issuance of the 2016 Sampling and Analysis Plan (SAP) prepared by Aspect Consulting (Aspect). The SAP was the most recent document relating to environmental conditions at the Site made available to Ecology for review at the time of the March 30 meeting. As requested, Aspect prepared a Construction Completion Report (CCR) and Confirmation Groundwater Monitoring Report (CGMR) dated May 19 and May 31, 2023, respectively. These documents were made available to the Ecology Site Manager on June 20, 2023 following receipt of permission from the property owner to share them with Ecology.

The CCR and CGMR reflect the most up to date understanding of environmental conditions at the Site.

This document presents data gaps in site characterization by environmental media based on review of the CCR and CGMR, and a proposed scope of work to address the data gaps. It is understood that SCIDpda's goal is to address these data gaps prior to purchase of the property so as to expedite commencement of cleanup actions upon purchase and subsequent redevelopment.

2.0 BACKGROUND

The Site is comprised of one 0.3-acre tax lot and portions of surrounding properties and city right of way (ROW). The property was operated as Spic 'N Span Cleaners, a dry-cleaning facility, from approximately 1963 to 2019. A known release to the subsurface of tetrachloroethene (PCE), a common dry-cleaning solvent, and stoddard solvent/mineral spirits, characterized in previous environmental reports as total petroleum hydrocarbons (TPH) in the gasoline range (TPH-G), occurred at the subject property. The Site has undergone extensive environmental investigation and cleanup from 1998 to present day. An in-situ electrical resistance heating (ERH) thermal remediation system was installed at the Site from July 2019 to June 2021 to address concentrations of PCE and its degradation products, and TPH-G in various subsurface media (i.e., soil, groundwater, soil gas). The system operated from August 5, 2021 through January 29, 2022. Operation of the ERH system is summarized in Section 3.7 of this report, and thoroughly detailed in the CCR (Aspect, 2023a).

The following tables presents a summary of well construction details for existing and decommissioned monitoring wells at the Site.

Table 2. Summary of Well Construction Details

Well ID	Total Depth (feet bgs)	Screened Interval (feet bgs)	TOC Elevation (feet amsl)	Decommissioned?
MW-1	30	10-30	To be determined. Note that elevations provided for MW-1 through MW-6 do not match elevation of surrounding site. Elevations not provided for MW-7 through MW-12. Wells to be surveyed following installation of MW-13 and MW-14.	No
MW-2	30	10-30		Yes
MW-2R	30	10-30		No
MW-3	30	10-30		No
MW-4	30	10-30		No
MW-5	28	17.5-27.5		Yes
MW-5R	30	10-30		No
MW-6	27	17-27		No
MW-7	28	22.5-27.5		No
MW-8	24	17-22		No
MW-9	24	18-23		No
MW-10	30	10-30		No
MW-11	30	10-30		No
MW-12	30	10-30		No

Top of casing elevations provided by Hart Crowser for MW-1 through MW-6 do not match elevation of the surrounding site surface. Top of casing elevations for the remainder of site wells appear to have been surveyed using a site specific datum. Following installation of MW-13 and MW-14 as described in Section 7.2, remaining site wells will be resurveyed. Survey data will be provided in a supplemental remedial investigation (RI) report for the Site.

3.0 SITE-SPECIFIC CLEANUP LEVELS

Site-specific cleanup levels (CULs) were presented in the Remedial Investigation/Feasibility Study/Cleanup Action Plan (RI/FS/CAP) (Aspect, 2011). Below is a summary from the RI/FS/CAP summarizing how CULs were established for the Site:

Cleanup levels for groundwater are based on Model Toxics Control Act (MTCA) Method A cleanup levels (when available) or MTCA Method B cleanup levels (for drinking water use). Cleanup levels for all analytes historically detected in site groundwater are summarized in Table 5 (of the RI/FS/CAP). Cleanup levels for soil are based on MTCA Method B levels for unrestricted use. Two potential cleanup levels were compared, one for the direct contact pathway and one for protection of groundwater for drinking water beneficial use (soil leaching). The more restrictive of the two was chosen as the site cleanup level. Cleanup levels calculated for protection of groundwater as drinking water are also assumed to be protective of the vapor pathway. For mineral spirits, a site-specific soil cleanup level was calculated using Ecology's volatile petroleum hydrocarbons (VPH) petroleum fraction analysis and worksheet (see Appendix F of the RI/FS/CAP). Of two samples analyzed by VPH, only one had detectable levels of petroleum hydrocarbons; therefore, the results from this sample were used for the cleanup level calculation. MTCA Method B soil cleanup levels for protection of groundwater were calculated in accordance with WAC 173-340-747(4) using drinking water cleanup levels and the default MTCA parameters, except that the geometric mean site-specific soil organic content (0.39 percent) was used. The MTCA Method B equation and default parameters are shown in Table 5 (of the RI/FS/CAP). Soil cleanup levels for the direct contact and groundwater protection pathways are summarized in Table 5 (of the RI/FS/CAP).

Ecology provided comments on the site-specific CUL calculations in a February 25, 2013 opinion letter. In the letter, Ecology concluded that the fraction organic carbon (foc) parameter used in the Method B calculations to compute the cleanup levels in soil protective of groundwater for volatile organics and mineral spirits was not derived correctly. The foc value for the Site was derived utilizing the geometric mean of total organic carbon analytical results from 10 soil samples. Eight of the soil samples were acquired within the area of the Site impacted by TPH/mineral spirits contamination, and showed higher percentages of organic carbon than the two samples acquired from outside this area. Per MTCA 747-(5)(b)(i), soil organic carbon measurements shall be based on uncontaminated soil. Ecology suggested that a site-specific foc value utilizing additional soil samples outside the TPH-impacted soil should be utilized to recalculate the cleanup levels in soil that are protective of groundwater. Additionally, Ecology noted that the toxicity values of PCE and trichloroethene (TCE) have been revised, which affected Method B cleanup levels for these compounds in soil and groundwater, and suggested using the updated values to recalculate site-specific soil CULs for these compounds.

Aspect presented recalculated site-specific CULs in the Supplemental Data Collection letter (Aspect, 2014). The new site-specific CULs were calculated using the updated toxicity values as well as foc values derived from soil samples collected outside of the area of TPH contamination. Ecology offered opinions of the Supplemental Data Collection letter in a July 19, 2016 opinion letter. No additional revisions to the site-specific CULs were provided in the opinion letter, and thus the site-specific CULs presented in the Supplemental Data Collection letter were adopted for the Site. Site-specific CULs by media and compound were presented in Table 2 of the Supplemental Data Summary letter, which is included in Appendix A of this document.

SCIDpda plans to redevelop the source property at the Site with a new affordable housing development. While design of the new development is still underway, design is known to include impervious surfaces covering the entirety of the property footprint. As such, direct contact with soil will be an incomplete exposure pathway except by construction workers during earthwork to facilitate site redevelopment. Following completion of redevelopment, the soil to groundwater and vapor intrusion pathways will be the only remaining potentially complete exposure pathways. The soil vapor pathway will be evaluated by soil vapor characterization as detailed in Section 7.3 of this document. Mitigation measures will be incorporated into new building design if warranted by soil vapor characterization. As such, recalculation of site-specific CULs for soil and groundwater will be performed to ensure values for site contaminants of concern (COCs) are consistent with Ecology's current toxicity values. This information will be included in the forthcoming RI Report.

4.0 RECENT ENVIRONMENTAL ACTIONS AND REGULATORY CORRESPONDENCE

Historic environmental investigation and remedial actions performed at the Site are well documented in the RI/FS/CAP prepared by Aspect Consulting (Aspect) dated November 16, 2011 (Aspect, 2011). Ecology responded to the RI/FS/CAP with opinions on proposed remedial action at the Site in a letter dated February 25, 2013 (Ecology, 2013). Additional site characterization data was collected by Aspect in support of design of an in-situ thermal remediation system using electrical resistance heating (ERH) which was summarized in a Supplemental Data Collection letter dated November 18, 2014 (Aspect, 2014) and a Sampling and Analysis Plan (SAP) dated February 9, 2016 (Aspect, 2016).

It is noted that Ecology also issued a Request for Information letter inquiring as to the status of the VCP site dated July 23, 2019. Aspect responded to the request for information in an August 5, 2019 status letter noting that design and permitting for the selected cleanup action using in situ thermal remediation by ERH was underway and presenting a proposed schedule for performance of the cleanup action. The request for information and subsequent status update letter are of little substance to the environmental investigation and cleanup of the Site and are not discussed further herein.

This section summarizes the most recent Ecology opinion of substance issued for the Site in a July 19, 2016 opinion letter regarding proposed remedial action for the Site (Ecology, 2016) as well as environmental investigation and remedial action performed at the Site since issuance of that opinion letter.

4.1 Opinion on Proposed Remedial Action – Ecology, 2016

The 2016 Ecology opinion letter was issued following review of the SAP (Aspect, 2016), Supplemental Data Collection letter (Aspect, 2014), 2013 opinion letter (Ecology, 2013) and RI/FS/CAP (Aspect, 2011). Ecology offered the following opinions in the July 19, 2016 letter regarding environmental conditions at the Site:

1. Based on additional data presented in the 2014 Supplemental Data Collection letter, it was determined that the northern extent of soil contaminated with PCE extended further north than previously expected, onto the north adjacent parcel. Groundwater was also found to be contaminated with volatile organic compounds (VOCs) in that area. The area of contaminated soil which also contained TPH-G was also found to extend further southeast beneath the on-property structure.
2. In the 2013 opinion letter, Ecology agreed that the selection of in-situ thermal remediation using ERH was an appropriate cleanup action plan for the Site. A compliance monitoring plan included in the RI/FS/CAP presented performance and long term monitoring procedures to evaluate performance of the ERH system and the degradation of downgradient contaminants in groundwater.
3. Based on the additional contamination discovered in the Supplemental Data Collection letter, the compliance monitoring plan presented in the RI/FS/CAP was no longer considered adequate.
4. The revised compliance monitoring plan presented in the SAP (Aspect, 2016) provided adequate coverage of the Site and was considered acceptable.
5. Based on concentrations of VOCs in soil and groundwater on the eastern portion of the Site, Ecology recommended vapor intrusion (VI) evaluation of the east adjacent office building.
6. There has been no data entry into Ecology's Environmental Information Management (EIM) database.

4.2 Construction Completion & Confirmation Groundwater Monitoring – Aspect, 2023

Aspect prepared a Construction Completion Report (CCR) for the Site dated May 19, 2023 (Aspect, 2023a). Additionally, Aspect prepared a Confirmation Groundwater Monitoring Report (CGMR) dated May 31, 2023 (Aspect, 2023b). The reports were submitted to Ecology by PBS via email on June 20, 2023. The CCR provides extensive detail on the installation and operation of the ERH system from August 2021 to January 2022, as well as baseline and confirmation soil and groundwater monitoring performed prior to and during system operation. The CGMR details results of groundwater sampling and analysis of on-site monitoring wells following shutoff of the ERH system. Relevant findings of the CCR and CGMR relating to ERH system performance and contaminant concentration reductions are summarized below by media.

4.2.1 Soil

<u>Soil Sample Collection</u>

Two rounds of performance soil sampling were completed in accordance with the revised compliance monitoring plan presented in the 2016 SAP with minor deviations from the plan as noted in this subsection. The first round was performed in November and December 2021 and the second round in January 2022. The soil sampling rounds were performed after 60 and 80 percent of the design energy had been applied to the subsurface, respectively, as specified in the 2016 SAP. Sampling locations CB-01 through CB-14 were selected based on areas of historically high soil concentrations as shown on Figure 3 of the CCR (Figures and Tables from Aspect's CCR are included as Appendix A of this document). The following minor deviations from the revised compliance monitoring plan are noted with respect to soil sampling locations: CB-12 was moved 5 feet east onto the property boundary from its proposed location due to a temporary holiday moratorium for right-of-way permitting and CB-

14 was drilled at an angle to collect the target depth intervals due to access constraints between the ERH system and the building.

Per the compliance monitoring plan, soil samples were collected from the 14 performance monitoring borings (CB-01 through CB-14) at a minimum of four depth intervals. The four depth intervals for soil sample collection were specified in the compliance monitoring plan as follows: 0 to 7 feet bgs, 7 to 14 feet bgs, 14 to 21 feet bgs, and 21 to 28 feet bgs. Depths for soil sample collection within these specified depth intervals were selected based on the highest detected photoionization detector (PID) measurements of the soil core, and depths of highest detected contaminant concentrations in adjacent borings. The initial round of performance soil sampling was performed in November and December 2021 in accordance with the compliance monitoring plan with the following exceptions: soil samples were collected from less than four depth intervals from borings CB-07, CB-08, CB-11, and CB-13 due to drill rig refusal. Aspect returned to the Site to characterize these locations with a larger direct push rig in January 2022. The rig successfully advanced new borings in these locations to depths greater than the previous depths of refusal encountered in November and December of 2021. Additional soil samples were collected at each of these locations such that the requirement for soil sample analysis from a minimum of four depth intervals was achieved.

A total of 67 soil samples were collected from fourteen borings from November 2021 to January 2022 for the purpose of performance monitoring of the in-situ thermal remediation system. Soil samples were analyzed for the following in accordance with the compliance monitoring plan:

- VOCs by EPA Method 8260C
- TPH-G by Method NWTPH-Gx (only for sample locations within the historical area of TPH impacts: CB-8 through CB-11, VE-1R, MW-2R, MW-3R, and MW-10).

<u>Analytical Results for Soil</u>

COCs were not detected in exceedance of site-specific CULs in performance soil samples with the following exceptions:

- PCE was detected at a concentration of 0.2 milligrams per kilogram (mg/kg) in the 3-foot sample collected from boring CB-02 located in the parking lot on the north-adjacent parcel. This concentration exceeds the site-specific CUL for PCE in soil of 0.15 mg/kg.
- TPH-G was detected at concentrations of 310 and 580 mg/kg in the 21 and 22 foot soil samples collected from boring CB-14, respectively. These concentrations exceed the site-specific CUL for TPH-G in soil of 97 mg/kg. TPH-G was not detected above laboratory reporting limits in soil samples collected at depths of 20 and 22.5 feet bgs in this location during the second round of performance monitoring in January 2022, indicating that additionally focused treatment in this area reduced contaminant concentrations to below the site-specific CUL.

Based on the following statistical analysis, soil across the Site is in compliance with site-specific CULs per Washington Administrative Code (WAC) 173-340-740.

- Following resampling of the 20 to 22.5 foot bgs depth interval in location CB-14, no soil sample result is greater than two times the site-specific CUL [compliance via WAC 173-340(7)(e)(i)].
- One out of 67 soil samples exceeded the site-specific CUL for PCE. This sample represents approximately 1.5% of the total number of soil samples collected for compliance monitoring. As such, less than 10% of the sample locations exceeded the CUL [compliance via WAC 173-340(e)(ii)].
- Due to the high percentage of non-quantifiable data within this data set, statistical test measures outlined in WAC 173-340-740(7)(d)(i)(A) and WAC 173-340-740(7)(f)(iv) are not suitable for the confirmation soil sample set.

4.2.2 Groundwater

Groundwater Sample Collection

The compliance monitoring plan specifies that subsurface temperatures will be monitored during the cool-down period following treatment until groundwater temperatures stabilize. Groundwater monitoring will be implemented on a quarterly basis to evaluate the potential for rebound. Quarterly groundwater monitoring will be conducted during cool down and for 1 year afterwards, and will include the sampling of on-site wells MW-1 through MW-12 and vapor extraction well VE-1R. Groundwater will be analyzed for the following in accordance with the compliance monitoring plan:

- VOCs by EPA Method 8260C
- TPH-G as mineral spirits from wells VE-1R, MW-2R, MW-3R, and MW-10

Two quarterly groundwater monitoring events were performed during ERH operation. Additionally, four quarterly events have been completed during system cool down.

Analytical Results for Groundwater

Analytical results of performance monitoring groundwater samples indicate that concentrations of COCs were below site-specific CULs for all contaminants in the most recent sampling event completed in April 2023 with the following exception: concentrations of vinyl chloride (VC) in groundwater remain above the CUL in monitoring wells MW-4 and MW-6.

Based on these analytical results, groundwater is not in compliance with site-specific CULs. Per the RI/FS/CAP, monitored natural attenuation was selected as the remedial alternative for the downgradient groundwater plume. As summarized in Section 5.5, subsurface temperatures are expected to have stabilized throughout the Site by the next groundwater monitoring event. As such, on-site monitoring wells will be sampled for four consecutive quarters to establish contaminant concentration trends post cooling. Following completion of the four quarterly events, PBS will likely request approval from Ecology to reduce the monitoring well network utilized for quarterly sampling to focus on remaining groundwater impacts in the downgradient direction, and potentially within the source area located on the property.

4.2.3 Soil Vapor

The compliance monitoring plan specifies that three soil vapor samples will be collected following stabilization of subsurface temperatures. To date, soil vapor samples have yet to be collected following completion of in-situ thermal remediation by ERH.

5.0 CURRENT UNDERSTANDING OF NATURE AND EXTENT OF CONTAMINATION

The following section presents the current understanding of the nature and extent of contamination in soil and groundwater at the Property.

5.1 Contaminants of Concern

The RI/FS/CAP defined the COCs for the Site (Aspect, 2011). In addition to the COCs defined in the RI/FS/CAP, constituents detected above site-specific CULs in either soil or groundwater during performance monitoring have been added to the list of COCs below. COCs are listed below by media:

COCs in Soil

- PCE
- Mineral spirits (TPH-G)
- Trichloroethene (TCE)
- Cis-1,2-dichloroethene (cis-1,2-DCE)

COCs in Groundwater

- PCE
- TCE
- cis-1,2-DCE
- VC
- Naphthalene

COCs in Soil Vapor

- PCE
- Mineral spirits (TPH-G)
- TCE
- cis-1,2-DCE
- VC
- Naphthalene

5.2 Extent of Contamination in Soil

The RI/FS/CAP defined the extent of soil contamination at the Site (Aspect, 2011). The Supplemental Data Collection letter refined the extent of soil contamination at the Site (Aspect, 2014). The in-situ thermal remediation system was installed within the footprint of soil contamination exceeding site-specific CULs and operated as detailed in the CCR (Aspect, 2023a). As detailed in the CCR and summarized in Section 4.2.1 of this document, performance monitoring during system operation has displayed soil to be in compliance with site-specific CULs for all COCs.

5.3 Extent of Contamination in Groundwater

The RI/FS/CAP defined the lateral extent of groundwater contamination at the Site (Aspect, 2011). The Supplemental Data Collection letter refined the lateral extent of groundwater contamination at the Site (Aspect, 2014). Following operation of the in-situ thermal remediation system, performance monitoring during and after system operation has displayed that COCs are not present in groundwater in exceedance of CULs with the exception of VC in downgradient wells MW-4 and MW-6. The downgradient VC plume is bound in four cardinal directions by monitoring wells with VC concentrations below the site-specific CUL as follows: MW-11 and MW-12 to the north, MW-2R, MW-10 and MW-3R to the east, MW-7 and MW-9 to the south and MW-8 to the west.

However, based on comments provided to the draft version of this document, Ecology considers the lack of recent groundwater data in the portion of the Site in between monitoring wells MW-6, MW-7, MW-8 and MW-9 to be a data gap in site characterization.

PCE and its degradation products are denser than water, and as such are expected to descend in the water column upon reaching saturated subsurface conditions. Aspect reported to PBS that groundwater samples were collected from on-site wells with the pump/tubing inlet placed at a depth corresponding to approximately halfway between the depth of static groundwater and bottom of well screen. MW-2R and VE-1R, located within the source area at the Site, are screened from 10 to 30 feet bgs. Table 2 outlines new well construction details. Based on a lack of characterization of potential variations in contaminant concentrations with depth within the water column, the vertical extent of groundwater contamination remains undefined.

5.4 Extent of Contamination in Soil Vapor

Soil vapor sampling has not been performed at the Site since installation, operation, and shutoff of the in-situ thermal remediation system. As such, the extent of soil vapor contamination at the Site remains undefined.

5.5 Subsurface Temperatures

Subsurface temperatures have been periodically recorded by Aspect at three temperature probe locations – H3, D4 and G6 (see Appendix A). Aspect communicated to PBS that subsurface temperatures in all three probes were recorded through April 2023, with the highest temperatures consistently recorded at a depth of 25 feet bgs at each location. In April 2023, maximum temperatures by location were 40 degrees Celsius (° C) at H3, 35° C at D4 and 31° C at G6. Aspect returned to the Site in July 2023 to measure temperatures but D4 and G6 were unable to be monitored due to vandalism and theft of the temperature probe cables. A temperature of 33° C was measured at H3. Based on a linear extrapolation of data, Aspect expects that subsurface temperatures at probes D4 and G6 have already dropped below 30° C. Aspect collected measurements again in early September 2023. A maximum temperature measured below the water table of 32° C was recorded in H3. Additionally, Aspect was able to collect readings a previously inaccessible probe F3, where a maximum temperature of 25° C was measured below the water table. A groundwater temperature of 28° C was also recorded at monitoring well MW-11 at this time.

An ambient soil temperature value indicating completion of subsurface cooling was not specified in the revised compliance monitoring plan presented in the SAP (Aspect 2016). Based on conversations with TRS, the thermal remediation contractor, Aspect understands that Ecology has accepted a temperature of 30° C at other ERH remediation sites to indicate that the site has sufficiently cooled to allow for representative groundwater monitoring.

It is noted that groundwater temperatures presented in the CCR were recorded after groundwater had passed through a cooling bath per the hot sampling procedures outlined in the SAP. As such, subsurface soil temperature probes are considered a more reliable indication of subsurface temperature than groundwater temperatures presented in the CCR.

6.0 DATA GAPS

6.1 Soil

As established in Section 5.2 of this document based on data provided in the CCR (Aspect, 2023a), the extent of soil contamination at the Site is well defined. Soil is in compliance with site-specific CULs. As such, no data gaps remain to be investigated at the Site with respect to soil.

6.2 Groundwater

As established in Section 5.3 of this document based on data provided in the CCR (Aspect, 2023a) and CGMR (Aspect, 2023b) the lateral extent of groundwater contamination at the Site is well defined. However, based on a lack of characterization of contaminant concentrations by depth within the well screen, the vertical extent of groundwater contamination at the Site remains undefined. This represents a data gap in site characterization.

6.3 Soil Vapor

As established in Section 5.4 of this document, the extent of soil vapor contamination at the Site remains undefined. This represents a data gap in the characterization of environmental contamination at the Site.

7.0 WORK PLAN FOR ADDITIONAL INVESTIGATION OF DATA GAPS

7.1 Soil

PBS proposes collecting soil samples from wells MW-13 and MW-14. Two soil samples will be collected from each boring, one immediately above the groundwater interface, and one either at the depth of greatest evidence of contamination, or at 25 feet bgs. Soil will be logged continuously, noting grain size, color, odor, and moisture. All soil samples will be collected in accordance with PBS' Standard Operating Procedure (SOP) Drilling and Soil Sampling Procedures.

Photoionization detector (PID) measurements will be taken to assess the presence of volatile contaminants. For the PID screening, soil will be collected at approximately 5-foot intervals and placed into disposable zipper-type plastic bags that were sealed, gently shaken, and the PID tip inserted into the bag to measure total volatile compounds.

Soil samples will be collected in laboratory-supplied containers, placed on ice in a cooler, and transported to a Washington accredited laboratory, with chain-of-custody documentation.

Soil samples will be analyzed for the following:

- Chlorinated VOCs (cVOCs) by EPA Method 8260

7.2 Groundwater

PBS proposes to install two additional groundwater monitoring wells (MW-13 and MW-14) at the Site. These wells will be used to further quantify vinyl chloride concentrations downgradient of MW-4 and MW-6. Monitoring wells MW-4 and MW-6 are screened from 10-30 feet bgs and 17-27 feet bgs, respectively. In an attempt to construct wells aimed at characterizing contaminant concentrations in a similar screen interval as these two existing wells, MW-13 and MW-14 will be installed to a total depth of 30 feet bgs with a screened interval from 15-30 feet bgs. Proposed locations for wells MW-13 and MW-14 are shown on Figure 1. Groundwater sampling and analysis will be conducted in accordance with the Sampling and Analysis/Quality Assurance Project Plan (SAP/QAPP), provided in Appendix B.

As summarized in Section 5.5, subsurface temperatures at the Site following in situ thermal remediation by ERH have decreased to below 30° C beneath the majority of the Site. Temperatures in the vicinity of probe H3, near monitoring well MW-10, remain slightly elevated at 32° C.

Quarterly groundwater sampling will be continued by PBS in accordance with the compliance monitoring plan, following Ecology approval of this work plan, projected for Q4 2023. Subsurface temperatures are expected to have stabilized by this time. As such, quarterly groundwater sampling will be performed from Q4 2023 through Q3 2024 to satisfy the requirement of 4 consecutive quarters post cooling.

Following completion of four quarters of groundwater monitoring post temperature stabilization, PBS proposes reducing the monitoring well network to a select group of monitoring wells sufficient to monitor plume stability in collaboration with Ecology. In order to monitor natural attenuation, several additional constituents will be analyzed in accordance with section 2.3.1 of EPA's 1998 guidance for Technical Protocol for Evaluating Natural Attenuation.

Until Ecology and PBS reach an agreement on a reduced well network for groundwater monitoring, the 12 existing on-site monitoring wells and one vapor extraction well will continue to be sampled quarterly and analyzed for the following constituents:

Analyte	Method	Justification
VOCs	EPA Method 8260	Site COC
TPH-G	Method NWTPH-Gx	Site COC
Naphthalene	EPA Method 8260	Site COC
Trimethylbenzene Isomers	EPA Method 8260	MNA Parameter
Nitrate	EPA Method 300.0	MNA Parameter
Iron	EPA Method SM3500	MNA Parameter
Sulfate	EPA Method 300.0	MNA Parameter
Methane	EPA Method RSK 175 (portable gas meter)	MNA Parameter
Alkalinity	EPA Method SM2320	MNA Parameter
Dissolved Hydrogen	EPA Method AM206Ax	MNA Parameter
Chloride	EPA Method 300.0	MNA Parameter
Total Organic Carbon	EPA Method SM5310C	MNA Parameter
Oxygen Reduction Potential	Field Screening	MNA Parameter
pH	Field Screening	MNA Parameter
Temperature	Field Screening	MNA Parameter
Specific Conductivity	Field Screening	MNA Parameter
Dissolved Oxygen	Field Screening	MNA Parameter

The depth of pump/tubing inlet for groundwater sample collection will be correspond to approximately halfway between the water table and bottom of well screen, with the exception of samples collected from wells MW-2R and VE-1R located within the source area of the release. Two groundwater samples will be collected from these wells for the next two groundwater monitoring events performed at the Site. Samples will be collected with the depth of pump/tubing inlet corresponding to approximately halfway between the water table and bottom of well screen as noted above. Additionally, a second sample will be collected from these two wells with the depth of pump/tubing inlet corresponding to 18-inches above the bottom of well screen. It is noted that both wells are screened from 10 to 30 feet bgs. Samples will be labeled such that the deeper sample in each well is distinguishable from the shallower sample. Analytical results of the groundwater samples collected from two different depths will be evaluated to determine the potential for contaminant concentrations in groundwater to increase with depth.

In the absence of formal Ecology policy or guidance defining a significant increase in contaminant concentrations with depth, PBS proposes the following rationale to establish a significant increase in contaminant concentrations with depth which would warrant additional exploration of deeper groundwater concentrations: A significant increase in contaminant concentrations with depth will be defined as: 1) a detection of any COC in the deeper groundwater sample at a concentration three times (or greater) than that of the concentration of the same COC in the shallower groundwater sample collected from the same well; OR 2) detection of any COC in the deeper groundwater sample at a concentration of greater than half the site-specific cleanup level for that COC AND greater than two times the concentration detected from the shallower groundwater sample collected from the same well. Groundwater concentrations are not expected to be homogeneous throughout the water column. Some variability with depth is expected based on general heterogeneity of the groundwater formation. If contaminant concentrations in the deeper groundwater sample are less than three times that of the shallower sample AND the concentration is less than half the site-specific cleanup level for that COC, it is considered unlikely that concentrations continue to increase with depth resulting in a concentration of groundwater at depths greater than the bottom of well screen which would exceed the site-specific cleanup level. If contaminant concentrations in the deeper sample are greater than two times that of the shallower sample AND greater than half the site-specific cleanup level, it is reasonable to expect that a further increase in contaminant concentrations at depths beyond the bottom of well screen may result in groundwater concentrations which exceed site-specific cleanup levels.

Should laboratory analysis indicate that contaminant concentrations in groundwater significantly increase with depth as defined in the paragraph above, a deeper monitoring well will be installed adjacent to MW-2R or VE-1R, whichever has the greater magnitude of contamination as defined by laboratory analysis. The new monitoring well would be constructed with a screen interval from 30 to 45 feet bgs. Should an additional monitoring well be installed at the Site, it would be included in the monitoring well network for sampling during quarterly groundwater monitoring events moving forward.

Should laboratory analysis indicate that contaminant concentrations in groundwater do not significantly increase with depth as defined above, no additional monitoring wells will be installed at the Site for the purpose of vertical delineation, and a single groundwater sample each will be collected from wells MW-2R and VE-1R following this same methodology as the remainder of wells at the Site. It is noted that MW-13 and MW-14 are still proposed for installation to evaluate downgradient concentrations regardless of the results of vertical delineation sampling.

7.3 Soil Vapor

As established in Section 6.3 of this document, the lack of soil vapor data from the Site following in-situ remediation represents a data gap with respect to site characterization. PBS proposes to install seven soil vapor probes (SV-1 through SV-7) in the locations depicted on Figure 1 to investigate soil vapor concentrations within the former source area at the Site and surrounding vicinity. Soil vapor probes will be installed following the methodology established in Appendix D of Ecology Publication No. 09-09-047: Guidance for Evaluating Vapor Intrusion in Washington State (Ecology, 2022). Soil vapor probes will be installed to a total depth of 7 feet bgs and screened from 6 to 7 feet bgs. Screen intervals are selected to characterize near surface contaminant concentrations in soil vapor while ensuring an appropriate vapor well seal in accordance with Appendix D of the Vapor Intrusion Guidance.

Soil vapor samples will be collected from the three newly installed soil vapor probes twice to establish contaminant concentrations as well as seasonal variability of concentrations. Pending work plan and permit approval, PBS proposes to collect soil vapor samples from the seven newly installed probes in December 2023 and June of 2024. Soil vapor sampling and analysis will be conducted in accordance with the SAP/QAPP, provided in Appendix B.

Soil vapor samples will be analyzed for the following COCs:

- cVOCs by EPA Method TO-15
- Air Phase Hydrocarbons (APH) by EPA Method MA-APH

Additionally, soil vapor samples will be analyzed for the following constituents to assess MNA conditions at the Site:

- Oxygen
- Carbon Dioxide
- Methane

Detected concentrations in soil vapor will be compared to Ecology's Method B Sub-Slab Soil Gas Screening Levels as established in the Cleanup Levels and Risk Calculation (CLARC) master data tables (Method B SLs). In the event that a cancer and non-cancer value exist for a given compound, the lower of the two values will be used as the screening level.

7.4 Summary of Additional Investigations

The following table summarizes additionally proposed investigation at the Site as well as rationale for each new location.

Table 7-4. Rationale for Additional Exploratory Locations

Proposed Location ID	Rationale	Estimated Surface Elevation (feet amsl)	Total Depth	Sample Matrix	Screened Interval	Sample Elevation (feet amsl)	Proposed Analyses
SV-01	Characterize soil vapor concentrations throughout the Site	61	7	Soil vapor	6-7	54.5	APH, cVOCs
SV-02		60	7	Soil vapor	6-7	53.5	
SV-03		59	7	Soil vapor	6-7	52.5	
SV-04		59	7	Soil vapor	6-7	52.5	
SV-05		61	7	Soil vapor	6-7	54.5	
SV-06		58	7	Soil vapor	6-7	51.5	
SV-07		60	7	Soil vapor	6-7	53.5	
MW-13	Characterize groundwater concentrations downgradient of MW-4 and MW-6	57	30	Groundwater	15-30	49.5	VOCs
MW-14		58	30	Groundwater	15-30	50.5	

APH – Air Phase Hydrocarbons
cVOCs – chlorinated volatile organic compounds including PCE, TCE, cis-1,2-DCE, trans-1,2-DCE and vinyl chloride
Feet amsl – feet above mean sea level
VOCs – volatile organic compounds (full EPA 8260 suite)

8.0 FIELD AND REPORTING SCHEDULE

The most recent groundwater monitoring event at the Site was performed on April 5, 2023. PBS plans to perform the next quarterly event as well as installation and sampling of the soil vapor probes in Q4 2023 pending Ecology approval of this work plan. Groundwater monitoring events of the existing well network will continue for four consecutive quarters, including the Q4 2023 sampling event. Upon completion of these four consecutive quarters of groundwater monitoring, PBS intends to reduce the monitoring well network for groundwater monitoring in collaboration with Ecology.

PBS aims to deliver a report detailing results of the upcoming groundwater monitoring event as well as soil vapor probe installation, sampling and analysis by February 15, 2024.

9.0 LIMITATIONS

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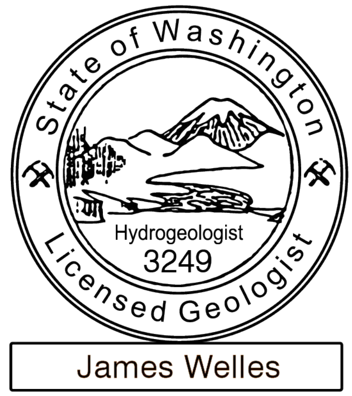
Sincerely,
PBS Engineering and Environmental Inc.

Digitally signed by James Welles
Date: 2023.12.22 10:18:53 -08'00'



James Welles, LHG — Date
Senior Hydrogeologist

Digitally signed by Melanie Young
Date: 2023.12.22 10:30:17 -08'00'

Melanie Young, PE — Date
Senior Environmental Engineer

10.0 REFERENCES

Aspect Consulting (Aspect), 2011, *Remedial Investigation, Feasibility Study and Cleanup Action Plan,* November 16, 2011.

Aspect, 2014, *Supplemental Data Collection Letter,* November 18, 2014.

Aspect, 2016, *Sampling and Analysis Plan,* February 9, 2016.

Aspect, 2023a, *Construction Completion Report Spic'N Span Cleaners Thermal Remediation,* May 19, 2023.

Aspect, 2023b, *Confirmation Groundwater Sampling Results,* May 31, 2023.

Washington State Department of Ecology (Ecology), 2013, *Opinion Pursuant to WAC 173-340-515(5) on Proposed Remedial Action for the Spic N Span Cleaners Hazardous Waste Site,* February 25, 2013.

Ecology, 2016, *Opinion Pursuant to WAC 173-340-515(5) on Proposed Remedial Action for the Spic N Span Cleaners Hazardous Waste Site,* July 19, 2016.

Ecology, 2022, *Guidance for Evaluating Vapor Intrusion in Washington State, Publication No. 09-09-047,* March, 2022.

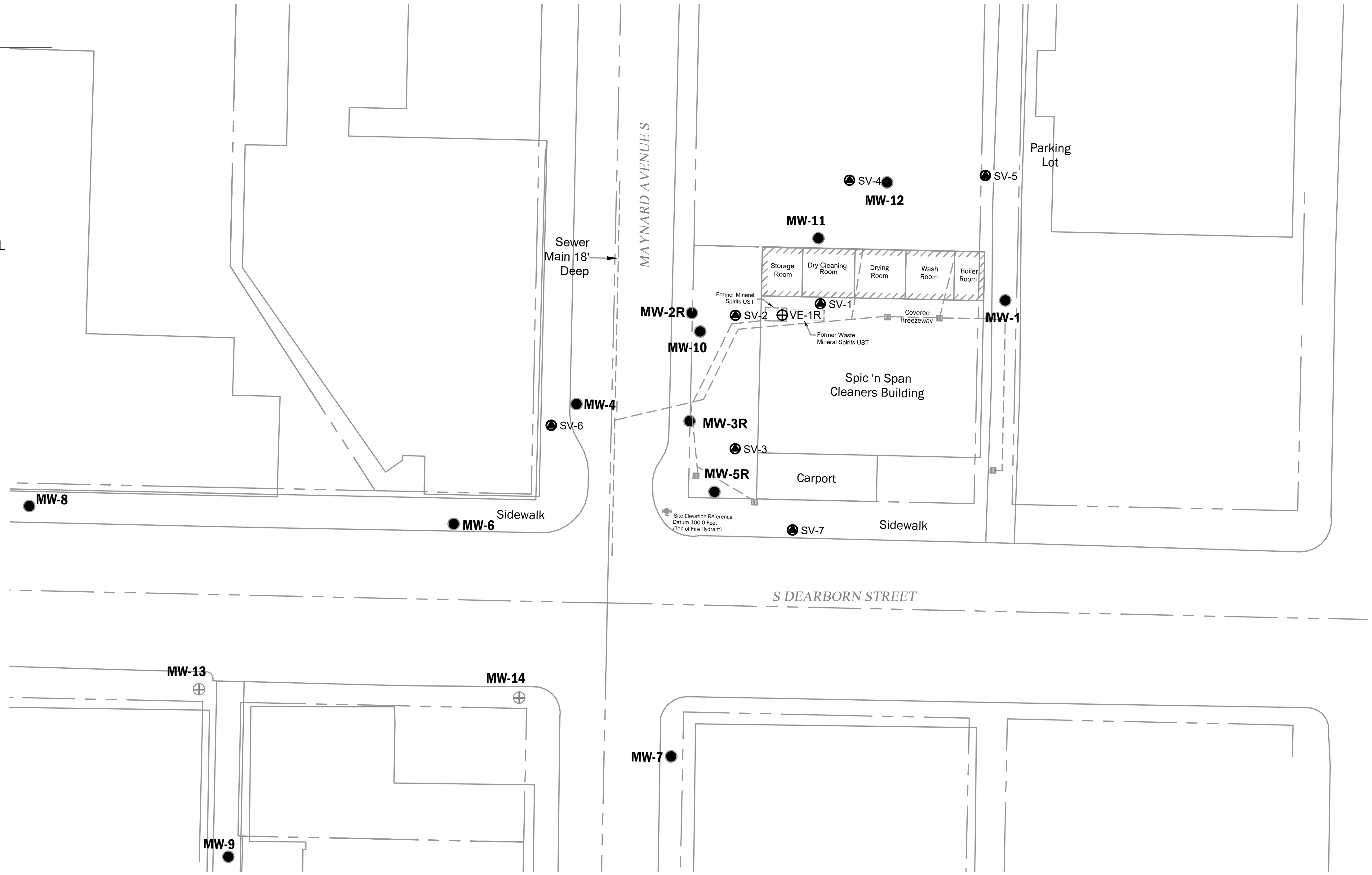
FIGURES

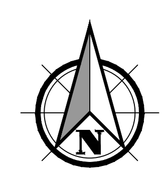
GENERAL NOTES

1. THIS DRAWING IS DIAGRAMMATIC. IT IS FOR GENERAL INFORMATION ONLY.
2. BASEMAP, MONITORING WELL LOCATIONS AND PROPOSED SOIL VAPOR LOCATIONS PROVIDED BY ASPECT CONSULTING, 2023.

LEGEND

- MONITORING WELL (EXISTING)
- SV-# PROPOSED SOIL VAPOR PROBE
- FORMER UST LOCATION
- CATCH BASIN
- VE-# VAPOR EXTRACTION LOCATION
- PROPOSED NEW MONITORING WELL





SCALE: 1" = 50'

0 25' 50' 100'

PREPARED FOR: SCIDpda

FULL SIZE SHEET FORMAT IS 11X17; IF PRINTED SIZE IS NOT 11X17, THEN THIS SHEET FORMAT HAS BEEN MODIFIED & INDICATED DRAWING SCALE IS NOT ACCURATE.

Filename: L:\Projects\41000\41593 Big Village LLLP-SCID\41593.006 650 Dearborn Street\DWG\41593.006_FIG-1.dwg Layout Tab: 11X17 DRAWINGS User: Jim Blanco CAD Plot Date/Time: 7/14/2023 1:03:42 PM

PBS Engineering and Environmental Inc.
214 East Galer St, Ste 300
Seattle, WA 98102
206.233.9639
pbsusa.com

SITE PLAN

SPIC 'N SPAN CLEANERS SITE

652 S DEARBORN STREET, SEATTLE, WASHINGTON

PROJECT	41593.006
DATE	JULY 2023
FIGURE:	1

APPENDIX A

Supporting Documentation from Previous Environmental Reports
Figures and Soil Analytical Tables from Construction Completion Report (Aspect, 2023a)
Tables from Confirmation Groundwater Monitoring Report (Aspect 2023b)
Site Specific Cleanup Levels from the Supplemental Data Letter (Aspect, 2014)
Map of Soil Temperature Probe Locations (provided by email from Aspect in 2023)

FIGURES

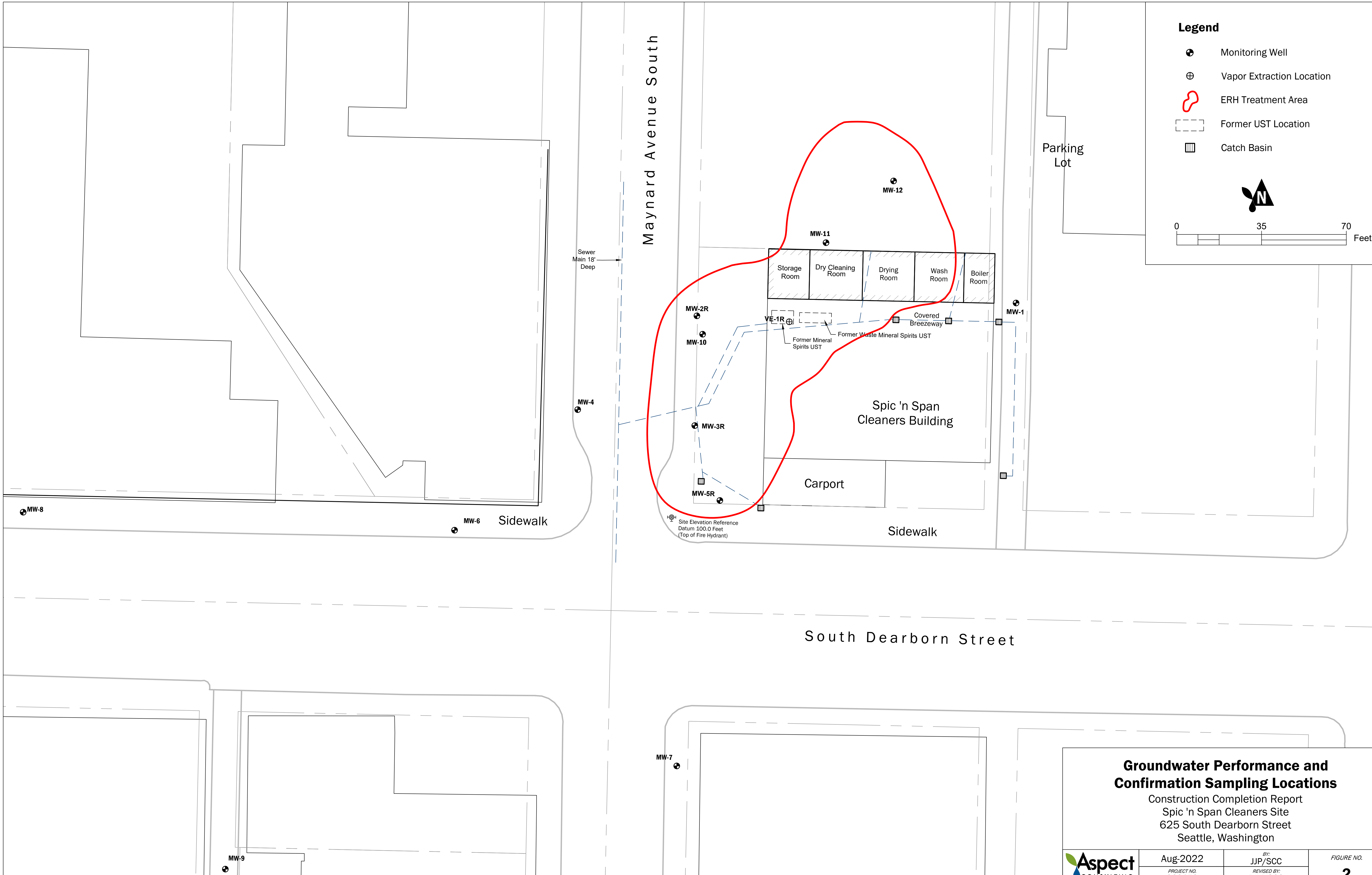
Site Location Map

Construction Completion Report
Spic 'n Span Cleaners Site
625 South Dearborn Street
Seattle, Washington

Aspect CONSULTING	AUG-2022	BY: DIM / SCC	FIGURE NO.
	PROJECT NO. 060172	REVISED BY: - - -	1

GIS Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2022-08 Construction Completion Report\GIS\01 Site Location Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 8/15/2022 || User: scudd || Print Date: 8/15/2022

Basemap Layer Credits || Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

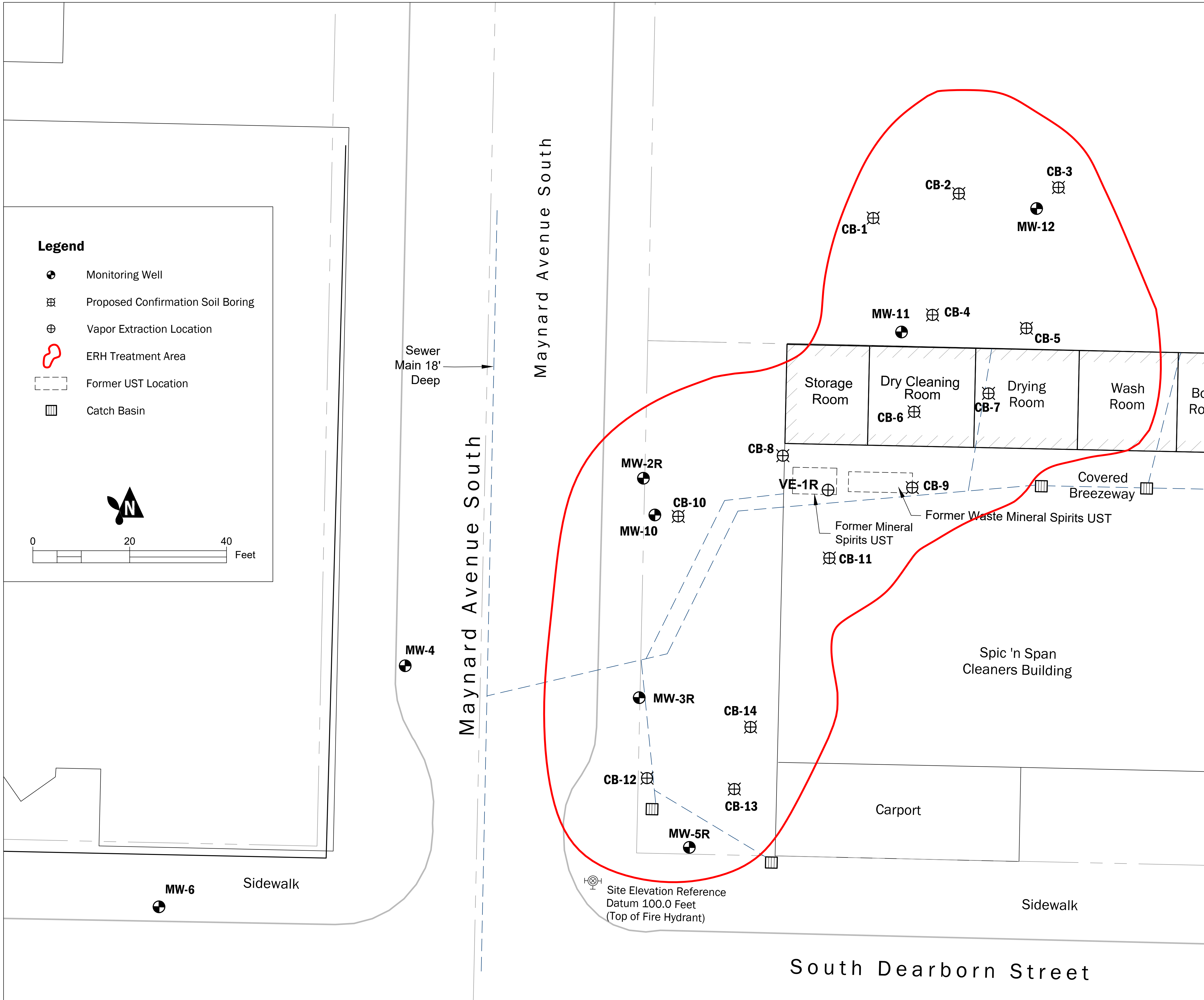


Groundwater Performance and Confirmation Sampling Locations

Construction Completion Report
Spic 'n Span Cleaners Site
625 South Dearborn Street
Seattle, Washington

Aspect CONSULTING	Aug-2022	BY: JJP/SCC	FIGURE NO.
	PROJECT NO. 060172	REVISED BY: DIM/SCC	2

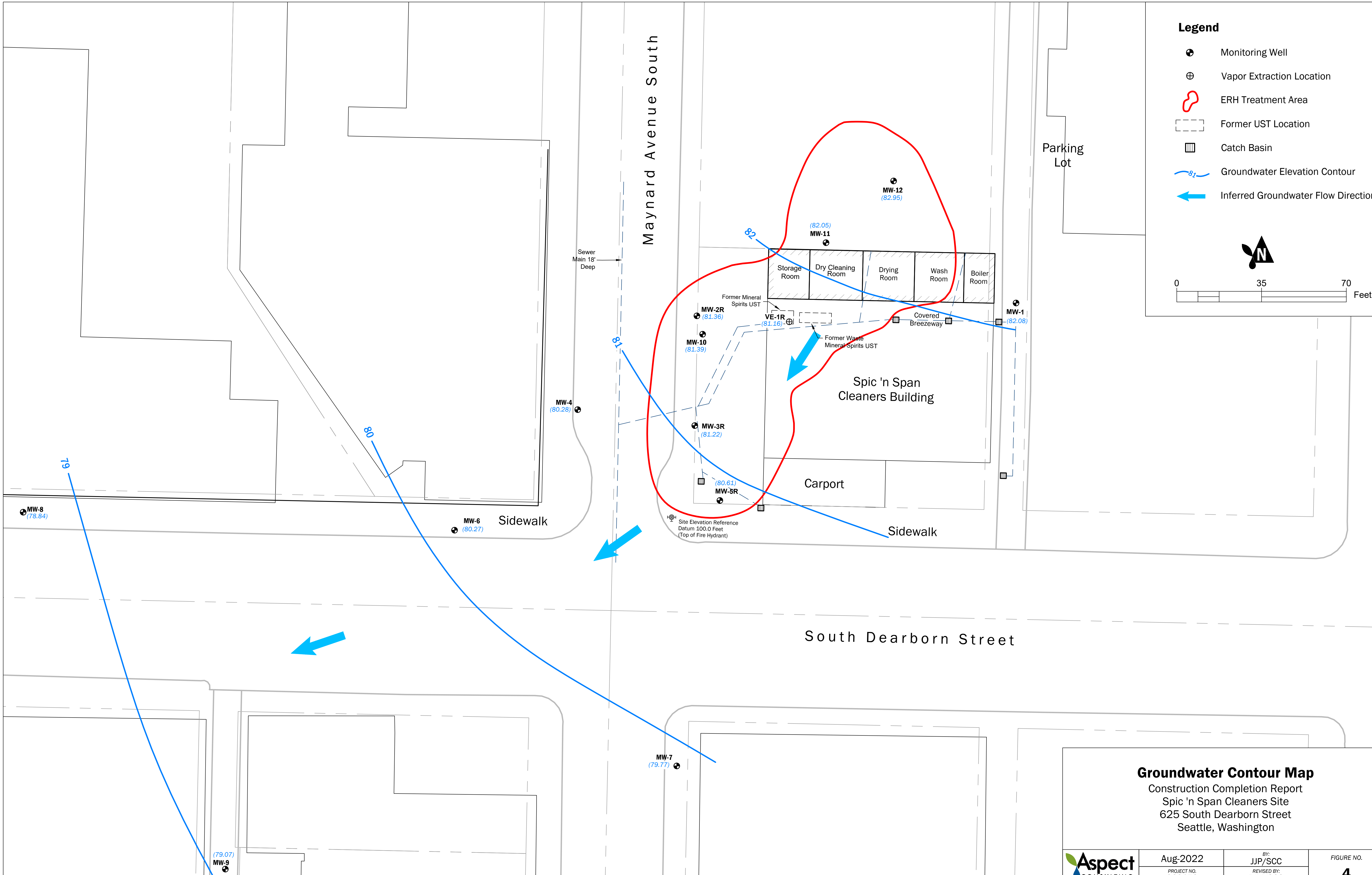
CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2022-08 Construction Completion Report\060172-02.dwg 02 GW Performance & Confirmation Sampling Locations || Date Saved: Aug 17, 2022 1:46pm || User: scudd



ERH Performance Soil Sampling Locations

Construction Completion Report
Spic 'n Span Cleaners Site
625 South Dearborn Street
Seattle, Washington

Aspect CONSULTING | Aug-2022 | BY: JJP/SCC | FIGURE NO.
PROJECT NO. 060172 | REVISED BY: DIM/SCC | 3



Groundwater Contour Map
Construction Completion Report
Spic 'n Span Cleaners Site
625 South Dearborn Street
Seattle, Washington

TABLES

Table 5. Soil Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

Sample Location	Sample Event	Sample Date	Depth	Gasoline Range TPH	Perchloroethene (PCE)	Trichloroethene (TCE)	cis-1,2-Dichloroethene (cis-DCE)	Vinyl Chloride
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Site Soil Cleanup Level				97	0.15	0.066	0.12	0.05
CB-01	1	11/18/2021	7 ft	< 6.2 U	**0.0040**	< 0.00088 U	< 0.00088 U	< 0.00088 U
		11/18/2021	13 ft	< 8.7 U	**0.089**	**0.017**	< 0.0019 U	< 0.0019 U
		11/18/2021	19 ft	< 10 U	**0.030**	**0.0049**	< 0.0013 U	< 0.0013 U
		11/18/2021	23 ft	< 5.0 U	< 0.00086 U	< 0.00086 U	< 0.00086 U	< 0.00086 U
CB-02	1	11/18/2021	8 ft	< 7.2 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
		11/18/2021	13 ft	< 7.7 U	**0.0070**	< 0.0010 U	< 0.0010 U	< 0.0010 U
		11/18/2021	21 ft	< 6.1 U	**0.016**	< 0.00099 U	< 0.00099 U	< 0.00099 U
		11/18/2021	22 ft	< 4.5 U	< 0.00080 U	< 0.00080 U	< 0.00080 U	< 0.00080 U
		12/3/2021	3 ft	< 5.1 U	**0.2**	**0.012**	< 0.00090 U	< 0.00090 U
		12/3/2021	18 ft	< 6.6 U	< 0.00092 U	< 0.00092 U	< 0.00092 U	< 0.00092 U
CB-03	1	11/18/2021	7 ft	< 10 U	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
		11/18/2021	8 ft	< 7.2 U	< 0.0013 U	< 0.0013 U	< 0.0013 U	< 0.0013 U
		11/18/2021	21 ft	< 5.5 U	< 0.00073 U	< 0.00073 U	< 0.00073 U	< 0.00073 U
		11/18/2021	26 ft	< 4.9 U	< 0.00091 U	< 0.00091 U	< 0.00091 U	< 0.00091 U
CB-04	1	11/18/2021	8.5 ft	< 6.1 U	< 0.0015 U	< 0.0015 U	< 0.0015 U	< 0.0015 U
		11/18/2021	13 ft	< 6.5 U	**0.0021**	< 0.0010 U	< 0.0010 U	< 0.0010 U
		11/18/2021	15 ft	< 8.5 U	**0.016**	**0.0016**	< 0.0012 U	< 0.0012 U
		11/18/2021	23.5 ft	< 7.6 U	< 0.0013 U	< 0.0013 U	< 0.0013 U	< 0.0013 U
		11/18/2021	26.5 ft	< 8.0 U	< 0.0014 U	< 0.0014 U	< 0.0014 U	< 0.0014 U
		12/3/2021	6 ft	< 5.7 U	**0.0076**	**0.002**	< 0.0012 U	< 0.0012 U
CB-05	1	11/18/2021	7 ft	< 7.8 U	**0.03**	**0.0038**	**0.0025**	< 0.0013 U
		11/18/2021	12 ft	< 7.4 U	**0.069**	**0.0028**	< 0.0018 U	< 0.0018 U
		11/18/2021	18 ft	< 5.4 U	< 0.0013 U	< 0.0013 U	< 0.0013 U	< 0.0013 U
		11/18/2021	27.5 ft	< 4.8 U	**0.0016**	< 0.00084 U	< 0.00084 U	< 0.00084 U
CB-06	1	11/22/2021	5 ft	< 6.6 U	< 0.0013 U	< 0.0013 U	< 0.0013 U	< 0.0013 U
		11/22/2021	8 ft	< 6.8 U	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
		11/22/2021	15 ft	< 6.8 U	< 0.00095 U	< 0.00095 U	< 0.00095 U	< 0.00095 U
		11/22/2021	21 ft	< 8.3 U	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
	2	1/11/2022	21.5 ft	--	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
CB-07	1	11/22/2021	5 ft	< 5.6 U	**0.0019**	< 0.0012 U	< 0.0012 U	< 0.0012 U
		11/22/2021	10.5 ft	< 7.4 U	**0.0029**	< 0.0014 U	< 0.0014 U	< 0.0014 U
		11/23/2021	17 ft	--	**0.0066**	**0.0011**	< 0.0011 U	< 0.0011 U
	2	1/11/2022	13.5 ft	--	**0.014**	< 0.0011 U	< 0.0011 U	< 0.0011 U
		1/11/2022	17 ft	--	**0.0013**	< 0.0012 U	< 0.0012 U	< 0.0012 U
		1/11/2022	26 ft	--	**0.0016**	< 0.00097 U	**0.0023**	< 0.00097 U
CB-08	1	11/22/2021	3 ft	**8.6**	**0.0016**	< 0.0011 U	< 0.0011 U	< 0.0011 U
		11/22/2021	10 ft	< 7.1 U	**0.0033**	< 0.0014 U	< 0.0014 U	< 0.0014 U
	2	1/10/2022	19 ft	< 8.3 U	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
		1/10/2022	27 ft	< 5.0 U	< 0.00097 U	< 0.00097 U	< 0.00097 U	< 0.00097 U
CB-09	1	11/23/2021	5 ft	< 5.1 U	< 0.00095 U	< 0.00095 U	< 0.00095 U	< 0.00095 U
		11/23/2021	13 ft	< 6.7 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
		11/23/2021	18 ft	< 8.3 U	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
		11/23/2021	22 ft	**7.7**	< 0.0013 U	< 0.0013 U	< 0.0013 U	< 0.0013 U
CB-10	1	11/22/2021	6 ft	< 6.0 U	**0.14**	**0.0079**	**0.0013**	< 0.00095 U
		11/22/2021	13 ft	< 8.1 U	< 0.0014 U	< 0.0014 U	< 0.0014 U	< 0.0014 U
		11/22/2021	16 ft	< 8.4 U	< 0.0015 U	< 0.0015 U	< 0.0015 U	< 0.0015 U
		11/22/2021	23.5 ft	< 6.9 U	**0.0019**	< 0.0015 U	< 0.0015 U	< 0.0015 U
CB-11	1	11/23/2021	5 ft	< 5.0 U	< 0.00095 U	< 0.00095 U	< 0.00095 U	< 0.00095 U
		11/23/2021	8.5 ft	< 6.4 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
	2	1/12/2022	20 ft	**8.1**	< 0.00060 U	< 0.00060 U	< 0.00060 U	< 0.00060 U
		1/12/2022	24 ft	< 4.8 U	< 0.0015 U	< 0.0015 U	< 0.0015 U	< 0.0015 U
CB-12	1	11/19/2021	5 ft	< 5.1 U	**0.0019**	< 0.00091 U	< 0.00091 U	< 0.00091 U
		11/19/2021	13 ft	< 4.7 U	< 0.00082 U	< 0.00082 U	< 0.00082 U	< 0.00082 U
		11/19/2021	17 ft	< 8.0 U	**0.0018**	< 0.0014 U	< 0.0014 U	< 0.0014 U
		11/19/2021	22 ft	< 5.4 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
CB-13	1	11/19/2021	5 ft	< 6.2 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
		11/19/2021	8 ft	< 5.6 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
		11/19/2021	16 ft	< 6.5 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
		11/19/2021	20 ft	< 6.5 U	**0.0013**	< 0.00092 U	< 0.00092 U	< 0.00092 U
	2	1/10/2022	22.5 ft	--	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
CB-14	1	11/19/2021	6 ft	< 7.5 U	**0.0025**	< 0.0012 U	< 0.0012 U	< 0.0012 U
		11/19/2021	13 ft	< 6.6 U	< 0.0011 U	< 0.0011 U	< 0.0011 U	< 0.0011 U
		11/19/2021	*21 ft*	***310***	< 0.0012 U	< 0.0012 U	< 0.0012 U	< 0.0012 U
		11/19/2021	*22 ft*	***580***	< 0.0014 U	< 0.0014 U	< 0.0014 U	< 0.0014 U
	2	1/10/2022	15.5 ft	< 5.4 U	--	--	--	--
		1/10/2022	20 ft	< 5.8 U	--	--	--	--
		1/10/2022	22.5 ft	< 6.4 U	--	--	--	--

Notes
- ft - Feet
- mg/kg - milligrams/kilogram
- **Bold** - Analyte was detected above the laboratory reporting limit.
- Blue Shaded - Detected concentration exceedes the Site groundwater cleanup levels
- U - Analyte was not detected at or above Reporting Limit (RL) shown
- -- - not tested

green italics - data superseded by subsequent sampling of the same interval.

Sample depths from January 2022 were corrected and are not accurately reflected in the sample names.

Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

Analyte	Unit	Sample Event Site Groundwater Cleanup Level (ug/L)	Post-ERH Operation MW-1 06/21/2022 MW-1-062122	MW-1 10/07/2022 MW-1-100722	MW-1 01/04/2023 MW-1-010423	ERH Operation MW-2R 01/12/2022 MW-2R-011222	MW-2R 01/26/2022 MW-2R-012622
PAHs							
Naphthalene	ug/L	160	**1.4**	< 1.0 U	< 1 U	**74**	**230**
TPHs							
Gasoline Range Organics	ug/L	1000	--	--	--	**350 X**	--
VOCs							
cis-1,2-Dichloroethene (cDCE)	ug/L	16	< 0.20 U	< 0.20 U	< 0.2 U	**52**	**55**
Tetrachloroethene (PCE)	ug/L	5	**1.4**	**2.9**	**1.3**	< 0.80 U	< 1.0 U
Trichloroethene (TCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	**4.8**	**3.9**
Vinyl Chloride	ug/L	0.2	< 0.20 U	< 0.20 U	< 0.1 U	**2.5**	**3.4**
Field Parameters							
Temperature	deg C		**15.7**	**19.79**	**16.54**	**23.3**	**15.6**
Specific Conductance	uS/cm		**536.4**	**230.25**	**776.64**	**579**	**605.8**
Dissolved Oxygen	mg/L		**0.51**	**6.15**	**0.4**	**0.32**	**5.14**
pH	pH units		**6.25**	**6.33**	**6.34**	**6.31**	**6.26**
Oxidation Reduction Potential	mV		**69.4**	**138.5**	**131.7**	**117.5**	**68.5**
Turbidity	NTU		**49.2**	**10.3**	**9.8**	**5.23**	**20.8**

Notes:

Bold - detected
Yellow Shaded - Detected result exceeded screening level
Blue Shaded - Non-detected RL exceeded screening level
U - Analyte not detected at or above Reporting Limit (RL) shown
J - Result value estimated
UJ - Analyte not detected and the Reporting Limit (RL) is an estimate
X - Chromatographic pattern does not match fuel standard used for quantitation
"--" - indicates results not available

Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

		Sample Event	Post-ERH Operation				ERH Operation	
Analyte	Unit	Site Groundwater Cleanup Level (ug/L)	MW-2R 06/21/2022 MW-2R-062122	MW-2R 10/07/2022 MW-2R-100722	MW-2R 01/04/2023 MW-2R-010423	MW-2R 04/05/2023 MW-2R-040523	MW-3R 01/12/2022 MW-3R-011222	MW-3R 06/21/2022 MW-3R-062122
PAHs								
Naphthalene	ug/L	160	**85**	**82**	**97**	**55**	**16**	**150**
TPHs								
Gasoline Range Organics	ug/L	1000	< 500 U	< 500 U	< 500 U	--	**130 X**	**720 X**
VOCs								
cis-1,2-Dichloroethene (cDCE)	ug/L	16	**10**	**4.6**	**0.74**	**1.6**	< 2.0 U	< 10 U
Tetrachloroethene (PCE)	ug/L	5	< 0.40 U	< 0.40 U	< 0.4 U	< 0.4 U	< 2.0 U	< 10 U
Trichloroethene (TCE)	ug/L	5	**0.84**	**0.67**	< 0.4 U	< 0.4 U	< 2.0 U	< 10 U
Vinyl Chloride	ug/L	0.2	**0.82**	**0.55**	< 0.2 U	**0.096**	< 2.0 U	< 10 U
Field Parameters								
Temperature	deg C		**13**	**27.37**	**16.21**	**18.8**	**17.9**	**10.3**
Specific Conductance	uS/cm		**784**	**765**	**661.52**	**1136.8**	**628**	**986**
Dissolved Oxygen	mg/L		**1.5**	**0.21**	**0.19**	**0.13**	**0.9**	**0.6**
pH	pH units		**6.44**	**7.28**	**6.75**	**6.83**	**5.42**	**6.56**
Oxidation Reduction Potential	mV		**28**	**-249.6**	**36.4**	**-15.3**	**35.1**	**39.9**
Turbidity	NTU		**3.11**	**65**	**3.28**	**6.58**	**7.58**	**2.82**

Notes:

Bold - detected

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

		Sample Event	Post-ERH Operation			Baseline	ERH Operation
Analyte	**Unit**	**Site Groundwater Cleanup Level (ug/L)**	**MW-3R 10/06/2022 MW-3R-100622**	**MW-3R 01/03/2023 MW-3R-010323**	**MW-3R 04/05/2023 MW-3R-040523**	**MW-4 11/20/2019 MW-4-112019**	**MW-4 01/26/2022 MW-4-012622**
PAHs							
Naphthalene	ug/L	160	**220**	**200**	**110**	< 1.3 U	< 1.0 U
TPHs							
Gasoline Range Organics	ug/L	1000	< 500 U	< 500 U	--	< 100 U	--
VOCs							
cis-1,2-Dichloroethene (cDCE)	ug/L	16	< 1.0 U	< 1 U	< 0.8 U	**36**	**36**
Tetrachloroethene (PCE)	ug/L	5	< 1.0 U	< 1 U	< 0.8 U	< 0.20 U	< 0.20 U
Trichloroethene (TCE)	ug/L	5	< 1.0 U	< 1 U	< 0.8 U	< 0.20 U	**0.22**
Vinyl Chloride	ug/L	0.2	< 1.0 U	< 0.5 U	< 0.08 U	**31**	**9.6**
Field Parameters							
Temperature	deg C		**23.7**	**39.13**	**12.55**	**16.7**	**16.3**
Specific Conductance	uS/cm		**754.47**	**1177**	**1198.2**	**918**	**815**
Dissolved Oxygen	mg/L		**0.04**	**0.16**	**0.14**	**1.15**	**0.33**
pH	pH units		**6.51**	**6.57**	**6.93**	**6.68**	**6.75**
Oxidation Reduction Potential	mV		**-199.3**	**-46**	**18.9**	**-1.2**	**33.1**
Turbidity	NTU		**12.5**	**2.86**	**11.3**	**20.3**	**56.5**

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

		Sample Event	Post-ERH Operation				Baseline	ERH Operation
Analyte	**Unit**	**Site Groundwater Cleanup Level (ug/L)**	**MW-4 06/22/2022 MW-4-062222**	**MW-4 10/06/2022 MW-4-100622**	**MW-4 01/03/2023 MW-4-010323**	**MW-4 04/05/2023 MW-4-040523**	**MW-5R 11/20/2019 MW-5R-112019**	**MW-5R 12/16/2021 MW-5R-121621**
PAHs								
Naphthalene	ug/L	160	< 2.0 U	< 1.0 U	< 1 U	< 2 U	< 1.3 U	< 4.0
TPHs								
Gasoline Range Organics	ug/L	1000	--	--	--	--	< 100 U	--
VOCs								
cis-1,2-Dichloroethene (cDCE)	ug/L	16	**36**	**11**	**34**	**11**	**6.1**	< 0.80
Tetrachloroethene (PCE)	ug/L	5	< 0.40 U	< 0.20 U	< 0.2 U	< 0.4 U	< 0.20 U	< 0.80
Trichloroethene (TCE)	ug/L	5	< 0.40 U	< 0.20 U	< 0.2 U	< 0.4 U	< 0.20 U	< 0.80
Vinyl Chloride	ug/L	0.2	**6.9**	**19**	**28**	**13**	**2.8**	< 0.80
Field Parameters								
Temperature	deg C		**19.4**	**23.06**	**21.97**	**21.3**	**15.7**	--
Specific Conductance	uS/cm		**1116**	**761.19**	**1002**	**753.27**	**961**	--
Dissolved Oxygen	mg/L		**0.47**	**0.23**	**0.17**	**0.14**	**0.38**	--
pH	pH units		**6.56**	**6.5**	**6.52**	**6.58**	**6.64**	--
Oxidation Reduction Potential	mV		**20.7**	**-74.8**	**-6.1**	**-13.6**	**31.2**	--
Turbidity	NTU		**8.23**	**6.06**	**3.31**	**7.37**	**4.11**	--

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

		Sample Event	Post-ERH Operation			Baseline	Post-ERH Operation			
Analyte	Unit	Site Groundwater Cleanup Level (ug/L)	MW-5R 06/22/2022 MW-5R-062222	MW-5R 10/07/2022 MW-5R-100722	MW-5R 01/03/2023 MW-5R-010323	MW-6 01/06/2020 MW-6-010620	MW-6 06/22/2022 MW-6-062222	MW-6 10/06/2022 MW-6-100622	MW-6 01/04/2023 MW-6-010423	MW-6 04/05/2023 MW-6-040523
PAHs										
Naphthalene	ug/L	160	**5.6**	**4.2**	**2.9**	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
TPHs										
Gasoline Range Organics	ug/L	1000	--	--	--	< 100 U	--	--	--	--
VOCs										
cis-1,2-Dichloroethene (cDCE)	ug/L	16	< 0.20 U	< 0.20 U	< 0.2 U	**0.53**	**0.31**	**0.26**	**0.31**	**0.34**
Tetrachloroethene (PCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	< 0.20 U	< 0.20 U	< 0.20 U	< 0.2 U	< 0.2 U
Trichloroethene (TCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	< 0.20 U	< 0.20 U	< 0.20 U	< 0.2 U	< 0.2 U
Vinyl Chloride	ug/L	0.2	< 0.20 U	< 0.20 U	< 0.1 U	**1.2**	**0.63**	**0.49**	**0.9**	**0.85**
Field Parameters										
Temperature	deg C		**27.3**	**22.18**	**13.78**	**16.5**	**16.5**	**18.64**	**16.5**	**16.59**
Specific Conductance	uS/cm		**1228**	**1019.8**	**1240**	**917**	**733**	**472.52**	**689**	**562.37**
Dissolved Oxygen	mg/L		**0.13**	**0.18**	**0.3**	**0.51**	**0.13**	**0.14**	**0.18**	**0.1**
pH	pH units		**6.62**	**6.83**	**6.97**	**6.79**	**6.75**	**6.91**	**6.99**	**7.04**
Oxidation Reduction Potential	mV		**-26**	**-67.9**	**44.9**	**-7.00**	**55.2**	**-87.2**	**-62.5**	**-30.5**
Turbidity	NTU		**4.63**	**5.41**	**2.24**	**7.00**	**16.7**	**4.85**	**5.65**	**18.8**

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

Analyte	Unit	Sample Event Site Groundwater Cleanup Level (ug/L)	Post-ERH Operation MW-7 06/22/2022 MW-7-062222	Post-ERH Operation MW-7 10/06/2022 MW-7-100622	Post-ERH Operation MW-7 01/03/2023 MW-7-010323	Post-ERH Operation MW-8 06/22/2022 MW-8-062222	Post-ERH Operation MW-8 10/06/2022 MW-8-100622	Post-ERH Operation MW-8 01/04/2023 MW-8-010423
PAHs								
Naphthalene	ug/L	160	< 1.0 U	< 1.0 U	< 1 U	< 1.0 U	< 1.0 U	< 1 U
TPHs								
Gasoline Range Organics	ug/L	1000	--	--	--	--	--	--
VOCs								
cis-1,2-Dichloroethene (cDCE)	ug/L	16	< 0.20 U	< 0.20 U	< 0.2 U	< 0.20 U	< 0.20 U	< 0.2 U
Tetrachloroethene (PCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	< 0.20 U	< 0.20 U	< 0.2 U
Trichloroethene (TCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	< 0.20 U	< 0.20 U	< 0.2 U
Vinyl Chloride	ug/L	0.2	< 0.20 U	< 0.20 U	**0.19**	< 0.20 U	< 0.20 U	< 0.1 U
Field Parameters								
Temperature	deg C		**15.7**	**17.76**	**16.16**	**17.2**	**19.94**	**17.82**
Specific Conductance	uS/cm		**1166**	**834.9**	**1178.4**	**1380**	**865.16**	**1301.9**
Dissolved Oxygen	mg/L		**0.56**	**0.1**	**0.35**	**0.58**	**1.06**	**0.18**
pH	pH units		**6.61**	**6.46**	**6.74**	**6.74**	**6.83**	**6.98**
Oxidation Reduction Potential	mV		**-40.3**	**-69.3**	**-38.8**	**-67.7**	**-71.5**	**-83.2**
Turbidity	NTU		**64.2**	**62.5**	**5.75**	**5.72**	**2.65**	**1.78**

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

		Sample Event	Post-ERH Operation			Baseline	ERH Operation	
Analyte	Unit	Site Groundwater Cleanup Level (ug/L)	MW-9 06/22/2022 MW-9-062222	MW-9 10/06/2022 MW-9-100622	MW-9 01/03/2023 MW-9-010323	MW-10 11/20/2019 MW-10-112019	MW-10 01/12/2022 MW-10-011222	MW-10 01/26/2022 MW-10-012622
PAHs								
Naphthalene	ug/L	160	< 1.0 U	< 1.0 U	< 1 U	< 1.3 U	**170**	**130**
TPHs								
Gasoline Range Organics	ug/L	1000	--	--	--	**110**	< 100 U	--
VOCs								
cis-1,2-Dichloroethene (cDCE)	ug/L	16	< 0.20 U	< 0.20 U	< 0.2 U	**38**	**32**	**44**
Tetrachloroethene (PCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	**1.5**	**4**	< 4.0 U
Trichloroethene (TCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	**2.2**	**5.6**	< 4.0 U
Vinyl Chloride	ug/L	0.2	< 0.20 U	< 0.20 U	< 0.1 U	**1.4**	< 2.0 U	< 4.0 U
Field Parameters								
Temperature	deg C		**16.3**	**18.66**	**15.16**	**15.2**	**33.7**	**38.8**
Specific Conductance	uS/cm		**683**	**636.32**	**689.29**	**647**	**401.6**	**574**
Dissolved Oxygen	mg/L		**1.14**	**1.08**	**2.63**	**0.29**	**0.39**	**1.11**
pH	pH units		**6.7**	**6.66**	**6.83**	**6.54**	**5.77**	**5.99**
Oxidation Reduction Potential	mV		**8.8**	**81.8**	**33.1**	**39.1**	**-15**	**65.6**
Turbidity	NTU		**3.95**	**3.34**	**1.53**	**6.49**	**2.35**	**7.15**

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

Analyte	Unit	Sample Event / Site Groundwater Cleanup Level (ug/L)	Post-ERH Operation: MW-10 06/21/2022 MW-10-062122	Post-ERH Operation: MW-10 10/06/2022 MW-10-100622	Post-ERH Operation: MW-10 01/04/2023 MW-10-010423	Post-ERH Operation: MW-10 04/05/2023 MW-10-040523	Baseline: MW-11 11/20/2019 MW-11-112019	ERH Operation: MW-11 12/02/2021 MW-11-120221	ERH Operation: MW-11 12/16/2021 MW-11-121621
PAHs									
Naphthalene	ug/L	160	**270**	**190**	**97**	**55**	< 1.3 U	< 10 U	< 10 UJ
TPHs									
Gasoline Range Organics	ug/L	1000	< 500 U	< 500 U	< 500 U	--	< 100 U	--	--
VOCs									
cis-1,2-Dichloroethene (cDCE)	ug/L	16	**2.8**	**1.5**	< 0.4 U	< 0.4 U	**5.8**	**7.3**	**2.5 J**
Tetrachloroethene (PCE)	ug/L	5	< 1.0 U	< 0.80 U	< 0.4 U	< 0.4 U	**11**	**6.5**	**2.5 J**
Trichloroethene (TCE)	ug/L	5	< 1.0 U	< 0.80 U	< 0.4 U	< 0.4 U	**2.5**	**5.7**	**2.1 J**
Vinyl Chloride	ug/L	0.2	< 1.0 U	< 0.80 U	< 0.2 U	< 0.04 U	< 0.20 U	< 2.0 U	< 2.0 UJ
Field Parameters									
Temperature	deg C		**13.6**	**12.84**	**13.59**	**16.69**	**14.6**	**41.3**	--
Specific Conductance	uS/cm		**999**	**976.47**	**966.67**	**1382.8**	**645**	**907**	--
Dissolved Oxygen	mg/L		**0.33**	**0.05**	**0.1**	**0.15**	**0.5**	**2.18**	--
pH	pH units		**6.65**	**6.46**	**6.75**	**7.07**	**6.32**	**6.04**	--
Oxidation Reduction Potential	mV		**-8.1**	**-138.9**	**-36.7**	**-39.6**	**31.8**	**-12.4**	--
Turbidity	NTU		**5.07**	**10**	**3.47**	**6.58**	**8.02**	**7.89**	--

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

		Sample Event	Post-ERH Operation			Baseline	ERH Operation	
Analyte	Unit	Site Groundwater Cleanup Level (ug/L)	MW-11 06/21/2022 MW-11-062122	MW-11 10/07/2022 MW-11-100722	MW-11 01/03/2023 MW-11-010323	MW-12 11/20/2019 MW-12-112019	MW-12 12/02/2021 MW-12-120221	MW-12 12/16/2021 MW-12-121621
PAHs								
Naphthalene	ug/L	160	< 1.0 U	< 1.0 U	< 1 U	< 1.3 U	< 1.0 U	< 2.0 UJ
TPHs								
Gasoline Range Organics	ug/L	1000	--	--	--	< 100 U	--	--
VOCs								
cis-1,2-Dichloroethene (cDCE)	ug/L	16	**0.32**	< 0.20 U	< 0.2 U	< 0.20 U	< 0.20 U	< 0.40 UJ
Tetrachloroethene (PCE)	ug/L	5	**0.26**	< 0.20 U	< 0.2 U	**3.2**	**22**	**3.9 J**
Trichloroethene (TCE)	ug/L	5	**0.36**	< 0.20 U	< 0.2 U	< 0.20 U	**0.51**	< 0.40 UJ
Vinyl Chloride	ug/L	0.2	< 0.20 U	< 0.20 U	< 0.1 U	< 0.20 U	< 0.20 U	< 0.40 UJ
Field Parameters								
Temperature	deg C		**15.6**	**16.32**	**24.17**	**15.3**	**23.4**	--
Specific Conductance	uS/cm		**434**	**472.52**	**942.85**	**663**	**689**	--
Dissolved Oxygen	mg/L		**0.5**	**0.21**	**0.18**	**1.32**	**1.09**	--
pH	pH units		**6.28**	**7.04**	**6.82**	**6.26**	**5.83**	--
Oxidation Reduction Potential	mV		**-29.3**	**-39.8**	**-90.6**	**38.4**	**-2.7**	--
Turbidity	NTU		**2.65**	**5.7**	**2.47**	**10.2**	**4.1**	--

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Table 1. Groundwater Analytical Results

Project No. 060172, Spic'n Span Cleaners, Seattle, Washington

Analyte	Unit	Sample Event Site Groundwater Cleanup Level (ug/L)	Post-ERH Operation MW-12 06/21/2022 MW-12-062122	MW-12 10/07/2022 MW-12-100722	MW-12 01/03/2023 MW-12-010323	ERH Operation VE-1R 01/12/2022 VE-1R-011222	Post-ERH Operation VE-1R 06/21/2022 VE-1R-062122	VE-1R 10/06/2022 VE-1R-100622	VE-1R 01/04/2023 VE-1R-010423
PAHs									
Naphthalene	ug/L	160	< 1.0 U	< 1.0 U	< 1 U	**96**	**72**	**33**	**56**
TPHs									
Gasoline Range Organics	ug/L	1000	--	--	--	**180 X**	< 500 U	< 500 U	< 500 U
VOCs									
cis-1,2-Dichloroethene (cDCE)	ug/L	16	< 0.20 U	< 0.20 U	< 0.2 U	< 2.0 U	**0.58**	< 0.20 U	< 0.4 U
Tetrachloroethene (PCE)	ug/L	5	**2.1**	**2.1**	**1.2**	< 2.0 U	< 0.40 U	< 0.20 U	< 0.4 U
Trichloroethene (TCE)	ug/L	5	< 0.20 U	< 0.20 U	< 0.2 U	< 2.0 U	< 0.40 U	< 0.20 U	< 0.4 U
Vinyl Chloride	ug/L	0.2	< 0.20 U	< 0.20 U	< 0.1 U	< 2.0 U	< 0.40 U	< 0.20 U	< 0.2 U
Field Parameters									
Temperature	deg C		**18**	**10.16**	**19.09**	**54**	**15.7**	**12.03**	**9.66**
Specific Conductance	uS/cm		**709**	**612.68**	**808.84**	**435**	**536.4**	**591.33**	**932.69**
Dissolved Oxygen	mg/L		**6.9**	**0.22**	**0.43**	**0.11**	**0.51**	**0.43**	**0.22**
pH	pH units		**6.28**	**6.18**	**6.48**	**6.32**	**6.45**	**6.45**	**7.06**
Oxidation Reduction Potential	mV		**16.3**	**127.2**	**1.8**	**-134.9**	**-4**	**-208.7**	**39**
Turbidity	NTU		**5.99**	**14.3**	**2.59**	**1.82**	**76.9**	**12.8**	**2.31**

Notes:

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Table 2 - Summary of Cleanup Levels for Site Contaminants of Concern

Spic 'n Span Cleaners

Chemical Name	GROUNDWATER: MTCA Cleanup Levels in ug/L [1]	SOIL: MTCA Cleanup Levels in mg/kg	
		Direct Contact [2]	Groundwater Protection [3]
Total Petroleum Hydrocarbons			
Mineral Spirits/Stoddard Solvent	**1,000**	--	**97**
Chlorinated Volatile Organics			
Tetrachloroethene	**5**	480	**0.15**
Trichloroethene	**5**	12	**0.066**
Cis-1,2-dichloroethene	**16**	160	**0.12**
Vinyl Chloride	**0.2**	0.67	**0.05** [(4)]

Notes

Site cleanup levels are in **bold**.

[1] Cleanup levels based on MTCA Method A table values (WAC 173-340-900, Table 720-1). When Method A values are not available, Method B Standard Formula Values are listed, as provided in Ecology's CLARC database.

[2] Cleanup levels based on MTCA Method Method B Standard Formula Values for Unrestricted Land Use, as provided in Ecology's CLARC database.

[3] The soil cleanup level for TPH as Mineral Spirits is calculated using the MTCATPH 11.1 workbook. The worksheet is provided in Appendix F. The soil cleanup level for the volatile organics is calculated based on the equation below (WAC 173-340-747, Equation 747-1). If no MTCA cleanup level for groundwater, Henry's law constant, and/or Koc value are available for a given compound, the calculation is not completed.

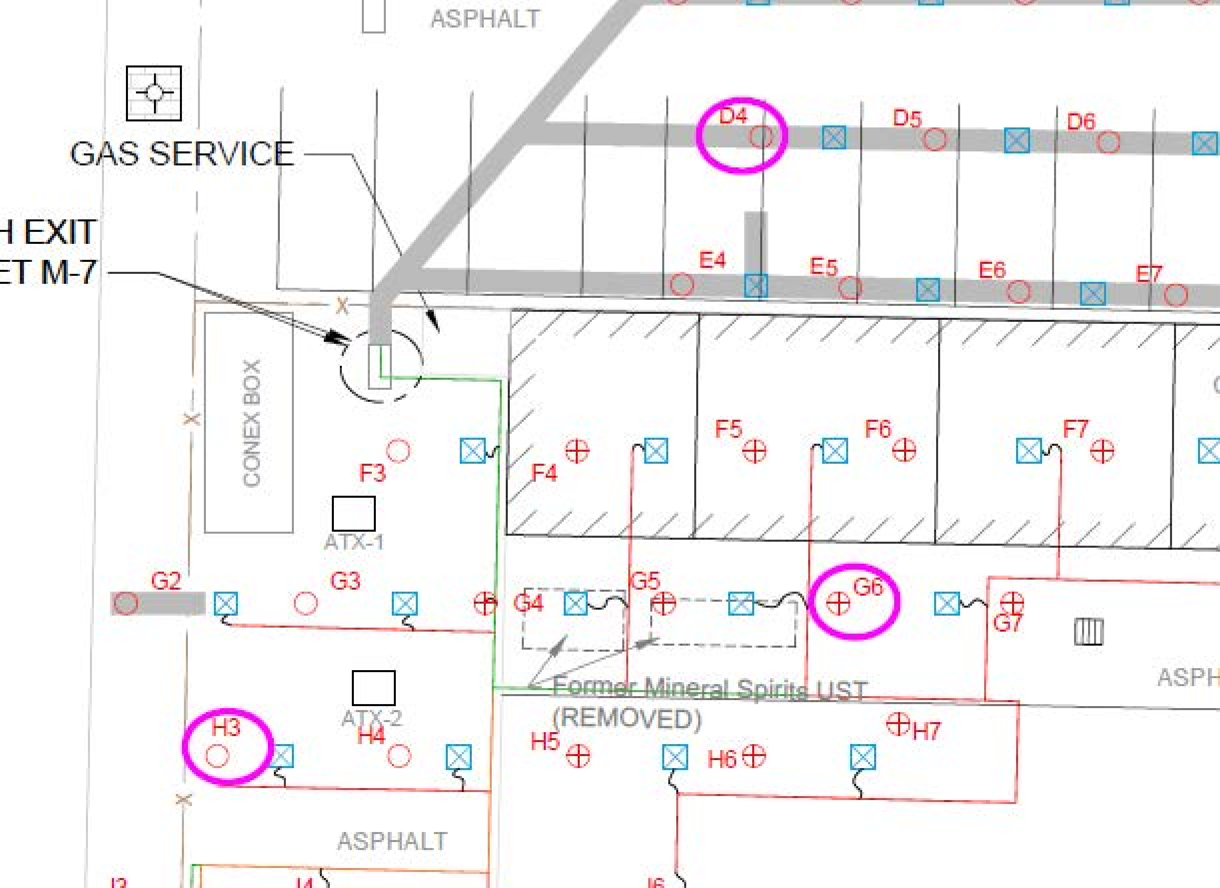
$$C_s = C_w(UCF)DF\left[K_d + \frac{(\theta_w + \theta_a H_{cc})}{\rho_b}\right]$$

Where:

Cs= Soil cleanup level in mg/kg
Cw= Groundwater cleanup level as listed above in ug/L
UCF= Unit conversion factor (0.001 g/ug)
DF= Dilution factor (dimensionless; MTCA default value is 20 for unsaturated soils)
Kd= Koc x foc
Koc as listed in the Ecology's CLARC database
foc = 0.0045 (geometric mean of values in Table 1 of this report)
Θw= Water-filled soil porosity in ml water/ ml soil (MTCA default value is 0.3 for unsaturated soils)
Θα= Air-filled soil porosity in ml air/ml soil (MTCA default value is 0.13 for unsaturated soils)
Hcc= Henry's law constant as listed in Ecology's CLARC database
ρb= Dry soil bulk density in kg/L (MTCA default value is 1.5 kg/L)

4 Based on PQL.

TEMPERATURE PROBE LOCATIONS


ASPHALT
GAS SERVICE
H EXIT
ET M-7
D4
D5
D6
E4
E5
E6
E7
CONEX BOX
F3
F4
F5
F6
F7
ATX-1
G2
G3
G4
G5
G6
G7
Former Mineral Spirits UST
(REMOVED)
ATX-2
H3
H4
H5
H6
H7
ASPHALT

APPENDIX B

Sampling and Analysis Plan/Quality Assurance Project Plan

Sampling and Analysis Plan/Quality Assurance Project Plan

Spic 'N Span Cleaners Site
652 S Dearborn Street
Seattle, Washington
King County Assessor's Parcel 5247802485

Prepared for:
Seattle Chinatown International District Preservation and Development Authority (SCIDpda)
409 Maynard Avenue S, P2
Seattle, WA 98104

December 2023
PBS Project No. 41593.006

PBS
214 E GALER STREET, SUITE 300
SEATTLE, WA 98102
206.233.9639 MAIN
866.727.0140 FAX
PBSUSA.COM

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Supporting Data

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APPENDICES

1 INTRODUCTION

PBS Engineering and Environmental Inc. (PBS) has prepared this Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) for the Seattle Chinatown International District Preservation and Development Authority (SCIDpda) for the Spic N Span Cleaners Site located at 652 S Dearborn Street in Seattle, Washington (the Site).

1.1 Purpose and Objectives

The purpose of the SAP is to describe the sample collection, handling, and analysis procedures to be implemented during the field investigation. The purpose of the QAPP is to define the policies, organization, procedures, and criteria necessary to achieve project data quality objectives (DQO).

This SAP/QAPP identifies specific sampling and analysis protocols, project schedule, and organization and responsibilities in accordance with Washington Administrative Code (WAC) Chapter 173-340-820. It also provides detailed information regarding the sampling, DQOs, sample location and frequency, equipment, and procedures to be used during the field investigation; sample handling and analysis; procedures for management of waste; quality assurance protocols for field activities and laboratory analysis; and reporting requirements.

1.2 Background

The Site is comprised of one 0.3-acre tax lot and portions of surrounding properties and City right of way (ROW). The property was operated as Spic 'N Span Cleaners, a dry-cleaning facility, from approximately 1963 to 2019. A known release to the subsurface of tetrachloroethene (PCE), a common dry-cleaning solvent, and stoddard solvent/mineral spirits, characterized in previous environmental reports as total petroleum hydrocarbons (TPH) in the gasoline range (TPH-G), occurred at the subject property. The Site has undergone extensive environmental investigation and cleanup from 1998 to present day. An in-situ electrical resistance heating (ERH) thermal remediation system was installed at the Site from July 2019 to June 2021 to address concentrations of PCE and its degradation products, and TPH-G in various subsurface media (i.e., soil, groundwater, soil gas). The system operated from August 5, 2021 through January 29, 2022. Operation of the ERH system is summarized in the Data Gaps Analysis Work Plan and thoroughly detailed in the Construction Completion Report (CCR - Aspect, 2023a).

2 PROJECT ORGANIZATION AND MANAGEMENT

This section describes the overall project management strategy for implementing the field investigation. To ensure efficient decision making for field sampling and laboratory analysis, key data collection decisions, decision criteria, process for decision making, quality assurance/quality control (QA/QC) procedures, and responsibilities are described below.

These decision and communication plans will be followed by field personnel under direction of the field coordinator and project manager. The following key personnel have been identified for the project. A summary of key personnel roles and contact information is provided in Table 2-1.

2.1 Project Manager

The Project Manager has overall responsibility for developing the SAP/QAPP, monitoring the quality of the technical and managerial aspects of the RI/FS process, implementing the SAP/QAPP, and corresponding corrective measures, where necessary. The project manager for this project is James Welles, LHG, Senior Hydrogeologist.

2.2 Project Principal

The Project Principal provides oversight of all project activities and reviews all deliverables before their submittal to SCIDpda or the regulatory agency. The Project Principal is Tom Mergy, LHG, Principal Hydrogeologist.

2.3 Laboratory Project Manager

The Laboratory Project Manager will provide analytical support and will be responsible for providing certified, pre-cleaned sample containers and sample preservatives (as appropriate) and for ensuring that all chemical analyses meet the project quality specifications detailed in this SAP. Friedman and Bruya, Inc. of Seattle, Washington will be the laboratory for this project. The Laboratory Project Manager (PM) is Mike Erdahl, B.S.

2.4 Project QA/QC Officer

The Project QA/QC Officer has the following responsibilities:

- Monitor and verify that the work is performed in accordance with the SAP/QAPP and other applicable procedures.
- Assess the effectiveness of the QA/QC program and to recommend modifications to the program when applicable.
- Assure that the personnel assigned to the project are trained relative to the requirements of the QA/QC program and for reviewing and verifying the disposition of nonconformance and corrective action reports.

The project QA/QC Officer is Melanie Young, PE, Senior Environmental Engineer.

2.5 Field Coordinator

The Field Coordinator (FC) has the following responsibilities:

- Supervise field collection of all samples.
- Ensure proper recording of sample locations, depths, and identification; sampling and handling requirements, including field decontamination procedures; physical evaluation and logging of samples; and completion of chain-of-custody forms.
- Ensure that all field staff follows the SAP, that the physical evaluation and logging of soil is based on the visual-manual classification method American Society for Testing and Materials (ASTM) D2488, and that standardized methods for sample acceptability and physical description of samples be followed.
- Ensure that field staff maintains records of field sampling events using the forms included in Appendix B of this SAP.
- Completion and storage of field forms.

The FC for this project is Wesley Garcia, Staff Geologist.

Table 2-1. Key Project Roles and Contact Information

Project Role	Name	Phone/Email	Email
Project Manager	James Welles, LHG	206.766.7605	james.welles@pbsusa.com
Project Principal	Tom Mergy, LHG	206.766.7633	tom.mergy@pbsusa.com
Project QA/QC Officer	Melanie Young, PE	206.766.7660	melanie.young@pbsusa.com
Field Coordinator	Wesley Garcia	509.375.7842	wesley.garcia@pbsusa.com
Laboratory PM	Mike Erdahl	206.285.8282 x 247	merdahl@friedmanandbruya.com

3 FIELD INVESTIGATION SAMPLING APPROACH

3.1 Soil Sampling

Per the Data Gaps Analysis Work Plan, the extent of soil contamination at the site is fully delineated. Soil characterization is in compliance with site-specific cleanup levels (CULs). As such, additional soil sampling is not proposed at the Site at this time. Should additional soil sampling be determined to be necessary at a later date, soil sampling will be performed following PBS' Standard Operating Procedure (SOP) for Drilling and Soil Sampling (Appendix A).

3.2 Well Installation and Groundwater Sampling

PBS will oversee the installation of two additional groundwater monitoring wells to a depth of 30 feet below ground surface (bgs). Monitoring wells will be installed by a Washington State licensed well driller in accordance with state well regulations established in WAC Chapter 173-160. Wells will be installed with a direct push drill rig as allowed by drilling conditions during the same mobilization for installation of soil vapor probes. Should drilling refusal be met at depths shallower than 30 feet bgs with the direct push rig, a hollow stem auger drilling rig will be mobilized to install the wells to proposed depth.

The two new monitoring wells (MW-13 and MW-14) will be located along the south sidewalk of S Dearborn Street between Maynard Avenue S and 6th Avenue S as depicted on Figure 1 of the Data Gaps Analysis Work Plan.

Depth to water measurements will be collected periodically during drilling. The boring will be advanced to a depth of 30 feet bgs. Upon reaching total depth in the soil boring, a monitoring well will be constructed in the boring with a screen interval of 15-30 feet bgs using 0.010-inch slotted polyvinyl chloride (PVC) well screen. A sand filter pack will be placed surrounding the screened interval to a depth of 13 feet bgs. A well seal constructed of hydrated bentonite chips will be installed from a depth of 3-13 feet bgs. The top 3 feet of the boring will be sealed with concrete and a traffic rated flush mount well box.

The purpose of groundwater sampling is to continue monitoring contaminant concentration trends in groundwater following implementation of thermal remediation at the Site. Field personnel collecting groundwater samples will follow PBS' Standard Operating Procedure (SOP) for Low-Flow Groundwater Monitoring, a copy of which is provided in Appendix A.

Groundwater samples will be collected from a depth corresponding to the midpoint between the top and bottom of the well screen interval. Additionally, a second groundwater sample will be collected from a depth 18-inches above the bottom of the well screen from monitoring wells MW-2R and VE-1R as detailed in the Data Gaps Analysis Work Plan. Field conditions may warrant changes to the SOP to ensure achievement of the DQOs. One-time deviations from the SOP will be discussed in in the remedial investigation report if applicable.

3.3 Soil Vapor Sampling

Soil vapor samples will be collected from seven newly installed soil vapor probes twice to establish contaminant concentrations, as well as seasonal variability of concentrations. Pending work plan and permit approval, PBS will collect soil vapor samples from the seven newly installed probes in December of 2023 and June of 2024. Samples will be collected in accordance with the PBS SOP for Soil Gas Sampling in Appendix A.

Proposed locations for soil vapor probes are presented on Figure 1 of the Data Gaps Analysis Work Plan.

3.4 Field Schedule

PBS plans to install monitoring wells and soil vapor probes in December 2023 pending Ecology approval of the Data Gaps Analysis Work Plan, issuance of street use permits from the Seattle Department of Transportation (SDOT) and Ecology and Department of Archaeology and Historic Preservation (DAHP) approval of the Archaeological Monitoring Plan.

PBS plans to sample existing and newly installed monitoring wells in December, and then quarterly thereafter. PBS plans to sample the newly installed soil vapor probes in December 2023 and June 2024.

4 SAMPLE HANDLING AND QUALITY CONTROL PROCEDURES

4.1 Sample Identification

Sample labels will be completed and attached to containers in the field to prevent misidentification. Sample labels will include identifying information including sampler, site name, sample identification, analytical parameters, and sample collection date and time. Sample naming conventions for groundwater and soil vapor samples are discussed in the following sections.

Groundwater

Groundwater sample IDs will include a prefix of the monitoring well identification and a suffix of the date. For example, the groundwater sample collected from monitoring well MW-1 on December 20, 2023 would be identified as MW1-20231220. In the event that a duplicate groundwater sample is collected, the parent sample will be identified as described above and the duplicate sample will have the ID DUP-01-YYYYMMDD. In the event a second duplicate sample is collected in the same monitoring event it will be identified as DUP-02-YYYYMMDD. The relationship between the duplicate sample and associated parent sample will be noted in the DFAR but will not be disclosed on the chain-of-custody or to the laboratory.

Soil Vapor

Soil vapor sample IDs will include a prefix of the vapor probe identification and a suffix of the date. For example, the soil vapor sample collected from soil vapor probe SV-1 on December 20, 2023 would be identified as SV1-20231220. In the event that a duplicate soil vapor sample is collected, the parent sample will be identified as described above and the duplicate sample will have the ID DUP-01-YYYYMMDD. In the event a second duplicate sample is collected in the same monitoring event it will be identified as DUP-02-YYYYMMDD. The relationship between the duplicate sample and associated parent sample will be noted in the DFAR but will not be disclosed on the chain-of-custody or to the laboratory.

4.2 Decontamination Procedures

Non-disposable tools and sampling equipment will be decontaminated between collection of samples. Equipment requiring decontamination between samples includes but is not limited to drilling rods, water level meter, and bladder pump (if used, it is likely wells will be sampled using a peristaltic pump using disposable tubing as allowed by depth to water). Decontamination will consist of submersion and physical scrubbing of sampling equipment in a tap water and laboratory grade detergent solution. Following scrubbing in the detergent solution, equipment will be rinsed with tap water and then final rinsed with distilled water.

Decontamination and residual sample media will be containerized and disposed of in accordance with the procedures established in Section 6.

4.3 Sample Container and Handling Procedures

In addition to providing analytical methods, Table 4–1 summarizes the specifications for minimum sample volume, sample preservation, container requirements, and holding times. Sample handling protocols, including specifications for sample labeling, handling, and shipping, along with chain-of-custody record preparations and control, are described in detail in the following sections.

Table 4–1. Laboratory Container Requirements

Parameter	Method	Container(s)	Preservative	Holding Time
Groundwater				
TPH as gasoline	NWTPH-Gx	3x VOA	HCl / cool to 4°C	Analyze within 14 days
VOCs	EPA 8260D	3x VOA	HCl / cool to 4°C	Analyze within 14 days
Soil Vapor				
APH	MassDEP	1-L Summa	none	30 days
cVOCs	EPA TO-15	1-L Summa	none	30 days

Notes:
L= liters
HCl = hydrochloric acid
VOA vial = Clear glass vial with a screw cap with a hole in the center and TFE-faced silicone septum
EPA = Environmental Protection Agency

4.4 Field Quality Assurance/Quality Control Samples

QA/QC samples are collected and analyzed to assess the quality of the sampling and analysis by both the field personnel and the laboratory. For samples sent to the laboratory, field QA samples will be collected as provided in Table 4-2; additional sample descriptions follow.

Table 4-2. Summary of Field QA/QC Samples

Laboratory	QA/QC Sample	Purpose	Frequency	Number of Samples
Analysis by F&B Lab	Field Duplicate	Precision	10%	1 per groundwater / soil vapor monitoring event
Analysis by F&B Lab	MS/MSD	Accuracy	5%	1 per groundwater monitoring event
Analysis by F&B Lab	Trip Blank	Cross-Contamination Check	One per cooler containing 40 mL VOAs	1 per groundwater sample batch/delivery

MS/MSD – Matrix spike / matrix spike duplicate

A separate field duplicate sample will be collected for groundwater and soil vapor samples in the event soil vapor and groundwater monitoring events are conducted simultaneously. One MS/MSD sample will be collected per groundwater monitoring event. No MS/MSD samples are proposed for soil vapor sampling.

Field Duplicates

Field duplicates are used to document sampling and laboratory analysis reproducibility or precision. Duplicate samples are typically selected from sampling locations known to have historical detections of analytes. Field duplicates will be issued unique sample identifications that will not allow the laboratory to identify the source. The duplicate names will be established as noted in Section 4.1.

Matrix Spike and Matrix Spike Duplicate (MS/MSD)
MS/MSD samples are used to evaluate matrix interference and to a lesser extent, determine laboratory accuracy. The sampling location in which the MS/MSD samples are collected will be selected in the field.

Trip Blank
The purpose of the trip blank is to detect possible contaminants that may result from sample transport, and not from the sample source. It consists of a sealed 40-mL glass vial of deionized water provided by the laboratory that remains sealed and accompanies the groundwater collection bottles in the field. The trip blank is then submitted to the laboratory for analysis for VOCs.

4.5 Sample Documentation and Chain-of-Custody Procedures

Collected samples are to be handled in a manner that ensures their integrity and traceability to the sampling location. This is achieved through the use of trained field and laboratory personnel; controlled field, transport, and laboratory conditions; and implementation of rigorous sample preparation, containerization, preservation, storage, packaging, transportation, and custody procedures. Sample custody procedures are designed to ensure that the following objectives are met:

- Each sample is identified uniquely and correctly.
- Each sample is traceable to its source/point of origin.
- Sample representativeness is preserved.
- Sample alteration, such as by preservation or filtration, is documented.
- A record of sample integrity is established and maintained throughout the custody process.
- Sample custody is to be maintained and documented in the field, during shipment, and at the analytical laboratory.
- Shipment custody includes time spent under the control of, and tracking by, the carrier (Federal Express or United Parcel Service).

A permanent record for each sample will be documented by sample labels, DFARs, Groundwater Sampling Field Form, Surface Water Sampling Field Form, chain of custody, sampler receipt (completed by the lab), and occasionally in photographs.

Chain-of-Custody
Chain-of-custody forms will accompany sample containers during transit to, and upon receipt by, the laboratory. A sample of a chain-of-custody form is provided in Appendix B. The chain-of-custody form will be prepared prior to field activities and completed at the end of each field day. Following courier pick-up of the samples, a photocopy of the chain-of-custody will be made and retained in the project files. The original copy will be submitted with the data package to the lab. PBS will retain an electronic copy (returned by the lab) with the project files.

The chain-of-custody will be filled out using indelible ink and will include the following:

- Project name and number
- The signatures of sampling personnel
- Sample identification number, which includes sample location code
- Sampling dates and times

- Total number of containers per sample location
- Analyses to be performed on each sample
- Sample relinquisher, date, and time
- Hazards associated with samples
- Any remarks and/or special instructions

Standard protocol is that samples will be delivered to the lab by PBS personnel. Transfer of sample custody will occur as follows:

- PBS will sign, date, and enter time on the chain-of-custody form under "Relinquished by."
- Lab will sign under "Received by" and enter date and time.

If an individual other than the sampler in charge of sample custody is to deliver the samples to a common carrier (such as Federal Express), custody must first be transferred to the individual following the previously described protocol. The samples are now under the custody of the individual, who will perform the following:

- Sign, date, and enter the time on the chain-of-custody form under "Relinquished by"
- Retain a copy of the original signed chain-of-custody
- Place the chain-of-custody within the shipment container in a sealable water-tight plastic bag
- Seal the container and affix a custody seal, using a minimum of two seals per container
- Complete other carrier-related shipping papers
- Deliver the sealed container to the common carrier and retain all shipping information with the copy of the chain-of-custody.

Sample Labels
A label is affixed to each sample bottle prior to transportation to the laboratory. The label and the sample number will not indicate whether a sample is a duplicate. Such designation will be made only on the DFAR and Field Form. Information on sampling labels will include:

- Sampler (Company)
- Site Name
- Sample Number
- Date
- Time
- Parameters to be analyzed

The label will be identified upon receipt by the laboratory and cross-referenced to the chain-of-custody record. When the samples arrive at the laboratory following delivery, the sample custodian will receive the samples. Any inconsistencies will be noted on the custody record. Laboratory personnel will notify PBS immediately if any inconsistencies exist in the paperwork associated with the samples. PBS will verify the sample custodian has accurately transcribed sample names from the chain-of-custody and notify Friedman and Bruya, Inc. of any discrepancies.

Field Forms
PBS field personnel are responsible for preparing and submitting the DFAR and Groundwater Sampling Forms to the PBS PM. Samples of these forms are provided in Appendix B. A DFAR with attachments, such as the Groundwater Sampling Field Form and chains-of-custody forms, is to be submitted daily. DFARs, in combination with its attachments, are to present an accurate and complete picture of sampling activities; they should be precise, factual, legible, and objective, and at minimum contain:

- The project number

- The day's weather conditions (temperature, humidity, wind, cloud cover)
- Work performed, samples taken including QC samples, and personnel involved
- Available analytical field results
- Physical parameter measurements, calculation results, and any required QC data
- All sampling, sample handling, chemical parameter measurements problems, deviations from the approved plan, and corrective actions that could affect fulfillment of DQOs or minimum data reporting requirements
- Signatures of responsible authority and initials of persons conducting changes
- Verbal or written instructions from PBS PM for retesting or changes of work

Sample Receipt Form

The laboratory directly logs samples into their data base and notes problems in sample packaging, chain-of-custody, and sample preservation. The following will occur during sample receipt:

- The carrier and the time of arrival are documented in the log. The number of items on the bill (if applicable) is checked with the actual number received to ensure that all samples have arrived.
- Notation is made as to whether the sample container was sealed.
- The container is opened, the internal ambient temperature is taken by use of an included temperature blank, and the samples itemized. All deviations are noted and reported to the sample coordinator.

Documentation

All completed forms should be reviewed and maintained by the PBS PM. Corrective actions taken upon discovery of anomalies are to be documented. All QC records are to ultimately be maintained as part of the project QC file.

Corrections to Documentation

The PBS PM is responsible for ensuring that the requisite QC records are generated and controlled. The QA/QC officer will verify that these controls are implemented as follows:

- Measurements and observations are recorded at the time they are made.
- Documentation is orderly, legible, and traceable to relevant items/conditions.
- Documentation includes sufficient information to be readily interpreted by staff other than those responsible for its generation.
- Changes or revisions to a record are made in a manner that preserves the original data, such as by drawing a single line through a hard copy entry or maintaining historical records of electronic entries/files.
- Changes to records are signed (or initialed) and dated.
- As a minimum standard, changes to a record are subject to the same review and approval protocols as the original entry.
- Records adequately document digressions from specified procedures and identify authorization for the digression.
- Project documents and records, including photographic and electronic records, are protected from loss, damage, misuse, or deterioration.

4.6 Sample Packaging and Delivery

Samples will be transferred to the selected laboratory for analysis via sturdy waterproof coolers. Samples will be packaged, stored on ice and delivered on a per mobilization basis to ensure that samples are held for the minimum amount of time prior to delivery to the laboratory. Samples will be held under established chain-of-custody procedures and kept at 4 ± 2 degrees Celsius (°C). Before a sample can be put in the cooler, any drains in the cooler will be sealed with tape to prevent leaking and all pertinent information shall be placed on the sample label. Each cooler will be packed as follows:

- Ensure sample lids are tight.
- Place sufficient inert cushioning material in the bottom of the cooler.
- Wrap all glass sample containers in plastic-bubble wrap. Place samples upright in the cooler so they do not and will not touch during transport.
- Fill cooler with enough packing material to prevent breakage of glass bottles.
- Place sufficient ice in cooler to maintain the internal temperature at 4 ± 2°C during transport. The ice will be double-bagged to prevent the melt water from contacting the samples. If chemical ice is used, it should also be placed in a plastic bag.
- Shipment of samples is not expected for this project. If the sample cooler will be shipped by PBS, the following will occur:
  - Place associated chain-of-custody in a waterproof plastic bag and place it on top of the sample containers.
  - Seal coolers at a minimum of two locations with signed custody seals or evidence tape before transferring off site. Attach a completed shipping label with return address to the top of the cooler. Place "This Side Up" labels on all four sides and "Fragile" labels on at least two sides.
  - Affix custody seals on the front right and back left corners so the cooler can’t be opened without breaking the tape. Further seal the cooler with strapping tape applied completely around it at least three times in two different locations. Do not cover any labels.
- If the cooler will be picked up by a Friedman and Bruya, Inc. courier, place the signed chain-of-custody on top of the shipment.
- Evidence of sample custody shall be traceable from the time the sample is taken until the filled sample bottles are received by the laboratory. Receipts from post offices, copies of bills of lading, and air bills will be retained as part of the chain-of-custody documentation.
- In the event that sample coolers are to be shipped, they shall be shipped such that samples arrive at the laboratory the day after shipping or be sent by a courier to arrive the same day. The laboratory will be notified of the sample shipment and the estimated date of arrival.
- For each cooler, weight limit for the carrier will be observed (if applicable).

Laboratory Addresses and Points of Contact:

PBS Shipping Contact: Project Manager – James Welles
206.766.7605

Contracting Analytical Laboratory:
Friedman and Bruya, Inc.
5500 4th Ave S
Seattle, Washington 98108
206.285.8282

5 ANALYTICAL TESTING

All samples will be submitted to Friedman and Bruya, Inc., an Ecology-accredited analytical laboratory located in Seattle, WA. The laboratory follows approved methods (EPA, Standard Methods, ASTM, State-specific methods) for the analysis of soil vapor and water. Samples will be submitted on a standard 5- to 10-day turnaround time. Analytical parameters for specific soil vapor and groundwater samples are presented in Table 5-1. Analytical methods for these parameters are specified in Table 4-1.

Table 5-1. Proposed Sampling Locations and Analyses

Location ID	TPH-G	VOCs	APH	cVOCs
Groundwater Monitoring Wells				
MW-1	X	X		
MW-2R	X	X		
VE-1	X	X		
MW-3	X	X		
MW-4	X	X		
MW-5R	X	X		
MW-6	X	X		
MW-7	X	X		
MW-8	X	X		
MW-9	X	X		
MW-10	X	X		
MW-11	X	X		
MW-12	X	X		
MW-13	X	X		
MW-14	X	X		
Soil Vapor Probes				
SV-1			X	X
SV-2			X	X
SV-3			X	X
SV-4			X	X
SV-5			X	X
SV-6			X	X
SV-7			X	X
Field Duplicates/Event	1	1	1	1
Total Samples	**16**	**16**	**8**	**8**

Note:
X – sample will be analyzed for given parameter
TPH-G – Gasoline range total petroleum hydrocarbons
cVOCs – chlorinated VOCs including PCE, TCE, cis-1,2-DCE, trans-1,2-DCE and vinyl chloride only
VOCs – volatile organic compounds

6 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Drilling spoils generated from soil boring advancement for soil vapor probe and monitoring well installation along with wastewater generated from decontamination procedures and well purging will be containerized in sealed, labeled drums. Waste contained in the drums will be sampled for the purposes of waste profiling. PBS will contract with a waste disposal vendor to transport, profile and properly dispose of the waste. Drums will be stored at the Site in a locked, secure location pending profiling and disposal. Upon receipt of analytical results, PBS will work with the vendor to profile the waste. Upon completion of a waste profile, the vendor will transport the waste to an appropriate facility for disposal.

Disposable consumables generated during the field investigation such as used gloves and disposable sampling equipment will be disposed of as nonhazardous waste. Federal hazardous waste or Washington State dangerous waste is not expected to be encountered or generated. Waste generated from the investigation will be managed in accordance with local, state, and federal regulations. A contained-in-determination may be sought from Ecology to facilitate disposal of waste containing VOCs as non-dangerous.

7 DATA QUALITY OBJECTIVES

Field and laboratory activities will be conducted in such a manner that the results will be valid and meet the DQOs for this project. Guidance for QA/QC will be derived from the protocols developed within the most recent version of USEPA SW-846 (Test Methods for Evaluating Solid Waste: Physical/Chemical Methods), as appropriate. The DQOs are designed to achieve the following:

- Assist the Project Manager and project team to focus on the factors affecting data quality during the planning stage of the project.
- Facilitate communication among field, laboratory, and project staff as the project progresses.
- Document the planning, implementation, and assessment procedures for QA/QC activities for the field investigation.
- Verify that the DQOs are achieved.
- Provide a record of the project to facilitate report preparation.

The DQOs for the project include both qualitative and quantitative objectives, which define the appropriate type of data and specify the tolerable levels of potential decision errors that will be used as a basis for establishing the quality and quantity of data needed to support the field investigation. To verify that the DQOs are achieved, this SAP details aspects of sample collection and analysis, including analytical methods, QA/QC procedures, and data quality reviews. This SAP describes both qualitative and quantitative measures of data quality to verify that the DQOs are achieved.

Detailed QA/QC procedures in the field and laboratory are provided in the following sections. The DQOs for the investigation will be used to develop and implement procedures to verify that data collected is of sufficient quality to adequately address the objectives of the remedial investigation. All observations and measurements will be made and recorded in such a manner as to yield results representative of the media and conditions observed and/or measured. Goals for representativeness will be met by verifying that sampling locations are selected properly, that a sufficient number of samples are collected, and that field screening and laboratory analyses are conducted properly.

The quality of the laboratory data will be assessed by precision, accuracy, representativeness, completeness, comparability, and sensitivity. Definitions of these parameters and the applicable QC procedures are described in Sections 7.1 through 7.6. Quantitative DQOs are provided following each definition. Laboratory DQOs have been established by the analytical laboratory. Applicable quantitative goals for these DQOs are listed in Table 7-1.

Chemical analyses shall meet data quality objectives for precision, accuracy, and completeness. Accuracy goals, measured by the LCS and to a lesser extent, the MS recovery and the surrogate recovery, are determined by the laboratory and are based upon QC limits established in published EPA methods. The completeness goal for the soil, groundwater and surface water analytical data is 95 percent. Table 7–1 summarizes targeted data quality objectives for the laboratory parameters. Data quality objectives are applicable to all samples submitted to the laboratory, including primary samples, duplicates, and MS/MSDs.

The maximum allowable reporting limit for each analyte shall be no greater than the concentration of the applicable cleanup level listed under MTCA.

There are no specific data quality objectives for the measurement of field parameters, such as temperature, pH, conductivity, and turbidity. PBS' SOP on low-flow groundwater sampling describes the acceptable criteria for the measurement of field parameters.

7.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of two or more measurements compared to their average values. Precision is calculated from results of duplicate sample analyses. Precision is quantitatively expressed as the relative percent difference (RPD) and is calculated as follows:

$$\text{RPD (\%)} = \left| \frac{X_1 - X_2}{(X_1 + X_2)/2} \right| \bullet 100\%$$

where: X_1 = measured concentration in the first sample
X_2 = measured concentration in the second sample

There are no specific RPD criteria for organic chemical analyses. If organic analyses become necessary, quantitative RPD criteria for will be based on laboratory-derived control limits.

7.2 Accuracy

Accuracy is a measure of the closeness (bias) of the measured value to the true value. The accuracy of chemical analytical results is assessed by "spiking" samples in the laboratory with known standards (a surrogate or matrix spike of known concentration) and determining the percent recovery. The accuracy is measured as the percent recovery (%R) and is calculated as follows:

$$\%R = \left(\frac{(M_{sa} - M_{ua})}{C_{sa}}\right) \times 100$$

Where:

%R = percent recovery
M_{sa} = measured concentration in spiked aliquot
M_{ua} = measured concentration in unspiked aliquot
C_{sa} = actual concentration of spike added

Laboratory matrix spikes and surrogates will be carried out at the analytical laboratory in accordance with EPA SW-846 and Ecology methods and procedures for inorganic and organic chemical analyses. The frequency of matrix spikes and matrix spike duplicates will each be one per batch of 20 samples or less for soil samples. Quantitative percent recovery criteria for organic analyses will be based on laboratory-derived control limits for surrogate recovery and matrix spike results. The accuracy of sample results can also be affected by the introduction of contaminants to the sample during collection, handling, or analysis. Contamination of the sample can occur because of improperly cleaned sampling equipment, exposing samples to chemical concentrations in the field or during transport to the laboratory, or because of chemical concentrations in the laboratory. To demonstrate that the samples collected are not contaminated, laboratory method blank samples will be analyzed. The laboratory will run method blanks at a minimum frequency of 5 percent, or one per batch, to assess potential contamination of the sample within the laboratory.

7.3 Representativeness

Representativeness is a qualitative assessment of how closely the measured results reflect the actual concentration or distribution of the constituent concentrations in the matrix sampled. The sampling plan design, sample collection techniques, sample handling protocols, sample analysis methods, and data review procedures have been developed to verify that the results obtained are representative of the site conditions. These issues are addressed in detail in Sections 4 and 5, Analytical Testing, and Section 8.0, Quality Control Procedures.

7.4 Completeness

Completeness is defined as the percentage of measurements judged to be valid (%C). Results will be considered valid if they are not rejected during data validation (Section 9.0, Quality Control Procedures). Completeness is calculated as follows:

$$\%C = \frac{(SE - SR)}{SE} \bullet 100\%$$

where: *SE* = number of samples collected
SR = number of samples rejected

Objectives for completeness are based, in part, on the subsequent uses of the data (i.e., the more critical the use, the greater the completeness objective). The objectives for completeness of samples are expressed as percentages, which refer to the minimum acceptable percentages of samples received at the laboratory in good condition and acceptable for analysis. The objectives of completeness for other samples are 95 percent for soil and water samples. These objectives will be met through the use of proper sample containers, proper sample packaging procedures to prevent breakage during shipment, proper sample preservation, and proper labeling and chain-of-custody procedures. A loss of 5 to 10 percent of intended samples is common, and the goals set are sufficient for intended data uses.

The objectives for completeness of chemical analyses are also expressed as percentages and refer to the percentages of analytical requests for which usable analytical data are produced. The initial objective for completeness of chemical analyses in the laboratory is 95 percent.

7.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. The use of standard Ecology and EPA methods and procedures for both sample collection and laboratory analysis will make the data collected comparable to both internal and other data generated.

7.6 Sensitivity

Analytical sensitivities are measured by practical quantitation limits (PQLs), which are defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. PQLs are determined by the laboratory. The detection or reporting limits for actual samples may be higher depending on the sample matrix and laboratory dilution factors.

Table 7-1. Project Data Quality Objectives For Laboratory Analysis

Analyte	Analytical Method	Precision – Water (RPD %)	Precision - Soil Vapor (RPD %)	Accuracy (%R)	Completeness (%C)
TPH-G	NWTPH-Gx	+/- 35%	+/- 50%	Lab-determined	95
VOCs	EPA 8260D	+/- 35%	+/- 50%	Lab-determined	95
cVOCs	EPA TO-15	+/- 35%	+/- 50%	Lab-determined	95
APH	MassDEP	+/- 35%	+/- 50%	Lab-determined	95

RPD – relative percent difference
%C – percent complete
%R – percent recovery

8 QUALITY CONTROL PROCEDURES

8.1 Field Quality Control

Field QC samples (e.g., duplicate samples) will be collected during this project as specified in Section 4.3. The basis for field data collection activities will be documented in the DFAR. Deviations from established protocols will also be documented in the DFAR.

Based on the sampling frequency and number of soil vapor and groundwater samples anticipated, and the associated analytical methods used to analyze the samples, it is estimated that one field duplicate soil vapor sample and one field duplicate groundwater sample will be collected per sampling event and submitted for laboratory analysis.

8.2 Laboratory Quality Control

Laboratory QC procedures are summarized below:

Laboratory Quality Control Criteria. Results of the QC samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine whether control limits were exceeded. If control limits are exceeded in the sample group, corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

All primary chemical standards and standard solutions used in this project will be traceable to documented and reliable commercial sources. Standards will be validated to determine their accuracy by comparison with an independent standard. Any impurities identified in the standard will be documented.

The following paragraphs summarize the procedures that will be used to assess data quality throughout sample analysis.

Laboratory Duplicates. Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates are subsamples of the original sample that are prepared and analyzed as a separate sample. A minimum of one duplicate will be analyzed per sample group or for every 20 samples, whichever is more frequent.

Matrix Spikes and Matrix Spike Duplicates. Analysis of matrix spike (MS) samples provides information on the extraction efficiency of the method on the sample matrix. By performing matrix spike duplicate (MSD) analyses, information on the precision of the method is also provided for organic analyses. A minimum of 1 MS/MSD will be analyzed for every sample group or for every 20 samples, whichever is more frequent.

Laboratory Control Samples. A laboratory control sample (LCS) is a method blank sample carried throughout the same process as the samples to be analyzed, with a known amount of standard added. The blank spike compound recovery assesses analytical accuracy in the absence of any sample heterogeneity or matrix effects.

Surrogate Spikes. All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods. Surrogate recoveries will be reported by the laboratories; however, no sample result will be corrected for recovery using these values.

Method Blanks. Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of one method blank will be analyzed for every extraction batch or for every 20 samples, whichever is more frequent.

8.3 Data Quality Control

All data generated by Friedman and Bruya, Inc. will undergo two levels of QA/QC evaluation: one by the laboratory and one PBS. The laboratory will perform initial data reduction, evaluation, and reporting. The analytical data will then be validated at PBS under the supervision of the Project QA/QC Officer. The following types of QC information will be reviewed, as appropriate:

- Method deviations
- Sample transport conditions (temperature and integrity)
- Sample extraction and holding times
- Method reporting limits
- Blank samples
- Duplicate samples
- Surrogate recoveries
- Percent completeness
- RPD (precision)

PBS will review field records and results of field observations and measurements to verify procedures were properly performed and documented. The review of field procedures will include the following:

- Completeness and legibility of field logs
- Preparation and frequency of field QC samples
- Equipment calibration and maintenance
- Sample Chain-of-Custody forms

Corrective actions are described in Section 9, Corrective Actions.

8.4 Data Assessment Procedures

The Project Manager and Project QA/QC Officer are responsible for data review and validation. Upon receipt of each data package from the laboratory, calculations using the equations presented for precision, accuracy and completeness will be performed. Results will be compared to DQOs. Data validation parameters are outlined in Section 7.

8.5 Performance Audits

Field performance will be monitored by the Project Manager through regular review of sample chain-of-custody forms, field forms, and field measurements. The Project Manager and/or the Project QA/QC Officer may also perform periodic review of work in progress at the site.

Accreditations held by the Friedman and Bruya, Inc. are considered to demonstrate the laboratory's ability to properly perform the requested analyses in accordance with the specified methods. As such, performance audits of the laboratory by PBS will not be conducted.

9 CORRECTIVE ACTIONS

Corrective actions will be the joint responsibility of the Project Manager and the Project QA/QC Officer. Corrective procedures can include the following:

- Identifying the source of the violation.
- Reanalyzing samples, if holding time criteria permit.
- Resampling and analyzing.
- Re-measuring parameter.
- Evaluating and amending sampling and analytical procedures.
- Qualifying data to indicate the level of uncertainty.

During field sampling operations, the Project Manager and field staff will be responsible for identifying and correcting protocols that may compromise the quality of the data. All corrective actions taken will be documented in the field notes.

10 DOCUMENTATION AND RECORDS

Project files and raw data files will be maintained at PBS's Seattle office. Project records will be stored and maintained in a secure manner. Each project team member is responsible for filing all necessary project information or providing the information to the person responsible for the filing system. Individual team members may maintain files for individual tasks, but team members must provide such files to the central project files upon completion of each task. A project-specific index of file contents will be kept with the project files. Hard copy documents will be scanned and converted to electronic data and will be maintained in the database at PBS throughout the duration of the project. All sampling data will be submitted to Ecology in both printed and electronic formats in accordance with WAC 173-340-840(5).

11 PERSONNEL QUALIFICATIONS AND TRAINING

11.1 PBS Engineering and Environmental Inc.

Project staff shall be qualified to perform assigned jobs, which is accomplished by establishing and enforcing minimum qualification requirements for key positions, verifying initial and continued personnel proficiency, and implementing a formal training program. Field sampling personnel conducting or observing sampling activities are to be trained and certified in accordance with established PBS protocols. All personnel engaged in site activities will have completed the OSHA HAZWOPER 40-hour health and safety training and have current annual 8-hour refresher training.

Senior technical staff will provide on-the-job training to newly assigned technical staff that is related to their job requirements and techniques, with particular emphasis on solutions to unanticipated field conditions. Work performed by newly assigned staff is to be monitored by senior staff. The frequency of monitoring depends on the individual's demonstrated proficiency to perform his or her assigned duties.

11.2 Laboratory Qualifications

The selected analytical laboratory for this project is Friedman & Bruya, Inc., providing specialty analyses, with a lab in Seattle, Washington. Friedman & Bruya is Washington Department of Ecology (Ecology)-certified for the various analytical procedures they will perform for this project.

12 LABORATORY ANALYTICAL PROCEDURES

Project samples, whether analyzed in the field or at the laboratory, are to be prepared, extracted, and analyzed per specifications of the project DQO. Table 4-1 gives container type, preservative, and holding times for each analytical method. Table 4-2 identifies the analytical methods to be used. SOPs for the laboratory are maintained internally in their operations and quality assurance manuals. The analytical laboratory is to demonstrate achievement of the specified detection/quantitation limits and method performance criteria. Project samples are to be prepared, extracted, and analyzed by the specific analytical laboratory identified herein.

Specified methods are to be implemented as published. Modifications to approved procedures, alternate procedures, or additional procedures are to be pre-approved in writing by PBS. If non-standard methods are considered, the analytical laboratory shall provide, upon request, method validation data for consideration. Where deemed necessary to fulfill the requirements of the project, a request for approval for an alternate or modified method is to be made by PBS. QAPP-specified QC requirements are to be followed explicitly.

All analytical data will be validated at a Level II data package. Level II refers to the laboratory analysis quality control levels established by various government agencies to allow investigations to meet the DQOs established for a particular project site. These levels follow the criteria in the EPA's "Data Quality Objectives for Remedial Response Activities Development Process," National Technical Information Service (PB88-131370). Though all data from this project will be validated at Levels II, descriptions for all data validation levels is provided below for completeness:

- Level I validations and reporting include a brief narrative of the laboratory data, and presentations of the sample results and surrogate results for organic compounds.
- Level II validation and reporting add review of QC samples: method blank results, laboratory control sample (LCS) results, and MS/MSD or duplicate sample results.
- Level III validation and reporting add internal standards, blank association, serial dilution results, post-digestion spike results, GC/MS tune table, initial calibration table, continuing calibration verifications, calibration blanks, ICSA/AB, CRDL, MDL/IDL form, column confirmation, and instrument run logs.

12.1 Calibration Procedures and Frequency

Measurement and test equipment is to be calibrated to the appropriate traceable standards. Records of these activities are to be generated by the laboratory individual performing the activity and retained by the laboratory. The SW-846 Method protocols are to be regarded as establishing the minimum calibration goals.

Calibration procedures and instrumentation shall be consistent with the sample analysis requirements of this project and the applicable EPA approved methods.

12.2 Internal Quality Control Checks

12.2.1 Sample Batching

Project samples are to be prepared, extracted, and analyzed in batches. Each batch will have no more than 20 uniquely numbered samples of the same matrix to be analyzed for the same analyte or group of analytes.

- To the extent practical, project samples of the same matrix and analytes are to be grouped together in a batch.
- Samples within a preparation batch are to be prepared consecutively or simultaneously, by the same personnel, using the same equipment, reagent and glassware lots, and methodology.
- To the extent practical, project samples prepared and extracted as a batch are to be analyzed as a batch.
- Ideally, samples within a batch are to be analyzed in the same run sequence, by the same personnel, and using the same instrument (under the same calibration and tune, as applicable), reagent lots, and methodology.
- Field QC samples such as Matrix Spike/Matrix Spike Duplicate (MS/MSD) and field duplicates, are to be delivered so they will be prepared and analyzed within the same sample batch as their associated field sample.
- The analytical results pertaining to the samples in the batch are to be reported in a single data package.

12.2.2 Method Quality Control

Method QC includes the analyses and activities required to ensure that the analytical system is in control prior to and during an analytical run. Method QC requirements for this project are specified within each method. These include, but are not limited to, the following: laboratory blanks (method and instrument), laboratory control spikes, surrogate spikes, matrix spikes, laboratory duplicates and/or matrix spike duplicate pairs, LCS, field duplicates, and field blanks.

Internal quality control checks are designed to establish technically sound criteria for each measurement parameter, which shall serve to accept, qualify, or reject data in a uniform and systematic manner. Ten percent of the total number of a given type of sample shall be devoted to internal QC checks. These checks include blanks, laboratory control spikes, duplicates, matrix spikes, reference standards, and performance evaluation samples.

13 DATA REDUCTION, REVIEW, AND REPORTING

Conversion of raw data into reported results is to be performed by the laboratory's QC chemist as detailed in the analytical methods. Laboratory SOPs include automated or manual data reduction procedures, equations, conversion factors, significant figures, and reporting units. Suspected outliers are to be reviewed for calculation and transcription errors, instrument malfunctions, and verification of measurement. If no errors are found, statistical methodology can be performed to determine whether the data point is to be rejected or retained. The PBS PM will be responsible for inspection of reported results for laboratory data.

13.1 Data Review

13.1.1 General

Data review is independent of the intended use of the data and determines the technical merit of the data by comparing QC results to method and Ecology-specified criteria. Data are reviewed for traceability, documentation, calculations, transcription errors, and evaluation of data deliverables for contract compliance.

13.1.2 Field Parameters

Field crews are to review their data and implement any necessary corrective actions prior to submitting data for use. All field data must be within the acceptance criteria specified in the SAP before being used for decision-making purposes. Any corrective actions should be noted in the DFAR.

13.2 Data Tracking and Reporting

13.2.1 Data Tracking

Submittals from the analytical laboratory will be tracked and reviewed by the PBS PM. Final data submittals will be included in the quarterly monitoring reports. Data are to include data qualifiers from the data review process.

13.2.2 Electronic Data

The format for electronic data delivery from the laboratory will be a customized electronic data deliverable (EDD) package. The information in the EDD will be checked against each input source using input file structure comparison, comparison of requested and reported data, sample number verification, parameter spelling check, reporting unit consistency, consistency between electronic and validated results, independent spot checks of electronic and hard copy data, detection limit specifications, and other internal consistency checks of the data. The output from the database will also to be checked by the PBS PM to determine if it makes sense from an historical perspective, is representative, and agrees with previous data collected or literature reported values. No project data will be released for use until QC checks have been performed and discrepancies resolved.

13.2.3 Data Reporting

Following each quarterly field event, the PBS PM will submit a monitoring report that includes sampling effort results and comparison with State of Washington Model Toxics Control Act (MTCA) criteria. Following each submission, comments generated as a result of Ecology’s review will be incorporated into the next event’s monitoring report submitted.

13.3 Quality Control Reports

13.3.1 Data Review—Laboratories

Laboratory data are to be reviewed by Friedman & Bruya’s laboratory QC chemist prior to delivery as prescribed in the analytical laboratory's approved Laboratory Quality Management Plan (LQMP). Data will be reviewed following contract laboratory program function guidelines using SW-846 method requirements, SOPs, and the DQOs. Data reviews by the laboratory QC chemist will include data on initial and continuing calibration, blanks, laboratory control spikes, duplicates, controls, surrogates, and MS/MSD. The reviews will include an assessment of accuracy, precision, representativeness, calibration, comparability, sensitivity, and completeness, any performance or system audit results, and any significant QA problems encountered. All data outside DQOs will be flagged by the laboratory. Data that are qualified (flagged) during analysis or review will be noted as such in reports where they are used.

13.3.2 Data Review—PBS

The PBS PM will conduct the initial data review for PBS. The sample parameter quantification level data will be reviewed and include cross-checking data from original, duplicate, and MS/MSD samples for consistency; and review of sample data flagged by the laboratory. The data will be compared with Ecology requirements and DQOs before being submitted. All results will be entered into PBS' Environmental Quality Information System (EQuIS) data management system.

If there are no qualifiers, that will indicate that the data are acceptable both qualitatively and quantitatively. If data need to be flagged during the QC data review, the qualifiers outlined in the following table will be used. Under certain circumstances, additional flags may be used; these flags will be described in the associated quarterly monitoring report.

Table 13-1. Laboratory Data Qualifiers

Qualifier	Reason
B	Results are estimated because the compound was detected in an associated blank.
C2	RPD between the primary column and the confirmation column results exceed the laboratories RPD criteria. The higher result was reported. The results are acceptable both qualitatively and quantitatively.
E	Results exceeded the concentration range for the instrument. Data are not acceptable for any purpose.
J	Results are estimated, and the data are valid for limited purposes. The results are qualitatively acceptable.
N	Analysis was not performed.
R	Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound. Data are not acceptable for any purpose.
U	Reported value is below method reporting limit. The results are qualitatively acceptable.

13.4 Relevant Project Schedules

Table 13-2 contains the standard timetable for all events or deliverables related to sampling and analysis.

Table 13-2. Timeline for Laboratory Analysis Data Reports

Task	**Duration**	**Deliverable**
DFAR	Daily	Prepared daily by PBS field personnel.
Analytical lab data	10 business days (minimum)	Lab turnaround for Level II samples.
QA by PBS	5 working days	Notify project manager of any deviation or non-compliance.
Draft monitoring report	30 calendar days	After final laboratory results are received.
Final monitoring report	21 calendar days	From Ecology review and approval.

Notes: DFAR = Daily Field Activity Report
QA = Quality Assurance

14 PREVENTITIVE MAINTENANCE

The laboratory's preventive maintenance program is described in their Quality Assurance Manual, which is maintained at the laboratory. Equipment used by PBS personnel in the field for sampling, measuring, and analysis will be maintained following manufacturer's recommended practices.

15 PERFORMANCE AND SYSTEM AUDITS

Laboratory and field audits may be scheduled and performed at the direction of the PBS PM.

16 CORRECTIVE ACTIONS BY LAB

Documentation for corrective actions implemented by the laboratory is to be generated and retained in the laboratory's project file.

16.1 Corrective Action Documentation

This documentation is to be made accessible to the PBS PM. Corrective actions are required for the following conditions:

- QC data outside the defined acceptance windows for precision or accuracy.
- Blanks or LCS that contain contaminants above acceptable levels stated in the DQOs.
- Undesirable trends in spike or surrogate recoveries or RPD between spiked duplicates.
- Unusual changes in method reporting limits.
- Deficiencies identified during internal or external audits, or from the results of performance evaluation samples.
- Project management inquiries concerning data quality.

The following corrective actions should be taken for common problems:

Incoming Samples

Problems noted during sample receipt are to be documented on the Cooler Receipt Form. The PBS PM is to be notified for problem resolution.

Sample Holding Times

If maximum holding time is or may be exceeded by the laboratory, the PBS PM must be notified for problem resolution. Resampling may be necessary for the requested parameters.

Instrument Calibration

Sample analysis may not proceed until initial calibrations meet method criteria. Calibrations must meet method time requirements or recalibration must be performed. Continuing calibrations that do not meet accuracy criteria should result in a review of the calibration, rerun of the appropriate calibration standards, and reanalysis of samples affected back to the previous acceptable calibration check.

Practical Quantitation Limits
Appropriate sample clean-up procedures must be employed to attempt to achieve the practical quantitation limits as stated in the method. If difficulties arise in achieving these limits due to a particular sample matrix, the laboratory should notify the PBS PM of the problem for resolution. Dilutions are to be documented in the case narrative along with the revised practical quantitation limits for those analytes directly affected. Analytes detected above the method detection limits but below the practical quantitation limits are to be reported as estimated values and qualified "J."

Method Quality Control
Results related to method QC, including blank contamination, duplicate measurement reproducibility, MS/MSD recoveries, surrogate recoveries, LCS recoveries, and other method-specified QC measures are to meet the laboratory's SOPs and DQOs specified in this plan; otherwise, the affected samples may be reanalyzed and/or re-extracted and reanalyzed within method-required holding times to verify the presence or absence of matrix effects. In order to confirm matrix effects, QC results must observe the same direction and magnitude (ten times) bias. The PBS PM should be notified as soon as possible to discuss appropriate corrective action.

Calculation Errors
Reports must be reissued if calculation and/or reporting errors are noted with any given data package. The case narrative is to state the reason(s) for re-issuance of a report.

17 QUALITY IMPROVEMENT PROCESS

PBS' quality improvement process (QIP) comprises the internal systems that evaluate our quality program's effectiveness in ensuring and continually improving the quality of our work. The primary goals of our QIP and the QC program defined in this document are to prevent non-conformance and facilitate continual process improvement. To the extent that the first of these goals is not achieved, identified deficiencies or non-conformance are to be corrected in a timely and cost-effective manner, and with the intent of preventing their recurrence. This QAPP includes provisions for preventing quality problems and facilitating process improvements as well as for identifying, documenting, and tracking deficiencies until corrective action has been verified.

17.1 Preventive Measures
While the entire QC program is directed toward solutions to unforeseen conditions, certain elements of the program have greater potential to be proactive. The primary tools for problem prevention on this project and the specific sections of the SAP where they are addressed include defined responsibilities and authorities, technical project planning, documentation, and project procedures. Should these preventive measures fail, tracking and communicating deficiencies provide a mechanism for preventing their recurrence.

17.2 Continual Improvement
Project staff at all levels are to be encouraged to provide recommendations for improvements in established work processes and techniques. The intent is to identify activities that are compliant but can be performed in a more efficient or cost-effective manner. Typical quality improvement recommendations include identifying an existing practice that should be improved (e.g., a bottleneck in production) and/or recommending an alternative practice that provides a benefit without compromising prescribed standards of quality. Project staff are to bring their recommendations to the attention of project management or the QC staff through verbal or written means; however, deviations from established protocols are not to be implemented without prior written approval by the PBS PM and concurrence of the PBS QA/QC officer.

17.3 Deficiency Identification and Resolution

Deficiency identification and resolution are primary responsibilities of the operational staff (both PBS and any subcontractors) and the PBS PM. In the interest of timeliness of corrective actions, a corrective action request can be issued by any member of the project staff. If the individual issuing the request is also responsible for correcting the problem, then he or she should do so and document the results appropriately; otherwise, the request should be forwarded to the PBS PM, who is then responsible for evaluating the validity of the request, formulating a resolution and prevention strategy, assigning personnel and resources, and specifying and enforcing a schedule for corrective actions. Once a corrective action has been completed, the request and supporting information should be maintained in PBS project files.

While deficiency identification and resolution occur primarily at the operational level, QC inspections provide a backup mechanism to address problems that either are not identified or cannot be resolved at the operational level. Through implementation of an inspection program, the QC inspection staff is responsible for verifying that deficiencies are identified, documented as prescribed herein, and corrected in a timely manner. Deficiencies identified by the QC inspection staff are to be corrected by the operational staff and properly documented in PBS project files.

If the identified deficiency warrants it, a written corrective action plan (CAP) is to be developed by the PBS PM with concurrence by the PBS QA/QC officer. The CAP is to indicate whether it is submitted for informational purposes or for review and approval. In either event, operational staff is to be encouraged to discuss corrective action strategy with the QC staff throughout the process.

The QA/QC officer will have full stop-work authority for unresolved deficiencies.

18 PLAN AMENDMENTS

This combined SAP and QAPP will serve as the primary plan governing all field and reporting activities related to groundwater and soil vapor monitoring at the Site. If any portion of this plan warrants or requires amendment, the changes shall be communicated by either issuing a revised plan in its entirety, or preparing an addendum describing the changes and implementation schedule.

19 DOCUMENTATION AND RECORDS

Project files and raw data files will be maintained at PBS's Seattle office. Project records will be stored and maintained in a secure manner. Each project team member is responsible for filing all necessary project information or providing the information to the person responsible for the filing system. Individual team members may maintain files for individual tasks, but team members must provide such files to the central project files upon completion of each task. A project-specific index of file contents will be kept with the project files. Hard copy documents will be scanned and converted to electronic data and will be maintained in the database at PBS throughout the duration of the project. All sampling data will be submitted to Ecology in both printed and electronic formats in accordance with WAC 173-340-840(5).

20 HEALTH AND SAFETY

PBS has prepared a separate site-specific Health and Safety Plan (HASP) that applies to project work in accordance with WAC 173-340-810. The written HASP will be used for the duration of the project for activities related to the field investigation.

21 LIMITATIONS

PBS has prepared this work plan for use by SCIDpda. This document is for the exclusive use of the client and its partners and is not to be relied upon by other parties. It is not to be photographed, photocopied, or similarly reproduced, in total or in part, without the expressed written consent of the client and PBS.

22 APPROVAL AND CONCURRENCES

Sincerely,
PBS Engineering and Environmental Inc.

Digitally signed by James Welles
Date: 2023.12.22 10:15:51 -08'00'

James Welles, LHG — Date
Senior Hydrogeologist

Melanie L. Young

Digitally signed by Melanie Young
Date: 2023.12.22 10:31:57 -08'00'

Melanie Young, PE — Date
Senior Environmental Engineer

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Appendix A

Standard Operating Procedures

Drilling and Soil Sampling Procedures
Sampling Groundwater Monitoring Wells

STANDARD OPERATING PROCEDURE
Drilling and Soil Sampling Procedures

1 PURPOSE
This Standard Operating Procedure (SOP) provides an overview of mobile drilling methods typically used during environmental investigations along with associated health and safety issues. This document outlines procedures to be followed by PBS personnel during drilling and soil sampling activities. Groundwater and soil gas sample collection through the use of drill rigs are covered under separate SOPs.

2 TYPES OF DRILL RIGS
There are three types of drilling methods that are typically used for environmental investigations: direct push, auger, and sonic. Each type of drilling method is described below. A fourth option, discussed in Section 2.4, is a hand auger tool.

2.1 Direct-Push Drilling
Direct-push drilling methods are a common drilling technology used in environmental investigations due to the small diameter borehole (two and one-quarter inch (2.25")) that generates significantly less investigation-derived waste (IDW). The rigs are hydraulically powered, and use static and percussion force to advance the drill rods. Limited access rigs are available for interior locations while track-mounted rigs allow for sampling in locations with unimproved roads.

The rods are equipped with disposable plastic liners that contain the soil retrieved for observation and sampling. The entire column of rods is removed from the ground each time to retrieve soil for sampling. The rod lengths can be 3, 4, or 5 feet. Because of this, if caving or excessive slough is a concern, the borehole may be temporarily cased to keep it clear and open during soil sample retrieval.

2.2 Hollow Stem Auger Drilling (HSA)
Hollow stem auger drilling methods use hollow corkscrew drilling flights to advance into the subsurface. The borehole is typically 11 inches in diameter, with the flights having a 6-inch inner diameter space in which to retrieve samples or construct wells. The hollow stem auger drill rigs have better capability to penetrate higher density deposits that the direct push probe method. Some direct-push rigs have the capacity to drill with hollow stem auger flights, but these rigs typically do not have the mechanical power to drill through challenging soil. The use of auger drill rigs for environmental investigations is typically for the installation and decommissioning of monitoring wells.

Soil sampling with an auger drill rig is conducted through the use of split spoon samplers or Shelby tubes deployed through the inner hollow space. Split spoon samplers are typically 2.5 feet in length and advanced by hammer weight blow into the undisturbed soil. Shelby tubes are typically used in soft deposits such as clays. Soil brought to the surface on the exterior of drilling flights is considered drill or soil cuttings. Soil samples should not be collected and analyzed from the cuttings because that soil may have come in contact with other soil or contamination from varying depths.

2.3 Rotosonic Drilling
Rotosonic drilling methods (hereafter referenced as sonic method) advance drill rod flights into the ground through the use of vibration, and full-size sonic rigs can advance rods through very challenging unconsolidated geologic formations including large cobbles. The borehole size varies but typically is 4 to 6 inches in diameter.

Due to the nature of the drilling technology, the soil can be disturbed by the vibrations, so consistency and compaction are unreliable. Soil is vibrated out of the lead flight into plastic bags for observation and sampling. The entire column of rods is removed from the ground each time to retrieve soil for sampling; if caving or excessive slough is a concern, the borehole may be temporarily cased to keep it clear during soil sample retrieval.

2.4 Hand Auger Tool

A fourth drilling option is the use of a hand auger tool, sometimes called a handheld auger. This tool, made of steel, is used to bore a hole in soil or sediments. It is intended for use only by hand and is powered by human force by twisting or screwing the tool into the soil. The soil is retrieved through a short barrel that attaches to the base of the auger rods. This tool is used for sites where the soil is relatively easy to penetrate, and when sampling is limited to the upper 5 to 10 feet of the shallow surface. Different barrels are available for coarse-grained or fine-grained material.

3 HEALTH AND SAFETY PLAN

A Health and Safety Plan (HASP) must be developed prior to fieldwork commencing. Typically, a site-specific HASP is prepared from a PBS template for drilling investigations. In all cases, pertinent safety information must be relayed to field personnel, including subcontractors, to communicate mandatory elements from the federal code for hazardous waste operations and emergency response (29 CFR 1910.120(b)(4)).

4 UTILITY LOCATES

Utility locates will be completed on all drilling projects including hand-augered sampling. The property owner or site manager should be interviewed regarding the potential location of buried utilities or other subsurface obstructions on the property. The call-in numbers are provided below. Alternately, PBS personnel can obtain log-ins to file locate requests on-line (Internet Ticket Processing, http://www.callbeforeyoudig.org/index.asp).

Oregon Utility Notification Center: 1-800-332-2344
Washington Utility Notification Center: 1-800-424-5555

The Utility Notification Center needs to be contacted at least 48 hours (two business days) in advance to locate utility-owned lines up to the meter (e.g., water, gas, electric), and public utilities within the public right-of-way (e.g., sewer). In addition, a private utility locating company is typically contracted to survey for private utilities such as utility lines from meters to buildings, drain lines, buried electric cables, or irrigation and sprinkler lines.

When filing utility notification requests, PBS personnel should be as specific as possible about where to locate. Washington law requires that the proposed excavation/drilling work areas are field-marked with white paint prior to the locating event.

When beginning a project, PBS personnel must carefully think through where boreholes can be safely drilled, considering both subsurface and overhead obstructions. A site walk may be prudent once the utilities have been marked and prior to the drilling fieldwork. If safe drilling conditions cannot be confirmed, the PBS Project Manager should determine if engineering controls should be implemented, such as shielding or shutting down utility and/or power lines.

SAFETY NOTE: Drill rig masts must be a safe distance from overhead power lines to prevent mast lines and power lines being moved together by wind. Occupational Safety and Health Administration (OSHA) rules for drillers require a minimum distance of 10 feet, with additional spacing required depending on the voltage carried by the power line. The drill rig subcontractor is responsible for ensuring sufficient clearance. However, PBS personnel should verify that potentially unsafe conditions do not exist.

5 SAFETY EQUIPMENT REQUIREMENTS

The following safety equipment is required for all drilling investigations:

- Hard hat
- Hearing protection (ear muffs or plugs, must be worn when drill rig is in operation)
- Safety-toe work boots
- Safety vest
- Gloves (typically disposable)
- Safety goggles or glasses
- Life vests (only when working over water)

6 FIELD EQUIPMENT AND SUPPLIES REQUIREMENTS

The following equipment is typically required for drilling projects when soil sampling will occur. Groundwater or soil gas sampling is discussed in separate SOPs. PBS personnel should confirm that the drilling contractor will provide decontamination water, soap, brushes, and buckets.

General field supplies/equipment includes:

- 5-gallon buckets
- Bags (garbage)
- Bags (plastic zipper-type)
- Camera
- Cellular telephone and phone numbers of client, project laboratory, subcontractors, etc.
- Field notebook or daily log
- Measuring tape
- Paper towels
- Pens
- Spray paint (optional)

Soil sampling supplies/equipment includes:

- Project proposal/scope of work
- Alconox/Liquinox or similar decontamination detergent
- Distilled water (for decontamination)
- Environmental borehole log forms
- Hand auger (if required by scope)
- Ice chest with blue ice or party ice
- Nitrile or other chemically compatible gloves
- Photoionization detector (PID)
- Sample chain-of-custody forms
- Sample containers (ask lab about sample volume, preservatives, etc.)
- Sampling spade or spoons (if required by scope)

7 PRE-DRILLING ACTIVITIES

The following tasks must be performed before beginning work:

- Conduct tailgate safety meeting with all field personnel, including visitors such as the client or regulator; review Health and Safety Plan.

- Install traffic cones/barrier tape or other barrier to control pedestrian and vehicle access to work area as necessary.

The drilling subcontractor is responsible to ensure that the area on which the rig is to be positioned is cleared of removable obstacles and the rig should be leveled if parked on a sloped surface. The cleared/leveled area should be large enough to accommodate the rig and supplies. PBS personnel must confirm that the work area is cleared and safe for work prior to initiating drilling activities.

8 SOIL SAMPLING PROCEDURES

8.1 Logging and Field Screening Soil

Upon retrieval of the soil, describe as per the Geo-Environmental Field Classification chart for soil (included as an attachment). Record observations on an environmental borehole log.

If conducting head-space screening with a PID, remove one-quarter to one-half cup of soil and place in a sealable plastic bag. Seal the bag, break up the soil, and let sit for a minimum of five minutes (in colder weather, either wait for 15 to 30 minutes or put into a warm car or room). The purpose of the headspace screening is to measure what is off-gassing from the sample, and sufficient time must be allowed for that to occur. After the appropriate interval, place the end of the PID probe into the bag (through a small opening in the "zipper") and record the peak value.

If performing sheen testing, place a small sample volume (preferably darker or stained material) in a bowl partially filled with water and observe sheen indicative of petroleum contamination.

8.2 Collecting Soil Samples for Laboratory Analysis

Prior to collecting a sample for laboratory analysis, the sampler should don new gloves. If there are multiple samples to be collected from a single borehole, the gloves should be replaced to avoid cross-contamination.

Collect soil samples using a gloved hand or a clean sampling tool and place directly into the sample jar(s). For volatile organic compounds (VOCs), pack the soil to minimize jar headspace, or field preserve for VOCs using EPA Method 5035 (the field kit is obtained from the laboratory). Label samples as described under Section 8.3 Sample Numbering. Place labeled sample container(s) in the cooler with ice.

8.3 Sample Identification

Sample labels will be completed and attached to the jars in the field to prevent misidentification. All sample labels will include the following information:

- Project name or number
- Sample identification
- Sample collection date and time

The sample identification is unique to a particular sample and the format must be consistently used for all samples collected at the site. The sample identification typically includes the sample location and the collection depth. The sample location is the soil boring number or otherwise designated sample location. Standard abbreviations for sample location types are:

- DP = Direct push
- MW = Monitoring well
- SB = Soil boring
- SE = Sediment
- SO = Surface soil
- SS = Soil sample
- TP = Test pit
- WP = Well point

Examples of sample identifications are: DP-5 (4'), SS-22 (1'), and MW-3 (15')

Other naming conventions may be used, as long as the labeling is consistent and each location is clearly identifiable.

9 BOREHOLE ABANDONMENT

The licensed driller is responsible for abandoning boreholes in compliance with state regulations. PBS personnel should ensure that this occurs, and that the sealing material (typically bentonite chips) is sufficiently hydrated for a proper seal. State regulations governing this are:

- Oregon Administration Rule (OAR) 690-240
- Washington Administrative Code (WAC) 173-160

10 DECONTAMINATION PROCEDURES

Minimizing the possibility of cross-contamination between samples is a critical component of a successful soil sampling project. This is achieved by consistent and thorough decontamination of sampling equipment, such as drill rods, sampling devices (split spoons, trowels, etc.), and other tools that may come in contact with soil to be sampled.

For drilling equipment, the drilling contractor is responsible for the decontamination procedures. Typically, a pressure washer with hot water or water with added detergent is used to clean drill rods and other equipment. The use of a steam cleaner is not appropriate because of the risk of burns, and steam cleaners do a poor job of removing soil particles from equipment.

For equipment and supplies used by PBS personnel, water with added detergent is typically used for decontamination. Alternately, disposable supplies, such as gloves and sampling scoops, can be used to avoid having to decontaminate them.

PBS field personnel should work with the PBS Project Manager to confirm the appropriate decontamination procedure for each project. For example, it may be important to know the source of the driller's water used for decontamination, and distilled or deionized water may need to be used to clean hand tools.

All water and sludge generated during decontamination will be captured for later disposal. Release of water directly onto the ground or into drains or catch basins is not allowed.

11 INVESTIGATION-DERIVED WASTE

Investigation-derived waste consists of soil cuttings, decontamination water, purge water (if groundwater is encountered), and personal protective equipment (e.g., nitrile gloves, rags, paper towels, Tyvex suits, disposable bailers, and tubing). All disposable personal protective equipment may be disposed of as general refuse unless otherwise instructed by the PBS Project Manager.

Soil cuttings are typically placed in 5-gallon buckets or other appropriate containers during the execution of the fieldwork, and transferred to 55-gallon drums as the project progresses. If appropriate, the cuttings may remain in buckets as long as tight-fitting lids are placed on each bucket. For some projects, the PBS Project Manager may request that decontamination/purge water be placed into the same drums as the soil, instead of keeping the two media separate. Depending on the type of contamination, this may result in cost savings for the client during disposal. Field personnel should confirm how to contain soil and water prior to each field event.

11.1 Drum Labeling

The storage containers must be labeled as hazardous, non-hazardous, or unknown pending laboratory results. The labels must be completed using an indelible marker and include:

- Date that the contents were generated
- Nature of the contents - for example:
  - Drill cuttings
  - Purged groundwater
  - Decontamination water and/or sludge
- Contact phone number in the event emergency response personnel need to identify the contents of the container.

Drums or other storage containers should be placed in as secure a location as possible, which may be a building if the exterior area is not secure from vandalism.

12 POST-DRILLING ACTIVITIES

Upon return to the office, PBS personnel should:

- Clean and calibrate equipment prior to placing back into storage. If there were any operational issues noted, they should be reported immediately to the equipment manager.
- Submit field borehole logs for electronic formatting for future reports.
- Submit the daily field notes to the PBS Project Manager for placement into the project file. If a field notebook was used, and that notebook is not dedicated to that project, a copy of those notebook pages should be submitted.

STANDARD OPERATING PROCEDURE
Sampling Groundwater Monitoring Wells

1 BACKGROUND AND PURPOSE

Groundwater samples are collected from monitoring wells for analysis of physical and chemical parameters, either by using field observations and portable equipment and/or using established laboratory analytical methods. The goal of this process is to obtain groundwater samples that are representative of the aquifer (i.e., avoiding a sample that has been impacted by surface or atmospheric conditions).

Low-flow or zero volume purging and sampling methods were developed to produce samples with the least amount of interference resulting from the collection method. Low-flow purging techniques became the industry standard for collecting a groundwater sample because the methods slow groundwater velocity to the well, minimize turbidity and agitation in the water column, and reduce the volume of purged groundwater requiring disposal. These techniques include the use of pumps dedicated to specific wells or the use of a portable pump system. A zero volume/no purging method requires installation of a collection vessel within the well prior to the sample collection event, allowing the water column within the well to equilibrate with the aquifer prior to retrieving the sample. The appropriate technique is dependent on project-specific goals and data quality requirements. Sampling methodology should be confirmed with the PBS project manager (PM) prior to preparing for groundwater monitoring.

The procedures in this Standard Operating Procedure (SOP) are specific to standard monitoring wells with a single-slotted interval. It is assumed that low-flow purging and sampling protocols are used, although these protocols can be easily adjusted for other sampling methods. Temporary borings advanced for a single field event may be sampled using the techniques presented in this SOP.

2 EQUIPMENT AND SUPPLY LIST

- Well lock keys
- Groundwater Sampling Field Form and Depth to Groundwater Field Form
- Copies of field forms and data tables from previous groundwater monitoring event
- Electronic water level probe or interface probe (if dense or light non-aqueous phase liquids [DNAPL or LNAPL] are potentially present)
- Tubing cutters, knife or scissors (note: some sites do not allow the use of a knife on-site)
- Decontamination equipment
- Measuring cup
- Safety cones
- Bolt cutters
- Replacement well caps, bolts, and padlocks
- Small cup, turkey baster, or large sponge to purge standing water inside well monument
- Fish hooks, stainless steel weight, and fishing line to retrieve objects in the well
- Site map and health and safety plan

- Personal protection equipment (PPE) required for the site, including nitrile gloves (confirm with site-specific health and safety plan)
- Submersible pump or peristaltic pump and associated equipment
- Compressed gas source (nitrogen or air compressor), battery source, or generator and fuel
- Control box
- Disposable tubing, if necessary
- Flow-through cell and water quality parameter meter (e.g. YSI model)
- Buckets or containers for purge water and drum labels
- Sample containers, labels, packaging material
- Coolers and ice for samples

3 PROCEDURE

This section outlines standard procedures used for collecting groundwater samples from a monitoring well. Project Managers may modify or remove tasks as dictated by project needs; for example, turbidity or depth-to-bottom measurements may not be warranted at a site with sufficiently developed wells.

Preparation for a monitoring event begins in the office. The first step is to read the scope of work (e.g., proposal, sampling and analysis plan (SAP), work plan) to determine the number and location of monitoring wells to be sampled, health and safety considerations, quality control (QC) samples needed, sample containers required, and equipment needed for the site (peristaltic pump, bladder pump, both, etc.). Recommended preplanning procedures are as follows:

- Prepare, review, or update Health and Safety Plan (HASP) for the site.
- Obtain appropriate PPE for the site (e.g., hard hat, safety vest, gloves, safety glasses, life vest, flame retardant [FR] shirt or other client-required PPE).
- Determine number and type of samples to be collected.
- Determine which laboratory can meet analytical requirements (required analysis, screening levels).
- Order sample containers from laboratory, making sure to order QC sample containers and at least one extra set of containers. Ensure that a Safety Data Sheet (SDS) is provided for any sample preservative supplied by the laboratory.
- Print all forms needed for sampling event (work plan, HASP, depth to water forms, groundwater sampling forms, labels, chain of custody, etc.).
- Schedule PBS vehicle and equipment use on PBS calendars, as warranted.
- Order rental equipment for sampling event, if not available internally.

After arriving at the site, the following procedures should be followed:

- Don appropriate PPE and place safety cones around the work zone, if required by the HASP or deemed necessary by site conditions.
- Open all of the monitoring wells on-site and wait a minimum of 15 minutes for water levels to approach an equilibrium state with atmospheric pressure before taking any measurements.

- Note the general condition of the well on the depth to groundwater field form. Check well for damage or evidence of tampering, and record pertinent observations. Note any maintenance tasks that should be completed, such as well cap or padlock replacement.
- Collect depth to water measurements from each monitoring well, decontaminating the probe between locations. If possible, gauging should be conducted in order from the least to the most contaminated well. The measurements should be collected from all wells prior to beginning sample collection, unless project scope or site conditions indicate otherwise.
- Measure the depth to water relative to the marking on the well casings. If there is no mark, use the north side of the casing. Record the water level on the depth to groundwater field form. Note if DNAPL or LNAPL is present (this typically requires a meter capable of detecting NAPL-water interfaces). If NAPL is present, additional decontamination procedures will be warranted.
- Measure depth to bottom of well to record if sedimentation in the well has occurred.
- Make sure all information is completed on the depth to groundwater field form and sign and date it.

Sampling a groundwater monitoring well utilizing low-flow techniques relies on stabilization of field water quality parameters to determine when groundwater is representative of aquifer conditions. Measurement of groundwater quality parameters with a water quality parameter meter occurs in a closed system in which groundwater does not come in contact with open air; this is important for valid measurements because dissolved oxygen (DO), oxidation-reduction potential (ORP), and pH measurements can be sensitive to reactions with the atmosphere. A flow-through cell (flow cell) connected to the water quality parameter meter provides this closed system and is used to measure field parameters prior to collecting groundwater samples. Stabilization of selected parameters indicates that collected groundwater is representative of the aquifer and conditions are suitable for sampling to begin. See protocol below for stabilization parameters.

Low-flow purge and sample methods require care when placing a portable pump and/or tubing in the well to minimize disturbance to the water column. Pumping rates must be maintained at 0.1 to 0.5 liter per minute to reduce drawdown; the pump should never be run higher than 0.5 liters per minute prior to sampling.

For monitoring wells, sampling should proceed as follows:

- If using a portable pump setup, slowly lower the pump or tubing to the midpoint of the screen or sample interval. Secure the pump or tubing at the surface to prevent it from moving (not applicable if using dedicated pumps).
- Connect the bladder pump (attaching control box, compressor or nitrogen tank with regulator) or peristaltic pump to flow cell containing water quality parameter probes. Place the water level probe in the well so water levels can be measured as you are pumping. Start the pump and adjust the pumping rate to between 0.1 and 0.5 liters per minute (using a measuring cup to calculate the flow rate). Begin recording readings on the groundwater sampling field form. Be sure to purge the initial volume of water in the tubing before taking a reading.
- During purging, record readings of groundwater parameters (listed below) and water level every 3 to 5 minutes on the groundwater sampling field form. A drawdown of less than 0.3 feet in the water column, once the pumping rate has stabilized, is desirable; however, less permeable aquifer material or a clogged well filter pack may result in a deeper drawdown. At a minimum, the depth-to-water should be stabilized for three consecutive readings taken between 3 to 5 minutes apart (in conjunction with the stabilization of the other parameters). Visually describe and record turbidity. Purging is considered complete when the groundwater parameters have stabilized for three consecutive readings.

Field Parameter	Stabilization Goal
Temperature	+/-3%
Specific Conductance	+/- 3% mS/cm
pH	+/- 0.1 pH units
DO	+/- 10% or +/- 0.3 mg/L
ORP	+/- 10 millivolts
Depth to Water	+/- 0.3 feet

Please note that multi-parameter meters may have a resolution greater than the stabilization goal. Note the meter capabilities. If the field parameters do not stabilize within the stabilization goal, but are within the resolution of the meter, it may be acceptable to collect a sample in this scenario. This MUST be noted on the field form.

- Measure turbidity of the sample water using field instruments prior to sample collection and upon any obvious visual changes in turbidity during sample collection.
- Prior to collecting the water sample, the tubing originating in the well must be disconnected from the influent (inflow) side of the flow cell.
- Directly fill the sample containers from the tubing originating in the well. If you are collecting samples for volatile organic compound (VOC) analysis, you may need to decrease the pump rate to minimize volatilization of compounds from the sample; if this is the case, other samples should be collected first. You may restore the flow rate upon completion of filling sample containers for VOC analysis. Fill unpreserved bottles first. Filtered samples should be collected after all other samples have been collected.
- Groundwater samples collected for VOC analysis must be collected with zero headspace in the sample vial. This can be confirmed by gently tapping the sealed vial against a gloved hand to ensure that air bubbles are not present.
- If a duplicate sample is required for the well, it should be filled concurrently with the regular sample. This is accomplished by alternating bottles of the same type during sample collection (e.g., filling one bottle from each sample, then the second bottle from each sample.)
- Groundwater samples for dissolved metals analysis must be field filtered with a 0.45 micron filter directly connected to the tubing. Mark “field filtered” or “FF” on the bottle label, field form, and chain of custody.
- Prior to filling or just after filling, label each bottle with the project name, sample name, and sample date and time, and make sure it is properly sealed. The sample containers may also be labeled with what analysis will be performed (confirm with Project Manager). Place in a cooler with ice and pack for transportation.
- As necessary, pull pump and discard tubing. Decontaminate the pump based on the decontamination procedures established for the site.
- Make sure all information is completed on the groundwater field form and sign and date it.
- Close and lock the well.
- Contain purge and decontamination water in the appropriate containers as established for the project.
- Dispose of used sampling supplies and other waste in appropriate container as established for the project.

If low-flow sampling is not used at the site, these procedures should be modified as appropriate. The objective is to provide high-quality groundwater samples representative of the aquifer. Modifications to this SOP should keep this objective in mind at all times.

After fieldwork is completed:

- Ensure that chain-of-custody form has necessary information including site name, project manager, sample names, date and time collected, requested analysis, special notes (field filtered, MS/MSD, etc.).
- Scan and save field sheets to project folder on server. Retain original field copies in project folder; these are legal documents and should be retained as per PBS guidelines for document retention.
- Report any sampling or well maintenance issues to the project manager for evaluation and remedy.
- Clean and store PBS equipment for use on next project. Report any equipment damage or malfunctions or missing/depleted calibration solutions to the office equipment manager.
- Ship rental equipment back to vendor immediately to minimize project costs. Borrowed PBS equipment should be returned promptly to the lending office.

References

Puls, R.W. and M.J. Barcelona. *Groundwater Issue Paper: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. US Environmental Protection Agency, EPA 540-S-95-504 (1996).

Yeskis, D. and Bernard Zavala. *Groundwater Issue Paper: Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. US Environmental Protection Agency, EPA 542-S-02-001 (May 2002).

Appendix B
Field Forms

Daily Field Activity Report
Soil Boring Log
Groundwater Sampling Field Form
Sample Chain of Custody (Friedman and Bruya, Inc.)

DAILY FIELD REPORT

PROJECT INFORMATION

Project Number:		Date:	
Project Name:		PBS Staff:	
Purpose:		Time Arrive:	
Weather:		Time Depart:	

FIELD OBSERVATIONS AND COMMENTS

Attach (as appropriate): Photographs, copy of field notes from permanent notebook, laboratory chain-of-custody

SIGNATURE

PBS

ENVIRONMENTAL SOIL BORING FIELD LOG

Boring No.: _______

Project Number:	Project Name:	Drilling Equipment/Method:
Date Begin/End:	Location:	Drilling Company/Driller:
Boring Total Depth:	Coordinates (X/Y, Lat/Lon, Sta.):	Outer Hole Diameter (in.):
Surface Type:	Sample ID Prefix:	Field Meter (units):
Logged By:	Groundwater (ft.): During Drilling DTW / Time: /	After Drilling DTW / Time: /

Recovery (%)	Depth / Sample Interval	Sample ID	Field Meter Reading	Consistency / R.D.	Field Soil Description & Classification (ASTM D 2488)							Field Notes
					Color, ASTM Soil Name (USCS Symbol)	Plasticity (NP, LP, MP, HP)	Size Range Sand (F, M, and/or C)	Size Range Gravel (F and/or C)	Shape of Gravel (R, SR, SA, A)	Moisture Content (Dr, D, M, W)	Fill (Y/N)	Conditions, Organics, Odor, Sheen? Cobbles/Boulders,Cementation? Other Notes?
	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											
	0											
	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											

Sheet: _____ of _____

PBS	PBS Engineering and Environmental Inc. **GROUNDWATER SAMPLING FORM (YSI Pro)**	**Project No:** **Project Name/ Location:** **Date:**	
		Monitoring Well ID	
Initial DTW (feet bgs)		**Sample ID** (if not well ID)	
Screen Interval (feet bgs)		**Sample Time**	
Well depth (feet bgs)		**QC Sample** **type:** ______________	☐ Not collected ID__________ Time______
Depth of pump/tubing inlet (feet bgs)			
Sampling method (describe pump or sampler)		**Field Personnel**	
Purge Rate (L/min)		**Weather Conditions**	

WELL PURGING INFORMATION

Time ☐ elapsed ☐ actual	DTW (feet)	Temp. (C)	Dissolved oxygen (mg/L)	Specific conductivity ☐ mS/cm ☐ µS/cm	pH	ORP (mV)	Turbidity (NTU)	Observations	Volume purged ☐ ltr ☐ gal
								Total Volume Purged	

FIELD OBSERVATIONS / NOTES (such as well head condition, groundwater color, sediment load, recovery, sheen, odor, equipment)

Signature of Field Personnel:

SAMPLE CHAIN OF CUSTODY

Report To______________________________

Company______________________________

Address______________________________

City, State, ZIP______________________________

Phone________________Email______________________________

SAMPLERS (*signature*)	
PROJECT NAME	PO #
REMARKS Project Specific RLs - Yes / No	INVOICE TO

Page # __________ of __________

TURNAROUND TIME
Standard Turnaround RUSH______________________ Rush charges authorized by: ______________________________
SAMPLE DISPOSAL
Dispose after 30 days Archive Samples Other______________________

						ANALYSES REQUESTED											
Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	NWTPH-Dx	NWTPH-Gx	BTEX EPA 8021	VOCs EPA 8260	PAHs EPA 8270	PCBs EPA 8082						Notes

Friedman & Bruya, Inc.

5500 4th Avenue S

Seattle, WA 98108

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:				
Received by:				
Relinquished by:				
Received by:				

SAMPLE CHAIN OF CUSTODY

Report To______________________________

Company______________________________

Address______________________________

City, State, ZIP__________________________

Phone____________Email________________

SAMPLERS (*signature*)	
PROJECT NAME & ADDRESS	PO #
NOTES:	INVOICE TO

Page # ________ of ________

TURNAROUND TIME
Standard RUSH________________ Rush charges authorized by: ________________________
SAMPLE DISPOSAL Default:Clean following final report delivery Hold (Fee may apply):________

SAMPLE INFORMATION										ANALYSIS REQUESTED						
Sample Name	Lab ID	Canister ID	Flow Cont. ID	Reporting Level: IA=Indoor Air SG=Soil Gas (Circle One)	Date Sampled	Initial Vac. ("Hg)	Field Initial Time	Final Vac. ("Hg)	Field Final Time	TO15 Full Scan	TO15 BTEXN	TO15 cVOCs	APH	Helium		Notes
				IA / SG												
				IA / SG												
				IA / SG												
				IA / SG												
				IA / SG												
				IA / SG												
				IA / SG												
				IA / SG												

Friedman & Bruya, Inc.
5500 4th Avenue South
Seattle, WA 98108
Ph. (206) 285-8282
Fax (206) 283-5044

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:				
Received by:				
Relinquished by:				
Received by:				