
REVISED SODIUM PERMANGANATE PILOT TEST WORK PLAN



Property:

Plastic Sales and Service Site
6870 Woodlawn Avenue Northeast
Seattle, Washington

Report Date:

June 24, 2026

Prepared for:

Washington State Department of Ecology
Toxics Cleanup Program
Northwest Regional Office
15700 Dayton Avenue North
Shoreline, Washington

Revised Sodium Permanganate Pilot Test Work Plan

Prepared for:

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Toxics Cleanup Program, Northwest Regional Office
15700 Dayton Avenue North
Shoreline, Washington 98133

Plastic Sales and Service Site

6870 Woodlawn Avenue Northeast
Seattle, Washington 98115
Cleanup ID# 2074
Facility ID# 19488927

Project No.: 0651-002

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1.0 INTRODUCTION

On behalf of the Lutheran Retirement Home of Greater Seattle (The Hearthstone), SoundEarth Strategies, Inc. (SoundEarth) has prepared this Revised Sodium Permanganate (NaMnO_4) Pilot Test Work Plan (Work Plan) for the Plastic Sales and Service Site (the Site) located at 6870 Woodlawn Avenue Northeast in Seattle, Washington. In December 2025 and January 2026, a bench-scale study was performed to evaluate the feasibility of using NaMnO_4 , a chemical oxidant, to degrade tetrachloroethylene (PCE), trichloroethylene (TCE), cis 1,2-dichloroethylene (cis-1,2-DCE), and vinyl chloride (VC) in the soil and groundwater within the deep water-bearing zone (DWZ). For the purposes of the Work Plan, these compounds are collectively identified as chlorinated volatile organic compounds (CVOCs). The bench-scale test concluded that NaMnO_4 can effectively degrade CVOCs in the DWZ at the Site.

This Work Plan presents the scope of work for completing a pilot test for in situ treatment of CVOCs in soil and groundwater within the DWZ using NaMnO_4 . The scope of work includes a description of the selected in situ groundwater treatment technology, pilot test objectives, injection layout and scheme, and the progress and performance groundwater monitoring program. Based on the results of pilot test, SoundEarth, in consultation with the Washington Department of Ecology (Ecology), will determine if full-scale implementation is warranted using NaMnO_4 to remediate CVOCs in soil and groundwater at the Site.

1.1 SITE DESCRIPTION

Under the Consent Decree dated June 2, 2016, the Site is defined as the extent of hazardous substances at 6870 Woodlawn Avenue Northeast (the former Dry Cleaner Property). In 2009, the Site was defined by the extent of contamination caused by the releases of hazardous substances at the former Dry Cleaner Property and included the following:

- Former Dry Cleaner Building property
- The property adjoining the former Dry Cleaner property to the north, located at 6869 Woodlawn Avenue Northeast
- The property adjoining the former Dry Cleaner property to the south, located at 6565 4th Avenue Northeast
- The property adjoining the former Dry Cleaner property to the west, located at 6850 Woodlawn Avenue Northeast
- Portions of the western alley, and Woodlawn Avenue Northeast and 4th Avenue Northeast rights-of-way (ROWS; Woodlawn Avenue ROW and 4th Avenue ROW, respectively)

1.2 BACKGROUND

Groundwater treatment was implemented at the Site in 2019 by injecting Electron Donor Solution-Extended Release (carbon substrates) into 34 pairs of injection wells to stimulate the anaerobic biological degradation of PCE, TCE, cis-1,2-DCE, and VC, which are the contaminants of concern (COCs) for the Site. Evidence gathered from groundwater monitoring and sampling events performed since 2019 demonstrates that the injectate successfully degraded PCE and TCE to concentrations below cleanup levels in the majority of DWZ. As anticipated, cis-1,2-DCE and VC concentrations increased substantially after 2019 but have decreased with time.

SoundEarth performed supplemental investigations at the Site in 2021 and 2022. Those investigations included the installation of temporary monitoring wells DZ-B01 to DZ-B09 in DWZ. The temporary monitoring wells were screened at multiple intervals to profile the vertical distribution of CVOCs. Results from groundwater samples collected from temporary monitoring wells indicated elevated concentrations of CVOCs in the DWZ beneath the 4th Avenue ROW. The presence of CVOCs in the DWZ in the 4th Avenue ROW is beyond the known extent of the CVOCs plume in 2019 when groundwater treatment was implemented. The Site now includes the 4th Avenue ROW to the north of the intersection with the Woodlawn Avenue Northeast ROW.

In response to the presence of high concentrations CVOCs in the groundwater samples collected from the DWZ temporary monitoring wells, SoundEarth in 2022, installed monitoring wells MW32 to MW37 on the northeast side of 4th Avenue ROW to monitor the downgradient extent of the CVOCs in the DWZ. CVOCs were detected in downgradient monitoring wells MW32, MW34, and MW35 at a concentration several orders of magnitude less than the concentration of CVOCs detected in the temporary monitoring wells. The location of the temporary monitoring wells, monitoring wells MW32 to MW37, and the current extent of CVOCs in the groundwater are shown in Figure 1.

In response to the elevated residual concentrations of CVOCs in the groundwater at the Site and the presence of the CVOC in DWZ beneath the 4th Avenue ROW, SoundEarth, with the approval of Ecology, performed a pilot test that included injecting electron donor solution – extended release (EDS-ER) combined with liquid zero-valent iron (ZVI) in selected injection wells. Results from the pilot show that introducing EDS-ER combined with liquid ZVI into the groundwater at the Site did not lead to substantial decline in the concentrations of cis-1,2-DCE and VC, which was the primary objective of the pilot test. The results for the pilot test are presented in the *Technical Memorandum regarding the Analysis of ZVI and EDS-ER Pilot Test Results, Plastic Sales and Service Site, 6870 Woodlawn Avenue Northeast, Seattle, Washington*, dated January 16, 2025, and prepared by SoundEarth.

In anticipation of additional groundwater treatment in the 4th Avenue ROW, SoundEarth, in November 2025, installed injection wells IW69 to IW72 at the locations shown on Figure 1. The injection wells were installed at multiple depths in the DWZ to profile the vertical distribution of CVOCs in the water column and allow for subsequent treatment of CVOCs.

1.3 GEOLOGY BENEATH 4TH AVENUE NORTHEAST

Groundwater at the Site is generally confined to the shallow water-bearing zone (SWZ) and the DWZ in the vicinity of the Former Dry Cleaner Building property located at 6870 Woodlawn Avenue Northeast. The SWZ is present within the upper 20 feet of soil and is typically composed of stiff to very stiff silt and medium-dense to very dense silty sand, with trace amounts of gravel, between depths of 15 to 20 feet below ground surface (bgs). Moving to the north (downgradient) of the Former Dry Cleaner Building property into and beyond the Woodlawn Avenue ROW, the soil texture of the SWZ transitions to a silt with a minimal coarse-grained fraction. As documented previously in the *Draft Remedial Investigation and Feasibility Study Report* prepared by Farallon Consulting, LLC (Farallon) in July 2013, the low-transmissivity silty sands present in the SWZ in the vicinity of the Former Dry Cleaner Building property are observed to pinch out moving downgradient to the north beneath the Woodlawn Avenue Northeast and 4th Avenue Northeast ROWs. In soil borings advanced during Farallon's previous investigations in locations downgradient of the source area near the intersection of Woodlawn Avenue Northeast and 4th Avenue Northeast, soil in the upper 20 feet was observed to be unsaturated, indicating a hydrogeologic discontinuity in the SWZ (Farallon 2013).

The findings of subsurface investigation activities conducted by SoundEarth between 2022 and 2025 in the 4th Avenue Northeast ROW further substantiate the SWZ interpretations presented in Farallon's 2013 report. Field observations during the installation of deep zone soil borings DZ-B01 through DZ-B09, monitoring wells MW32 through MW37, and injection wells IW69 through IW72 indicated that soil conditions between approximately 5 and 20 feet beneath the 4th Avenue Northeast ROW generally consisted of dense, unsaturated silt. Moist to wet silty sand was not encountered in these soil borings until depths of approximately 20 to 25 feet bgs, which is below the known depth of the SWZ at the Site. In the majority of these boring locations, the shallowest observed groundwater was present within the silty sand at depths between 20 to 25 feet bgs. During field screening of soil samples collected in the upper 20 feet of these soil borings, evidence of CVOC impacts was not observed in photoionization detector readings, which did not exceed 1.0 part per million by volume between 0 and 20 feet bgs. Elevated PID readings were observed in the majority of these soil borings beginning between approximately 20 and 25 feet bgs, where the intermediate DWZ was intercepted. These observations support the conclusion of a hydrogeologic discontinuity in the SWZ moving downgradient across Woodlawn Avenue Northeast and along 4th Avenue Northeast, resulting in the absence of a SWZ in downgradient areas of the Site. Representative boring logs for soil borings advanced along 4th Avenue Northeast are provided in Appendix A. The subsurface stratigraphy for the Site is shown in cross-section on Figures 2 through 5.

2.0 PILOT STUDY DESIGN AND OBJECTIVES

This section presents the pilot test objectives and design for the NaMnO₄ pilot test for treating CVOCs in the DWZ.

2.1 IN SITU GROUNDWATER TREATMENT USING SODIUM PERMANGANATE

In 2025, soil and groundwater samples were collected from newly installed injection wells IW69 and IW70. These samples were collected as source material to perform a bench-scale test. The purpose of the bench-scale test was to assess the efficacy of using a NaMnO₄ to treat CVOCs in the DWZ. The bench-scale study concluded that NaMnO₄ is favorable for in situ treatment of groundwater at the Site as demonstrated as follows:

- NaMnO₄ oxidized all CVOCs in soil and groundwater, achieving greater than 99 percent reduction.
- NaMnO₄ is not selective for any CVOC, oxidizing all CVOCs and eliminating the accumulation of cis-1,2-DCE and VC.
- Dissolve manganese concentrations and oxidation reduction potential (ORP) measurements increased in water samples due to the addition of NaMnO₄. pH was not affected.
- Treatment mobilized up to 250 micrograms per liter dissolved chromium due to the oxidizing nature of NaMnO₄, which can oxidize trivalent chromium (Cr+3) to hexavalent chromium (Cr+6).

Bench-scale testing performed in 2025/2026 is documented in the *Revised Bench-Scale Test Report, Plastic Sales and Service Site, 6870 Woodlawn Avenue Northeast, Seattle, Washington*, dated April 2, 2026, and prepared by SoundEarth.

2.2 PILOT TEST OBJECTIVES

The NaMnO₄ pilot test will be performed to satisfy the following objectives:

- Evaluate the reduction in CVOCs concentrations and changes in the geochemistry of the DWZ to determine if results observed during the bench-scale test can be reproduced under field conditions.
- Estimate design parameters, including but not limited to pressure/flowrate/volume, injection radius of influence and distribution, and remediation product dosing/loading in support of full-scale design.

2.3 PILOT TEST TREATMENT AREA AND LAYOUT

NaMnO₄ pilot testing will be performed utilizing existing DWZ monitoring and injection wells located along Woodlawn Avenue Northeast and 4th Avenue Northeast ROWs. The pilot test will include two injection alignments and treatment areas. the injection alignments and treatment areas have been designated as follows:

Injection Alignments #1 and #2

- **Injection Alignment #1.** MW09, IW29, IW32, IW34, IW36, and IW38 (north side of Woodlawn Avenue Northeast ROW; total of one monitoring well and five injection wells).
- **Injection Alignment #2.** MW10, MW31, IW69, IW70, IW71 and IW72 (west side of 4th Avenue Northeast ROW; total of two monitoring wells and four injection wells).

Treatment Areas A and B

- **Treatment Area A.** Downgradient of Injection Alignments #1 and beneath the north-adjoining property, located at 6869 Woodlawn Avenue Northeast.
- **Treatment Area B.** Downgradient of Injection Alignment #2 and within the 4th Avenue Northeast ROW.

The pilot study injection alignments and treatment areas are shown on Figure 1. The pilot study treatment areas for Treatment Area A and Treatment Area B are estimated at 4,500 and 5,700 square feet, respectively.

2.4 DESIGN PARAMETERS

The NaMnO₄ loading and injection volume are based on the SOD, geologic/hydrogeologic parameters, and mass/concentration/volume relationship, as follows:

- **SOD.** Per the bench-scale test, the 2-day SOD was estimated at 1,950 mg NaMnO₄/kg soil (medium dosage) and 3,600 mg NaMnO₄/kg soil (high dosage), with an average of 2,775 mg NaMnO₄/kg soil.
- **Target NaMnO₄ Injection Solution Concentration.** The NaMnO₄ liquid reagent is provided as a 40-percent-by-weight solution (REmOx®L; see Appendix B for product cutsheet). The NaMnO₄ liquid reagent will be diluted to prepare a target NaMnO₄ injection solution between 10 and 20 percent, which will be dictated by volume of injection solution delivered to a well (i.e., concentration/volume relationship; higher volume lower concentration and vice versa).
- **Target Pore Volume Replacement.** The total pore volumes within Treatment Area A and Treatment Area B are estimated at approximately 8,415 and 8,530 gallons, respectively. The target pore volume replacement is 5 percent.

Based on these design parameters, the volumes of NaMnO₄ liquid reagent (40 percent by weight) for Treatment Area A and Treatment Area B are estimated at 1,580 and 2,000, gallons, respectively. The pilot study design specifics for Treatment Areas A and Treatment Area B are summarized in Tables 1 and 2, respectively.

3.0 PILOT TEST SCOPE OF WORK

3.1 PRELIMINARY ACTIVITIES

3.1.1 Health and Safety Plan

A Site-specific Health and Safety Plan (HASP) will be prepared under separate cover for the injection activities that meets the minimum requirements for such a plan identified in federal regulations (Parts 1910.120 and 1926 of Title 29 of the Code of Federal Regulations) and state regulations (Chapter 296 of the Washington Administrative Code). The HASP will identify the known physical, chemical, and biological hazards; hazard monitoring protocols; and administrative and engineering controls required to mitigate the identified hazards. The Safety Data Sheets for NaMnO₄ are provided in Appendix B.

3.1.2 Street Use Permits

Access to the Woodlawn Avenue Northeast and 4th Avenue Northeast ROWs to install monitoring wells and perform injections will require a Major Utility Permit from the City of Seattle.

3.1.3 Utility Locating

A utility survey will be performed including a public one call and a private utility locate to clear the proposed soil boring/monitoring well locations of subsurface utilities.

3.1.4 Underground Injection Control Registration

An application for an Underground Injection Control (UIC) registration will be completed through Ecology.

3.2 SOIL BORING AND MONITORING WELL INSTALLATION

Two soil boring will be advanced at a location between paired wells monitoring wells MW-34/MW-35 and MW36/MW37 located in the 4th Avenue Northeast ROW to supplement the existing downgradient monitoring well network in the DWZ. The proposed soil boring/monitoring well locations (B42/MW38 and B43/MW39) are shown on Figure 1.

3.2.1 Soil Borings

The soil boring will be advanced using a sonic drill rig to a depth of approximately 50 feet bgs within the DWZ. During the advancement of the soil boring, soil samples will be collected from the continuous cores for lithologic description and field screening. Soil samples will be logged by a SoundEarth field geologist in general accordance with ASTM International Method D2488-17. Soil samples will be field screened for potential evidence of contamination through visual and olfactory observations and through headspace analysis using a photoionization detector to identify the presence of volatile organic vapors. Soil samples will not be submitted for chemical analyses.

3.2.2 Monitoring Well Installation

Following completion of each soil boring, the monitoring well be installed and screened over a 15-foot interval within the DWZ. The paired monitoring wells will be screened between 20 to 35 and 35 to 50 feet bgs. The monitoring will be constructed of 2-inch-diameter blank Schedule 40 PVC casing that is flush-threaded to a 0.020-inch slot well screen. The bottom of the well will be fitted with a threaded PVC bottom cap, and the top of the well casing will be fitted with a locking compression-fit well cap. The annulus of the well will be filled with #10/20 silica sand to a minimum height of 1 foot above the top of the screened interval, and a seal (1 foot of hydrated bentonite chips followed by neat cement grout) will be installed above the sand pack. The well will be completed with a flush-mounted, traffic-rated well box set in concrete.

Following installation, the well will be developed with the use of a submersible pump. Well development will consist of surging and purging until the groundwater no longer appears turbid and the measured total depth in the well is equivalent to the overall length of the well. Turbidity will be measured visually during well development activities.

4.0 BASELINE GROUNDWATER MONITORING

Before injection of NaMnO_4 , a baseline groundwater monitoring event will be performed to establish baseline conditions in groundwater at the proposed injection wells and observation monitoring wells. The baseline groundwater monitoring event will coincide with the regularly scheduled semi-annual groundwater monitoring and sampling event in the fourth quarter of 2026, assuming there is no delay in implementing the pilot test. The baseline groundwater monitoring event will be performed using groundwater monitoring and samples procedures present in the 2025 Progress Report for the Site prepared by SoundEarth and dated February 4, 2025. Baseline groundwater samples will be analyzed for CVOCs by EPA Method 8260D, with the addition of Cr+6 by EPA Method 7199/218.6. Baseline groundwater samples will analyzed for Cr+6 because the bench-scale testing indicated the mobilization of dissolved chromium, due to the oxidizing nature of NaMnO_4 , can oxidize Cr+3 to Cr+6. Groundwater samples collected from existing groundwater monitoring wells MW09, MW10, MW31, MW32 through MW37, and two newly installed groundwater monitoring wells MW38 and MW39 will be submitted for Cr+6 chemical analysis.

5.0 INJECTION/MONITORING WELL REDEVELOPMENT

Prior to injection activities, monitoring and injection wells used as injection points for the pilot test will be redeveloped. The wells will be redeveloped to remove solids that have accumulated in the wells over time and enhance the connectivity between the well screens and surrounding water-bearing zone. The wells will be redeveloped by purging up to 50 gallons of water (approximately ten casing volumes for a 2-inch diameter well with 15 feet of water column). The purged groundwater will be temporarily stored in 250-gallon totes pending waste characterization and disposal.

5.1 INJECTION ACTIVITIES

Holt Drilling Services of Everett, Washington, under the direction of SoundEarth, will mobilize an injection trailer to perform the injections of the prepared NaMnO_4 solution.

5.1.1 Injection Equipment

An injection trailer will be mobilized to the Property and will include two 250-gallon batch tanks, a static mixer, centrifugal injection pump, and generator. A multi-port injection manifold will include gate and check valves, pressure gauges, and flow meters (flow rate and totalizer). The injection manifold will permit the injection to multiple injection wells.

5.1.2 Injection Solution Preparation

The NaMnO₄ liquid reagent (40 percent solution by weight) will be provided in 55-gallon drums and 250-gallon totes. The NaMnO₄ liquid reagent will be mixed with potable water in an aboveground tank to prepare a NaMnO₄ injection solution of between 10 and 20 percent. The mixing will occur at the Site.

5.1.3 Injection Scheme

The NaMnO₄ injections will be performed at Treatment Area A (Injection Alignment #1) followed by Treatment Area B (Injection Alignment #2). The prepared target NaMnO₄ injection solution (between 10 and 20 percent by volume) will be delivered to the monitoring and injection wells under gravity or moderate injection pressure. The injection sequence is as follows:

- Treatment Area A. The prepared NaMnO₄ injection solution will be delivered to monitoring and injection wells in Injection Alignment #1 (monitoring well MW09 and injection wells IW29, IW32, IW34, IW36, and IW38). It is anticipated Treatment Area A injections will be completed within 2 weeks.
- Treatment Area B. The prepared NaMnO₄ injection solution will be delivered to monitoring and injections wells in Injection Alignment #2 (monitoring wells MW10 and MW31 and injection wells IW69 through IW72). It is anticipated Treatment Area B injections will be completed within 2 to 3 weeks.

The targeted NaMnO₄ injection solution volume per well is estimated between 1,360 and 1,720 gallons. The solution volume is based on anticipated injection well performance as determined from previous injections performed in DWZ. The injection system pressure, flowrate, and total volume will be measured and recorded.

6.0 PROCESS AND PERFORMANCE GROUNDWATER MONITORING PROGRAM

Process and performance groundwater monitoring and sampling will be conducted to evaluate the effectiveness of the NaMnO₄ injections over time. SoundEarth will perform groundwater monitoring and sampling prior to injecting the chemical oxidant in Treatment Area A (i.e., baseline event) and for approximately 3 months thereafter.

6.1 PROCESS GROUNDWATER MONITORING

Process groundwater monitoring will include measuring depth to groundwater and field parameters (pH, temperature, conductivity, turbidity, dissolved oxygen, and ORP) at injection and observation wells. In addition, measurement of the NaMnO₄ concentration using visible spectroscopy will be performed at injection and observation wells using a Hach DR 2800 spectrophotometer. Field parameters will be measured using a down well electronic data logger (i.e., ProDSS-10). In addition, groundwater samples will be submitted for laboratory analysis of total dissolved manganese and chromium using EPA Method 6020B. According to Freidman and Bruya, the laboratory for the pilot test, dissolved chromium in

groundwater is often considered representative of Cr+6 because Cr+6 is highly soluble and mobile in water, whereas trivalent chromium (Cr III) is insoluble and binds to soil particles. The samples will not be analyzed for Cr+6 because the NaMnO₄ interferes with the analysis of Cr+6.

SoundEarth will perform process monitoring during Injection Alignment #1 at observation monitoring well MW31 and injection wells IW69 through IW72. During Injection Alignment #2, SoundEarth will perform process monitoring at observation monitoring wells MW32 through MW37 and the two newly installed monitoring wells MW38 and MW39. Process monitoring will begin with the startup of injections in Treatment Area A. The frequency of process monitoring is presented below in Exhibit 1. The frequency of process monitoring may be modified based field observations and the behavior of field parameters during the pilot test.

Exhibit 1
Process Monitoring Schedule – 12 Weeks

Field Parameters	Method of Collection	Frequency	Duration
Depth to groundwater, pH, temperature, conductivity, turbidity, dissolved oxygen, and oxidation reduction	Data Logger	Continuous	Weeks 1 to 6
Depth to groundwater, pH, temperature, conductivity, turbidity, dissolved oxygen, and oxidation reduction	Manually	Weekly	Weeks 7 to 8
Dissolved Manganese and Chromium	Manually	Month 3	To be determined
Visible Spectroscopy	Manually	Month 3	To be determined

6.2 PERFORMANCE GROUNDWATER MONITORING

Performance groundwater monitoring will include collecting groundwater samples from select observation and injection wells for laboratory analysis of CVOCs by EPA Method 8260D. When groundwater samples are collected for CVOC analysis, where sodium permanganate is likely present in the groundwater, EPA guidelines recommends quenching collected groundwater samples (i.e., pink/purple color, elevated electrical conductivity measurements relative to background conditions) with ascorbic acid, sodium thiosulfate, or sodium sulfite prior to laboratory analysis (EPA 2012). Quenching stops the chemical reaction between the oxidant and the CVOCs at the time of sample collection and allows for an accurate representation of the chemical concentrations within the aquifer at the time of sampling.

SoundEarth will conduct performance monitoring at groundwater monitoring wells MW09, MW10, MW31 to MW37, the two newly installed monitoring wells MW38 and MW39 and injection wells IW29, IW32, IW34, IW36, IW38 and IW69 through IW71. Groundwater sample collection will be performed in general accordance with the *Groundwater Performance Monitoring Plan, Plastic Sales and Service Site, 6870 Woodlawn Avenue Northeast, Seattle, Washington*, prepared by SoundEarth dated March 4, 2020. Performance monitoring will be conducted three months following completion of the injection program.

7.0 SCHEDULE

The preliminary schedule for the pilot study injection and monitoring plan is as follows:

Injection and Monitoring Item	Schedule or Condition
Approval of the Pilot Test Work Plan	To be determined
UIC registration	Following approval of the NaMnO ₄ Work Plan
Major Utility Permit	60 to 100 days following approval of the NaMnO ₄ Work Plan
Baseline Groundwater Monitoring Event	Concurrent with the semi-annual monitoring event (October 2026)
Injections	Within 30 business days following approval of the Major Utility Permit by the City of Seattle
Injection Area A	Up to 2 weeks
Injection Area B	Up to 3 weeks
Progress Monitoring	During the injection process
Performance Groundwater Monitoring Events	Three months following completion of the injection program.

8.0 REPORTING

A NaMnO₄ Pilot Study Report will be prepared following post-injection groundwater monitoring activities. The Pilot Study Report will include the following:

- A description of injections and field monitoring activities
- A description baseline and post-injection groundwater monitoring activities
- Summary tables of groundwater monitoring analytical results
- Summary tables of injection parameters (pressures, injection flow rates, and volumes)
- A figure depicting the injection and monitoring well network
- Findings of the pilot study and recommendations for full-scale application

9.0 LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with SoundEarth's agreement with the client. This report is solely for the use and information of the client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this report are derived, in part, from data gathered by others, and from conditions evaluated when services were performed, and are intended only for the client, purposes, locations, time frames, and project parameters indicated. SoundEarth does not warrant and is not responsible for the accuracy or validity of work performed by others, nor from the impacts of changes

in environmental standards, practices, or regulations subsequent to performance of services. SoundEarth does not warrant the use of segregated portions of this report.

10.0 REFERENCES

Farallon Consulting, LLC (Farallon). 2013. *Draft Remedial Investigation and Feasibility Study Report, Plastic Sales and Service Site, 6870 Woodlawn Avenue Northeast, Seattle, Washington*. Prepared for Washington State Department of Ecology. July 3.

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United States Environmental Protection Agency (EPA). 2012. Ground Water Sample Preservation at In-Situ Chemical Oxidation Sites – Recommended Guidelines. *Ground Water Issue*. EPA/600/R-12/049. August.

FIGURES

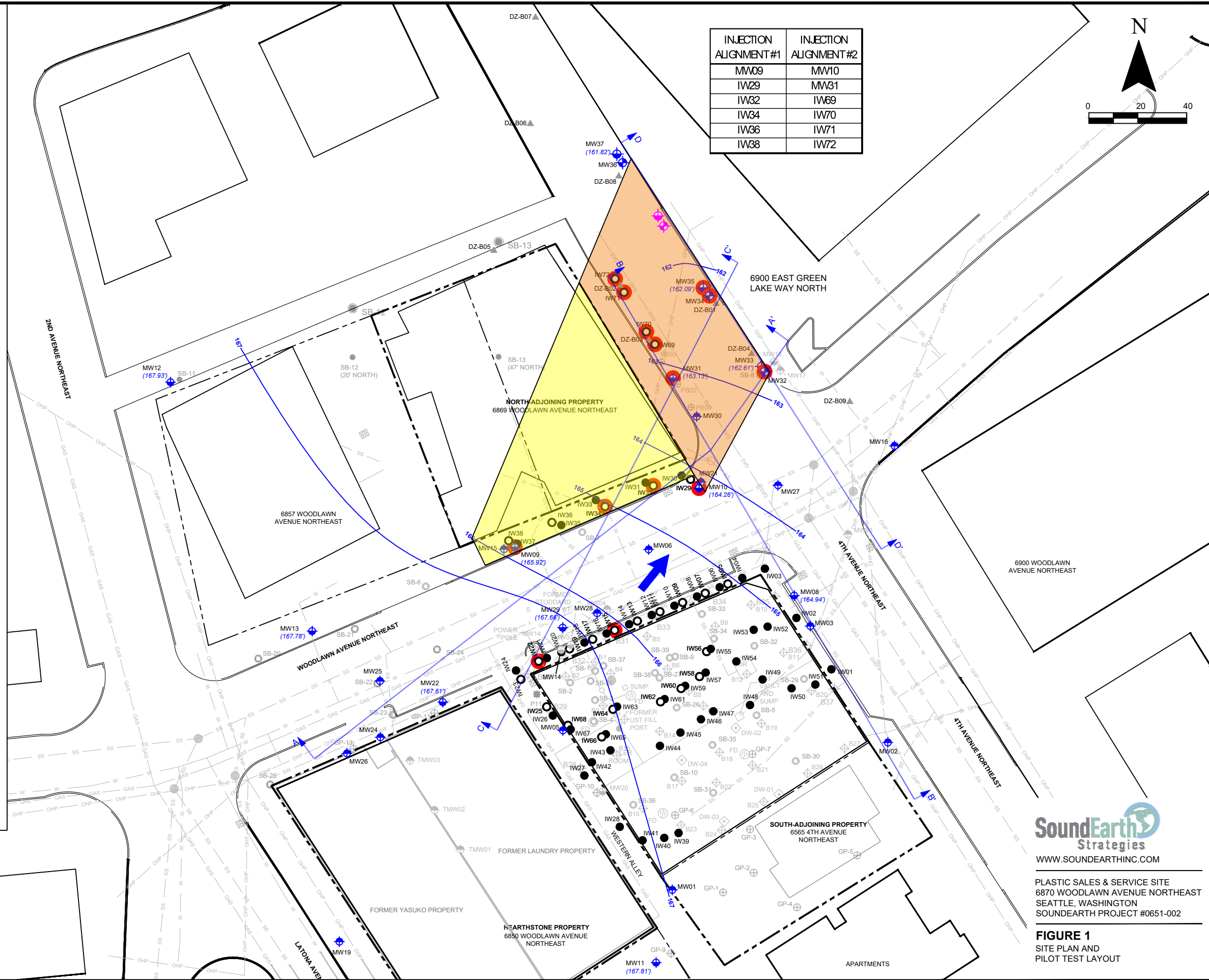
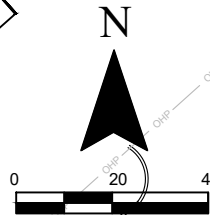
LEGEND

- CATCH BASIN
- MANHOLE
- SHALLOW-ZONE MONITORING WELL
- DEEP-ZONE MONITORING WELL
- INTERMEDIATE DEEP-ZONE MONITORING WELL
- DEEP DEWATERING WELL
- SHALLOW INJECTION WELL
- DEEP INJECTION WELL
- APPROXIMATE DIRECTION OF GROUNDWATER FLOW (DEEP ZONE)
- DEEP ZONE POTENTIOMETRIC SURFACE CONTOUR (OCTOBER 6, 2025)
- GROUNDWATER ELEVATION
- DECOMMISSIONED WELL
- DIRECT-PUSH BORING (GEOENGINEERS 2002/2003)
- DIRECT-PUSH BORING (GEOENGINEERS 2004)
- DIRECT-PUSH BORING (FARALLON 2004)
- DIRECT-PUSH BORING (FARALLON 2006/2007)
- DIRECT-PUSH BORING (FARALLON 2010)
- DIRECT-PUSH BORING (SOUNDEARTH 2008)
- HOLLOW-STEM AUGER (SOUNDEARTH 2009)
- POST-ELECTRICAL RESISTANCE HEATING BORING LOCATION
- SONIC BORING (SOUNDEARTH 2022)
- PROPOSED MONITORING WELL LOCATION OF NEW MONITORING WELL PAIR
- STORMWATER LINE
- GAS LINE
- SANITARY SEWER LINE
- WATER LINE
- OVERHEAD POWER LINE
- PROPERTY BOUNDARY LINE
- PARCEL BOUNDARY
- FLOOR DRAIN
- UNDERGROUND STORAGE TANK
- DENOTES CVOC CONCENTRATION IN GROUNDWATER THAT EXCEEDS MTCA METHOD A OR B CLEANUP LEVEL (2024 AND 2025)
- TREATMENT AREA A
- TREATMENT AREA B

NOTES:

- FIGURE DERIVED FROM BASEMAP BY FARALLON CONSULTING, 2010.

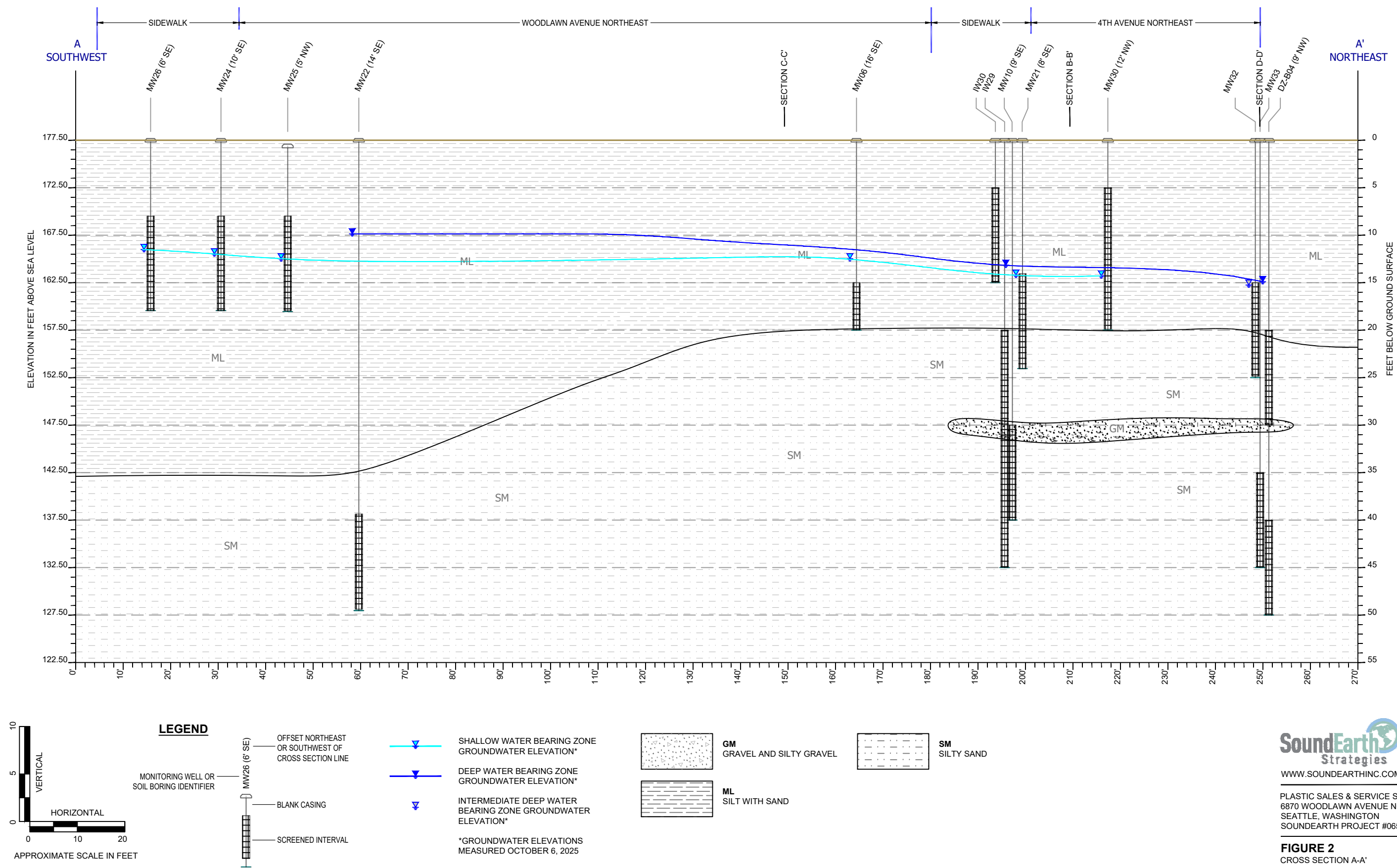
INJECTION ALIGNMENT #1	INJECTION ALIGNMENT #2
MW09	MW10
IW29	MW31
IW32	IW69
IW34	IW70
IW36	IW71
IW38	IW72

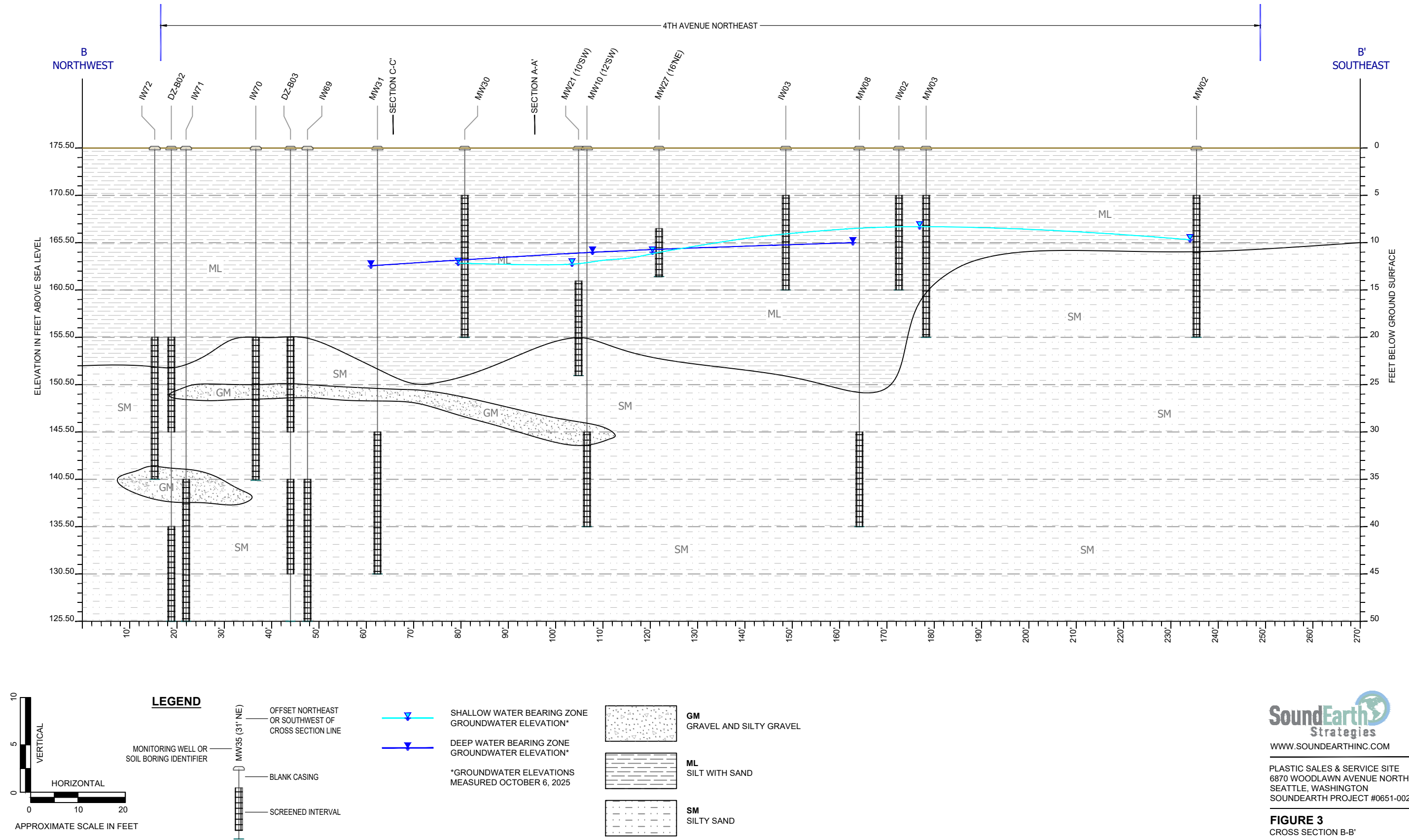


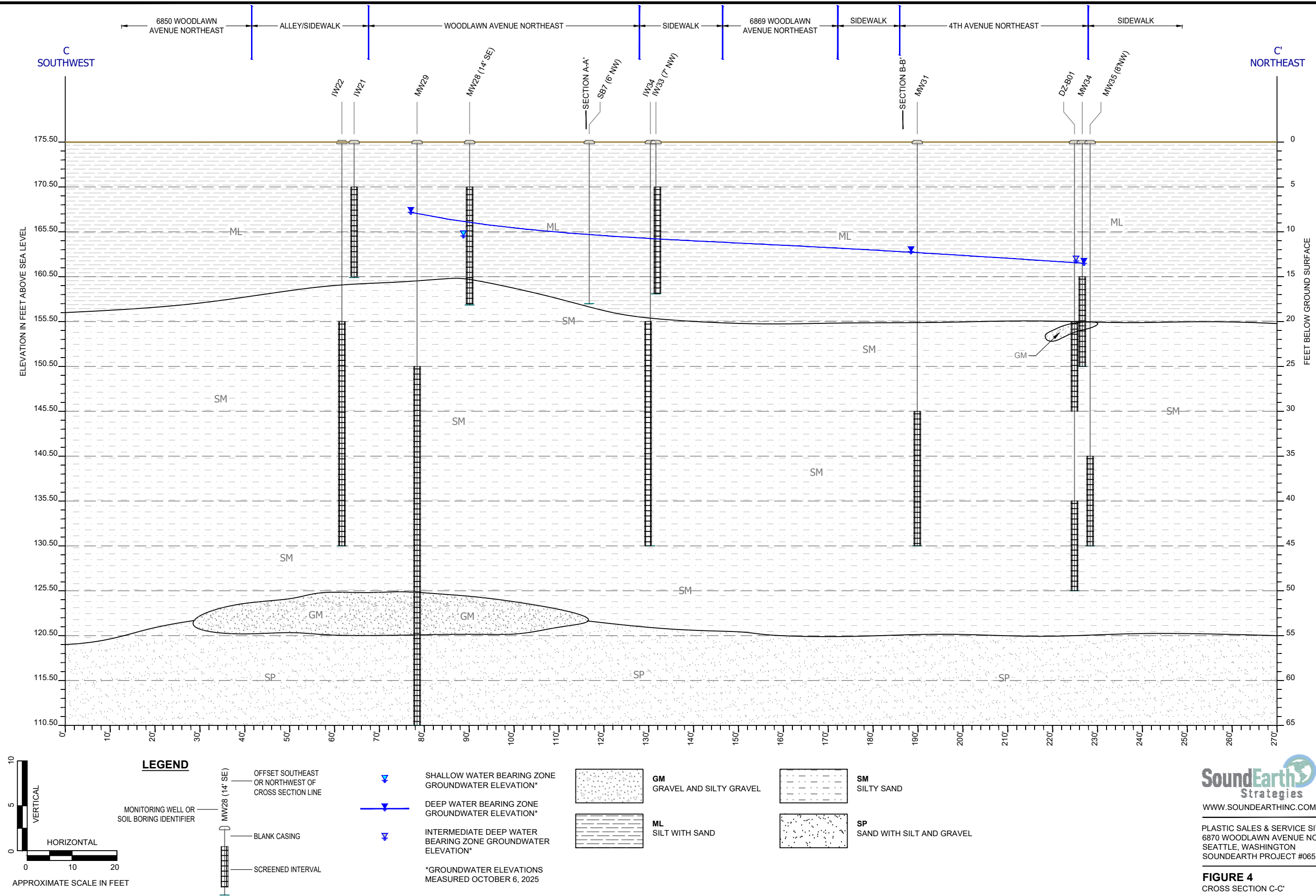
SoundEarth
Strategies
WWW.SOUNDEARTHINC.COM

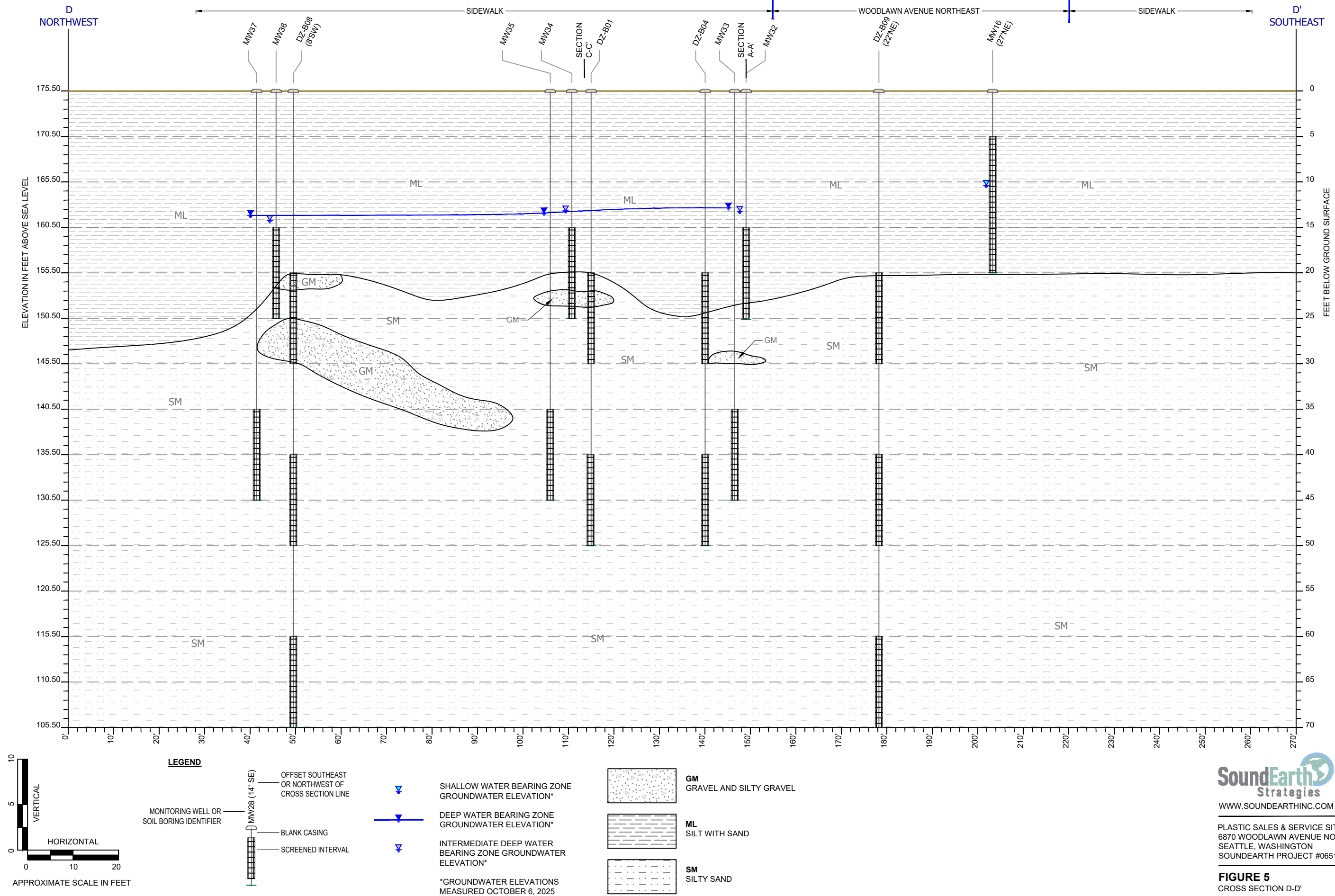
PLASTIC SALES & SERVICE SITE
6870 WOODLAWN AVENUE NORTHEAST
SEATTLE, WASHINGTON
SOUNDEARTH PROJECT #0651-002

FIGURE 1
SITE PLAN AND
PILOT TEST LAYOUT









TABLES



Table 1
Pilot Test Injection Design
Treatment Area A
Plastic Sales and Service Site
6870 Woodlawn Avenue Northeast
Seattle, Washington

Parameter	Value	Units	Notes
Treatment Area Layout			
Treatment Length (Perpendicular to Groundwater Flow Direction) (L)		feet	Approximately 90 feet along Woodlawn Avenue Northeast
Treatment Width (With Groundwater Flow Direction) (W)		feet	Approximately 80 feet along 4th Avenue Northeast
Treatment Area (A)	4,500	square feet	See "Treatment Area A" on Figure 1. CAD generated area estimate.
Total Injection Wells	6	well	MW09, IW29, IW32, IW34, IW36, and IW38 (total of 6 wells)
Treatment Interval Thickness (T)	20	feet	Targeting the deeper water-bearing zone.
Volume of Treatment Zone Soil (VS)	3,333	cubic yard	$VS = A * T / (27 \text{ cubic feet/cubic yard})$
Unit Weight of Soil (Y1)	1.5	ton/cubic yard	
Weight of Soil in Treatment Zone (WS1)	10,000,000	pound	$WS1 = VS * Y1 * (2,000 \text{ pound/ton})$
Weight of Soil in Treatment Zone (WS2)	4,545,455	kilogram	$WS2 = WS1 / (2.2 \text{ pound/kilogram})$
Hydrogeology			
Hydraulic Conductivity (K)	8.1	feet/day	
Hydraulic Gradient (i)	0.028	feet/feet	
Effective Porosity (ne)	25	percent	
Groundwater Seepage Velocity (vs)	0.91	feet/day	$vs = (K * i) / ne$
Travel Distance over 1 Month (D)	27	feet	$D = vs * (30 \text{ days/month})$
Total Pore Volume (TPV1)	168,300	gallon	$TPV1 = A * T * (7.48 \text{ gallon/cubic feet}) * ne$
Total Pore Volume (TPV2)	637,016	Liter	$TPV2 = TPV1 * (3.785 \text{ liter/gallon})$
Target Pore Volume Influence in Treatment Area (P1)	5.0	percent	
Target Injection Volume (V1)	8,415	gallon	$V1 = TPV1 * P1$
Reagent Dosing			
Soil Oxidant Demand (SOD1)	3.6	gram NaMnO ₄ /kilogram soil	2-day Soil Oxidant Demand (high dosage).
Effective SOD (P2)	20	percent	
Effective SOD Calculated (SOD2)	0.720	gram NaMnO ₄ /kilogram soil	$SOD2 = SOD1 * P2$
Calculated Oxidant Demand in Treatment Zone (M1)	7,209	pound NaMnO ₄	$M1 = WS2 * SOD2 / (454 \text{ gram/pound})$
Estimated Mass of RemOx L (40 Percent by Weight) (M2)	18,022	pound NaMnO ₄	$M2 = M1 / 0.4$
RemOx L Density (40 Percent by Weight) (Y2)	11.4	pound NaMnO ₄ / gallon NaMnO ₄	
Estimated Volume of RemOx L (40 Percent by Weight) Required (V1)	1,581	gallon	$V1 = M2 / Y2$
Injection Volumes			
RemOx L Reagent (C1)	40	percent by weight	
Target NaMnO ₄ Injection Concentration (C2)	10	percent by volume	
Total Volume at Target NaMnO ₄ Injection Concentration (TV)	8,149	gallon	$M2 * 0.4 / ((8.345 \text{ gallon/pound}) * 1.06 \text{ gram/Liter} * (0.1))$
Potable Water Volume Required to Achieve Target NaMnO ₄ Injection Concentration (V2)	6,568	gallon	$V2 = TV - V1$
Volume of RemOx L (40 Percent by Weight) Required per Well (V1Well)	260	gallon	$V1Well = V1 / 6$
Volume of Prepared Injection Solution per Well (V2Well)	1,360	gallon	$V2Well = TV / 6$
Effective Pore Volume Replaced (EP1)	4.8	percent	$EP1 = TV / TPV1$

NOTES:

CVOC = chlorinated volatile organic compound

Input Variable



Table 2
Pilot Test Injection Design
Treatment Area B
Plastic Sales and Service Site
6870 Woodlawn Avenue Northeast
Seattle, Washington

Parameter	Value	Units	Notes
Treatment Area Layout			
Treatment Length (Perpendicular to Groundwater Flow Direction) (L)	95	feet	Approximately 95 feet along 4th Avenue Northeast
Treatment Width (With Groundwater Flow Direction) (W)	60	feet	Approximately 60 feet from north to south side of 4th Avenue Northeast
Treatment Area (A)	5,700	square feet	See "Treatment Area B" on Figure 1.
Total Injection Wells	6	well	MW10, MW31 and IW69 through IW72 (total of 6 wells)
Treatment Interval Thickness (T)	20	feet	Targeting the deeper water-bearing zone.
Volume of Treatment Zone Soil (VS)	4,222	cubic yard	$VS = A * T / (27 \text{ cubic feet/cubic yard})$
Unit Weight of Soil (Y1)	1.5	ton/cubic yard	
Weight of Soil in Treatment Zone (WS1)	12,666,667	pound	$WS1 = VS * Y1 * (2,000 \text{ pound/ton})$
Weight of Soil in Treatment Zone (WS2)	5,757,576	kilogram	$WS2 = WS1 / (2.2 \text{ pound/kilogram})$
Hydrogeology			
Hydraulic Conductivity (K)	11.9	feet/day	
Hydraulic Gradient (i)	0.028	feet/feet	
Effective Porosity (ne)	20	percent	
Groundwater Seepage Velocity (vs)	1.67	feet/day	$vs = (K * i) / ne$
Travel Distance over 1 Month (D)	50	feet	$D = vs * (30 \text{ days/month})$
Total Pore Volume (TPV1)	170,600	gallon	$TVP1 = A * T * (7.48 \text{ gallon/cubic feet}) * ne$
Total Pore Volume (TPV2)	645,721	Liter	$TVP2 = TPV1 * (3.785 \text{ liter/gallon})$
Target Pore Volume Influence in Treatment Area (P1)	5.0	percent	
Target Injection Volume (V1)	8,530	gallon	$V1 = TPV1 * P1$
Reagent Dosing			
Soil Oxidant Demand (SOD1)	3.6	gram NaMnO ₄ /kilogram soil	2-day Soil Oxidant Demand (high dosage)
Effective SOD (P2)	20	percent	
Effective SOD Calculated (SOD2)	0.720	gram NaMnO ₄ /kilogram soil	$SOD2 = SOD1 * P2$
Calculated Oxidant Demand in Treatment Zone (M1)	9,131	pound NaMnO ₄	$M1 = WS2 * SOD2 / (454 \text{ gram/pound})$
Estimated Mass of RemOx L (40 Percent by Weight) (M2)	22,827	pound NaMnO ₄	$M2 = M1 / 0.4$
RemOx L Density (40 Percent by Weight) (Y2)	11.4	pound NaMnO ₄ / gallon NaMnO ₄	
Estimated Volume of RemOx L (40 Percent by Weight) Required (V1)	2,002	gallon	$V1 = M2 / Y2$
Injection Volumes			
RemOx L Reagent (C1)	40	percent	
Target NaMnO ₄ Injection Concentration (C2)	10	percent	
Total Volume at Target NaMnO ₄ Injection Concentration (TV)	10,322	gallon	$M2 * 0.4 / ((8.345 \text{ gallon/pound}) * 1.06 \text{ gram/Liter} * (0.1))$
Potable Water Volume Required to Achieve Target NaMnO ₄ Injection Concentration (V2)	8,320	gallon	$V2 = TV - V1$
Volume of RemOx L (40 Percent by Weight) Required per Well (V1Well)	330	gallon	$V1Well = V1 / 6$
Volume of Prepared Injection Solution per Well (V2Well)	1,720	gallon	$V2Well = TV / 6$
Effective Pore Volume Replaced (EP1)	6.1	percent	$EP1 = TV / TPV1$

NOTES:

CVOC = chlorinated volatile organic compound

Input Variable

APPENDIX A
SOIL BORING AND WELL CONSTRUCTION LOGS

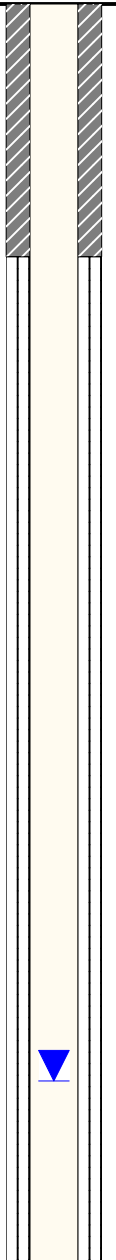


Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/10/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 45 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/11/25

BORING LOG | **B38**
IW69

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 12.6 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.1 feet bgs: Asphalt.	
									0.1-0.5 feet bgs: Concrete.	
									0.5-5.0 feet bgs: Boring vacuum and air-knife cleared to 5' bgs.	
5				0.0	B38-05		ML		5.0-8.0 feet bgs: Fine to medium sandy SILT with gravel, gray, no solvent odor, moist (50-20-30).	
			100							
							ML		8.0-19.0 feet bgs: Fine to medium sandy SILT with gravel, gray, no solvent odor, moist (70-20-10).	
10				0.0	B38-10					
			100							
15										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 55 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV360

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/10/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 45 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/11/25

BORING LOG | **B38**
IW69

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 12.6 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
			100	0.0	B38-15					
20				1.1	B38-20		SM		19.0-25.5 feet bgs: Silty fine to medium SAND with gravel, gray, faint to moderate solvent odor, moist (25-50-25).	
			100							
25				23.9	B38-25		GM		25.5-28.0 feet bgs: Silty subrounded GRAVEL with sand, gray, moderate to strong solvent odor, wet (45-10-45).	
			100							
							SM		28.0-30.0 feet bgs: Silty fine to medium SAND with gravel, gray, faint to moderate solvent odor, moist (25-50-25).	
30										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 55 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV360

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface

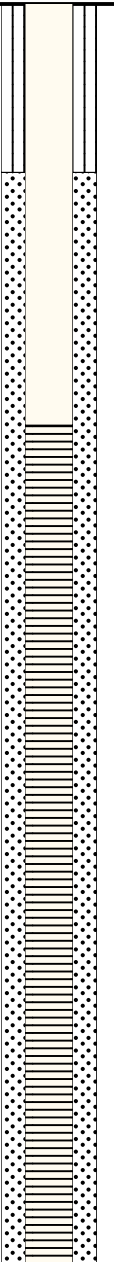


Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/10/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 45 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/11/25

BORING LOG | **B38**
IW69

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 12.6 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
35			100	45.4	B38-30		SM		30.0-36.0 feet bgs: Silty fine to medium SAND with gravel, gray, faint to moderate solvent odor, moist (25-50-25).	
			100	19.5	B38-35		SM		36.0-39.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, wet (15-65-20).	
40			100	19.9	B38-40		SM		39.0-42.0 feet bgs: Silty fine SAND with gravel, gray, no solvent odor, moist to wet (15-75-10).	
45			100				SM		42.0-45.0 feet bgs: Silty fine SAND with gravel, gray, no solvent odor, moist (35-50-15).	

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 55 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV360

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/10/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 45 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/11/25

BORING LOG | **B38**
IW69

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 12.6 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.0	B38-45		SM		45.0-51.0 feet bgs: Silty fine SAND, trace gravel, gray, no solvent odor, moist (25-70-5).	
50			100	0.4	B38-50		SM		51.0-55.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (20-60-20).	
55			100	0.2	B38-55				Boring terminated at 55 feet bgs. Native soil collapsed into bottom of borehole from 51-55 feet bgs before driller placed well screen and constructed sand pack. Completed as well IW69 with screened interval 35-50 feet bgs.	
60										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 55 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV360

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface

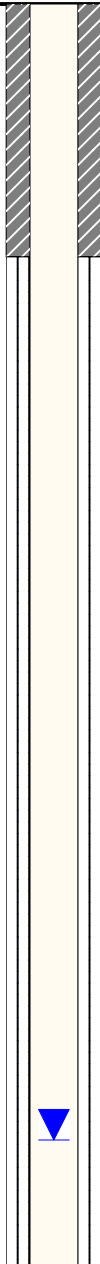
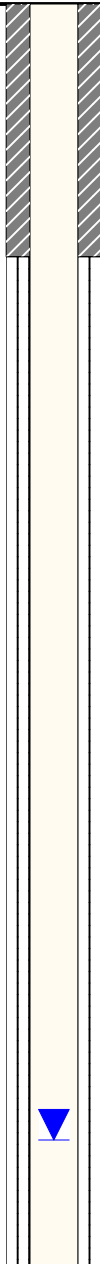
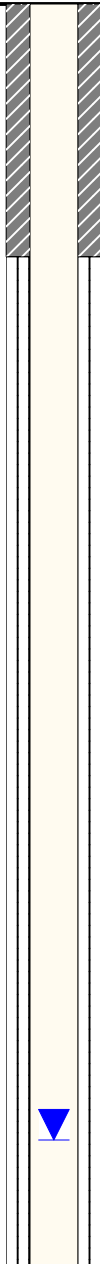


Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/11/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 51 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/11/25

BORING LOG | **B39**
IW70

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 13.3 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.1 feet bgs: Asphalt.	
									0.1-0.5 feet bgs: Concrete.	
									0.5-5.0 feet bgs: Boring vacuum and air-knife cleared to 5' bgs.	
5				0.7	B39-05		ML		5.0-12.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (70-15-15).	
		100								
10				0.7	B39-10	X				
							ML		12.0-15.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (70-20-10).	
		100								
15										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 35 feet bgs
Total Well Depth: 35 feet bgs
State Well ID No.: BNV361

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 20 to 35 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/11/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 51 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/11/25

BORING LOG | **B39**
IW70

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 13.3 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.0	B39-15		ML		15.0-20.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (70-20-10).	
20			100	0.1	B39-20		SM		20.0-21.5 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist to wet (25-40-35).	
			100				SM		21.5-25.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, wet (20-65-15).	
25				27	B39-25		GM		25.0-26.5 feet bgs: Silty subrounded GRAVEL with sand, gray, no solvent odor, wet (40-15-45).	
			100				GM		26.5-28.0 feet bgs: Silty subrounded GRAVEL with sand, gray, no solvent odor, wet (40-25-35).	
							SM		28.0-30.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, wet (25-45-30).	
30										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 35 feet bgs
Total Well Depth: 35 feet bgs
State Well ID No.: BNV361

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 20 to 35 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/11/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 51 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/11/25

BORING LOG | **B39**
IW70

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 13.3 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
35			100	29.9	B39-30		SM		30.0-35.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, wet (25-45-30).	
45				75.6	B39-35				Boring terminated at 35 feet bgs. Completed as well IW70 with screened interval 20-35 feet bgs.	

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 35 feet bgs
Total Well Depth: 35 feet bgs
State Well ID No.: BNV361

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 20 to 35 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface

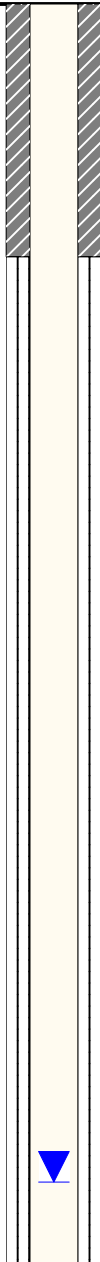


Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/12/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 67 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/12/25

BORING LOG | **B40**
IW71

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 13.8 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.1 feet bgs: Asphalt.	
									0.1-0.5 feet bgs: Concrete.	
									0.5-5.0 feet bgs: Boring vacuum and air-knife cleared to 5' bgs.	
5				0.3	B40-05		ML		5.0-14.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (70-15-15).	
10			100	0.1	B40-10					
			100							
15							ML		14.0-18.5 feet bgs: Fine sandy SILT with gravel, gray, no solvent odor, moist (65-25-10).	

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 50 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV362

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/12/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 67 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/12/25

BORING | **B40**
LOG | **IW71**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 13.8 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
			100	0.3	B40-15					
20				0.3	B40-20		ML		18.5-20.0 feet bgs: Fine sandy SILT with gravel, gray, no solvent odor, moist (60-30-10).	
			100				ML		20.0-22.0 feet bgs: Fine sandy SILT with gravel, gray, no solvent odor, moist (60-30-10).	
							ML		22.0-24.0 feet bgs: Fine sandy SILT with gravel, gray, no solvent odor, moist (50-30-20).	
25				0.3	B40-25		SM		24.0-26.5 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (30-45-25).	
			100				GM		26.5-27.5 feet bgs: Silty subrounded GRAVEL with sand, gray, faint solvent odor, wet (40-15-45).	
							SM		27.5-30.0 feet bgs: Silty fine to medium SAND with gravel, gray, faint solvent odor, wet (25-45-30).	
30										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 50 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV362

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/12/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 67 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/12/25

BORING LOG | **B40**
IW71

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling ~20 feet bgs
Water Depth After Completion 13.8 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
			10	16.7	B40-30		SM		30.0-35.0 feet bgs: Poor recovery. Soil types similar to interval from 27.5-30 feet bgs.	
35				7.4	B40-35		GM		35.0-38.0 feet bgs: Silty subrounded GRAVEL with sand, gray, faint to moderate solvent odor, wet (35-15-50).	
			100				SM		38.0-40.0 feet bgs: Silty fine to medium SAND with gravel, gray, faint solvent odor, moist to wet (25-50-25).	
40				8.1	B40-40		SM		40.0-43.5 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, wet (saturated) (25-40-35).	
			100				SM		43.5-46.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, wet (15-55-30).	
45										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 50 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV362

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/12/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 67 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/12/25

BORING LOG | **B40**
IW71

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~20 feet bgs
 **Water Depth After Completion** 13.8 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
50			100	15.2	B40-45		SP-SM		46.0-50.0 feet bgs: Fine to medium SAND with silt and gravel, gray, no solvent odor, wet (10-55-35).	
55				0.3	B40-50				Boring terminated at 50 feet bgs. Completed as well IW71 with screened interval 35-50 feet bgs.	
60										

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 50 feet bgs
Total Well Depth: 50 feet bgs
State Well ID No.: BNV362

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 35 to 50 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface

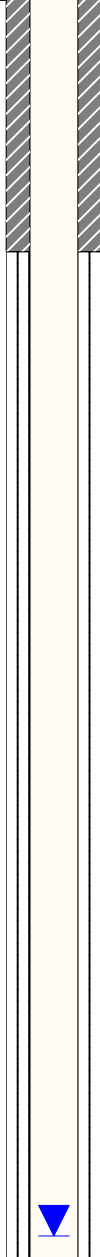


Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/13/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 74 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/13/25

BORING LOG | **B41 IW72**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~23 feet bgs
 **Water Depth After Completion** 14.5 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.1 feet bgs: Asphalt.	
									0.1-0.5 feet bgs: Concrete.	
									0.5-5.0 feet bgs: Boring vacuum and air-knife cleared to 5' bgs.	
5				0.1	B41-05		ML		5.0-9.0 feet bgs: Fine sandy SILT, trace gravel, gray, no solvent odor, moist (75-20-5).	
			100							
10				0.2	B41-10		ML		9.0-13.0 feet bgs: Fine sandy SILT with gravel, gray, no solvent odor, moist (75-15-10).	
			100							
15							ML		13.0-15.0 feet bgs: Fine sandy SILT with gravel, gray, no solvent odor, moist (65-20-15).	

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 35 feet bgs
Total Well Depth: 35 feet bgs
State Well ID No.: BNV363

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 20 to 35 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/13/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 74 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/13/25

BORING LOG | **B41**
IW72

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~23 feet bgs
 **Water Depth After Completion** 14.5 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.3	B41-15		ML		15.0-19.0 feet bgs: Fine sandy SILT with gravel, gray, no solvent odor, moist (65-20-15).	
20			100	0.2	B41-20		ML		19.0-23.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (60-20-20).	
25			100	0.3	B41-25		SM		23.0-30.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist to wet (30-45-25).	
30			100							

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 35 feet bgs
Total Well Depth: 35 feet bgs
State Well ID No.: BNV363

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 20 to 35 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: LGC
Date Started: 11/13/25
Surface Conditions: Asphalt-Covered Concrete Surface
Location N/S: 74 feet N of SE Corner of Building at 6869 Woodlawn Ave NE
Location E/W: 17 feet E of SE Corner of Building at 6869 Woodlawn Ave NE
Reviewed by: CGC
Date Completed: 11/13/25

BORING LOG | B41 IW72

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** ~23 feet bgs
 **Water Depth After Completion** 14.5 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
			100	2.2	B41-30		SM		30.0-34.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist to wet (30-45-25).	
35				2.6	B41-35		GM		34.0-35.0 feet bgs: Silty subrounded GRAVEL with sand, gray, faint to moderate solvent odor, wet (40-20-40).	
45									Boring terminated at 35 feet bgs. Completed as well IW72 with screened interval 20-35 feet bgs.	

Drilling Co./Driller: Cascade / Chris
Drilling Equipment: Track-Mounted Sonic Drill Rig
Sampler Type: Core Barrel
Hammer Type/Weight: -- lbs
Hammer Drop Distance: -- inches
Total Boring Depth: 35 feet bgs
Total Well Depth: 35 feet bgs
State Well ID No.: BNV363

Well/Auger Diameter: 4 / -- inches
Well Screened Interval: 20 to 35 feet bgs
Screen Slot Size: 0.020 inches
Filter Pack Used: Silica Sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Traffic-Rated Flushmount

Notes/Comments:
bgs = below ground surface



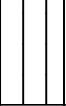
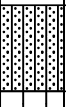
DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/20/21
Surface Conditions: Concrete
Location N/S: 36' N of SW Corner of 6900 E Green Lake Way N Building
Location E/W: 25' W of SW Corner of 6900 E Green Lake Way N Building
Reviewed by: CJT
Date Completed: 07/20/21

BORING LOG | **DZ-B01**

Site Address: 6870 Woodlawn Avenue Northeast
 Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete	
									0.5-5.0 feet bgs: Boring air-knifed to 5 feet bgs.	
5		1 3 1	15	0.2			ML		5.0-6.5 feet bgs: Sandy SILT, trace gravel, soft, brown, no hydrocarbon or solvent odor, moist (65-30-5).	
10		3 4 2	60	0.0			SM		10.0-11.0 feet bgs: Silty fine SAND, loose, gray, no hydrocarbon or solvent odor, moist (25-75-0).	
							ML		11.0-11.5 feet bgs: Sandy SILT, medium stiff, gray, no hydrocarbon or solvent odor, moist (70-30-0).	
15										

Drilling Co./Driller: Holocene / Matt
Drilling Equipment: B-58 Truck Mounted HSA
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/20/21
Surface Conditions: Concrete
Location N/S: 36' N of SW Corner of 6900 E Green Lake Way N Building
Location E/W: 25' W of SW Corner of 6900 E Green Lake Way N Building
Reviewed by: CJT
Date Completed: 07/20/21

BORING LOG | **DZ-B01**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		3 2 2	100	0.0			ML		15.0-16.5 feet bgs: Fine to coarse sandy SILT, soft, gray, no hydrocarbon or solvent odor, moist (70-30-0).	
20		3 2 4	100	0.0			ML		20.0-21.5 feet bgs: Fine to coarse sandy SILT, trace gravel, medium stiff, gray, no hydrocarbon or solvent odor, moist (60-35-5).	
25		12 29 28	40	17.9			SM		25.0-26.5 feet bgs: Fine to coarse silty SAND with gravel, very dense, gray, no hydrocarbon or solvent odor, wet (15-65-20).	
30										

Drilling Co./Driller: Holocene / Matt
Drilling Equipment: B-58 Truck Mounted HSA
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/20/21
Surface Conditions: Concrete
Location N/S: 36' N of SW Corner of 6900 E Green Lake Way N Building
Location E/W: 25' W of SW Corner of 6900 E Green Lake Way N Building
Reviewed by: CJT
Date Completed: 07/20/21

BORING LOG | **DZ-B01**

Site Address: 6870 Woodlawn Avenue Northeast
 Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
 Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		22 49 50/3"	70	2.6			SM		30.0-31.25 feet bgs: Fine to coarse silty SAND with gravel, very dense, gray, no hydrocarbon or solvent odor, moist (20-50-30).	
35		13 22 31	70	11.4			SP-SM		35.0-36.5 feet bgs: Poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-70-20).	
40		27 50/5"	60	124.6			SP-SM		40.0-41.0 feet bgs: Poorly graded SAND with silt, trace gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-85-5).	
45										

Drilling Co./Driller: Holocene / Matt
Drilling Equipment: B-58 Truck Mounted HSA
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/20/21
Surface Conditions: Concrete
Location N/S: 36° N of SW Corner of 6900 E Green Lake Way N Building
Location E/W: 25° W of SW Corner of 6900 E Green Lake Way N Building
Reviewed by: CJT
Date Completed: 07/20/21

BORING LOG | DZ-B01

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
 Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		19 50/6"	70	10.6			SP-SM		45.0-46.0 feet bgs: Poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-80-10).	
50		20 50/6"	70	1.7			SP-SM		50.0-51.0 feet bgs: Poorly graded SAND with silt, trace gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-85-5).	
55									Boring terminated at 51 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs and 40 to 50 feet bgs. Collect reconnaissance groundwater samples DZ-B01-20-30-20210720 and DZ-B01-40-50-20210720. Boring backfilled with bentonite and surface sealed with concrete patch.	
60										

Drilling Co./Driller: Holocene / Matt
Drilling Equipment: B-58 Truck Mounted HSA
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 70' N of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17.5' E of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | **DZ-B02**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete	
									0.5-5.0 feet bgs: Boring air-knifed to 5 feet bgs.	
5		4 2 1	80	0.0			SP-SM		5.0-6.0 feet bgs: Poorly graded SAND with silt, very loose, brown, no hydrocarbon or solvent odor, moist (10-90-0).	
							ML		6.0-6.5 feet bgs: Sandy SILT, trace gravel, soft, brown, no hydrocarbon or solvent odor, moist (65-30-5).	
10		3 2 3	70	0.0			SM		10.0-11.0 feet bgs: Silty fine SAND, loose, gray, no hydrocarbon or solvent odor, moist (25-75-0).	
							ML		11.0-11.5 feet bgs: Sandy SILT, trace gravel, medium stiff, gray, no hydrocarbon or solvent odor, moist (60-35-5).	
15										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 70' N of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17.5' E of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | DZ-B02

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		2 3 4	100	0.0			ML		15.0-16.5 feet bgs: Fine to coarse sandy SILT, trace gravel, medium stiff, gray, no hydrocarbon or solvent odor, moist (65-30-5).	
20		2 2 5	90	0.0			ML		20.0-21.5 feet bgs: Fine to coarse sandy SILT, trace gravel, medium stiff, gray, no hydrocarbon or solvent odor, moist (60-35-5).	
25		21 50/6"	80	86.7			SP-SM		25.0-26.0 feet bgs: Fine to coarse poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-80-10).	
30										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface

DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 70' N of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17.5' E of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | DZ-B02

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		32 50/6"	10	1.9			SM		30.0-31.0 feet bgs: Fine to coarse silty SAND with gravel, very dense, gray, no hydrocarbon or solvent odor, wet (15-55-30).	
35		22 50/6"	50	1.8			SP-SM		35.0-36.0 feet bgs: Fine to coarse poorly graded SAND with silt, trace gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-85-5).	
40		39 50/6"	60	1.8			SP-SM		40.0-41.0 feet bgs: Fine to coarse poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-60-30).	
45										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface

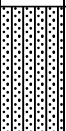
DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 70' N of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17.5' E of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | DZ-B02

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		50/5"	25	2.1			SP-SM		45.0-45.5 feet bgs: Fine to coarse poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-75-15).	
50		19 31 50/5"	50	1.3			SM		50.0-51.5 feet bgs: Fine to coarse silty SAND with gravel, very dense, gray, no hydrocarbon or solvent odor, wet (15-70-15).	
55									Boring terminated at 51.5 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs and 40 to 50 feet bgs. Collect reconnaissance groundwater samples DZ-B02-20-30-20210722 and DZ-B02-40-50-20210722. Boring backfilled with bentonite and surface sealed with concrete patch.	
60										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 46' N/NW of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17' E/NE of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | **DZ-B03**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete	
									0.5-5.0 feet bgs: Boring air-knifed to 5 feet bgs.	
5		4 2 2	100	0.1			SP		5.0-6.0 feet bgs: Fine to medium SAND, trace silt and gravel, very loose, brown, no hydrocarbon or solvent odor, moist (5-90-5).	
							ML		6.0-6.5 feet bgs: Sandy SILT, trace gravel, soft, gray, no hydrocarbon or solvent odor, moist (65-30-5).	
10		5 8 10	0	--					10.0-11.5 feet bgs: No recovery.	
15										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 50.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 46° N/NW of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17° E/NE of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | **DZ-B03**

Site Address: 6870 Woodlawn Avenue Northeast
 Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		3 1 2	100	0.0			ML		15.0-16.5 feet bgs: Fine to coarse sandy SILT, trace gravel, soft, gray, no hydrocarbon or solvent odor, moist (60-35-5).	
20		4 5 8	100	0.0			ML		20.0-21.0 feet bgs: Fine to coarse sandy SILT, trace gravel, soft, gray, no hydrocarbon or solvent odor, moist (60-35-5).	
							ML		21.0-21.5 feet bgs: Fine to coarse sandy SILT, stiff, gray, no hydrocarbon or solvent odor, moist (60-40-0).	
25		14 32 50/6"	100	46.5			SP-SM		25.0-26.5 feet bgs: Fine to coarse poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-80-10).	
30										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 50.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 46° N/NW of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17° E/NE of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | **DZ-B03**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
	18 50/3"	15		7.4			SP-SM		30.0-30.75 feet bgs: Fine to coarse poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-80-10).	
35	21 50/6"	100		50.4			SP-SM		35.0-36.0 feet bgs: Fine to coarse poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-75-15).	
40	36 50/6"	100		42.1			SP-SM		40.0-41.0 feet bgs: Fine to coarse poorly graded SAND with silt and gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-75-15).	
45										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 50.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 07/22/21
Surface Conditions: Concrete
Location N/S: 46° N/NW of SE Corner of 6869 Woodlawn Ave NE Building
Location E/W: 17° E/NE of SE Corner of 6869 Woodlawn Ave NE Building
Reviewed by: CJT
Date Completed: 07/22/21

BORING LOG | **DZ-B03**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		31 50/5"	100	13.7			SP-SM		45.0-46.0 feet bgs: Fine to medium poorly graded SAND with silt, very dense, gray, no hydrocarbon or solvent odor, wet (10-90-0).	
50		50/2"	20	37.6			SP-SM		50.0-50.5 feet bgs: Fine to medium poorly graded SAND with silt, trace gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-85-5).	
55									Boring terminated at 50.5 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs and 35 to 45 feet bgs. Collect reconnaissance groundwater samples DZ-B03-20-30-20210722 and DZ-B03-35-45-20210722. Boring backfilled with bentonite and surface sealed with concrete patch.	
60										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 50.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



BORING LOG | DZ-B04

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth**
After Completion -- feet bgs

Drilling Co./Driller:	Holocene / RJ	
Drilling Equipment:	Diedrich D50	
Sampler Type:	SPT	
Hammer Type/Weight:	Auto / 140	lbs
Total Boring Depth:	51.5	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

Well/Auger Diameter:	2 / 8.25	inches
Well Screened Interval:	--	feet bgs
Screen Slot Size:	--	inches
Filter Pack Used:	--	
Surface Seal:	--	
Annular Seal:	--	
Monument Type:	--	

Notes/Comments:

bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 07/23/21
Surface Conditions: Concrete
Location N/S: 22' N of SW Corner of 6900 E Green Lake Way N Building
Location E/W: 23' W of SW Corner of 6900 E Green Lake Way N Building
Reviewed by: CJT
Date Completed: 07/23/21

BORING LOG | **DZ-B04**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		0 0 0	100	0.0			ML		15.0-16.5 feet bgs: SILT with clay and sand, very soft, gray, no hydrocarbon or solvent odor, moist (90-10-0).	
20		4 4 5	100	0.0			ML		20.0-21.5 feet bgs: Sandy SILT, stiff, gray, no hydrocarbon or solvent odor, moist (65-35-0).	
25		28 26 50/3"	100	12.4			SM		25.0-26.25 feet bgs: Silty fine SAND, very dense, gray, no hydrocarbon or solvent odor, wet (30-70-0).	
30										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 07/23/21
Surface Conditions: Concrete
Location N/S: 22' N of SW Corner of 6900 E Green Lake Way N Building
Location E/W: 23' W of SW Corner of 6900 E Green Lake Way N Building
Reviewed by: CJT
Date Completed: 07/23/21

BORING LOG | DZ-B04

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		26 50/4"	75	6.2			SM		30.0-31.0 feet bgs: Silty SAND, trace fine gravel, very dense, gray, no hydrocarbon or solvent odor, wet (20-75-5).	
35		30 40 40	100	0.2			SM SM	 	35.0-35.5 feet bgs: Silty SAND with gravel, very dense, gray, no hydrocarbon or solvent odor, wet (20-55-25). 35.5-36.5 feet bgs: Silty SAND, trace gravel, very dense, gray, no hydrocarbon or solvent odor, moist (35-60-5).	
40		50/4"	30	0.2			SM		40.0-40.5 feet bgs: Silty SAND with gravel, very dense, gray, no hydrocarbon or solvent odor, moist (20-65-15).	
45										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
 bgs = below ground surface



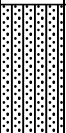
DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 07/23/21
Surface Conditions: Concrete
Location N/S: 22' N of SW Corner of 6900 E Green Lake Way N Building
Location E/W: 23' W of SW Corner of 6900 E Green Lake Way N Building
Reviewed by: CJT
Date Completed: 07/23/21

BORING LOG | **DZ-B04**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
		50/1"	5	0.2			SP-SM		45.0-45.5 feet bgs: SAND with silt, trace gravel, very dense, gray, no hydrocarbon or solvent odor, wet (10-85-5).	
50		31 35 37	50	0.1			SM		50.0-51.5 feet bgs: Fine SAND with silt, trace gravel, very dense, gray, no hydrocarbon or solvent odor, moist to wet (10-85-5).	
55									Boring terminated at 51.5 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs and 40 to 50 feet bgs. Collect reconnaissance groundwater samples DZ-B04-20-30-20210723 and DZ-B04-40-50-20210723. Boring backfilled with bentonite and surface sealed with concrete patch.	
60										

Drilling Co./Driller: Holocene / RJ
Drilling Equipment: Diedrich D50
Sampler Type: SPT
Hammer Type/Weight: Auto / 140 lbs
Total Boring Depth: 51.5 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: 2 / 8.25 inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/24/22
Surface Conditions: Concrete
Location N/S: 6' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 20' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 02/25/22

BORING LOG | **DZ-B05**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete at surface.	
									0.5-5.0 feet bgs: Boring air-knifed to 5 feet bgs on 02/21/22.	
5				0.0			SM		5.0-7.0 feet bgs: Silty fine to medium SAND, gray, no solvent odor, wet (40-60-0).	
			100	0.0			ML		7.0-10.0 feet bgs: Very fine sandy SILT, gray, no solvent odor, wet to moist (80-20-0).	
10				0.0			ML		10.0-15.0 feet bgs: Fine to medium sandy SILT with fine gravel, gray, no solvent odor, moist (65-25-10).	
			100	0.0						
15										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/24/22
Surface Conditions: Concrete
Location N/S: 6' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 20' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 02/25/22

BORING LOG | **DZ-B05**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.0			ML		15.0-20.0 feet bgs: Fine to medium sandy SILT with gravel and cobbles, gray, no solvent odor, moist (55-35-10).	
20			100	0.0			SM		20.0-23.0 feet bgs: Fine to coarse silty SAND with fine to coarse gravel and cobbles, gray, no solvent odor, moist (90-10-0).	
			100	0.0			SM		23.0-25.0 feet bgs: Fine to coarse silty SAND with fine to coarse gravel and cobbles, gray, no solvent odor, wet (90-10-0).	
25				0.0			SM		25.0-27.5 feet bgs: Silty fine SAND with gravel, gray, no solvent odor, wet (15-60-25).	
			100	0.0			SM		27.5-30.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist to wet (30-45-25).	
30				0.0						

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/24/22
Surface Conditions: Concrete
Location N/S: 6' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 20' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 02/25/22

BORING LOG | **DZ-B05**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.0			SM		30.0-32.5 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (25-60-15).	
			100	0.0			SM		32.5-35.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (15-70-15).	
35				0.0						
				0.0			SP-SM		35.0-38.0 feet bgs: Fine to medium SAND with silt, trace gravel, gray, no solvent odor, moist (10-85-5).	
			100	0.0						
				0.0			SP-SM		38.0-40.0 feet bgs: Fine to medium SAND with silt and gravel, gray, no solvent odor, moist (10-80-10).	
40				0.0						
				0.0			SP-SM		40.0-45.0 feet bgs: Fine SAND with silt and gravel, gray, no solvent odor, moist to wet (10-80-10).	
			100	0.0						
				0.2						
45										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/24/22
Surface Conditions: Concrete
Location N/S: 6' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 20' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 02/25/22

BORING LOG | **DZ-B05**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
50			100	0.0			SM		45.0-50.0 feet bgs: Silty fine SAND with gravel, gray, no solvent odor, moist (15-75-10).	
				0.2						
							SM		50.0-52.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, wet (25-65-10).	
				0.1						
			100	0.2			SM		52.0-55.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (25-65-10).	
55										
				0.1			SM		55.0-57.5 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (15-70-15).	
			100	0.1			SP-SM		57.5-60.0 feet bgs: Fine to medium SAND with silt and gravel, gray, no solvent odor, moist (10-70-20).	
60										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/24/22
Surface Conditions: Concrete
Location N/S: 6' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 20' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 02/25/22

BORING LOG | **DZ-B05**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
65			100				SP-SM		60.0-65.0 feet bgs: Fine to medium SAND with silt and fine to medium gravel, gray, no solvent odor, moist (10-80-10).	
							SM		65.0-69.5 feet bgs: Silty very fine to fine SAND, trace gravel, gray, no solvent odor, moist (40-55-5).	
70			100				ML		69.5-70.0 feet bgs: Very fine sandy SILT, gray, no solvent odor, moist (80-20-0).	
75									Boring terminated at 70 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs, 40 to 50 feet bgs, and 60 to 70 feet bgs. Collect reconnaissance groundwater samples DZ-B05-20-30-20220224, DZ-B05-40-50-20220225, and DZ-B05-60-70-20220225. Boring backfilled with bentonite and surface patched with concrete.	

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/28/22
Surface Conditions: Concrete
Location N/S: 48' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 14' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/01/22

BORING LOG | **DZ-B06**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete at surface.	
									0.5-5.0 feet bgs: Boring air-knifed to 5 feet bgs on 02/21/22.	
5				0.3			ML		5.0-10.0 feet bgs: Sandy SILT, trace gravel, gray-brown, no solvent odor, wet (65-30-5).	
10			75				ML		10.0-15.0 feet bgs: Sandy SILT with cobbles, gray, no solvent odor, moist (75-15-10).	
15			95	0.8						

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/28/22
Surface Conditions: Concrete
Location N/S: 48' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 14' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/01/22

BORING LOG | **DZ-B06**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
20			0				SM-ML		15.0-20.0 feet bgs: No recovery, drillers report soil conditions consistent with 20 to 25 foot bgs interval.	
25			100	0.0			SM-ML		20.0-25.0 feet bgs: SILT and SAND, gray, no solvent odor, moist (50-50-0).	
30			20	0.0			SM		25.0-30.0 feet bgs: Silty SAND, trace gravel, gray, no solvent odor, moist (30-65-5).	

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



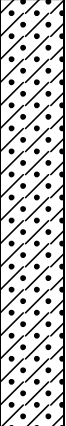
DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/28/22
Surface Conditions: Concrete
Location N/S: 48' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 14' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/01/22

BORING LOG | **DZ-B06**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
35			50	0.0			SM		30.0-35.0 feet bgs: Silty fine to medium SAND with fine gravel, gray, no solvent odor, moist (25-65-10).	
40			100	0.0			SM		35.0-40.0 feet bgs: Silty fine SAND with fine to medium gravel, gray, no solvent odor, moist (15-70-15).	
45			100	0.0			SP-SM		40.0-45.0 feet bgs: Silty fine SAND with silt and fine to medium gravel, gray, no solvent odor, moist (10-75-15).	

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/28/22
Surface Conditions: Concrete
Location N/S: 48' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 14' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/01/22

BORING LOG | **DZ-B06**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
			100	0.0			SM		45.0-50.0 feet bgs: Silty SAND, trace gravel, gray, no solvent odor, moist (20-75-5).	
50			100	0.0			SP-SM		50.0-55.0 feet bgs: Fine SAND with silt and fine to medium gravel, gray, no solvent odor, moist (10-75-15).	
55			100	0.1			SP-SM		55.0-57.5 feet bgs: Fine to coarse SAND with silt and gravel, gray, no solvent odor, moist (10-80-10).	
60			100	0.3			SP-SM		57.5-60.0 feet bgs: Fine to coarse SAND with silt and gravel, gray, no solvent odor, moist (10-70-20).	

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/28/22
Surface Conditions: Concrete
Location N/S: 48' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 14' W of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/01/22

BORING LOG | **DZ-B06**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
65			100	0.6			SM		60.0-62.5 feet bgs: Silty fine to medium SAND with fine to medium gravel, gray, no solvent odor, moist (20-60-20).	
				0.8			SM		62.5-65.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (20-55-25).	
				0.2			SM		65.0-69.0 feet bgs: Silty fine to medium SAND with fine to medium gravel, gray, no solvent odor, wet (15-70-15).	
			100	0.2						
				0.4			SM		69.0-70.0 feet bgs: Silty fine SAND with gravel, gray, no solvent odor, wet (30-55-15).	
70									Boring terminated at 70 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs, 40 to 50 feet bgs, and 60 to 70 feet bgs. Collect reconnaissance groundwater samples DZ-B06-20-30-20220228, DZ-B06-40-50-20220228, and DZ-B06-60-70-20220301. Boring backfilled with bentonite and surface patched with concrete.	
75										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



BORING LOG | DZ-B07

	Water Depth At Time of Drilling	--	feet bgs
	Water Depth After Completion	--	feet bgs

Drilling Co./Driller:	Cascade / Charles	
Drilling Equipment:	LAR Sonic	
Sampler Type:	Sleeve	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	70	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

Well/Auger Diameter:	--	inches
Well Screened Interval:	--	feet bgs
Screen Slot Size:	--	inches
Filter Pack Used:	--	
Surface Seal:	--	
Annular Seal:	--	
Monument Type:	--	

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/03/22
Surface Conditions: Concrete
Location N/S: 76' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 38' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/03/22

BORING LOG | **DZ-B07**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
			75	0.2			SM-ML		15.0-20.0 feet bgs: SILT and SAND, gray, no solvent odor, moist (50-50-0).	
20							ML		20.0-23.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (45-30-25).	
			100	0.3			ML		23.0-25.0 feet bgs: Sandy SILT with coarse gravel and cobbles, gray, no solvent odor, moist (45-30-25).	
25							SM		25.0-30.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (20-45-35).	
			90	0.2						
30										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



BORING LOG | DZ-B07

	Water Depth At Time of Drilling	--	feet bgs
	Water Depth After Completion	--	feet bgs

Drilling Co./Driller:	Cascade / Charles	
Drilling Equipment:	LAR Sonic	
Sampler Type:	Sleeve	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	70	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

Well/Auger Diameter:	--	inches
Well Screened Interval:	--	feet bgs
Screen Slot Size:	--	inches
Filter Pack Used:	--	
Surface Seal:	--	
Annular Seal:	--	
Monument Type:	--	

Page: 3 of 5



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/03/22
Surface Conditions: Concrete
Location N/S: 76' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 38' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/03/22

BORING LOG | **DZ-B07**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.1			SM		45.0-50.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (15-65-20).	
50			100	0.0			SM		50.0-55.0 feet bgs: Silty fine to coarse SAND with gravel, gray, no solvent odor, moist (15-70-15).	
55			90	0.0			SP-SM		55.0-60.0 feet bgs: SAND with silt and gravel, gray, no solvent odor, moist (10-70-20).	
60			80	0.1						
				0.0						

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/03/22
Surface Conditions: Concrete
Location N/S: 76' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 38' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/03/22

BORING LOG | **DZ-B07**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
65			100	0.2			SM		60.0-65.0 feet bgs: Silty fine to medium SAND with fine to coarse gravel, gray, no solvent odor, moist (15-65-20).	
				0.3						
				0.0			SM		65.0-70.0 feet bgs: Silty fine SAND with fine to medium gravel, gray, no solvent odor, moist (20-65-15).	
			100	0.1						
70										
									Boring terminated at 70 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs, 40 to 50 feet bgs, and 60 to 70 feet bgs. Collect reconnaissance groundwater samples DZ-B07-20-30-20220303, DZ-B07-40-50-202200303, and DZ-B07-60-70-20220303. Boring backfilled with bentonite and surface patched with concrete.	
75										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/01/22
Surface Conditions: Concrete
Location N/S: 14' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 39' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/02/22

BORING LOG | **DZ-B08**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete at surface.	
									0.5-5.0 feet bgs: Boring air-knifed to 6 feet bgs on 02/21/22.	
5									5.0-7.5 feet bgs: No recovery.	
			50	0.0			SM		7.5-8.5 feet bgs: Sandy SILT, trace gravel, gray, no solvent odor, moist to wet (40-55-5).	
							ML		8.5-10.0 feet bgs: Sandy SILT, trace gravel, gray, no solvent odor, moist (80-15-5).	
10				0.0					10.0-15.0 feet bgs: No recovery.	
15			0							

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/01/22
Surface Conditions: Concrete
Location N/S: 14' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 39' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/02/22

BORING LOG | **DZ-B08**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.0			ML		15.0-17.0 feet bgs: Sandy SILT, trace gravel, gray, no solvent odor, moist (55-40-5).	
			100	0.0			SM		17.0-18.0 feet bgs: Silty fine to medium SAND, gray, no solvent odor, moist (40-60-0).	
				0.0			ML		18.0-20.0 feet bgs: Sandy SILT, gray, no solvent odor, moist (55-40-5).	
20				0.0			GP		20.0-22.5 feet bgs: Fine to coarse GRAVEL with silt and sand, gray, no solvent odor, moist (20-30-50).	
			100	0.0			SM		22.5-25.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist to wet (30-50-20).	
25				0.0			SP		25.0-30.0 feet bgs: GRAVEL with silt and sand, gray, no solvent odor, moist (20-30-50).	
30			50							

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/01/22
Surface Conditions: Concrete
Location N/S: 14' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 39' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/02/22

BORING LOG | **DZ-B08**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

▽ **Water Depth At Time of Drilling** -- feet bgs
▼ **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
			20	0.0			SM		30.0-35.0 feet bgs: Silty fine to medium SAND with fine to coarse gravel and cobbles, gray, no solvent odor, wet (30-45-25).	
35				0.1			SM		35.0-37.5 feet bgs: Silty fine to medium SAND with fine to coarse gravel, gray, no solvent odor, moist (25-60-15).	
			90	0.3			SM		37.5-40.0 feet bgs: Silty fine to medium sand with fine gravel, gray, no solvent odor, moist to wet (15-70-15).	
40				0.3			SM		40.0-42.5 feet bgs: Silty fine SAND with fine gravel, gray, no solvent odor, moist (15-70-15).	
			100				SM		42.5-45.0 feet bgs: Silty fine SAND with fine to medium gravel, no solvent odor, moist (15-65-20).	
45				0.8						

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



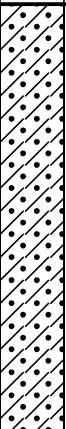
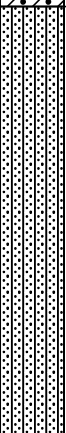
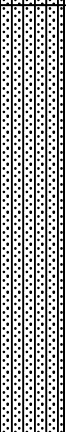
DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/01/22
Surface Conditions: Concrete
Location N/S: 14' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 39' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/02/22

BORING LOG | **DZ-B08**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.2			SP-SM		45.0-50.0 feet bgs: Fine SAND with silt, trace gravel, gray, no solvent odor, moist (10-85-5).	
50			90	0.2			SM		50.0-55.0 feet bgs: Silty fine SAND with fine to coarse gravel, gray, no solvent odor, moist (15-65-20).	
55			100	0.2			SM		55.0-60.0 feet bgs: Silty fine to medium SAND with fine to medium gravel, gray, no solvent odor, moist (20-65-15).	
			90	0.1						
				0.1						
60										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 03/01/22
Surface Conditions: Concrete
Location N/S: 14' N of NE corner of 6869 Woodlawn Ave NE building
Location E/W: 39' E of NE corner of 6869 Woodlawn Ave NE building
Reviewed by: TJC
Date Completed: 03/02/22

BORING LOG | DZ-B08

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
65			100	0.1			SM		60.0-61.0 feet bgs: Silty SAND with fine to coarse gravel, gray, no solvent odor, moist to wet (15-70-15).	
				0.0			SM		61.0-65.0 feet bgs: Silty fine to medium SAND with fine to coarse gravel and cobbles, gray, no solvent odor, moist (20-50-30).	
				0.0			SM		65.0-67.5 feet bgs: Silty fine to medium SAND with fine to medium gravel, gray, no solvent odor, moist (20-65-15).	
			100	0.0			SM		67.5-70.0 feet bgs: Silty fine to medium SAND with fine to medium gravel, gray, no solvent odor, moist (35-50-15).	
70									Boring terminated at 70 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs, 40 to 50 feet bgs, and 60 to 70 feet bgs. Collect reconnaissance groundwater samples DZ-B08-20-30-20220301, DZ-B08-40-50-20220302, and DZ-B08-60-70-20220302. Boring backfilled with bentonite and surface sealed with concrete patch.	
75										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/22/22
Surface Conditions: Concrete
Location N/S: 22' S of SW corner of 6900 E Green Lake Way N building
Location E/W: 7' W of SW corner of 6900 E Green Lake Way N building
Reviewed by: TJC
Date Completed: 02/23/22

BORING LOG | **DZ-B09**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete at surface.	
									0.5-5.0 feet bgs: Boring air-knifed to 6 feet bgs on 02/21/22.	
5							SM		5.0-6.0 feet bgs: Silty SAND with gravel, light brown, no solvent odor, moist (35-50-15).	
				0.1			ML		6.0-8.0 feet bgs: Sandy SILT, trace fine gravel, light brown/tan, no solvent odor, moist (70-25-5).	
			100	0.1			ML		8.0-10.0 feet bgs: Sandy SILT, trace gravel, gray, no solvent odor, moist, 2- to 3-inch-thick sand lens at 9 feet bgs (80-15-5).	
10				0.1			ML		10.0-15.0 feet bgs: SILT with very fine sand, gray, no solvent odor, moist (90-10-0).	
				0.1						
			100	0.1						
				0.0						
15										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/22/22
Surface Conditions: Concrete
Location N/S: 22' S of SW corner of 6900 E Green Lake Way N building
Location E/W: 7' W of SW corner of 6900 E Green Lake Way N building
Reviewed by: TJC
Date Completed: 02/23/22

BORING LOG | **DZ-B09**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.0			ML		15.0-19.0 feet bgs: SILT with very fine sand, gray, no solvent odor, moist (90-10-0).	
			100	0.0			ML		19.0-20.0 feet bgs: SILT with very fine sand and fine gravel, gray, no solvent odor, moist (80-10-10).	
20				0.0			SM		20.0-23.0 feet bgs: Silty fine to medium SAND with fine to coarse gravel, gray no solvent odor, moist (35-45-20).	
			100	0.0			SM		23.0-25.0 feet bgs: Silty SAND with fine to coarse gravel, gray, no solvent odor, moist (40-40-20).	
25				0.0			SM		25.0-28.0 feet bgs: Silty SAND with fine to coarse gravel, gray, no solvent odor, moist (25-50-25).	
			100	0.0			SM		28.0-30.0 feet bgs: Silty SAND with fine to coarse gravel, gray, no solvent odor, moist to wet (30-50-20).	
30				0.0						

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/22/22
Surface Conditions: Concrete
Location N/S: 22' S of SW corner of 6900 E Green Lake Way N building
Location E/W: 7' W of SW corner of 6900 E Green Lake Way N building
Reviewed by: TJC
Date Completed: 02/23/22

BORING LOG | **DZ-B09**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
35			100	0.1			SM		30.0-35.0 feet bgs: Silty SAND with fine to coarse gravel, gray, no solvent odor, wet (20-65-15).	
				0.1			SM		35.0-37.0 feet bgs: Silty SAND with fine to medium gravel, gray, no solvent odor, moist (15-70-15).	
			100	0.1			SM		37.0-38.0 feet bgs: Silty SAND with fine to medium gravel, gray, no solvent odor, wet (15-70-15).	
				0.1			SM		38.0-40.0 feet bgs: Silty SAND with fine to medium gravel, gray, no solvent odor, moist (15-65-20).	
40				0.0			SP-SM		40.0-45.0 feet bgs: Very fine to fine SAND with silt and fine gravel, gray, no solvent odor, moist to wet (10-80-10).	
			100	0.0						
				0.1						
45										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



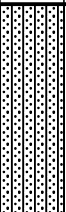
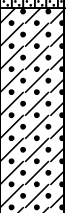
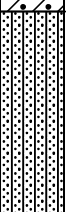
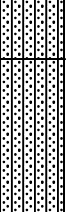
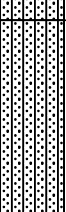
DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/22/22
Surface Conditions: Concrete
Location N/S: 22' S of SW corner of 6900 E Green Lake Way N building
Location E/W: 7' W of SW corner of 6900 E Green Lake Way N building
Reviewed by: TJC
Date Completed: 02/23/22

BORING LOG | **DZ-B09**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
				0.1			SM		45.0-47.5 feet bgs: Silty SAND with fine gravel, gray, no solvent odor, wet (35-55-10).	
				0.1			SP-SM		47.5-50.0 feet bgs: SAND with silt and fine gravel, gray, no solvent odor, moist (10-80-10).	
50			100	0.1			SM		50.0-53.0 feet bgs: Silty fine SAND with fine to coarse gravel, gray, no solvent odor, moist (30-60-10).	
				0.2			SM		53.0-55.0 feet bgs: Silty fine SAND with fine to coarse gravel, gray, no solvent odor, moist (25-55-20).	
55			100	0.1			SM		55.0-60.0 feet bgs: Silty fine SAND with fine to coarse gravel, gray, no solvent odor, moist (35-40-25).	
				0.1						
				0.1						
60										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: CJT
Date Started: 02/22/22
Surface Conditions: Concrete
Location N/S: 22' S of SW corner of 6900 E Green Lake Way N building
Location E/W: 7' W of SW corner of 6900 E Green Lake Way N building
Reviewed by: TJC
Date Completed: 02/23/22

BORING LOG | **DZ-B09**

Site Address: 6870 Woodlawn Avenue Northeast
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, density, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
65			100	0.1			SM		60.0-61.0 feet bgs: Silty SAND with fine to coarse gravel, gray, no solvent odor, moist to wet (15-70-15).	
				0.0			SP-SM		61.0-62.5 feet bgs: Fine SAND with silt and fine to coarse gravel, gray, no solvent odor, moist to wet (10-75-15).	
				0.0			SP		62.5-65.0 feet bgs: Fine to medium SAND with fine to medium gravel, trace silt, gray, no solvent odor, wet (5-80-15).	
				0.0			SM		65.0-67.0 feet bgs: Silty fine SAND with fine to coarse gravel, gray, no solvent odor, wet (15-65-20).	
			100	0.0			SP-SM		67.0-70.0 feet bgs: Fine to medium SAND with fine to coarse gravel, gray, no solvent odor, moist to wet (10-70-20).	
70				0.0					Boring terminated at 70 feet bgs. Temporary PVC well set with screen intervals of 20 to 30 feet bgs, 40 to 50 feet bgs, and 60 to 70 feet bgs. Collect reconnaissance groundwater samples DZ-B09-20-30-20220222, DZ-B09-40-50-20220222, and DZ-B09-60-70-20220223. Boring backfilled with bentonite and surface sealed with concrete patch.	
75										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: Sleeve
Hammer Type/Weight: -- lbs
Total Boring Depth: 70 feet bgs
Total Well Depth: -- feet bgs
State Well ID No.: --

Well/Auger Diameter: -- inches
Well Screened Interval: -- feet bgs
Screen Slot Size: -- inches
Filter Pack Used: --
Surface Seal: --
Annular Seal: --
Monument Type: --

Notes/Comments:
bgs = below ground surface



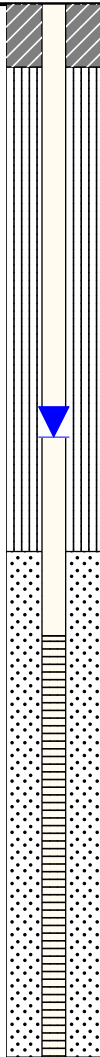
DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 10/25/22
Surface Conditions: Concrete
Location N/S: 36' N of street light on NE corner of 4th Ave & Woodlawn Ave
Location E/W: 10' W of street light on NE corner of 4th Ave & Woodlawn Ave
Reviewed by: CJT
Date Completed: 10/26/22

BORING LOG | **MW34**

Site Address: 6870 Woodlawn Ave NE
Seattle, Washington

 **Water Depth At Time of Drilling** -- feet bgs
 **Water Depth After Completion** 9.92 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete at surface.	
									0.5-6.0 feet bgs: Boring air knife cleared to 6' bgs.	
5				0.0			ML		6.0-8.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (65-25-10).	
				0.0			ML		8.0-13.0 feet bgs: Sandy SILT, trace gravel, gray, no solvent odor, moist (80-15-5).	
10				0.0			ML		13.0-16.0 feet bgs: Fine to coarse sandy SILT with gravel, gray, no solvent odor, moist (70-20-10).	
				0.0			ML		16.0-21.5 feet bgs: Fine to coarse sandy SILT with gravel, gray, no solvent odor, moist (65-25-10).	
15				0.0			GP		21.5-22.5 feet bgs: Fine to coarse GRAVEL with silt and sand, gray, no solvent odor, moist (20-30-50).	
				1.3			SM		22.5-25.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (30-45-25).	
20				5.3						
				17.5						
25				16.4						
									Boring terminated at 25 feet bgs, completed as monitoring well MW34.	
30										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: --
Hammer Type/Weight: -- lbs
Hammer Drop Distance: inches
Total Boring Depth: 25 feet bgs
Total Well Depth: 25 feet bgs
State Well ID No.: BNV 483

Well/Auger Diameter: 2 / -- inches
Well Screened Interval: 15-25 feet bgs
Screen Slot Size: 0.010 inches
Filter Pack Used: Silica sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Flush mount

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 10/26/22
Surface Conditions: Concrete
Location N/S: 39' N of street light on NE corner of 4th Ave & Woodlawn Ave
Location E/W: 10' W of street light on NE corner of 4th Ave & Woodlawn Ave
Reviewed by: CJT
Date Completed: 10/27/22

BORING LOG | **MW35**

Site Address: 6870 Woodlawn Ave NE
Seattle, Washington

Water Depth At Time of Drilling -- feet bgs
Water Depth After Completion 15.30 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete at surface.	
									0.5-6.0 feet bgs: Boring air knife cleared to 6' bgs.	
5									6.0-10.0 feet bgs: No recovery.	
10				0.0			ML		10.0-13.0 feet bgs: Sandy SILT with gravel, gray, no solvent odor, moist (70-20-10).	
				0.5			ML		13.0-17.0 feet bgs: Sandy SILT, gray, no solvent odor, moist (85-15-0).	
15				0.7			ML		17.0-21.5 feet bgs: Fine to coarse sandy SILT with gravel, gray, no solvent odor, moist (65-25-10).	
				0.5			ML			
				0.0			ML			
20				0.0			GP		21.5-22.5 feet bgs: Fine to coarse GRAVEL with silt and sand, gray, no solvent odor, moist (20-30-50).	
				24.3			SM		22.5-32.0 feet bgs: Silty fine to medium SAND with gravel, gray, no solvent odor, moist (30-45-25).	
25				50.4			SM			
				36.2			SM		32.0-37.0 feet bgs: Silty medium to coarse SAND with gravel, gray, no solvent odor, moist (25-65-10).	
				17.8			SM		37.0-42.0 feet bgs: Silty fine to coarse SAND with gravel, gray, no solvent odor, moist (15-75-10).	
30				8.9			SM		42.0-45.0 feet bgs: Silty fine to coarse SAND, gray, no solvent odor, moist (15-85-0).	
				51.2			SM			
				41.6			SM			
35				28.4			SM			
				45.6			SM			
				38.2			SM			
40				3.8			SM			
				0.0			SM			
				0.0			SM			
45				0.0			SM			
									Boring terminated at 45 feet bgs, completed as monitoring well MW35.	
50										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: --
Hammer Type/Weight: -- lbs
Hammer Drop Distance: inches
Total Boring Depth: 45 feet bgs
Total Well Depth: 45 feet bgs
State Well ID No.: BNV 484

Well/Auger Diameter: 2 / -- inches
Well Screened Interval: 35-45 feet bgs
Screen Slot Size: 0.010 inches
Filter Pack Used: Silica sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Flush mount

Notes/Comments:
bgs = below ground surface



DRAFT

Project: Plastic Sales & Service Site
Project Number: 0651-002
Logged by: KJL
Date Started: 10/24/22
Surface Conditions: Concrete
Location N/S: 103' N of street light on NE corner of 4th Ave & Woodlawn Ave
Location E/W: 11' W of street light on NE corner of 4th Ave & Woodlawn Ave
Reviewed by: CJT
Date Completed: 10/25/22

BORING LOG | **MW36**

Site Address: 6870 Woodlawn Ave NE
Seattle, Washington

Water Depth At Time of Drilling 7 feet bgs

Water Depth After Completion 13.19 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppm)	Sample ID	Sample Analyzed	Group Symbol	Graphic	Lithologic Description (ASTM texture, color, odor, moisture, supplemental descriptors, estimated grain size distribution) Field-estimated grain size distribution by volume (% Fines - % Sand - % Gravel)	Well Detail/ Water Depth
0									0.0-0.5 feet bgs: Concrete at surface.	
									0.5-6.0 feet bgs: Boring air knife cleared to 6' bgs.	
5										
			100	0.0			SM		6.0-7.5 feet bgs: Silty SAND, trace gravel, gray, no solvent odor, wet (40-55-5).	
				0.0			ML		7.5-11.0 feet bgs: SILT with sand, gray, no solvent odor, moist (90-10-0).	
10				0.0			ML		11.0-17.0 feet bgs: Medium to coarse sandy SILT with gravel, gray, no solvent odor, moist (75-15-10).	
			100	0.0						
				0.0			ML		17.0-21.0 feet bgs: Medium to coarse sandy SILT with gravel, gray, no solvent odor, moist (60-30-10).	
15				0.0						
			100	0.0			ML		21.0-23.0 feet bgs: SILT with coarse sand, trace gravel, gray, no solvent odor, moist (85-10-5).	
				0.0						
			100	0.0			SM		23.0-25.0 feet bgs: Silty SAND with gravel, gray, no solvent odor, moist (30-45-25).	
20				0.0						
				0.0						
25				0.0					Boring terminated at 25 feet bgs, completed as monitoring well MW36.	
30										

Drilling Co./Driller: Cascade / Charles
Drilling Equipment: LAR Sonic
Sampler Type: --
Hammer Type/Weight: -- lbs
Hammer Drop Distance: inches
Total Boring Depth: 25 feet bgs
Total Well Depth: 25 feet bgs
State Well ID No.: BNV 485

Well/Auger Diameter: 2 / -- inches
Well Screened Interval: 15-25 feet bgs
Screen Slot Size: 0.010 inches
Filter Pack Used: Silica sand
Surface Seal: Cement
Annular Seal: Bentonite
Monument Type: Flush mount

Notes/Comments:
bgs = below ground surface

Log of Boring: MW-21

Page 1 of 1

Client: Plastic Sales and Service
Project: Plastic Sales and Service
Location: Seattle, WA

Farallon PN: 343-002-011

Logged By: J. Ruark & J. Baptist

Date/Time Started: 11/10/2008 1150
Date/Time Completed: 11/10/2008 1300
Equipment: CME 85
Drilling Company: Cascade Drilling
Drilling Foreman: Steve Choate
Drilling Method: Hollow Stem Auger

Sampler Type: D&M Split Spoon 18-inch
Drive Hammer (lbs.): 300
Depth of Water ATD (ft bgs): 21.0
Total Boring Depth (ft bgs): 24.0
Total Well Depth (ft bgs): 24.0

Depth (feet bgs.)	Sample Interval	Lithologic Description	USCS	USGS Graphic	% Recovery	Blow Counts 8/8/8	PID (ppm)	Sample ID	Sample Analyzed	Boring/Well Construction Details
0		0-11" Concrete	CO							Monument
		11"-5' Boring air knifed and vacuum excavated to 5 feet.								
5		5-6.5' SILT with sand (80% silt, 15% sand, 5% gravel) fine sand, coarse gravel, light grey, medium dense, moist, no odor.	ML		100	5/5/7	1210	MW-21-6-111008	X	Bentonite Seal
										2" PVC Casing
10		10-11.5' SILT with sand (80% silt, 20% sand), fine sand, grey, dense, moist, no odor.	ML		100	7/9/11	142	MW-21-11-111008		
15		15-16.5' SILT with sand (80% silt, 15% sand, 5% gravel), fine sand, fine gravel, grey, medium dense, moist, no odor.	ML		100	7/9/9	161	MW-21-16-111008	X	0.01 Slot PVC Well Screen
20		20-21.5' Silty SAND (80% sand, 15% silt, 5% gravel), fine sand, fine gravel, grey, dense, no odor. @20.8 - 2" well graded medium to coarse gravel layer. Wet at 21'.	SM		80	9/10/12	175	MW-21-21-111008		
		22.5-24' Same as above.	SM		50	10/10/11	84.2	MW-21-23-111008		2/12 Sand Pack
25										

Monument Type: Flush Mount
Casing Diameter (inches): 2.0
Screen Slot Size (inches): 0.01
Screened Interval (ft bgs): 14-24

Well Construction Information

Filter Pack: 2/12 Sand
Surface Seal: Grout
Annular Seal: Bentonite

Ground Surface Elevation (ft): NA
Top of Casing Elevation (ft): 175.93
Boring Abandonment: NA
Surveyed Location: X: NA Y: NA

APPENDIX B
MATERIAL SAFETY DATA SHEETS



SAFETY DATA SHEET

1. Identification

Product identifier	LIQUOX® sodium permanganate
Other means of identification	
SDS number	-
Recommended use	Liquid oxidant recommended for applications that require a concentrated permanganate solution.
Recommended restrictions	Use in accordance with supplier's recommendations.
Manufacturer / Importer / Supplier / Distributor information	
Manufacturer/Supplier	CARUS CORPORATION
Address	315 Fifth Street, Peru, IL 61354, USA
Telephone	815 223-1500 - All other non-emergency inquiries about the product should be directed to the company
E-mail	salesmkt@caruscorporation.com
Website	www.caruscorporation.com
Contact person	Dr. Chithambarathanu Pillai
Emergency Telephone	For Hazardous Materials [or Dangerous Goods] Incidents ONLY (spill, leak, fire, exposure or accident), call CHEMTREC at CHEMTREC®, USA: 001 (800) 424-9300 CHEMTREC®, Mexico (Toll-Free - must be dialed from within country): 01-800-681-9531 CHEMTREC®, Other countries: 001 (703) 527-3887

2. Hazard(s) identification

Physical hazards	Oxidizing liquids	Category 2
Health hazards	Acute toxicity, oral	Category 4
	Skin corrosion/irritation	Category 1B
	Serious eye damage/eye irritation	Category 1
	Specific target organ toxicity, single exposure	Category 3 respiratory tract irritation
OSHA defined hazards	Not classified.	

Label elements



Signal word	Danger
Hazard statement	May intensify fire; oxidizer. Harmful if swallowed. Causes severe skin burns and eye damage. May cause respiratory irritation.
Precautionary statement	
Prevention	Keep away from heat. Take any precaution to avoid mixing with combustibles. Keep/Store away from clothing and other combustible materials. Use only outdoors or in a well-ventilated area. Do not breathe mist or vapor. Wear protective gloves/protective clothing/eye protection/face protection. Do not eat, drink or smoke when using this product. Wash hands thoroughly after handling.
Response	In case of fire: Use water for extinction. If swallowed: Rinse mouth. Do NOT induce vomiting. If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower. Wash contaminated clothing before reuse. If inhaled: Remove person to fresh air and keep comfortable for breathing. Immediately call a poison center/doctor. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
Storage	Store locked up. Store in a well-ventilated place. Keep container tightly closed.
Disposal	Dispose of contents/container in accordance with local/regional/national/international regulations.
Hazard(s) not otherwise classified (HNOC)	Not classified.
Environmental hazards	Hazardous to the aquatic environment, acute hazard Category 1

Supplemental information

Hazard symbol



Hazard statement

Very toxic to aquatic life with long lasting effects.

Precautionary statement

Prevention

Avoid release to the environment.

Response

Collect spillage.

3. Composition/information on ingredients

Mixtures

Chemical name	CAS number	%
Sodium permanganate	10101-50-5	36 - 40

Composition comments

All concentrations are in percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

4. First-aid measures

Inhalation

Remove victim to fresh air and keep at rest in a position comfortable for breathing. For breathing difficulties, oxygen may be necessary. Get medical attention immediately.

Skin contact

Take off immediately all contaminated clothing. (Caution: Solution may ignite certain textiles). Immediately flush skin with plenty of water. Get medical attention immediately. Wash contaminated clothing before reuse.

Eye contact

Contact with skin may leave a brown stain of insoluble manganese dioxide. This can be easily removed by washing with a mixture of equal volume of household vinegar and 3% hydrogen peroxide, followed by washing with soap and water.

Immediately flush with plenty of water for up to 15 minutes. Remove any contact lenses and open eyelids wide apart. Continue rinsing. Get medical attention immediately.

Ingestion

Immediately rinse mouth and drink plenty of water. Never give anything by mouth to a victim who is unconscious or is having convulsions. Do not induce vomiting. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs. Get medical attention immediately.

Most important symptoms/effects, acute and delayed

Contact with this material will cause burns to the skin, eyes and mucous membranes. Permanent eye damage including blindness could result.

Indication of immediate medical attention and special treatment needed

Provide general supportive measures and treat symptomatically. In case of shortness of breath, give oxygen. Decomposition products are alkaline. Brown stain is insoluble manganese dioxide.

General information

In the case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. Show this safety data sheet to the doctor in attendance. For personal protection, see Section 8 of the SDS. Wash contaminated clothing before reuse.

5. Fire-fighting measures

Suitable extinguishing media

Flood with water from a distance, water spray or fog.

Unsuitable extinguishing media

The following extinguishing media are ineffective: Dry chemical. Foam. Carbon dioxide (CO₂). Halogenated materials.

Specific hazards arising from the chemical

May intensify fire; oxidizer. May ignite combustibles (wood, paper, oil, clothing, etc.). Contact with incompatible materials or heat (135 °C / 275 °F) could result in violent exothermic chemical reaction. Oxidizing agent, may cause spontaneous ignition of combustible materials. By heating and fire, corrosive vapors/gases may be formed.

Special protective equipment and precautions for firefighters

Self-contained breathing apparatus and full protective clothing must be worn in case of fire. Selection of respiratory protection for firefighting: follow the general fire precautions indicated in the workplace.

Fire-fighting equipment/instructions

Move container from fire area if it can be done without risk. Cool containers exposed to flames with water until well after the fire is out. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply. Dike fire control water for later disposal. Water runoff can cause environmental damage.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

Keep unnecessary personnel away. Keep upwind. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Avoid inhalation of vapors and contact with skin and eyes. Wear protective clothing as described in Section 8 of this safety data sheet. Local authorities should be advised if significant spillages cannot be contained.

Methods and materials for containment and cleaning up

Keep combustibles (wood, paper, oil, etc.) away from spilled material. Should not be released into the environment. This product is miscible in water. Stop leak if possible without any risk. Dike the spilled material, where this is possible. Proceed with either of the following two options depending upon the size of the spill and the availability of the neutralizing agents:

Option # 1: Dilute to approximately 6% with water, and then reduce with sodium thiosulfate, a bisulfite or ferrous salt solution. The bisulfite or ferrous salt may require some dilute sulfuric acid (10% w/w) to promote reduction. Neutralize with sodium carbonate to neutral pH, if acid was used. Decant or filter and deposit sludge in approved landfill. Where permitted, the sludge may be drained into sewer with large quantities of water.

Option # 2: Absorb with inert media like diatomaceous earth or inert floor dry, collect into a drum and dispose of properly. Do not use saw dust or other incompatible media. Disposal of all materials shall be in full and strict compliance with all federal, state, and local regulations pertaining to permanganates.

To clean contaminated floors, flush with abundant quantities of water into sewer, if permitted by federal, state, and local regulations. If not, collect water and treat as described above.

Never return spills in original containers for re-use. For waste disposal, see Section 13 of the SDS.

Environmental precautions

Do not allow to enter drains, sewers or watercourses. Contact local authorities in case of spillage to drain/aquatic environment.

7. Handling and storage

Precautions for safe handling

Take any precaution to avoid mixing with combustibles. Keep away from clothing and other combustible materials. Do not get this material in your eyes, on your skin, or on your clothing. Do not breathe mist or vapor. Use Personal Protective Equipment recommended in section 8 of the SDS. If clothing becomes contaminated, remove and wash off immediately. Spontaneous ignition may occur in contact with cloth or paper. When using, do not eat, drink or smoke. Good personal hygiene is necessary. Wash hands and contaminated areas with water and soap before leaving the work site. Avoid release to the environment.

Conditions for safe storage, including any incompatibilities

Store locked up. Keep container tightly closed and in a well-ventilated place. Store in a cool, dry place. Store away from incompatible materials (See Section 10). Store in accordance with NFPA 430 requirements for Class II oxidizers.

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value
Sodium permanganate (CAS 10101-50-5)	Ceiling	5 mg/m3

US. ACGIH Threshold Limit Values

Components	Type	Value	Form
Sodium permanganate (CAS 10101-50-5)	TWA	0.1 mg/m3	Inhalable fraction.
		0.02 mg/m3	Respirable fraction.

US NIOSH Pocket Guide to Chemical Hazards: Recommended exposure limit (REL)

Components	Type	Value	Form
Sodium permanganate (CAS 10101-50-5)	TWA	1 mg/m3	Fume.

US NIOSH Pocket Guide to Chemical Hazards: Short Term Exposure Limit (STEL)

Components	Type	Value	Form
Sodium permanganate (CAS 10101-50-5)	STEL	3 mg/m3	Fume.

Biological limit values

No biological exposure limits noted for the ingredient(s).

Exposure guidelines

Follow standard monitoring procedures.

Appropriate engineering controls

Provide adequate general and local exhaust ventilation. An eye wash and safety shower must be available in the immediate work area.

Individual protection measures, such as personal protective equipment

Eye/face protection	Wear safety glasses with side shields (or goggles). Wear face shield if there is risk of splashes.
Skin protection	
Hand protection	Wear chemical-resistant, impervious gloves. Use protective gloves made of: Rubber or plastic. Suitable gloves can be recommended by the glove supplier.
Other	Wear appropriate chemical resistant clothing. Rubber or plastic apron.
Respiratory protection	In case of inadequate ventilation or risk of inhalation of vapors, use suitable respiratory equipment. In the United States of America, if respirators are used, a program should be instituted to assure compliance with OSHA 29 CFR 1910.134.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	When using, do not eat, drink or smoke. Keep from contact with clothing and other combustible materials. Remove and wash contaminated clothing promptly. Wash hands before breaks and immediately after handling the product. Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Appearance	Dark purple liquid.
Physical state	Liquid.
Form	Aqueous solution.
Color	Dark purple.
Odor	Odorless.
Odor threshold	Not available.
pH	5 - 8
Melting point/freezing point	< 24.8 °F (< -4 °C)
Initial boiling point and boiling range	> 213.8 °F (> 101 °C)
Flash point	Does not flash.
Evaporation rate	As water.
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not applicable.
Flammability limit - upper (%)	Not applicable.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	760 mm Hg (105 °C)
Vapor density	Not available.
Relative density	1.37 - 1.4 (20 °C) (Water = 1)
Solubility(ies)	Miscible with water.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.
Other information	
Explosive properties	Not explosive. Can explode in contact with sulfuric acid, peroxides and metal powders.
Oxidizing properties	Strong oxidizing agent.

10. Stability and reactivity

Reactivity	The product is non-reactive under normal conditions of use, storage and transport.
Chemical stability	Stable at normal conditions.
Possibility of hazardous reactions	Contact with combustible material may cause fire. Can explode in contact with sulfuric acid, peroxides and metal powders.
Conditions to avoid	Contact with incompatible materials or heat (135 °C / 275 °F) could result in violent exothermic chemical reaction.

Incompatible materials	Acids. Peroxides. Reducing agents. Combustible material. Metal powders.
Hazardous decomposition products	By heating and fire, corrosive vapors/gases may be formed. Contact with hydrochloric acid liberates chlorine gas.

11. Toxicological information

Information on likely routes of exposure

Ingestion	Harmful if swallowed.
Inhalation	May cause irritation to the respiratory system.
Skin contact	Causes severe skin burns.
Eye contact	Causes serious eye damage.

Symptoms related to the physical, chemical and toxicological characteristics Contact with this material will cause burns to the skin, eyes and mucous membranes. Permanent eye damage including blindness could result.

Information on toxicological effects

Acute toxicity Harmful if swallowed.

Components	Species	Test Results
Potassium permanganate (CAS 7722-64-7)		
Acute		
<i>Dermal</i>		
LD50	Rat	2000 mg/kg
<i>Oral</i>		
LD50	Rat	2000 mg/kg

Toxicity data are not available for sodium permanganate. Toxicity is expected to be similar to that of potassium permanganate.

Skin corrosion/irritation	Causes severe skin burns.
Serious eye damage/eye irritation	Causes serious eye damage.
Respiratory sensitization	Not classified.
Skin sensitization	Not classified.
Germ cell mutagenicity	Not classified.
Carcinogenicity	Not classified.
Reproductive toxicity	Not classified.
Specific target organ toxicity - single exposure	May cause irritation of respiratory tract.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not classified.
Chronic effects	Chronic effects are not expected when this product is used as intended. Prolonged exposure, usually over many years, to manganese oxide fume/dust can lead to chronic manganese poisoning, chiefly affecting the central nervous system.

12. Ecological information

Ecotoxicity Very toxic to aquatic life with long lasting effects.

Components	Species	Test Results
Potassium permanganate (CAS 7722-64-7)		
Aquatic		
Fish	LC50 Bluegill (<i>Lepomis macrochirus</i>)	2.7 mg/l, 96 hours, static
		2.3 mg/l, 96 hours, flow through
		2.3 mg/l, 96 hours
		1.8 - 5.6 mg/l
	Carp (<i>Cyprinus carpio</i>)	3.16 - 3.77 mg/l, 96 hours
		2.97 - 3.11 mg/l, 96 hours
	Goldfish (<i>Carassius auratus</i>)	3.3 - 3.93 mg/l, 96 hours, static
	Milkfish, salmon-herring (<i>Chanos chanos</i>)	> 1.4 mg/l, 96 hours
	Rainbow trout (<i>Oncorhynchus mykiss</i>)	1.8 mg/l, 96 hours

Components	Species	Test Results
		1.08 - 1.38 mg/l, 96 hours
		0.77 - 1.27 mg/l, 96 hours
	Rainbow trout,donaldson trout (Oncorhynchus mykiss)	0.275 - 0.339 mg/l, 96 hours

Toxicity data are not available for sodium permanganate. Toxicity is expected to be similar to that of potassium permanganate.

Persistence and degradability	Expected to be readily converted by oxidizable materials to insoluble manganese oxide.
Bioaccumulative potential	Potential to bioaccumulate is low.
Mobility in soil	The product is miscible with water. May spread in water systems.
Other adverse effects	None known.

13. Disposal considerations

Disposal instructions	Dispose of contents/container in accordance with local/regional/national/international regulations.
Hazardous waste code	D001: Ignitable waste The Waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Do not allow this material to drain into sewers/water supplies. Dispose in accordance with all applicable regulations.
Contaminated packaging	Since emptied containers may retain product residue, follow label warnings even after container is emptied. Rinse container at least three times to an absence of pink color before disposing. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

UN number	UN3214
UN proper shipping name	Permanganates, inorganic, aqueous solution, n.o.s. (Sodium permanganate)
Transport hazard class(es)	5.1
Subsidiary class(es)	-
Packing group	II
Environmental hazards	
Marine pollutant	Yes
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
Special provisions	26, 353, IB2, T4, TP1
Packaging exceptions	152
Packaging non bulk	202
Packaging bulk	242

IATA

UN number	UN3214
UN proper shipping name	Permanganates, inorganic, aqueous solution, n.o.s. (Sodium permanganate)
Transport hazard class(es)	5.1
Subsidiary class(es)	-
Packaging group	II
Environmental hazards	Yes
Labels required	5.1
ERG Code	5L
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.

IMDG

UN number	UN3214
UN proper shipping name	PERMANGANATES, INORGANIC, AQUEOUS SOLUTION, N.O.S. (Sodium permanganate)
Transport hazard class(es)	5.1
Subsidiary class(es)	-
Packaging group	II
Environmental hazards	
Marine pollutant	Yes
Labels required	5.1
EmS	F-H, S-Q
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code Not applicable.

15. Regulatory information

US federal regulations

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

All components are on the U.S. EPA TSCA Inventory List.

CERCLA/SARA Hazardous Substances - Not applicable.

Drug Enforcement Administration (DEA) (21 CFR 1310.02 (b) 8: List II chemical.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

CERCLA Hazardous Substance List (40 CFR 302.4)

Sodium permanganate (CAS 10101-50-5) LISTED

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories
Immediate Hazard - Yes
Delayed Hazard - No
Fire Hazard - Yes
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance No

SARA 311/312 Hazardous chemical Yes

SARA 313 (TRI reporting)

Chemical name	CAS number	% by wt.
Sodium permanganate	10101-50-5	36 - 40
Potassium permanganate	7722-64-7	2

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Sodium permanganate (CAS 10101-50-5)

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

Drug Enforcement Administration (DEA). List 2, Essential Chemicals (21 CFR 1310.02(b) and 1310.04(f)(2) and Chemical Code Number

Sodium permanganate (CAS 10101-50-5) 6588

Drug Enforcement Administration (DEA). List 1 & 2 Exempt Chemical Mixtures (21 CFR 1310.12(c))

Sodium permanganate (CAS 10101-50-5) 15 % wt

DEA Exempt Chemical Mixtures Code Number

Sodium permanganate (CAS 10101-50-5) 6588

Food and Drug Administration (FDA) Not regulated.

US state regulations

This product does not contain a chemical known to the State of California to cause cancer, birth defects or other reproductive harm.

US. Massachusetts RTK - Substance List

Not regulated.

US. New Jersey Worker and Community Right-to-Know Act

Sodium permanganate (CAS 10101-50-5) 500 lbs

US. Pennsylvania RTK - Hazardous Substances

Not regulated.

US. Rhode Island RTK

Sodium permanganate (CAS 10101-50-5)

US. California Proposition 65

US - California Proposition 65 - Carcinogens & Reproductive Toxicity (CRT): Listed substance

Not listed.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes

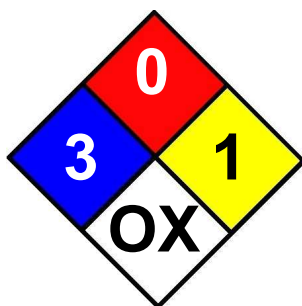
Country(s) or region	Inventory name	On inventory (yes/no)*
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	Yes
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates this product complies with the inventory requirements administered by the governing country(s).

A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date	27-November-2013
Revision date	12-January-2016
Version #	02
NFPA Ratings	



List of abbreviations	LD50: Lethal Dose, 50%. LC50: Lethal Concentration, 50%. TWA: Time weighted average. IATA: International Air Transport Association. IMDG: International Maritime Dangerous Goods. MARPOL: International Convention for the Prevention of Pollution from Ships.
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References	HSDB® - Hazardous Substances Data Bank Registry of Toxic Effects of Chemical Substances (RTECS) IARC Monographs. Overall Evaluation of Carcinogenicity National Toxicology Program (NTP) Report on Carcinogens ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices
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This SDS contains revisions in the following section(s):	This safety data sheet contains revisions in the following section(s): 1, 2, 4, 5, 6, 7, 8, 9, 13, 16.
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RemOX® L ISCO REAGENT

CAS Registry No. 10101-50-5 EINECS NO. 233-251-1 Data Sheet

RemOX® L ISCO reagent has been specifically manufactured for environmental applications such as remediation of soils and associated groundwater. This product can be used to degrade a variety of contaminants including chlorinated solvents, polyaromatic hydrocarbons, phenolics, organo-pesticides, and substituted aromatics. RemOX L is shipped with a certificate of analysis to document assay, pH, and trace metals.

PRODUCT SPECIFICATIONS

Assay:	39.5–41.0% as sodium permanganate (NaMnO_4)
pH:	5.0–8.0
Trace Metals:	(see Table 1)

CHEMICAL/PHYSICAL DATA

Form:	NaMnO_4
Formula Weight:	141.93 g/mol
Appearance:	Dark purple solution
Specific Gravity:	1.365–1.385
Freezing Point:	-15°C / 5°F
Solubility in Water:	Miscible with water in all proportions. Material will pass through a 10 micron filter.

APPLICATIONS

RemOX L is used for soil and groundwater remediation by in situ or ex situ chemical oxidation for treatment of chlorinated ethenes, phenolic compounds, polyaromatic hydrocarbons, RDX, HMX, and various pesticides.

HANDLING, STORAGE & INCOMPATIBILITY

Like any strong oxidizer, RemOX L should be handled with care. Protective equipment during handling should include face shields and goggles, rubber or plastic gloves, and rubber or plastic apron. If clothing comes into contact with RemOX L, wash off immediately; spontaneous ignition can occur with cloth or paper. In cases where significant exposure exists use the appropriate NIOSH/MSHA dust or mist respirator.

Store in accordance with NFPA (National Fire Protection Association) Code 400 Hazardous Materials Code, Chapter 15 - Oxidizer Solids and Liquids in the United States or the European Fire Protection Association in Europe for Class II oxidizers. Additional regulations in Europe are REACH (Regulation for Registration, Evaluation, Authorization and Restriction of Chemicals), and CLP (Classification, Labeling, Packaging). REACH is a regulation that increases the responsibility of the industry to manage the risks that the chemical may pose. For REACH registration numbers, refer to the eSDS. The product should be stored in a cool, dry area in closed containers. Concrete

HANDLING, STORAGE & INCOMPATIBILITY con't

floors are preferred. Check local regulations to ensure proper storage. Avoid wooden decks. Spillage should be collected and disposed of properly. To clean up spills and leaks follow the steps recommended in our Safety Data Sheet (SDS) or eSDS. Avoid contact with acids, peroxides, metal powders, sulfites, oxalates, and all other oxidizable inorganic chemicals. Contact with sulfuric acid, peroxides, or metal powders may result in an explosion. During contact with hydrochloric acid, chlorine gas is liberated. Additionally, avoid contact with reducing agents (e.g., sulfites, oxalates, etc.) as they can cause violent reactions. RemOX L is not combustible, but will support combustion. It may decompose if exposed to intense heat. **Fires may be controlled and extinguished by using large quantities of water. Refer to the SDS or eSDS for more information.**

COMPATIBILITY INFORMATION

RemOX L is compatible with many metals and synthetic materials. Natural rubbers and fibers are often incompatible. Solution pH and temperature are also important factors. The material selected for use with liquid permanganate must be compatible with any kind of acid or alkali being used.

In neutral and alkaline solutions, RemOX L is not corrosive to carbon steel and 316 stainless steel. However, chloride corrosion of metals may be accelerated when an oxidant such as liquid permanganate is present in solution. Plastics such as Teflon™, polypropylene, and HDPE are also compatible with liquid permanganate.

Aluminum, zinc, copper, lead, and alloys containing these metals may be (slightly) affected by RemOX L. Actual corrosion or compatibility studies should be made under the conditions in which RemOX L will be used.



SHIPPING

RemOx® L ISCO reagent is classified and listed as an oxidizer by PHMSA (Pipeline and Hazardous Materials Safety Administration), Department of Transportation, in 49 CFR Subchapter C, HMR (Hazardous Materials Regulation), Part 172.101 HMT (Hazardous Materials Table).

Proper Shipping Name: Permanganates, inorganics, aqueous solution n.o.s. (contains sodium permanganate).
Hazard Class: 5.1
Identification Number: UN 3214
Packaging Group: II
Label Requirements: Oxidizer, 5.1
Packaging Requirements: 49 CFR Parts 171 to 180
Sections: 173.152, 173.202, 173.242

SHIPPING CONTAINERS

5 gallon jerrican (20 L)

Made of high-density polyethylene (HDPE), weighs 3.3 lbs. (1.5 kg). The net weight is 57 lbs. (25.9 kg). The jerrican stands approximately 14.8 inches (37.6 cm) tall, 10.6 inches (26.9 cm) wide, and 11.0 inches (27.9 cm) deep. (Domestic and international) Weight tolerance +/-3%.

55 gallon drum (208 L)

Made of high-density polyethylene (HDPE), weighs 21 lbs. (9.5 kg). The net weight is 550 lbs. (250 kg). The drum stands approximately 34.8 inches (88.3 cm) tall, has an outside diameter of 23.3 inches (59.2 cm). (Domestic and international) Weight tolerance +/-1%.

275 gallon IBC (Intermediate Bulk Container) (1040 L)

IBC weighs 123 lbs. (55.8 kg). The net weight is 3000 lbs. (1361 kg). The IBC contains 263 gallons (996 L) of product. The IBC dimensions are 45.3 inches (114.9 cm) high, 47.3 inches (120.0 cm) long, and 39.4 inches (100.0 cm) wide. The IBC has a 2 inch (5 cm) male butterfly valve with NPS threads in bottom sump. (Domestic and international) Weight tolerance +/-1%.

Bulk Quantities up to 4000 gallons (15,142 L) are available. (Domestic only) Weight tolerance +/-10%.

TABLE 1: TYPICAL TRACE METAL CONTENT & SPECIFICATIONS

Element	Typical analysis (mg/kg)	Specifications (mg/kg)	DL* (mg/kg)	Element	Typical analysis (mg/kg)	Specifications (mg/kg)	DL* (mg/kg)
Ag	BDL**	0.15	0.034	Fe	BDL	2.00	0.053
Al	BDL	2.00	0.24	Hg	BDL	0.03	0.003
As	BDL	4.00	0.006	Ni	BDL	0.1	0.03
Ba	2.96	15.00	0.016	Pb	BDL	0.70	0.16
Be	BDL	0.50	0.08	Sb	BDL	0.70	0.16
Cd	BDL	0.10	0.016	Se	0.19	0.50	0.0003
Cr	3.2	10.00	0.031	Tl	BDL	3.50	0.80
Cu	BDL	0.10	0.022	Zn	BDL	0.40	0.011

DL* = detection limit BDL** = below detection limit



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APPENDIX C

EPA TECHNICAL GUIDANCE

Ground Water Sample Preservation at In-Situ Chemical Oxidation Sites – Recommended Guidelines

Saebom Ko¹, Scott G. Huling^{2,*}, Bruce Pivetz³

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1. INTRODUCTION

In-situ chemical oxidation (ISCO) involves the introduction of a chemical oxidant into the subsurface for the purpose of transforming ground water and/or soil contaminants into less harmful chemical by-products (Huling and Pivetz, 2006; Rivas, 2006; Ferrarese *et al.*, 2008; Kao *et al.*, 2008). Often, ground water samples collected specifically to analyze organic contaminants may contain the oxidant and the organic contaminants in a “binary mixture” (Huling *et al.*, 2011a; Johnson *et al.*, 2012). When organic contaminants and oxidants are commingled in the ground water sample, there is significant potential for oxidative transformation of contaminants to occur after the sample is collected and the results of the sample analysis to become non-representative of in-situ conditions at the time of sampling. Consequently, the quality of the ground water sample may be compromised and a false negative result may occur.

An integral component of ISCO is the collection and analysis of ground water samples to assess ISCO treatment performance. A technical issue faced by Remedial Project Managers is the collection and analysis of representative, high quality ground water samples that can be used to support a site assessment and remedial performance monitoring at sites where ISCO is being deployed. The purpose of this *Issue Paper* is to provide background information and general guidelines involving methods and procedures that can be used to detect whether an oxidant (i.e., permanganate or persulfate) is present in ground water, to approximate the oxidant concentration, and to estimate and deliver the volume or mass of preservative, specifically ascorbic acid, required to preserve the binary mixture ground water sample. The focus of this *Issue Paper* is on permanganate and persulfate, two oxidants that can persist for long periods of time in the subsurface and therefore represent the greatest potential for binary mixture ground water samples. An Appendix to this *Issue Paper* (Recommended Operating Procedures - Preservation of Ground Water Samples at ISCO Sites Using Ascorbic Acid) provides specific details regarding the preservation procedures for use by EPA Regional personnel, contractors, and other environmental professionals engaged in ground water sample collection and analysis.

The guidelines are also applicable to bench-scale studies where oxidants are used to investigate the feasibility of ISCO treatment. For

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example, aqueous samples collected from bench-scale soil reactors are analyzed for organic contaminants, but may also contain the oxidant amended to the reactor to destroy the contaminant. Consequently, the guidelines described below also extend to bench-scale studies where the potential for binary mixture aqueous samples may occur, and are analyzed for organic contaminants.

1.1. Reasons to Sample and Analyze Binary Mixtures

It is often desirable for oxidants in ground water to fully react prior to collecting and analyzing ground water samples for organic contaminants. However, there are circumstances where the collection and analysis of binary mixture ground water samples may not be avoided. These reasons vary widely and some examples include the need to:

- (1) conduct an immediate preliminary assessment of ISCO to validate in-progress treatment performance,
- (2) establish design parameters from interim ISCO pilot-scale studies needed to design full-scale ISCO deployment,
- (3) assess the potential redistribution of the ground water contaminant plume as affected by ISCO activities, and
- (4) evaluate reaction kinetics during oxidative treatment.

Rapid turnaround of field data and information may be needed to meet specified milestones and deadlines for full-scale remedy selection, design, construction, and implementation. In addition, regulatory-driven goals and associated timelines may require rapid completion of pilot-scale testing and full-scale deployment of ISCO. Therefore, a significant emphasis may be placed on the collection of ground water samples at ISCO sites prior to complete reaction of the oxidant (Huling *et al.*, 2011a).

1.2. Binary Mixtures of Oxidant and Organic Contaminants in Ground Water Samples

Heterogeneous distribution of oxidant and contaminants, and hydraulic conductivity variations in heterogeneous aquifers are two main causes of binary mixtures (Figure 1) (Huling *et al.*, 2011a). For example, oxidants and contaminants can enter a monitoring well screen from different lithologic zones. These solutes may be captured as separate solutes from different lithologic zones, or as separate or commingled solutes from the

same lithologic zone. Insufficient contact time (i.e., reaction time) between the oxidant and contaminants prior to, or after, entering the well leads to binary mixtures in the ground water sample.

Commingling of organic contaminants and oxidants in the ground water sample impacts the quality of the ground water sample, but may also impact the analytical instruments used to measure the concentration of analyte(s) in the ground water sample (Johnson *et al.*, 2012). Although rarely reported and documented, the impact of oxidants on analytical instruments is exclusively reported for permanganate and predominantly involves instrument malfunction resulting from $\text{MnO}_2(\text{s})$ -clogged lines and ports. No information was found that documented the impact of hydrogen peroxide or persulfate on analytical instruments despite numerous studies where binary mixtures were analyzed.

1.3. Impact of Binary Mixtures – Previous Studies

A detailed study involving the impact of residual persulfate on the quality of ground water samples was performed (Huling *et al.*, 2011a). A significant decline (49 to 100 percent (%)) in volatile organic compound (VOC) concentrations was measured in unpreserved binary mixture samples using gas chromatography (GC) purge and trap, and GC mass spectroscopy (MS) headspace analytical methods. In that study, preservation of the binary mixture samples was achieved through the addition of ascorbic acid and resulted in 99 to 100% VOC average recovery relative to oxidant-free control samples. Adding high concentrations of ascorbic acid (42 to 420 millimolar (mM)) to the samples did not interfere in the measurement of the VOCs and did not negatively impact the analytical instruments. These results indicated that if persulfate is present in the sample, and the binary sample is not appropriately preserved, the quality of the sample will be compromised. A companion study involving the impact of permanganate on the quality of ground water samples and analytical instruments, and the use of ascorbic acid yielded similar results (Johnson *et al.*, 2012). The results of these studies (Huling *et al.*, 2011a; Johnson *et al.*, 2012) serve as the basis for the guidelines provided in this *Issue Paper*.

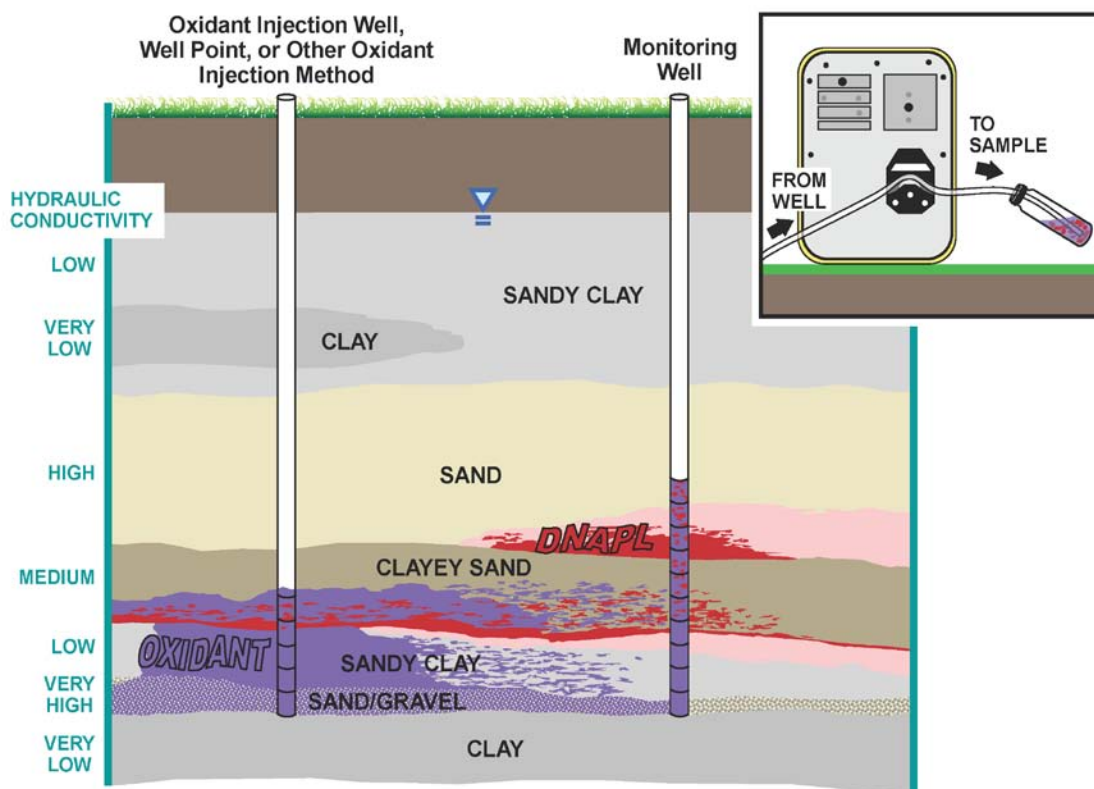


Figure 1. Conceptual model of hydrogeologic, and oxidant and contaminant fate and transport conditions that contribute to binary mixture ground water samples. The oxidant illustrated in purple, conceptually represents any oxidant (permanganate, persulfate) used for in-situ chemical oxidation (Huling *et al.*, 2011a).

The analytical methods used in these studies are commonly used in commercial analytical laboratories. The analytes, including benzene, toluene, xylene (BTX), perchloroethylene (PCE), and trichloroethylene (TCE), are representative of contaminants commonly found at hazardous waste sites. Similarly, empirical results were obtained in the analysis of binary mixtures comprised of persulfate and pentachlorophenol (PCP) by high performance liquid chromatography (HPLC) where significant loss of PCP was measured in unpreserved samples relative to persulfate-free control samples and ascorbic acid-preserved samples (data not included). Currently, we do not have a firm explanation for a viable mechanism responsible for persulfate activation and PCP oxidation in these samples.

Overall, results are applicable to a broad set of analytical methods, analytes, and site conditions. It is unclear to what extent these results extend to analytical methods and contaminants that were not tested in these studies, however. Additional specific studies are needed in cases

where different analytical methods and ground water contaminants are involved.

Specifically, analysis involved the measurement of (1) BTX, PCE, and TCE using the GC/MS headspace method, and (2) BTX using the GC purge and trap method (Huling *et al.*, 2011a). The GC/MS headspace method is involved in EPA Method Nos. 8260C and 5021A. The automated headspace GC/MS method is used to confirm the identity and quantity of purgeable VOCs in water samples in 40 mL volatile organic analysis (VOA) vials. This method is used to quantify over sixty VOCs in drinking water, including aromatics, haloalkenes, haloalkanes, haloaromatics, and fuel oxygenates. This automated method involves the transfer of an aqueous sub-sample (10 mL) to a sealed headspace vial which is heated from room temperature to 80 degrees Celsius (°C) in 30 minutes. A sample of the headspace gas is then transferred to the capillary column in the GC. After separation on the GC column and introduction into the MS, the VOCs are identified and

quantified using the MS. We propose that contaminant loss occurs during the heating step of the sub-sample where residual persulfate is thermally activated resulting in VOC oxidation.

The automated purge and trap GC (Agilent, Model 6890, Wilmington, DE) method was used to quantify BTX in water samples (40 mL VOA vials). This method is most similar to EPA Methods 602 and 8020, but shares similarities with several other EPA methods that involve purge and trap, including: EPA 501, 502.2, 503.1, 524.2, 601, 602, 624, 8010, 8020, 8021, 8240, and 8260. In this method, a sub-sample (10 mL) is transferred to a sparge chamber and purged with helium (6 minutes). The VOCs are transferred to a K VOCARB 3000 Encon trap and dry purged with helium to remove water vapor. The VOCs are thermally desorbed and transferred to the GC column for separation and measurement. Sample transfer is through a heated 1.9 mm×1.0 m Silcosteel (Restek, Bellefonte, PA) transfer line coupled directly to the analytical column. Following separation on the column, the presence of VOCs is determined and quantified with photoionization and flame ionization detectors. It was proposed that the contaminant loss was due to the helium sparging step where aerosols are formed containing persulfate and are transferred to the VOC granular activated carbon trap (Huling *et al.*, 2011a). Subsequently, during the VOC thermal desorption step where the trap is heated from room temperature to 260 °C (25 min), the persulfate residing in the trap is thermally activated resulting in the oxidation of the VOCs immobilized and concentrated on the trap. Similarly, highly efficient oxidation of organics immobilized in solid media (i.e., granular activated carbon) by thermally activated persulfate has been demonstrated (Huling *et al.*, 2011b).

The impact of residual permanganate was evaluated in water samples prepared in the lab using a multi-component standard, and in ground water samples collected at ISCO sites (Johnson *et al.*, 2012). Binary mixture aqueous samples were prepared that contained a 52-component standard of organic compounds and permanganate. Ascorbic acid was added to the binary mixture which reacted rapidly with the MnO_4^- , preserved the sample, and limited the reaction between MnO_4^- and the organic compounds. Consequently, the concentrations of the majority of the compounds in

the multi-component standard were within the control limits established for quality assurance. However, despite timely efforts to preserve the laboratory-prepared binary mixture samples, the quality of the sample was impacted; concentrations were generally lower than oxidant-free controls, and the concentration of several compounds (*cis*-1,3-dichloropropene, styrene, *trans*-1,2-dichloroethene, *trans*-1,3-dichloropropene, vinyl chloride) fell below the applicable lower control limit.

Concentrations of VOCs measured in field-preserved binary mixture ground water samples were greater than in replicate samples refrigerated in the field and preserved with ascorbic acid upon arrival at the lab (Johnson *et al.*, 2012). These results indicate that the VOCs reacted in transit despite refrigeration. Excess ascorbic acid did not negatively impact the quality of the simulated ground water samples containing a 52-component stock standard, or actual ground water samples collected from two field sites, and did not negatively impact the GC/MS instruments used in the analysis.

2. GROUND WATER SAMPLE COLLECTION, OXIDANT MEASUREMENT, AND OXIDANT NEUTRALIZATION/SAMPLE PRESERVATION

Specific details regarding the procedures used in amending ground water samples with ascorbic acid are provided in the Appendix entitled, “Recommended Operating Procedures - Preservation of Ground Water Samples at ISCO Sites Using Ascorbic Acid”.

It is recommended that a representative ground water sample be collected at the well head in a test vial for the specific purpose of measuring the oxidant concentration. Ground water sample collection for this purpose should follow the normal ground water sampling protocol established at the site. This initial screening ground water sample is not collected for the purpose of measuring organic contaminant concentrations. If contaminant analysis of the ground water sample is desired, additional samples must be subsequently collected and preserved, if necessary. Normal sampling procedures appropriate for site conditions and regulatory acceptance are recommended. Sample preservation and handling requirements are based on the type of analyses being performed and should be specified in project-specific documents such as the quality assurance project plan, field sampling

plan, or in general EPA documents such as the Resource Conservation and Recovery Act (RCRA) guidance document (U.S. EPA, 1992) or EPA SW-846 (U.S. EPA, 1982). Additional direction on ground water sampling techniques can be found in Yeskis and Zavala (2002).

2.1. Permanganate (MnO₄⁻)

Data and information presented below are reported in terms of the permanganate anion (MnO₄⁻; 118.9 grams per mole (g/mol)). Permanganate is purchased either as sodium permanganate (NaMnO₄; 141.9 g/mol) or potassium permanganate (KMnO₄; 158.0 g/mol) and as a result conversion to the permanganate anion concentration is needed to determine sample preservation needs as per the *Issue Paper*. Specifically, the ratios 118.9/141.9 (g-mole/g-mole) and 118.9/158.0 (g-mole/g-mole) are used to convert NaMnO₄ and KMnO₄, respectively to MnO₄⁻.

2.1.1. Analysis by Visual Observation

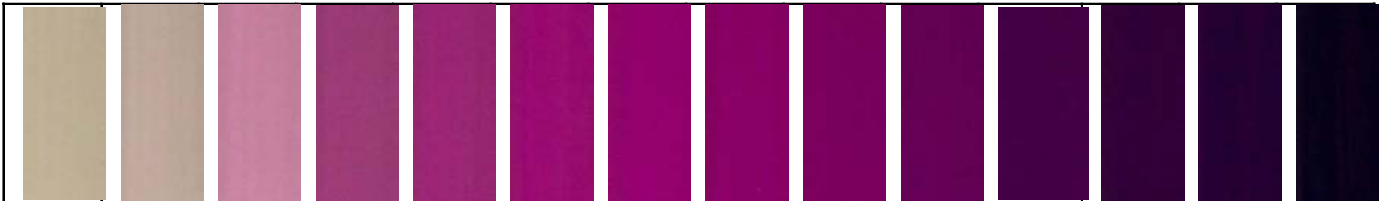
The characteristic pink or purple color of MnO₄⁻ in a 40 mL VOA vial can be used as a general guideline to

estimate the concentration by using the MnO₄⁻ colorimetric scale (Table 1). This method should be used with caution because ground water turbidity and colloidal manganese dioxide solids (MnO₂(s)) can affect sample color and result in deviations from the tabulated color scale. Field filtration can help minimize these interferences, but may not fully remove all color if sub-micron colloidal and/or dissolved constituents are present.

2.1.2. Spectrophotometric Analysis

The permanganate concentration can be determined using commercially available field test kits (SenSafe™, 2011; CHEMetrics, 2011). Additionally, an accurate measurement of the permanganate concentrations can be determined using a field spectrophotometer (maximum absorbance wavelength (λ) = 525 nanometers (nm) (A₅₂₅)) and a calibration curve involving a linear correlation between MnO₄⁻ concentration and A₅₂₅ (Figure 2, Table 1). Filtered samples (0.2-0.45 micron) may be required to eliminate background colloidal or suspended solid materials that can absorb light at 525 nm and interfere with permanganate measurement. Volatilization of

Table 1. Permanganate concentration, spectrophotometric absorbance at 525 nm, and required amount of ascorbic acid required to neutralize the oxidant in a 40 mL vial. The color scale represents actual photos of MnO₄⁻ vials and is included for conceptual guidance. Actual colors vary based on background lighting, and color printers. Additionally, photographs of low concentrations (i.e., clear solutions) do not accurately capture transparency.

													
[MnO ₄ ⁻] (mg/L) (millimolar in parentheses)													
0	0.75	3.8	7.5	11.3	18.8	30.1	37.6	56.4	75.3	113	151	188	376
(0)	(0.01)	(0.03)	(0.06)	(0.09)	(0.16)	(0.25)	(0.32)	(0.47)	(0.63)	(0.95)	(1.27)	(1.58)	(3.16)
Absorbance ⁽¹⁾ , wavelength (λ) = 525 nm													
0	0.011	0.059	0.134	0.197	0.329	0.516	0.627	NL	NL	NL	NL	NL	NL
Ascorbic Acid Stock Solution (M) ⁽²⁾													
-	0.015	0.015	0.15	0.15	0.15	0.15	0.15	1.5	1.5	1.5	1.5	1.5	1.5
Volume of Ascorbic Acid solution (μL)													
0	30	150	30	46	76	121	152	23	30	46	61	76	152
Mass of Ascorbic Acid (mg)													
0	0.08	0.4	0.79	1.21	2.1	3.32	4.17	6.1	7.9	12.2	16.1	20.1	40.2
(1) [MnO ₄ ⁻] (mg/L) = 58.8 × A ₅₂₅ ; A ₅₂₅ is the absorbance at 525 nm; non-linear above 38 mg/L MnO ₄ ⁻ .													
(2) To minimize sample dilution, the ascorbic acid stock solution used was 0.015, 0.15, and 1.5 M.													

contaminants is not a concern since the initial screening ground water sample is used specifically to determine the concentration of permanganate.

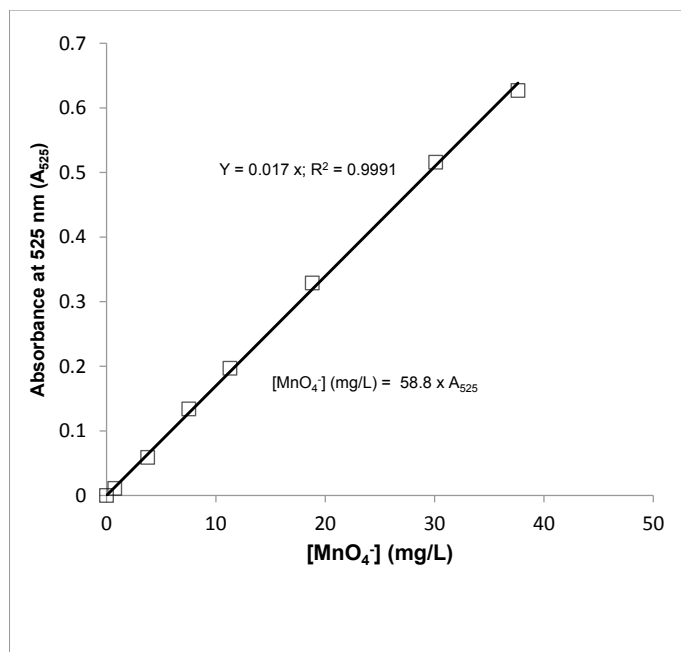


Figure 2. Calibration curve of MnO_4^- concentration versus absorbance at wavelength (λ) of 525 nm.

2.1.3. Results

If MnO_4^- is not detected in the ground water sample, it is recommended that normal ground water sampling and analysis procedures be used. If MnO_4^- is detected, there are two general options to consider. The first option is to delay the collection and analysis of the ground water sample for a sufficient time allowing the MnO_4^- concentration to fully diminish in the subsurface, if desired. In some cases, MnO_4^- persistence is lengthy and this option is not possible (as discussed above in Section 1.1). Due to the site-specific time-dependency of contaminant mass transfer and transport, the time required to approach chemical equilibrium in ground water will likely require additional time after the oxidant is fully consumed. Subsequently, ground water sampling would follow routine guidelines and requirements. The second option is to collect and preserve the ground water sample (i.e., neutralize the oxidant) prior to analysis to minimize the impact of the commingled oxidant. The second option may be desirable for a number of reasons described in Section 1.1.

2.1.4. Oxidant Neutralization and Sample Preservation

Given the MnO_4^- concentration, the volume of ascorbic acid stock solution (0.015, 0.15, or 1.5 mol/L), or weight of crystalline ascorbic acid (176.12 g/mol) required to preserve the binary mixture is determined (Table 1). Sample preservation involves the addition of the appropriate amount of ascorbic acid to preserve a binary mixture in a 40 mL VOA vial. In a lab study (Johnson *et al.*, 2012), the mass of ascorbic acid required to neutralize MnO_4^- ranging in concentration from 1-750 milligrams per liter (mg/L) was determined empirically. The average molar ratio ($n=14$) was 1.64 mol ascorbic acid/mol MnO_4^- and values ranged from 1.45 to 1.75 mol/mol. Therefore, the weight of ascorbic acid that corresponded with the MnO_4^- colorimetric scale was conservatively based on a stoichiometric ratio of 1.8 mol ascorbic acid/mol MnO_4^- , since, as noted below, no negative side-effects were noted with over-dosing. Detailed recommended operating procedures are provided in the Appendix to estimate the volume of crystalline ascorbic acid or ascorbic acid stock solution required to neutralize the MnO_4^- . Once the oxidant is neutralized, it is recommended that normal ground water sample handling and procedures be followed.

The recommended volume and mass of ascorbic acid included in Table 1 is a guideline. The addition of ascorbic acid will rapidly reduce the MnO_4^- concentration and eliminate the pink/purple color. The formation of colloidal or particulate $\text{MnO}_2(\text{s})$ (i.e., Mn^{+4}) may occur causing a brown tinge appearance of the solution. Incremental amendment of ascorbic acid is required to further reduce the Mn^{+4} to Mn^{+2} , and eliminate the brownish tinge color. Mn^{+2} is highly soluble and the most desirable form of Mn to minimize the impact of colloidal or particulate matter on the laboratory analytical instruments. Overall, Table 1 is used as a guideline but the actual amount of ascorbic acid to be added should be based on the amount required to fully eliminate the MnO_4^- and $\text{MnO}_2(\text{s})$, and to achieve a clear solution.

Excess ascorbic acid did not have a negative impact on the quality of the ground water sample involving GC and GC/MS analysis of a broad range of organic chemicals (Johnson *et al.*, 2012). The volume of ascorbic acid solution added to the sample vial should be recorded so

appropriate dilution calculations can be performed to obtain an accurate estimate of the contaminant concentrations. Pre-amending sample vials with ascorbic acid is also an option and is discussed further in Section 7.F of the Appendix. Other sample preservation requirements are based on the analyses being performed and are specified in the quality assurance project plan, field sampling plan, RCRA guidance document (U.S. EPA, 1992) or EPA SW-846 (U.S. EPA, 1982). Additional direction on ground water sampling techniques can be found in Yeskis and Zavala (2002)

2.2. Persulfate ($S_2O_8^{2-}$)

The data and information below are presented in terms of the persulfate anion ($S_2O_8^{2-}$; 192.0 g/mol). However, persulfate is predominantly purchased as sodium persulfate ($Na_2S_2O_8$; 238.1 g/mol). As a result, conversion of sodium persulfate to persulfate anion concentrations is necessary to determine sample preservation needs as per the *Issue Paper*. Specifically, the ratio of 192.0/238.1 (g-mol/g-mol) is used to convert $Na_2S_2O_8$ to $S_2O_8^{2-}$. Persulfate is colorless and requires field measurement at the well head to determine its presence and concentration in the ground water sample.

2.2.1. Analysis by Field Test Kit Colorimetry

Field test kits are commercially available to measure persulfate concentration in aqueous samples (CHEMetrics, 2011; FMC, 2012). CHEMetrics persulfate test kits are available for two sodium persulfate concentration ranges (0-7, 7-70 mg/L). Given the high concentrations of persulfate injected into the subsurface at ISCO sites, significant dilution may be required in the use of these test kits. FMC commercial test kits are dependent on whether the persulfate activator is base or thermal (test kit "K"), or whether persulfate is activated by iron chelates or H_2O_2 (test kit "C") (FMC, 2012). The lower detection limit of persulfate using the current FMC test kits is 500 mg/L, a sufficient quantity of oxidant to significantly impact the concentrations of VOCs and the quality of the sample. Based on the current detection limit using the FMC test kit, it is recommended that the minimum amount of ascorbic acid added to the sample vessel should conservatively account for 500 mg/L persulfate.

2.2.2. Analysis by Spectrophotometric Analysis (Ferrous Ammonium Sulfate (FAS) Method)

A spectrophotometric method can be used to analyze the persulfate concentration in aqueous samples. The ground water sample should be filtered (0.2-0.45 micron) to eliminate background material (i.e., turbidity) that may interfere with $S_2O_8^{2-}$ analysis. A small volume of de-ionized (DI) water (0.9 mL) and sulfuric acid (H_2SO_4) (10 mL, 2.5 normal (N)) (or, add 10.9 mL of 2.3 N H_2SO_4) is placed in a 20 mL glass or plastic test vessel. These can be prepared prior to transport to the field. A blank is prepared by mixing 1 mL DI water with H_2SO_4 (10 mL, 2.5 N). The filtered sample (0.1 mL) is placed in the test vessel, followed by the addition of ferrous ammonium sulfate (FAS) ($Fe(SO_4)_2(NH_4)_2 \cdot 6H_2O$) (0.1 mL, 0.4 N) (prepared immediately before use). Adding a couple drops of H_2SO_4 (conc.) to the FAS reagent increases the stability of the ferrous iron for several more hours (5 to 10 hours). The mixture is swirled/mixed and allowed to react for 30 to 40 minutes. Subsequently, the mixture is amended with ammonium thiocyanate (NH_4SCN) (0.2 mL, 0.6 N) and the absorbance of the solution is analyzed immediately with a spectrophotometer at a wavelength of $\lambda = 450$ nm (A_{450}) (Huang *et al.*, 2002; Huling *et al.*, 2011a; b). The general colorimetric scale provided below can be used to estimate the persulfate concentration in a ground water sample (Table 2) analyzed by the FAS method. Alternatively, a calibration curve involving a linear correlation between $S_2O_8^{2-}$ concentration and A_{450} can be used to determine a more precise estimate of the persulfate concentration (Figure 3).

2.2.3. Results

If $S_2O_8^{2-}$ is not detected in the ground water sample, it is recommended to proceed using normal ground water sampling and analysis procedures. If $S_2O_8^{2-}$ is detected, there are two general options to consider. The first is to delay collection and analysis of the ground water sample for sufficient time which allows the persulfate concentration to fully diminish in the subsurface, if desired. Due to the site-specific time-dependency of contaminant mass transfer and transport, the time required to approach chemical equilibrium in ground water will likely require additional time after the oxidant is fully consumed. Subsequently, ground water sampling would follow routine guidelines. The second option is to collect and

Table 2. Persulfate concentrations resulting from the ferrous ammonium sulfate analytical method involving the spectrophotometric measurement ($\lambda = 450$ nm) of the solution, and the required amount of ascorbic acid required to neutralize the oxidant in a 40 mL vial. The color scale represents actual photos of $S_2O_8^{2-}$ vials and is included for conceptual guidance. Actual colors vary based on background lighting, and color printers. Additionally, photographs of low concentrations (i.e., clear solutions) do not accurately capture transparency.

													
$[S_2O_8^{2-}]$ (mg/L) (millimolar in parentheses)													
0	80	200	400	610	810	1210	1610	2020	2420	2820	3230	3630	4030
0	(0.42)	(1.1)	(2.1)	(3.2)	(4.2)	(6.3)	(8.4)	(10.5)	(12.6)	(14.7)	(16.8)	(18.9)	(21.0)
Absorbance ⁽¹⁾ , wavelength (λ) = 450 nm													
0	0.011	0.019	0.04	0.062	0.076	0.121	0.164	0.204	0.245	0.275	0.313	0.349	0.397
Volume of Ascorbic Acid solution (mL)													
0	0.04	0.11	0.22	0.34	0.45	0.67	0.89	1.12	1.34	1.57	1.79	2.02	2.24
Mass of Ascorbic Acid (176.12 g/mol) (g)													
0	0.01	0.03	0.06	0.09	0.12	0.18	0.24	0.3	0.35	0.41	0.47	0.53	0.59
(1) Solubility of ascorbic acid in water = 330 g/L (1.87 mol/L); 80% solubility (1.5 mol/L) used as stock solution; $[S_2O_8^{2-}]$ (mg/L) = $10,000 \times A_{450}$; where A_{450} is the absorbance at 450 nm.													

preserve the ground water sample prior to analysis to minimize the impact of persulfate on the ground water sample. The second option may be desirable for a number of reasons described in Section 1.1.

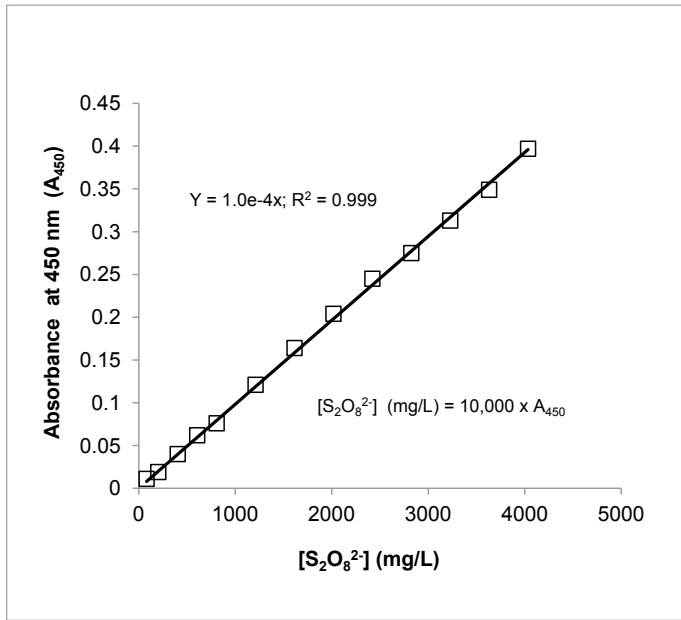


Figure 3. Calibration curve for $S_2O_8^{2-}$ concentration versus absorbance at wavelength 450 nm using the ferrous ammonium sulfate method.

2.2.4. Oxidant Neutralization and Sample Preservation

Guidelines for the volume of ascorbic acid stock solution (1.5 mol/L) or the weight of crystalline ascorbic acid (176.1 g/mol) required to preserve the binary mixture in a 40 mL sample vial are provided (Table 2). The mass of ascorbic acid that corresponds with the persulfate colorimetric scale is based on a stoichiometric ratio of 4 mol ascorbic acid/mol persulfate and was determined empirically in a laboratory study (Huling *et al.*, 2011a). Detailed recommended operating procedures are provided in the Appendix to estimate the volume of crystalline ascorbic acid or ascorbic acid stock solution required to neutralize the $S_2O_8^{2-}$. This stoichiometric ratio is in excess of the ideal stoichiometry for mineralization of persulfate by ascorbic acid. Excess ascorbic acid (4 – 40 mol ascorbic acid/mol persulfate) did not have a negative impact on the quality of the ground water sample involving GC and GC/MS analysis of BTX, TCE, and PCE (Huling *et al.*, 2011a). The basis for this quantity of ascorbic acid is to achieve favorable reaction kinetics between $\cdot SO_4^-$ and ascorbic acid, relative to the reaction between the sulfate radical ($\cdot SO_4^-$) and the VOCs. Following oxidant neutralization, it is recommended that other approved sample preservation and handling methods

in ground water sample handling be performed. For example, acidification of the sample is normally carried out to minimize biochemical and reduction reactions. Other sample preservation requirements are based on the analyses being performed and are specified in the quality assurance project plan, field sampling plan, RCRA guidance document (U.S. EPA, 1992) or EPA SW-846 (U.S. EPA, 1982). Additional direction on ground water sampling techniques can be found in Yeskis and Zavala (2002).

3. ADDITIONAL INFORMATION

It is recommended that the analytical laboratory be notified that the aqueous samples contain residual persulfate or permanganate and were preserved with ascorbic acid. The volume of ascorbic acid solution added to the sample should be recorded so the appropriate calculations can be used to correct for dilutions. If $\text{MnO}_2(\text{s})$ has settled on the bottom of the VOA vial, it is important that the sample not be disturbed prior to analysis. This precaution in sample handling prevents the suspension of the $\text{MnO}_2(\text{s})$ particles and the potential for accidental injection into the analytical instruments.

Other preservatives have been used to successfully neutralize these oxidants, but may negatively impact the quality of the sample (Huling *et al.*, 2011a). Despite efforts used to neutralize the oxidant and to preserve the quality of the ground water sample, the presence of oxidant in ground water samples introduces uncertainty in the precise measurement of contaminant concentrations in the subsurface. This is attributed to the potential impact of the oxidant on contaminant concentrations in the ground water sample prior to neutralization, the transient nature of contaminant fate and transport in the subsurface where ISCO activities were deployed, and the site-specific oxidant injection and hydrogeologic conditions contributing to binary mixtures. Consequently, additional ground water sample collection and analysis will likely be required to achieve an accurate evaluation of post-ISCO performance, and regulatory adherence with US EPA ground water compliance monitoring requirements.

Numerous examples exist where elevated permanganate and VOC concentrations have been measured in ground water samples collected over extended periods of time at

hazardous waste sites. It can be concluded from a simple kinetic analysis that long term VOC persistence can primarily be explained by spatial separation between the ground water containing the oxidant and contaminant (Figure 1) (Johnson *et al.*, 2012). Ground water samples derived from wells screened over spatially separate vertical intervals indicate an in-well mixture of ground water containing either oxidants or contaminants. Limited contact between the oxidant and contaminant within the same lithologic unit can be due to specific mass transfer or mass transport conditions including the dissolution of non-aqueous phase liquids (NAPLs) or slow diffusion of contaminants from low permeability materials. These fate and transport conditions indicate the oxidant has not been uniformly delivered to the contaminated zone(s). A critical analysis of screened intervals, injection intervals, contaminated intervals, oxidant and contaminant transport characteristics, and ground water sample results from analyzing preserved binary mixtures, could provide valuable insight for the development of a more accurate site conceptual model that could be used to design and deploy a more effective oxidant delivery system.

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Appendix Recommended Operating Procedures - Preservation of Ground Water Samples at ISCO Sites Using Ascorbic Acid

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1. PURPOSE (SCOPE AND APPLICATION)

The commingling of organic contaminants and oxidants in ground water or aqueous samples represents a condition in which there is significant potential for oxidative transformation of the contaminants after the sample is collected. Consequently, the quality of the ground water or aqueous sample may be compromised and a false negative result may occur. These recommended operating procedures describe the steps used to preserve ground water samples containing the oxidants permanganate (MnO_4^-), or persulfate ($\text{S}_2\text{O}_8^{2-}$) and organic contaminants of concern (COCs) prior to analysis. It is applicable for ground water samples containing volatile and non-volatile organic contaminants to be analyzed by

gas chromatography (GC), or gas chromatography-mass spectroscopy (GC-MS), using either the purge and trap or headspace sample introduction methods, and high performance liquid chromatography (HPLC).

These procedures are also applicable to bench-scale studies where oxidants are used to investigate the feasibility of ISCO treatment. For example, aqueous samples collected from bench-scale soil reactors are analyzed for organic contaminants, but may also contain the oxidant amended to the reactor to destroy the contaminant. Consequently, the guidelines and general procedures described below also extend to bench-scale studies where the potential for binary mixture aqueous samples may occur, and are analyzed for organic contaminants.

2. METHOD SUMMARY

Based on the measured or estimated oxidant concentration in a ground water or aqueous sample, a specific quantity of the preservative, ascorbic acid, is added to the ground water or aqueous sample to either neutralize or to limit the impact of the residual oxidant on the quality of the sample. Tables 1 and 2 in the *Issue Paper* are used as guidelines to estimate the amount of ascorbic acid to add to a 40 mL VOA vial to preserve binary mixture ground water and/or aqueous samples.

3. REAGENTS

Ascorbic Acid ($\text{C}_6\text{H}_8\text{O}_6$; 176.1 g mol^{-1})

De-ionized (DI) water

Ferrous ammonium sulfate (FAS) reagents – sulfuric acid (H_2SO_4), ferrous ammonium sulfate ($\text{Fe}(\text{SO}_4)_2(\text{NH}_4)_2 \cdot 6\text{H}_2\text{O}$), ammonium thiocyanate (NH_4SCN).

4. EQUIPMENT/APPARATUS

Pipette, volumetric flasks, spectrophotometer (or field test kits)

SenSafe™ or CHEMetrics field test kits for permanganate measurement (if used), or direct measurement.

CHEMetrics or FMC field test kits for persulfate measurement (if used), or measurement using FAS method.

5. HEALTH AND SAFETY PRECAUTIONS

The Materials Safety Data Sheet for ascorbic acid indicates potentially acute health effects: slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. In case of skin contact: wash

with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used. Other guidelines are available based on exposure (<http://www.sciencelab.com/msds.php?msdsId=9922972>). It is recommended to wear gloves and safety glasses during all of the procedures described herein due to the potential for exposure to oxidants, impacted ground water sample, and other chemicals involved in these procedures. Always consult site-specific health and safety plans prior to sampling.

6. INTERFERENCES

Colloidal and/or suspended solids in ground water samples may adsorb light and interfere with the measurement of oxidant concentration. For this reason, the ground water sample may require filtration (0.2-0.45 μm) to eliminate background material (i.e., turbidity).

7. PROCEDURES

A. Ascorbic Acid

Prepare ascorbic acid stock solution either in the lab prior to ground water sampling, or in the field. The appropriate use of these stock solutions is dependent on concentrations of the oxidant measured in the ground water samples. The stock solution should be stored in a refrigerator or cooler until used, and discarded after 150 days.

High Concentration Stock Solution: 1.5 M ascorbic acid (e.g., add 264 g of ascorbic acid (MW=176.1 g/mol) to 1L volumetric flask and fill with DI water). This stock solution can be diluted in the preparation of 0.015 and 0.15 M ascorbic acid stock solutions.

Medium Concentration Stock Solution: 0.15 M ascorbic acid: Dilute 1.5 M ascorbic acid stock solution 1:10 (e.g., dilute 100 mL of 1.5 M stock solution to 1L with DI water).

Low Concentration Stock Solution: 0.015 M ascorbic acid: Dilute 1.5 M ascorbic acid stock solution 1:100 (e.g., dilute 10 mL of 1.5 M stock solution to 1L with DI water).

B. Sample Filtration

Filter the ground water or aqueous sample using 0.2–0.45 μm filter (as needed in accordance with the

site QAPP or Sampling and Analysis Plan) to eliminate background material (i.e., turbidity) that may interfere with oxidant analysis.

C. Concentration Measurement

Determine the oxidant concentrations (permanganate or persulfate) through one of three methods below.

- 1) Commercially available test kits
 - a. Permanganate: SenSafe™ or CHEMetrics
 - b. Persulfate: CHEMetrics or FMC
- 2) UV-VIS absorbance
 - a. Permanganate (direct measurement): wavelength = 525 nm
 - b. Persulfate (Ferrous Ammonium Sulfate method): wavelength = 450 nm (Huang *et al.*, 2002; Huling *et al.*, 2011)
- 3) Colorimetric scales presented in Tables 1 and 2.

Based on the oxidant concentration determined, ascorbic acid stock solution is added to an empty sample vial according to Tables 1 and 2.

D. Quality Assurance and Quality Control (QA/QC)

Quality control includes regularly scheduled analysis of method blanks and sample replicates, and the verification of stock solutions of known concentration via the analysis for concentrations of secondary solutions prepared from the stocks. Results of the analyses of method blanks, replicate analyses, and the verification of stock solution concentrations are logged and maintained in record books specific to the research being conducted. The frequency, control limits, and corrective actions should be appropriately developed for specific applications.

E. Calculations

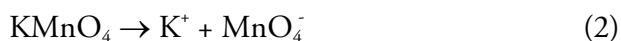
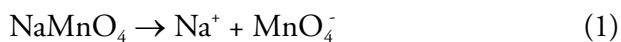
- 1) Concentration conversion

- a. Permanganate.

The concentrations of permanganate (MnO_4^-) have been presented in terms of the permanganate anion (118.9 g/mol) (Table 1). However, permanganate is purchased either as sodium permanganate (NaMnO_4 ; 141.9 g/mol) or potassium permanganate (KMnO_4 ; 158.0 g/mol) and as a result conversion to permanganate anion concentrations may be desired to determine

adequate sample preservation needs. Specifically, the ratios 118.9/141.9 (0.84) and 118.9/158.0 (0.75) are used to convert NaMnO₄ and KMnO₄ respectively, to MnO₄⁻ (Table A1).

Because 1 mmole of either sodium or potassium permanganate produces 1 mmole of permanganate (Eqs 1 and 2), the molar concentrations of sodium and potassium permanganate are the same as permanganate (Table 3).



Converting sodium and potassium permanganate concentrations from mg/L to millimolar, and calculating their permanganate equivalence,

$$\begin{aligned} X \text{ mg/L NaMnO}_4 &= \\ (X \text{ mg/L}) \times (1 \text{ mmol}/141.9 \text{ mg}) &= \\ X/141.9 \text{ mM NaMnO}_4 &= \\ X/141.9 \text{ mM MnO}_4^- &= \\ ((X/141.9) \text{ mmol/L}) \times (118.9 \text{ mg/mmol}) &= \\ 0.84X \text{ mg/L MnO}_4^- & \end{aligned}$$

NOTE: 1 mmol = 0.001 mol; mM= mmol/L

$$\begin{aligned} Y \text{ mg/L KMnO}_4 &= \\ (Y \text{ mg/L}) \times (1 \text{ mmol}/158.0 \text{ mg}) &= \\ Y/158.0 \text{ mM KMnO}_4 &= \\ Y/158.0 \text{ mM MnO}_4^- &= \\ ((Y/158.0) \text{ mmol/L}) \times (118.9 \text{ mg/mmol}) &= \\ 0.75Y \text{ mg/L MnO}_4^- & \end{aligned}$$

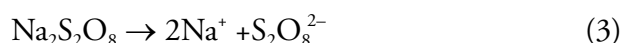
NOTE: 1 mmol = 0.001 mol; mM= mmol/L

b. Persulfate.

The concentration of persulfate is presented in terms of

the persulfate anion (S₂O₈²⁻; 192.0 g/mol) (Table A2). However, persulfate is purchased as sodium persulfate (Na₂S₂O₈; 238.1 g/mol) and as a result a conversion may be desired to correct for the anionic form of the oxidant and to determine adequate sample preservation needs. Specifically, the ratio of 192.0/238.1 (0.81) is used to convert Na₂S₂O₈ to S₂O₈²⁻. Persulfate is colorless and requires field measurement at the well head to determine its presence and concentration in the ground water sample.

Converting sodium persulfate concentrations from mg/L to millimolar, and calculating the persulfate equivalence,



$$\begin{aligned} Z \text{ mg/L Na}_2\text{S}_2\text{O}_8 &= \\ (Z \text{ mg/L}) \times (1 \text{ mmol}/238.1 \text{ mg}) &= \\ Z/238.1 \text{ mM Na}_2\text{S}_2\text{O}_8 &= \\ Z/238.1 \text{ mM S}_2\text{O}_8^{2-} &= \\ Z/238.1 \text{ mM S}_2\text{O}_8^{2-} &= \\ (Z/238.1) \text{ mmol/L} \times (192 \text{ mg/mmol}) &= \\ 0.81Z \text{ mg/L S}_2\text{O}_8^{2-} & \end{aligned}$$

2) Required volume and mass of ascorbic acid to neutralize oxidants.

a. Permanganate.

1.8 mole ascorbic acid per mole of permanganate was empirically determined to effectively neutralize permanganate in an aqueous sample containing VOCs (Johnson *et al.*, 2012). Therefore, the mass balance equation (Eq 4) can be set up as follows,

$$1.8C_{\text{MnO}_4^-}V_{\text{MnO}_4^-} = C_{\text{H}_2\text{A}}V_{\text{H}_2\text{A}} \quad (4)$$

Where,

C_{MnO4-} = permanganate concentration determined in step 7.C,

Table A1. Corresponding concentration of sodium permanganate and potassium permanganate to permanganate.

NaMnO ₄	mg/L	0.90	4.5	9.0	13.5	22.4	35.9	44.9	67.3	89.9	135	180	224	449
	mM	0.006	0.032	0.063	0.095	0.16	0.25	0.32	0.47	0.63	0.95	1.27	1.58	3.16
KMnO ₄	mg/L	1.00	5.0	10.0	15.0	25.0	40.0	50.0	74.9	100	150	201	250	500
	mM	0.006	0.032	0.063	0.095	0.16	0.25	0.32	0.47	0.63	0.95	1.27	1.58	3.16
MnO ₄ ⁻	mg/L	0.75	3.8	7.5	11.3	18.8	30.1	37.9	56.4	75.3	113	151	188	376
	mM	0.006	0.032	0.063	0.095	0.16	0.25	0.32	0.47	0.63	0.95	1.27	1.58	3.16

Table A2. Corresponding concentration of sodium persulfate to persulfate ($S_2O_8^{2-}$).

$Na_2S_2O_8$	mg/L	99	248	496	756	1004	1500	1996	2504	3000	3496	4004	4500	4996
	mM	0.42	1.0	2.1	3.2	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0
$S_2O_8^{2-}$	mg/L	80	200	400	610	810	1210	1610	2020	2420	2820	3230	3630	4030
	mM	0.42	1.0	2.1	3.2	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0

$V_{MnO_4^-}$ = volume of permanganate solution in the VOA vial (0.04 L),

C_{H_2A} = ascorbic acid concentration (0.015, 0.15 or 1.5 M), and

V_{H_2A} = volume of ascorbic acid required to neutralize permanganate.

V_{H_2A} can be calculated (Eq 5) through rearranging Eq. (4)

$$V_{H_2A} = (1.8 \times C_{MnO_4^-} \times V_{MnO_4^-}) / C_{H_2A} \quad (5)$$

For example, a 40 mL permanganate concentration of 1.27mM (151 mg/L) is neutralized using 1.5 M ascorbic acid. The volume of stock solution and mass of ascorbic acid can be calculated as follows.

$$V_{H_2A} = (1.8 \times 1.27 \text{ mmol/L} \times 0.04\text{L} / 1.5 \text{ mol/L}) \times (1 \text{ mol} / 1000 \text{ mmol}) \times (10^6 \text{ } \mu\text{L} / 1\text{L}) = 61 \text{ } \mu\text{L}$$

$$M_{H_2A} = 1.5 \text{ mol/L} \times 61 \text{ } \mu\text{L} \times (1\text{L} / 10^6 \text{ } \mu\text{L}) \times (176.12 \text{ g/mol}) \times (1000 \text{ mg/g}) = 16.1 \text{ mg}$$

Where,

M_{H_2A} = mass of ascorbic acid

The formation of colloidal or particulate $MnO_2(s)$ (i.e., Mn^{+4}) may occur causing a brown tinge appearance of the solution. Incremental amendment of ascorbic acid may be required to further reduce the Mn^{+4} to Mn^{+2} , and eliminate the brownish tinge color. Mn^{+2} is highly soluble and the most desirable form of Mn to minimize the impact of colloidal or particulate matter on the laboratory analytical instruments. Overall, Table 1 is used as a guideline but the actual amount should be based on the amount required to fully eliminate the MnO_4^- and $MnO_2(s)$, and to achieve a clear solution. The volume of ascorbic acid solution added to the sample vial should be recorded so appropriate dilution calculations can be performed to obtain an accurate estimate of the contaminant concentrations.

b. Persulfate.

4 mole of ascorbic acid per mole of persulfate was

empirically determined to effectively limit the impact of the oxidant on VOCs in aqueous samples (Huling *et al.*, 2011). Therefore, the mass balance equation (Eq 6) can be set up as follows,

$$4C_{S_2O_8^{2-}} \cdot V_{S_2O_8^{2-}} = C_{H_2A} V_{H_2A} \quad (6)$$

Where,

$C_{S_2O_8^{2-}}$ = persulfate concentration determined in step 7. $C_{S_2O_8^{2-}}$ = persulfate concentration determined in step 7. $V_{S_2O_8^{2-}}$ = volume of persulfate solution in the VOA vial 0.04 L,

C_{H_2A} = ascorbic acid concentration (1.5 M),

V_{H_2A} = volume of ascorbic acid required to neutralize persulfate

V_{H_2A} can be calculated (Eq 7) through rearranging Eq. (6)

$$V_{H_2A} = (4 \times C_{S_2O_8^{2-}} \times V_{S_2O_8^{2-}}) / C_{H_2A} \quad (7)$$

For example, persulfate concentration is 10.5 mM (2020 mg/L) and neutralized using 1.5 M ascorbic acid. The volume of stock solution and mass of ascorbic acid can be calculated as follows.

$$V_{H_2A} = (4 \times 10.5 \text{ mmol/L} \times 0.04\text{L} / 1.5 \text{ mol/L}) \times (1 \text{ mol} / 1000 \text{ mmol}) \times (1000 \text{ mL} / 1\text{L}) = 1.12 \text{ mL}$$

$$M_{H_2A} = 1.5 \text{ mol/L} \times 1.12 \text{ mL} \times (1 \text{ L} / 1000 \text{ mL}) \times (176.12 \text{ g/mol}) = 0.3 \text{ g}$$

Where,

M_{H_2A} = mass of ascorbic acid

The volume of ascorbic acid solution added to the sample vial should be recorded so appropriate dilution calculations can be performed to obtain an accurate estimate of the contaminant concentrations.

F. Pre-amending Sample Vials With Preservative

Pre-amending the 40 mL sample vials prior to performing ground water sample collection in the field is one step that may help simplify sample preservation procedures. The advantage is that all sample vials are

amended with the preservative in a uniform manner, and this reduces the number of steps and time required during ground water sampling activities in the field. Specifically, this would involve amending the sample vial with an appropriate quantity of ascorbic acid using the procedures recommended above. Successful sample preservation would be immediately obvious in the case with permanganate binary mixtures as the pink/purple color would disappear and the sample would become clear. A persistent pink/purple or brown tinge color would indicate the need for additional preservative. The immediate visual feedback would not occur in the preservation of persulfate binary mixtures due to the absence of oxidant coloration. Success of the preservation method will most likely require prior knowledge of oxidant concentrations in ground water samples to support the selection of an appropriate quantity of preservative. A quality assurance step could include the collection of duplicate samples, and subsequent analysis for persulfate, when time permits, to confirm that a sufficient quantity of preservative was amended. Other appropriate quality assurance steps could be developed.

8. REFERENCES

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9. DISCLAIMER

This recommended operating procedure has been prepared for general use. This is not an official approved U.S. Environmental Protection Agency method and has not undergone the Agency's peer review process.



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