Shallow Soil and Groundwater Treatment Work Plan

318 State Avenue
Olympia, Washington

for
City of Olympia

July 3, 2017

GeoEngineers
Earth Science + Technology

Shallow Soil and Groundwater Treatment Work Plan

318 State Avenue
Olympia, Washington

for
City of Olympia

July 3, 2017

GeoEngineers

1101 South Fawcett Avenue, Suite 200
Tacoma, Washington 98402
253.383.4940

Shallow Soil and Groundwater Treatment Work Plan

318 State Avenue
Olympia, Washington

File No. 0415-049-07

July 3, 2017

Prepared for:

City of Olympia
P.O. Box 1967
Olympia, Washington 98507-1967

Attention: Danelle MacEwen

Prepared by:

GeoEngineers, Inc.
1101 South Fawcett Avenue, Suite 200
Tacoma, Washington 98402
253.383.4940

Garrett R. Leque, LG
Senior Environmental Scientist

Abhijit R. Joshi, PE
Senior Environmental Engineer

Iain H. Wingard
Associate, Environmental Scientist

IHW:GRL:ARJ:ch:tt

GeoEngineers

Table of Contents

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

This Treatment Work Plan describes in-situ shallow soil and groundwater treatment activities to be performed by the City of Olympia (City) to remediate residual chlorinated compounds present at the 318 State Avenue NE property (Property) in Olympia, Washington. This Work Plan also describes groundwater sampling and analysis to be performed to monitor the performance of treatment activities and concentrations of chlorinated compounds in groundwater at the Property. The in-situ shallow soil and groundwater treatment is being completed to achieve cleanup levels in groundwater and to obtain a No Further Action (NFA) designation for the Property under the Washington State Department of Ecology's (Ecology's) Voluntary Cleanup Program (VCP). The location of the Property is shown in Figure 1. Ecology's Facility/Site Number for the project is 3024394, Cleanup Site Number is 2010 and VCP Project Number is SW1013.

Remedial actions were performed at the Property in 2009 to remove soil and fill material containing chlorinated compounds as well as other contaminants. Monitoring of the natural attenuation of chlorinated solvents and degradation products in groundwater has been performed at the Property since the completion of the remedial actions for soil. Residual concentrations of chlorinated solvents and degradation products have been detected at concentrations greater than cleanup and screening levels in groundwater collected from Property during the monitoring. The objective of the treatment described in this Work Plan is to reduce the concentrations of chlorinated solvents and associated degradation products to below cleanup and screening levels. Treatment includes subsurface injection of chemical reagents and microorganisms to accelerate in-situ degradation of the chlorinated compounds at the Property.

2.0 BACKGROUND

2.1. Remedial Action and Monitoring Methods

Remedial actions were performed at the Property in 2009 to remove soil and fill material from two areas (Contaminated Soil Zones 1 and 2 [CSZ 1 and CSZ 2] on Figure 2) containing volatile organic compounds (VOCs) including chlorinated compounds, metals and carcinogenic polycyclic aromatic compounds (cPAHs) at concentrations greater than the Model Toxics Control Act (MTCA) cleanup levels. Soil samples were collected from the boundary of the remedial action areas to confirm that soil and fill with contaminant concentrations greater than cleanup levels were removed from the remedial excavations. The results of the soil remedial actions are presented in the Remedial Action Construction Report prepared for the Property (GeoEngineers 2010).

Groundwater monitoring has been performed regularly since completion of soil remedial actions to monitor the natural attenuation of residual chlorinated compounds in groundwater at the Property. The residual chlorinated compounds include tetrachloroethylene (PCE), trichloroethylene (TCE), cis-1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE) and vinyl chloride. Groundwater monitoring has been documented in groundwater monitoring reports completed after each event. Groundwater monitoring at the Property has generally included the following:

- Installation and monitoring of wells at the Property. Monitoring wells at the Property have been installed as part of the remedial investigation of the Property and after the remedial action for soil to monitor the natural attenuation of chlorinated compounds in groundwater (Figure 2). With the concurrence of

Ecology, the number of wells monitored and monitoring frequency have been reduced over time as natural attenuation has occurred.[1] A new well, MW-19, was installed in July 2015 at the request of Ecology to monitor groundwater from the southeast portion of the Property. The most recent groundwater monitoring event that was completed at the Property, at the time this Work Plan was prepared, was performed in February 2016 and the results are presented in Groundwater Compliance Monitoring Data Summary Report – February 2016 (GeoEngineers 2016). The February 2016 Groundwater Monitoring Report provides additional information concerning the background and results of groundwater monitoring at the Property.

- Chemical analysis for chlorinated organic solvents and associated degradation products including PCE, TCE, 1,1-dichloroethene (1,1-DCE), cis-DCE, trans-DCE and VC.
- Comparison of the chemical analytical results to MTCA groundwater cleanup levels protective of the highest beneficial use for groundwater which is as marine surface water (GeoEngineers 2015a). The results were also compared to the MTCA Method B groundwater screening level protective of soil vapor intrusion provided in Ecology's Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State (Ecology 2009) as updated in April 2015 to revise the soil gas screening levels provided in Appendix B of the guidance document (Ecology 2015).
- Monitoring for indicators of natural attenuation and water quality parameters including ferrous iron, sulfate, dissolved oxygen (DO), pH, electrical conductivity, salinity, total dissolved solids (TDS), turbidity, temperature and oxidation-reduction potential (ORP).
- Monitoring of groundwater gradients across the Property, quarterly from May 2010 through February 2012 by measuring water levels at all existing monitoring wells. Groundwater level measurements in 2011/2012 have been used to create potentiometric surface maps, which indicate that groundwater generally flows to the north at the Property (Figures 3 through 6). Depth-to groundwater fluctuates between about 3 and 5 feet below ground surface (bgs) (i.e., Elevation 6.5 to 8.5 feet mean sea level).

2.2. Results of Remedial Actions and Monitoring

Residual chlorinated compounds have been detected in groundwater following the remedial actions for soil in 2009. Contaminant concentrations have decreased in most wells to below cleanup levels. However, residual concentrations of predominantly TCE and/or chlorinated compounds resulting from the degradation of TCE including cis-DCE, trans-DCE and VC continue to be detected in groundwater collected from monitoring wells MW-03, MW-16, MW-18 and MW-19. TCE has exceeded the MTCA screening level for protection of soil vapor intrusion in groundwater from wells MW-03 and MW-19. VC concentrations have exceeded the MTCA cleanup and/or screening level in groundwater from at all four wells. Table 1 summarizes the results for the chemical analyses performed between 2010 and 2016 at wells MW-03, MW-16, and MW-18 as well as the results for analyses performed between July 2015 and May 2016 at MW-19. The results in Table 1 are compared to the cleanup and screening levels described in Section 2.1. The detected chlorinated compound concentrations are plotted through time on Figures 7 through 10.

---

[1] Monitoring occurred in eight wells starting in 2010 (MW-03, MW-04, MW-08, MW-09, MW-13, MW-16, MW-17 and MW-18); five wells starting in 2011 (MW-03, MW-08, MW-16, MW-17 and MW-18); and three wells starting in 2014 (MW-03, MW-16, and MW-18). Wells MW-04 and MW-17 have been decommissioned, as discussed in the report titled "MW-19 Quarterly Groundwater Monitoring Report" (GeoEngineers 2016)

The following summarizes the results of trend analysis for MW-03, MW-16, MW-18 and MW-19:

- MW-03 – Monitoring well MW-03 is located downgradient/crossgradient of the soil remedial action area on the southeast portion of the Property (CSZ 1) (Figure 2). The concentrations of chlorinated compounds have fluctuated (i.e., increased and decreased) in groundwater at MW-03 between the soil remedial action and 2016 (Figure 7 and Table 1). Higher concentrations of chlorinated compounds are generally present in groundwater at MW-03 in the winter when groundwater levels are higher (Figure 7 and Tables 1 and 2). It is likely that high groundwater levels entrain residual chlorinated compounds present in vadose zone soil in proximity to MW-03 that are not normally in contact with groundwater. However, the VC concentration in groundwater at MW-03 in February 2016 (0.19 µg/L) was below the MTCA cleanup level for protection of surface water and screening level for soil vapor intrusion. The February 2016 groundwater sample result at MW-03 is the first time VC has been detected at a concentration less than the MTCA cleanup level for protection of surface water and screening level for soil vapor intrusion during monitoring performed in the winter. The concentration of TCE continues to periodically be detected at concentrations greater than the MTCA screening level for soil vapor intrusion during sampling events performed in the winter (i.e., February 2016, February 2014 and February and November 2011) but is less than the cleanup level for protection of surface water (7 µg/L). PCE and DCE are either not detected or are detected at concentrations less than the MTCA cleanup level for protection of surface water and screening level for soil vapor intrusion in groundwater from MW-03 (Table 1). The February 2016 results at MW-03 are likely attributed to higher precipitation and stormwater infiltration at the Property during the winter months.
- MW-16 – Monitoring well MW-16 is located downgradient of the soil remedial action area on the southeast portion of the Property (Figure 2). The concentration of VC in groundwater from MW-16 as well as other chlorinated compounds decreased after completion of soil remedial actions (Figure 8 and Table 1). Higher VC concentrations are generally present in groundwater in MW-16 during monitoring events performed in the summer which is likely attributed to the degradation of TCE and DCE in groundwater flowing from the upgradient area in proximity to MW-03. PCE, TCE, and DCE were either not detected or detected at concentrations less than the MTCA cleanup level for protection of surface water and screening level for soil vapor intrusion in groundwater from MW-16.
- MW-18 – Monitoring well MW-18 is located downgradient of soil remedial action area on the southeast portion of the Property (Figure 2). The VC concentrations in groundwater at monitoring well MW-18 have fluctuated between the soil remedial action and February 2016 (Figure 9 and Table 1). Similar to MW-16, higher concentrations of VC are generally present in groundwater in MW-18 during summer monitoring events which is likely attributed to the degradation of TCE and DCE in groundwater flowing from the upgradient area in proximity to MW-03. PCE, TCE, and DCE at MW-18 are consistently either not detected or detected at concentrations less than the MTCA cleanup level for protection of surface water and screening level for soil vapor intrusion.
- MW-19 – Monitoring well MW-19 was installed in July 2015 to monitor groundwater from the southeast portion of the Property (Figure 2). MW-19 was monitored in July 2015, October 2015, February 2016 and May 2016 prior to preparation of this Work Plan. Concentrations of VC in MW-19 have been detected at concentrations greater than the screening level for soil vapor intrusion (0.347 µg/L) but less than the cleanup level (CUL) for protection of surface water (1.6 µg/L) (Figure 10 and Table 2). TCE concentrations were detected at concentrations less than the CUL for protection of surface water and the MTCA Method B screening level for soil vapor intrusion with the exception of the February 2016 monitoring event during which the TCE concentration increased to greater than the MTCA screening

level (1.55 µg/L) for soil vapor intrusion. Other chlorinated compounds were not detected during the monitoring events with the exception of cis-1,2-DCE during the May 2016 monitoring event.

Table 2 summarizes water level, water quality and natural attenuation parameter measurements collected between 2010 and 2016 at MW-03, MW-16 and MW-18, and in 2015 and 2016 at MW-19. Depth-to-groundwater fluctuates between approximately three and five feet bgs at the Property. Natural attenuation parameters include pH, ferrous iron, sulfate, DO, ORP, and electrical conductivity. PH was generally between 7 and 8 pH units. Ferrous iron was either not detected or detected at up to 1.8 mg/L. Ferrous iron was detected in MW-03 during all but two monitoring events, and was typically present at higher concentrations during the summer months (July and August). Ferrous iron was detected during about half of the monitoring events in MW-16, MW-18 and MW-19 with detections generally occurring during the summer months (July and August). Sulfate was either not detected or detected at concentrations up to approximately 40 mg/L. The highest concentrations of sulfate were generally detected during the winter sampling events.

Average DO and ORP were 2.3 mg/L and -33 millivolts (mV), respectively, which are consistent with the presence of ferrous iron and sulfate. Dissolved oxygen and ORP tended to be lower (i.e. more reducing conditions) during the drier summer months and higher (i.e. more oxidative conditions) during the wetter winter months. This pattern is likely due to seasonal groundwater conditions including a lower summer groundwater table from decreased precipitation and infiltration and a higher winter groundwater table from increased precipitation and infiltration. This pattern is consistent with the higher concentrations of ferrous iron (more reducing conditions) observed during summer months.

2.3. Property Geology and Hydrogeology

Geologic conditions were summarized in a Remedial Investigation (RI) report for the Property (GeoEngineers 2009) and the observations from the RI were confirmed by visual observation during the remedial excavations as reported in the Remedial Action Construction Report (GeoEngineers 2010a). Hydrogeologic conditions were investigated as part of the RI as well as subsequent groundwater monitoring (i.e., 2009 to 2016).

Soil at the Property generally consist of fill overlying native soil. The fill can be divided into two layers. The upper fill layer extends from the present ground surface to a depth of 1 to 5 feet bgs. This upper fill layer consists of fine to medium sand with variable amounts of silt, gravel and brick debris. The lower fill layer is 2 to 10 feet thick and consists of fine to medium sand with variable amounts of silt, gravel and sea shell fragments. The total thickness of the two fill layers is approximately 5 feet in the southwest portion of the Property and 12 feet in the northeast portion of the Property. The native soil beneath the fill consists of silt with organics (roots) or peat overlying sand or silty sand to depths of 30 feet bgs. Native soil at greater depths consists of interbedded low-permeability soil representing a regional aquitard and coarser grained sands and gravels to depths as great as 400 feet bgs where an artesian aquifer is present beneath the regional aquitard.

A shallow aquifer is present at the Property above the regional aquitard. As previously stated, groundwater in the shallow aquifer generally flows north beneath the Property as shown in Figures 3 through 6. Depth-to-groundwater fluctuates between approximately 3 and 5 feet bgs (i.e., Elevation 6.5 to 8.5 feet mean sea level).

3.0 PURPOSE AND OBJECTIVES OF TREATMENT

Residual contamination continues to be detected in groundwater from MW-03, MW-16, MW-18 and MW-19. The purpose of treatment is to promote the degradation of the residual concentrations of TCE, cis-DCE, trans-DCE and vinyl chloride in shallow soil and groundwater at the Property. The objective of the treatment is to reduce concentrations of TCE and VC in groundwater to below cleanup and screening levels. The extent to which the objectives have been met will be evaluated based on pre- and post-treatment groundwater monitoring at wells MW-01, MW-03, MW-16, MW-18 and MW-19 as discussed in Section 6.

4.0 TREATMENT APPROACH

The treatment approach involves injecting microorganisms, an iron based reducing agent (i.e., electron donor), a fermentable carbon source and activated carbon into the subsurface to treat chlorinated compounds by enhanced anaerobic biodegradation/reductive dechlorination. The treatment approach does not use any chemicals that would result in exceedances of groundwater cleanup levels and thus meets the nonendangerment standard for groundwater (WAC 173-218-080).

The microorganisms that dechlorinate chlorinated compounds derive their energy from chemical redox reactions and use electron donors and sources of carbon to complete the dechlorination process. The native microorganisms present in the subsurface at the Property are expected to carry out the reductive dechlorination process. However, to enhance the native microorganism population, additional microorganisms of the dehalococcoides sp. (DHC) will be injected into the subsurface. DHC are widely used for reductive dechlorination and are capable of dechlorinating PCE, TCE, DCE and VC as well as other contaminants.

A reducing agent consisting of soluble iron will be injected into the subsurface to provide a controlled release of organic acids to shallow soil and groundwater to activate the reductive dechlorination. In anaerobic conditions, the soluble iron can also precipitate reduced iron sulfides, oxides, and/or hydroxides and these materials can reduce the concentration of chlorinated contaminants through abiotic (chemical) reduction.

The fermentable carbon source injected in the subsurface is expected to be fermented by native microorganisms already present in the subsurface at the Property. Fermentation will produce hydrogen, which is used by native and/or the introduced microorganisms to accelerate degradation of chlorinated compounds.

Microorganisms, reducing agent and fermentable carbon source will be injected into shallow soil and groundwater in liquid form over the entire treatment area shown on Figure 11 through direct-push borings situated on approximately 15-foot centers. The treatment area measures approximately 12,150 square feet and approximately 55 borings will be completed for injection of microorganisms, reducing agent and fermentable carbon source. The number of borings will be increased, if necessary, based on the results of treatment monitoring as discussed in Section 5.4 (Treatment Monitoring).

Fine particles of activated carbon in a suspended liquid form will also be injected in the southern portion of the treatment area (Figure 11) to enhance the sorption capacity of soil and therefore, promote sorption and biodegradation of dissolved phase residual chlorinated compounds that might remain in the upgradient portions of the Property and are subsequently transported in groundwater towards the treatment area. Liquid activated carbon will be injected using a row of direct-push borings completed at 15-foot centers along the southern portion of the treatment area.

The depth of treatment will be from 2 to 9 feet bgs in each boring, which is based on where monitoring indicates residual contaminants are present in shallow soil and groundwater. A treatment contractor selected by the City will be responsible for identifying specific treatment products that meet the requirement of this Work Plan and has a successful track record in remediating chlorinated compounds. The treatment contractor will also be responsible for identifying quantities and application rates for treatment products to ensure that an even distribution of treatment products is achieved for effective treatment to occur. The City will solicit a Contractor in the future to implement the activities described in this Treatment Work Plan.

5.0 APPLICATION METHODOLOGY

The treatment products will be applied in a liquid form using direct-push drilling technology as identified in Section 4.0. The approximate treatment area is shown in Figure 11. Treatment application and monitoring described in this section will be completed by a treatment Contractor to be solicited by the City. Groundwater monitoring described in Section 6.0 will be completed by GeoEngineers. The treatment equipment is expected to be on site approximately 1 to 2 weeks to complete the application. The following sections describe the elements involved in application of the treatment products. Prior to start of the field work, the site will be registered with Ecology's Underground Injection Control (UIC) division.

5.1. Equipment

The major pieces of equipment to be used for treatment are listed below. An additional description is provided for selected equipment in Section 5.3. The list below is not exhaustive but summarizes the major pieces of required equipment. Application control equipment will be located in a fully enclosed injection trailer temporarily mobilized to the Property. Equipment includes:

- Direct-push drilling system;
- Depth-discrete injection tooling;
  - Capable of top-down or bottom-up product application; and
  - Monitoring and documentation of injection flow rate and pressure at each injection point.
- Treatment products (microorganisms, reducing agent, carbon source and activated carbon;
- Mixing tanks fitted with drains to allow complete drainage;
- Vortex/Cyclone mixer;
- Application pump;
  - Pump rate from 0 to 18 gallons per minute (gpm);
  - Pressure up to 350 pounds per square inch (psi); and
  - Variable frequency drive controller.
- Multiple fluid delivery pipes and/or hoses;
- Self-sufficient, dedicated power;
- Potable water supply (fire hydrant), including totalizing flow meter and backflow preventer;

- Slip-resistant and chemical resistant flooring;
- Injection flow meter, pressure gauge, and control valves to regulate treatment product delivery to each injection location;
- Backflow prevention;
- Pressure bypass controls;
- System to collect and reuse treatment product, if necessary; and
- Emergency eyewash and First-Aid station.

5.2. Personnel

The treatment Contractor's personnel operating the injection equipment will have substantial previous experience handling, mixing, and applying the treatment products. The treatment Contractor will provide a project scientist/engineer capable of evaluating treatment product distribution during application. A GeoEngineers employee will be at the Property to monitor and record treatment activities (Section 5.4). All personnel onsite must have Occupational Safety and Health Administration (OSHA) 40 hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training with a current 8-hour refresher. The Contractor will have an established health and safety program and will be responsible for the health and safety of the Contractor's personnel. A site-specific Health and Safety Plan (HASP) for GeoEngineers employees is included as Appendix A.

5.3. Treatment Methods

The treatment Contractor will have the means and methods to perform "top down" and/or "bottom-up" application techniques to adapt to a variety of conditions, avoid project delays, and maximize distribution of treatment products. Top down application means the Contractor can drill to the upper treatment depth (i.e., approximately 2 feet bgs), inject treatment products, then drill incrementally deeper and inject treatment products to the lowest treatment depth (i.e., approximately 9 feet bgs). Bottom up application means the Contractor can drill to the lowest treatment depth, inject treatment products, then retract the injection equipment incrementally shallower and inject treatment products to the upper treatment depth (i.e., approximately 2 feet bgs). The direct-push drill rig will be able to "work ahead" of the injection manifold system to install up to 3 injections points to be manifolded and injected simultaneously. The drill rig will utilize 1.25- to 3.25-inch diameter threaded hollow steel drill rods. The rods will be 3 to 5 feet in length, and connections will include O-rings to maintain a watertight seal between rods. Injection tips available will include both expendable tips and retractable sleeve-type tips.

Treatment products will be applied in at least two separate vertical intervals over the 7-foot-thick target treatment zone. The injection tooling will have the ability to isolate treatment product distribution over the vertical limits of each injection interval. Injection volumes for each injection point will be distributed evenly across the target treatment zone as the injection rods are moved vertically. Each injection point will be abandoned in accordance with WAC 173-218-120 and WAC 173-160-460 using bentonite grout and finished with a surface seal of concrete. If treatment product surfaces through an abandoned injection point (i.e., "daylights"), the abandoned point will be re-grouted prior to resuming injections in that area.

The application pump will be a peristaltic pump, multiple diaphragm positive displacement pump, or piston pump designed to prevent hard pulsation of the treatment products during injection. The application pump and other equipment that will come into contact with treatment products will be compatible with the products. The treatment product delivery system, which includes the pump, injection hose, flow meters, pressure gauges and connections, must be capable of delivering the treatment products at pressures and rates necessary for achieving even distribution to specified treatment depths. Additionally, a mechanical high pressure bypass and manual pressure relief mechanism will be installed for the safety of personnel.

Each treatment product delivery pipe or hose will be at least 100 feet in length to limit the number of times the fully enclosed injection trailer needs to be moved.

5.4. Treatment Monitoring

Groundwater parameters will be monitored in up to two monitoring wells nearest the injection activities. Monitoring will likely be performed in MW-03, MW-16, MW-18, MW-19 and possibly MW-08 and/or MW-14. GeoEngineers and the treatment Contractor will coordinate over the most ideal wells to monitor as the project proceeds. Monitoring will begin prior to the beginning of each day's injection activities to establish a baseline. Parameters to be monitored include depth-to-water, pH, temperature, DO, conductivity, ORP, ferrous iron, sulfate, salinity, TDS, and turbidity. Monitoring will continue during injection, and will be performed to measure the response, if any, in adjacent monitoring wells to the injections. If the treatment products are not influencing the monitoring wells using the designed injection point spacing (15 feet), the following options may be employed: reduced spacing of injection points and more injection points, increased injection volumes/flow rates, or alternative injection tooling or techniques. The treatment Contractor will ensure the application is performed in an efficient and effective manner to meet the purpose and objectives of the treatment. Injection tooling may include retractable screen, expendable tip, open screen top-down tooling, and pressure activated tooling.

The treatment Contractor's project scientist/engineer will be familiar with this Treatment Work Plan and the treatment design rationale. Observations, real-time monitoring data and application delivery information will be documented and provided to GeoEngineers on a daily basis. Application delivery information such as start/stop times, injection intervals, flow rates, pressures, total gallons injected, gallons per interval, and other information will be documented for each injection point.

6.0 GROUNDWATER MONITORING PLAN

Groundwater monitoring will be performed once before treatment and four quarters after treatment at a minimum. The pre-treatment monitoring will be performed approximately three months before treatment. Post-treatment monitoring will be performed at approximately 3-, 6-, 9- and 12-months post-treatment. It is anticipated that the treatment will reduce contaminants to below cleanup and screening levels prior to the first post-treatment monitoring event. In the event contaminants are detected above cleanup and/or screening levels during post-treatment monitoring, additional monitoring may be performed.

Each monitoring round will include monitoring at one well located upgradient of the treat area (MW-01) and four monitoring wells in/downgradient of the treatment area (MW-03, MW-16, MW-18 and MW-19) (Figure 11). The wells to be monitored, as well as the field parameters and laboratory analyses to be performed, are summarized in the table below.

Well	Field Parameters	Laboratory Analyses	
		Chlorinated Compounds	Natural Attenuation Parameters
MW-01*	X	X	X
MW-03	X	X	X
MW-16	X	X	X
MW-18	X	X	X
MW-19	X	X	X

Note:

*MW-01 is being used as a "background" monitoring well for the purpose of monitoring field and natural attenuation parameters upgradient of the treatment area. Chlorinated compounds have never been detected in MW-01 at concentrations exceeding cleanup and screening levels.

Groundwater monitoring will be performed in a manner consistent with monitoring that has been performed since 2010 under previous monitoring plans (GeoEngineers 2010b and 2015b). The groundwater monitoring procedure is as follows:

- Water levels will be measured in each well at the beginning of each groundwater monitoring event. The groundwater levels will be measured to the nearest 0.01 foot using a decontaminated electric water level indicator. The water level will be measured relative to the top of the north side of the casing rim.
- Purging and sampling will be performed using low-flow/low-turbidity sampling techniques to minimize the suspension of sediment in the samples. Groundwater samples will be obtained using dedicated submersible pumps and disposable polyethylene tubing. Groundwater will be pumped at a rate of approximately 0.5 liters per minute. This rate has proven effective at Property monitoring wells and has not drawn down wells significantly.
- A water quality measuring system with a flow-through cell will be used to monitor the following water quality parameters during purging: conductivity, DO, pH, salinity, total dissolved solids, ORP and temperature. A turbidity meter will be used to measure turbidity. It will be assumed that ambient groundwater conditions will have been reached once the parameters measured by the water quality monitoring instruments vary by less than 10 percent on three consecutive measurements. The field measurements will be documented on field forms. If all field parameters do not stabilize after five well volumes of water have been removed, samples will be collected. Historically, the majority of water quality parameters have stabilized satisfactorily in groundwater from wells at the Property.
- Following well purging, the flow-through cell will be disconnected and groundwater samples will be collected from MW-01, MW-03, MW-16, MW-18 and MW-19. Samples will be placed in labeled laboratory-prepared containers, placed into a cooler with ice and sample information will be logged on the chain-of-custody. Sample handling procedures including labeling, container and preservation requirements and holding times as well as decontamination procedures are described in the QAPP provided in Appendix B. Laboratory analyses on MW-01, MW-03, MW-16, MW-18 and MW-19 will include:
  - Chlorinated compounds including PCE, TCE, 1,1- DCE, cis-DCE, trans-DCE, and VC using United States Environmental Protection Agency (EPA) Method 8260B;
  - Nitrate and sulfate by EPA Method 300.0;
  - Total and dissolved iron and manganese by EPA Method 200.8;

- Chemical oxygen demand (COD) by Method SM 5220C;
- Biochemical oxygen demand (BOD) by Method SM 5210B;
- Dissolved gases (methane, ethane, ethene and carbon dioxide [CO_2]) by Method RSK-175; and
- Total organic carbon (TOC) by EPA Method 9060A or SM 5310 B-00.

Laboratory analyses on MW-01 will include all of the above except chlorinated compounds. Analyses will be performed by TestAmerica Laboratory in Fife, Washington, an Ecology accredited laboratory.

Purge water removed from the monitoring wells and decontamination water generated during sampling activities will be stored in labeled and sealed 55-gallon drums. The drums will be temporarily stored at a secure location pending receipt of analytical results and off-site disposal at a permitted facility.

7.0 PROJECT REPORTING

Reporting will include providing a summary of the results of each individual groundwater monitoring event in an email to the City and Ecology and preparation of a report that presents the results of treatment and pre- and post-treatment groundwater monitoring.

A report will be prepared that presents the results of the shallow soil and groundwater treatment and pre-and post-treatment groundwater monitoring. The report will be prepared upon completion of four quarters of post-treatment groundwater monitoring. The report will include the following:

- A description of treatment activities including the treatment report supplied by the treatment Contractor. The treatment Contractor will submit a digital, comprehensive Treatment Summary Report to GeoEngineers within two weeks of completing treatment activities that details treatment product application information (i.e., Treatment Summary Report).
- A description of groundwater sampling and analysis activities including pre-treatment monitoring and four quarters of post-treatment monitoring.
- Tabulated summary of the results of water quality and natural attenuation parameter measurements and analyses during each monitoring event.
- Tabulated summary of the results for chlorinated compounds compared to MTCA cleanup and screening levels.
- Appendices that include the laboratory analytical reports and a data quality review for chemical analyses for chlorinated compounds.

The report will be provided to Ecology for review. If the results of post-treatment groundwater monitoring indicate that the concentrations of chlorinated compounds are less than cleanup and screening levels for four consecutive quarters, it is assumed that the City will request a NFA determination for the Property from Ecology based on the results presented in the report. If a chlorinated compound is detected at a concentration greater than a cleanup and/or screening level, it is anticipated that additional groundwater monitoring will be performed. Any groundwater monitoring performed after the four quarters of post-treatment groundwater monitoring will be presented in a separate, subsequent report.

Additionally, reporting will include providing a summary of the results from each of the individual pre- and post-treatment groundwater monitoring events to the City and Ecology after each event. The email summary will include the tabulated results of the groundwater monitoring event compared to MTCA cleanup and screening levels. In accordance with WAC 173-340-840 (5) and Ecology Toxics Cleanup Program Policy 840 (Data Submittal Requirements), data generated will be submitted both in written and electronic format.

8.0 REFERENCES

GeoEngineers 2009. "Final Draft Remedial Investigation, 318 State Avenue NE, Olympia Washington," February 19, 2009.

GeoEngineers 2010a, "Remedial Action Construction Report, 318 State Avenue NE, Olympia Washington," January 5, 2010.

GeoEngineers 2010b, "Groundwater Compliance Monitoring Plan, 318 State Avenue NE, Olympia Washington," April 16, 2010.

GeoEngineers 2015a, "Groundwater Compliance Monitoring Data Summary Report – July 2015, 318 State Avenue NE, Olympia, Washington," October 9, 2015.

GeoEngineers 2015b, "Groundwater Monitoring Plan, Southeast Portion of the 318 State Avenue NE Property, Olympia, Washington," October 1, 2015.

GeoEngineers 2016, "Draft Quarterly Groundwater Monitoring Data Summary Report – May 2016, 318 State Avenue NE Property, Olympia, Washington," July 8, 2016.

Washington State Department of Ecology 2009, "Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action," 2009.

Washington State Department of Ecology 2015, Amendment Appendix B, Table B-1, "Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, Toxics Cleanup Program," April 6, 2015.

TABLE 1

SUMMARY OF GROUNDWATER COMPLIANCE MONITORING PARAMETERS[1]

318 STATE AVENUE NE

OLYMPIA, WASHINGTON

			Chlorinated Compounds					
		Analyte	Tetrachloroethene (PCE)	Trichloroethene (TCE)	1,1-Dichloroethene (1,1-DCE)	Cis-1,2-Dichloroethene (cis 1,2-DCE)	Trans-1,2-Dichloroethene (trans 1,2-DCE)	Vinyl Chloride (VC)
		Unit	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
		MTCA Groundwater Cleanup Levels[2]	8.85	7	3.2	NE	4,000	1.6
		Groundwater Screening Level for Soil Vapor Intrusion[3]	22.9	1.55	130	NE	NE	0.347
Location	Sample ID	Sample Date						
MW-03	MW3-052410-W	05/24/10	0.1 U	0.48	0.1 U	0.14	0.1 U	0.48
	MW3-082510-W	08/25/10	0.1 U	0.26	0.1 U	0.11	0.1 U	0.12
	MW3-112410-W	11/24/10	0.1 U	1.3	0.1 U	0.28	0.1 U	1.1
	MW3-022311-W	02/23/11	0.1 U	1.6	0.1 U	0.59	0.1 U	0.92
	MW3-052511-W	05/25/11	0.1 U	1.5	0.1 U	0.60	0.15	0.83
	DUP-052511-W[4]	05/25/11	0.1 U	1.2	0.1 U	0.36	0.12	0.69
	MW3-082411-W	08/24/11	0.1 U	0.64 J	0.1 U	0.31	0.11	0.37 J
	DUP-082411-W[5]	08/24/11	0.1 U	0.49 J	0.1 U	0.23	0.1 U	0.27 J
	MW3-112911-W	11/29/11	0.1 U	2.6	0.1 U	0.39	0.11	0.45
	DUP-112911-W[6]	11/29/11	0.1 U	2.7	0.1 U	0.41	0.10	0.52
	MW3-022812-W	02/28/12	0.1 U	0.99	0.1 U	0.63	0.18	1.4
	DUP-022812-W[7]	02/28/12	0.1 U	1.3	0.1 U	0.84	0.19	1.9
	MW3-082312-W	08/23/12	0.1 U	0.11	0.1 U	0.36	0.30	0.27
	DUP-082312-W[8]	08/23/12	0.1 U	0.11	0.1 U	0.34	0.33	0.26
	MW3-022813-W	02/28/13	0.1 U	0.70	0.1 U	0.34	0.14	0.72
	DUP-022813-W[9]	02/28/13	0.1 U	0.68	0.1 U	0.32	0.12	0.69
	MW03-82213-W	08/22/13	0.1 U	0.1 U	0.1 U	0.24	0.28	0.15
	DUP01-82213-W[10]	08/22/13	0.1 U	0.1 U	0.1 U	0.23	0.32	0.16
	MW3-140227-W	02/27/14	0.1 U	2.5	0.1 U	0.75	0.12	0.79
	MW03-140825-W	08/25/14	0.1 U	0.1 U	0.1 U	0.35	0.36	0.25
	MW03-150225-W	02/25/15	0.5 U	0.58	0.1 U	1.8	0.2 U	3.6
	MW03-150723-W	07/23/15	0.5 U	0.2 U	0.1 U	0.34	0.34	0.28
	MW3-160217-W	02/17/16	0.5 U	4.0	0.1 U	0.41	0.2 U	0.19
MW-16	MW16-052410-W	05/24/10	0.1 U	0.44	0.1 U	0.20	0.18	0.76
	MW16-082510-W	08/25/10	0.1 U	0.46	0.1 U	0.32	0.34	1.0
	MW16-112410-W	11/24/10	0.1 U	0.49	0.1 U	0.17	0.19	0.33
	DUP-1-112410-W[11]	11/24/10	0.1 U	0.50	0.1 U	0.16	0.21	0.38
	MW16-022311-W	02/23/11	0.1 U	0.42	0.1 U	0.13	0.13	0.22
	DUP-1-022311-W[12]	02/23/11	0.1 U	0.43	0.1 U	0.11	0.15	0.23
	MW16-052511-W	05/25/11	0.1 U	0.47	0.1 U	0.1 U	0.16	0.18
	MW16-082411-W	08/24/11	0.1 U	0.41	0.1 U	0.26	0.24	0.70
	MW16-112911-W	11/29/11	0.1 U	0.35	0.1 U	0.10	0.12	0.15
	MW16-022812-W	02/28/12	0.1 U	0.40	0.1 U	0.1 U	0.13	0.17
	MW16-082312-W	08/23/12	0.1 U	0.52	0.1 U	0.21	0.20	0.47
	MW16-022813-W	02/28/13	0.1 U	0.28	0.1 U	0.1 U	0.1 U	0.086
	MW16-82213-W	08/22/13	0.1 U	0.26	0.1 U	0.22	0.13	0.44
	MW16-140227-W	02/27/14	0.1 U	0.24	0.1 U	0.1 U	0.1 U	0.093
	DUP01-140227-W[13]	02/27/14	0.1 U	0.26	0.1 U	0.1 U	0.1 U	0.090
	MW16-140825-W	08/25/14	0.1 U	0.37	0.1 U	0.25	0.18	0.52
	DUP01-140825-W[14]	08/25/14	0.1 U	0.36	0.1 U	0.25	0.19	0.51
	MW16-150225-W	02/25/15	0.5 U	0.24	0.1 U	0.2 U	0.2 U	0.16
	DUP01-150225-W[15]	02/25/15	0.5 U	0.23	0.1 U	0.2 U	0.2 U	0.15
	MW16-150712-W	07/23/15	0.5 U	0.23	0.1 U	0.27	0.2 U	0.60
	DUP01-150723-W[16]	07/23/15	0.5 U	0.24	0.1 U	0.28	0.2 U	0.54
	MW16-160217-W	02/17/16	0.5 U	0.23	0.1 U	0.2 U	0.2 U	0.02 U
	DUP1-160217-W[17]	02/17/16	0.5 U	0.25	0.1 U	0.2 U	0.2 U	0.02 U
MW-18	MW18-052410-W	05/24/10	0.1 U	0.62	0.1 U	0.28	0.16	2.3
	MW18-082510-W	08/25/10	0.1 U	0.25	0.1 U	0.22	0.13	1.9
	MW18-112410-W	11/24/10	0.1 U	0.81	0.1 U	0.34	0.23	1.7
	MW18-022311-W	02/23/11	0.1 U	0.72	0.1 U	0.30	0.16	0.90
	MW18-052511-W	05/25/11	0.1 U	0.63	0.1 U	0.21	0.14	1.2
	MW18-082411-W	08/24/11	0.1 U	0.40	0.1 U	0.39	0.24	2.3
	MW18-112911-W	11/29/11	0.1 U	0.57	0.1 U	0.30	0.15	0.86
	MW18-022812-W	02/28/12	0.1 U	0.49	0.1 U	0.20	0.16	1.20
	MW18-082312-W	08/23/12	0.1 U	0.62	0.1 U	0.43	0.29	2.7
	MW18-022813-W	02/28/13	0.1 U	0.34	0.1 U	0.1 U	0.1 U	0.15
	MW18-82213-W	08/22/13	0.1 U	0.61	0.1 U	0.45	0.28	2.1
	MW18-140227-W	02/27/14	0.1 U	0.57	0.1 U	0.26	0.26	1.3
	MW18-140825-W	08/25/14	0.1 U	0.48	0.1 U	0.51	0.43	2.7
	MW18-150225-W	02/25/15	0.5 U	0.68	0.1 U	0.23	0.20	1.5
	MW18-150723-W	07/23/15	0.5 U	0.29	0.1 U	0.34	0.27	2.0
	MW18-160217-W	02/17/16	0.5 U	0.48	0.1 U	0.26	0.26	1.5
MW-19	MW-19-150723-W	07/23/15	0.5 U	0.47	0.1 U	0.2 U	0.2 U	0.89
	MW-19-151027-W	10/27/15	0.5 U	0.91	0.1 U	0.2 U	0.2 U	0.41
	MW19-160217-W	02/17/16	0.5 U	1.7	0.1 U	0.2 U	0.2 U	0.02 U
	MW19-160503-W	05/03/16	0.5 U	1.2	0.1 U	0.1 J	0.2 U	0.51
	DUP1-160217-W[18]	05/03/16	0.5 U	1.5	0.1 U	0.2 U	0.2 U	0.41

Notes:

[1] The parameters presented are the groundwater compliance monitoring parameters specified in the Groundwater Compliance Monitoring Plan (GeoEngineers, 2010).

[2] MTCA groundwater cleanup levels based on the highest beneficial use of groundwater as marine surface water. The cleanup levels provided are the lowest of the available marine surface water criteria including MTCA Method B surface water (Chapter 173-340 WAC). Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC), National Recommended Water Quality Criteria (Clean Water Act Section 304) and National Toxics Rule (40 CFR 131).

[3] Groundwater Screening Level based on Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation on Remedial Action (Ecology, 2009) as updated in 2015 (Ecology, 2015) to revise screening levels in Appendix B.

[4] Sample DUP-052511-W is a field duplicate of sample MW3-052511-W.

[5] Sample DUP-082411-W is a field duplicate of sample MW3-082411-W.

[6] Sample DUP-112911-W is a field duplicate of sample MW3-112911-W.

[7] Sample DUP-022812-W is a field duplicate of sample MW3-022812-W.

[8] Sample DUP-082312-W is a field duplicate of sample MW3-082312-W.

[9] Sample DUP-022813-W is a field duplicate of sample MW3-022813-W.

[10] Sample DUP01-82213-W is a field duplicate of sample MW03-82213-W.

[11] Sample DUP-1-112410-W is a field duplicate of sample MW16-112410-W.

[12] Sample DUP-1-022311-W is a field duplicate of sample MW16-022311-W.

[13] Sample DUP01-140227-W is a field duplicate of sample MW16-140227-W.

[14] Sample DUP01-140825-W is a field duplicate of sample MW16-140825-W.

[15] Sample DUP01-150225-W is a field duplicate of sample MW16-150225-W.

[16] Sample DUP01-150723-W is a field duplicate of sample MW16-150723-W.

[17] Sample DUP1-160217-W is a field duplicate of sample MW16-160217-W.

[18] Sample DUP-1-160503-W is a field duplicate of sample MW19-160503-W.

MTCA = Model Toxics Control Act

μg/l = microgram per liter

mg/l = milligram per liter

J = The analyte concentration is estimated

U = The analyte was not detected at a concentration greater than the identified reporting limit

UJ = The analyte was not detected at a concentration greater than the identified reporting limit and the reporting limit concentration is estimated

NE = Not Established

Bold indicates analyte was detected.

Gray shading indicates concentration is greater than groundwater cleanup and/or screening level.

TABLE 2

SUMMARY OF GROUNDWATER QUALITY PARAMETERS[1]

318 STATE AVENUE NE
OLYMPIA, WASHINGTON

Location ID	Sample Date	Ferrous Iron (mg/l)	Sulfate (mg/l)	Dissolved Oxygen (mg/l)	pH	Conductivity (mS/m)	Salinity (ppt)	Total Dissolved Solids (g/l)	Turbidity (NTU)	Temperature (C)	ORP[2] (mv)	Water Level (ft btoc)
MW-03	05/24/10	0.9	7.5	4.38	9.79	27.2	0.1	1.4	0.89	16.2	-211	4.27
	08/25/10	1.4	1.2 U	0.31	6.96	75.0	0	0.48	0.94	21.32	-133	4.99
	11/24/10	0.8	6.6	0.00	7.04	66.7	0	0.43	0.84	15.53	-94	3.80
	02/23/11	0.6	2.5	0.01	7.10	46.3	0	0.3	2.51	11.26	-117	4.05
	05/25/11	0.8	2.4	0.01	7.07	46.7	NC	NC	0.59	15.12	-130	4.10
	08/24/11	1.1	1 U	0.40	7.20	72.3	0	0.46	0.44	21.02	-90	4.82
	11/29/11	0.6	11	5.00	7.10	59.0	0	0.38	3.06	13.67	89	3.49
	02/28/12	0.8	40 UJ	2.60	7.25	41.5	0	0.27	5.45	10.99	-59	3.75
	08/23/12	1.0	1.2 U	7.14	6.87	53.0	0	0.34	0.59	21.3	-117	4.92
	02/28/13	1.5	2.1	0.78	6.53	48.0	0	0.31	17.6	11.52	-48	3.98
	08/22/13	1.6	1.2 U	0.10	7.61	61.7	0	0.40	37.4[3]	23.2	-156	4.98
	02/27/14	0.0	11	3.80	7.30	33.2	0	0.31	0.63	10.3	204.4	3.44
	08/25/14	1.8	1.2 U	0.68	7.25	52.0	0.26	0.35	2.48	22.99	-108.6	4.78
	02/25/15	0.5	2.1	1.25	7.31	31.9	0.2	0.26	1.56	12.21	-70.3	4.14
	07/23/15	0.5	1.2 U	0.09	7.11	48.8	0.25	0.34	0.81	22.6	-150	5.04
	02/17/16	0.0	12	4.94	7.50	30.0	0.19	0.25	2.3	12.7	46.5	3.41
MW-16	05/24/10	0.0	20.0	2.44	8.19	26.6	0	0.17	2.9	15.1	-116	4.24
	08/25/10	0.4	42.0	0.04	7.26	69.8	0	0.44	1.2	21.91	-106	5.02
	11/24/10	0.0	28	1.93	7.54	49.8	0	0.36	1.16	15.42	-34	3.68
	02/23/11	0.0	17	5.08	7.53	37.5	0	0.24	2.58	11.53	-9	4.04
	05/25/11	0.0	11	1.02	7.55	33.1	NC	NC	2.28	13.87	64	4.06
	08/24/11	1.2	4.9	1.00	7.66	51.0	0	0.33	1.28	20.26	-56	4.86
	11/29/11	0.4	19	6.20	7.60	35.3	0	0.23	4.00	13.82	96	3.33
	02/28/12	0.0	54 UJ	6.80	7.70	29.8	0	0.19	1.87	10.89	87	3.72
	08/23/12	0.0	3.9	3.21	7.02	31.4	0	0.2	1.22	19.7	-109	4.91
	02/28/13	0.0	7.7	5.86	6.84	29.4	0	0.19	0.40	11.36	115	3.86
	08/22/13	0.0	3.5	0.11	7.93	46.5	0	0.3	62[3]	22.9	-177	4.91
	02/27/14	0.0	7.3	2.61	7.24	23.6	0	0.21	0.31	10.9	206.2	3.33
	08/25/14	0.5	3.1	0.72	7.59	42.1	0.21	0.28	0.42	22.35	-30.8	4.73
	02/25/15	0.0	5.7	3.07	7.64	23.1	0.15	0.2	1.39	11.51	-52.2	4.09
	07/23/15	0.5	1.2 U	0.11	7.41	42.6	0.22	0.31	0.91	20.6	-168.8	4.93
	02/17/16	0.0	8.5	3.32	7.66	21.3	0.13	0.18	2.65	12.6	40.1	3.28
MW-18	05/24/10	0.0	34.0	3.92	9.16	9.0	0	0.5	1.9	14.3	-194	4.39
	08/25/10	0.2	11.0	0.00	6.81	71.9	0	0.46	4.12	21.82	-75	5.09
	11/24/10	0.0	38	0.01	7.11	47.9	0	0.31	0.61	15.52	39	3.87
	02/23/11	0.0	23	0.17	7.22	40.3	0	0.26	0.99	11.7	55	4.15
	05/25/11	0.0	17	0.00	7.15	40.8	NC	NC	1.07	12.8	31	4.21
	08/24/11	0.2	18.5	0.50	7.33	74.1	0	0.47	0.48	19.54	-48	4.97
	11/29/11	0.4	23	3.50	6.81	34.3	0	0.22	2.82	13.18	183	3.53
	02/28/12	0.0	67 UJ	8.20	7.21	32.9	0	0.21	1.56	10.33	93	3.87
	08/23/12	1.0	7.5	4.03	7.08	53.4	0	0.34	3	18.2	-110	5.02
	02/28/13	0.0	7.4	5.68	6.05	21.1	0	0.14	7	10.94	182	4.02
	08/22/13	1.1	4.1	1.90	7.72	59.3	0	0.38	54.8[3]	20.9	-153	5.04
	02/27/14	0.0	11	3.00	7.1	22.2	0	0.2	0.48	10.6	201.3	3.52
	08/25/14	0.8	1.2 U	2.02	9.23	46.7	0.25	0.33	2.79	20.37	-102.9	4.85
	02/25/15	0.0	5.9	1.71	7.37	25.4	0.17	0.23	1.81	11.2	-35.2	4.21
	07/23/15	0.6	1.2 U	0.07	7.06	44.2	0.24	0.31	3.67	20.4	-102.6	5.08
	02/17/16	0.0	6.7	1.56	7.23	20.8	0.13	0.18	3.2	11.9	-5.2	3.53
MW-19	07/23/15	0.5	1.2 U	0.11	7.36	47.6	0.34	0.33	5.02	21.6	-144.5	4.66
	10/27/15	1.0	5.0	0.24	7.07	37.8	0.21	0.28	12.9	18.3	-136.7	3.47
	02/17/16	0.0	8.1	6.85	7.69	15.4	0.10	0.13	5.2	12.3	23.4	2.85
	05/03/16	0.0	11.0	0.28	7.02	290.0	0.17	0.23	4.54	15.5	-46.2	3.99

Notes:

[1] Groundwater quality parameters include the analytes ferrous iron and sulfate to evaluate and monitor natural attenuation.

[2] ORP field readings are considered to be an estimate.

[3] Turbidity measurements collected at this compliance monitoring location are considered to be biased high due to a water quality equipment malfunction. Visual observation made at the time of sampling identified that the sample was clear and free of particulates.

ORP = Oxidation/reduction potential

mg/l = milligrams per liter

g/l = grams per liter

ppt = parts per trillion

mv = Millivolts

mS/m = milliSiemens per meter

C = Celsius

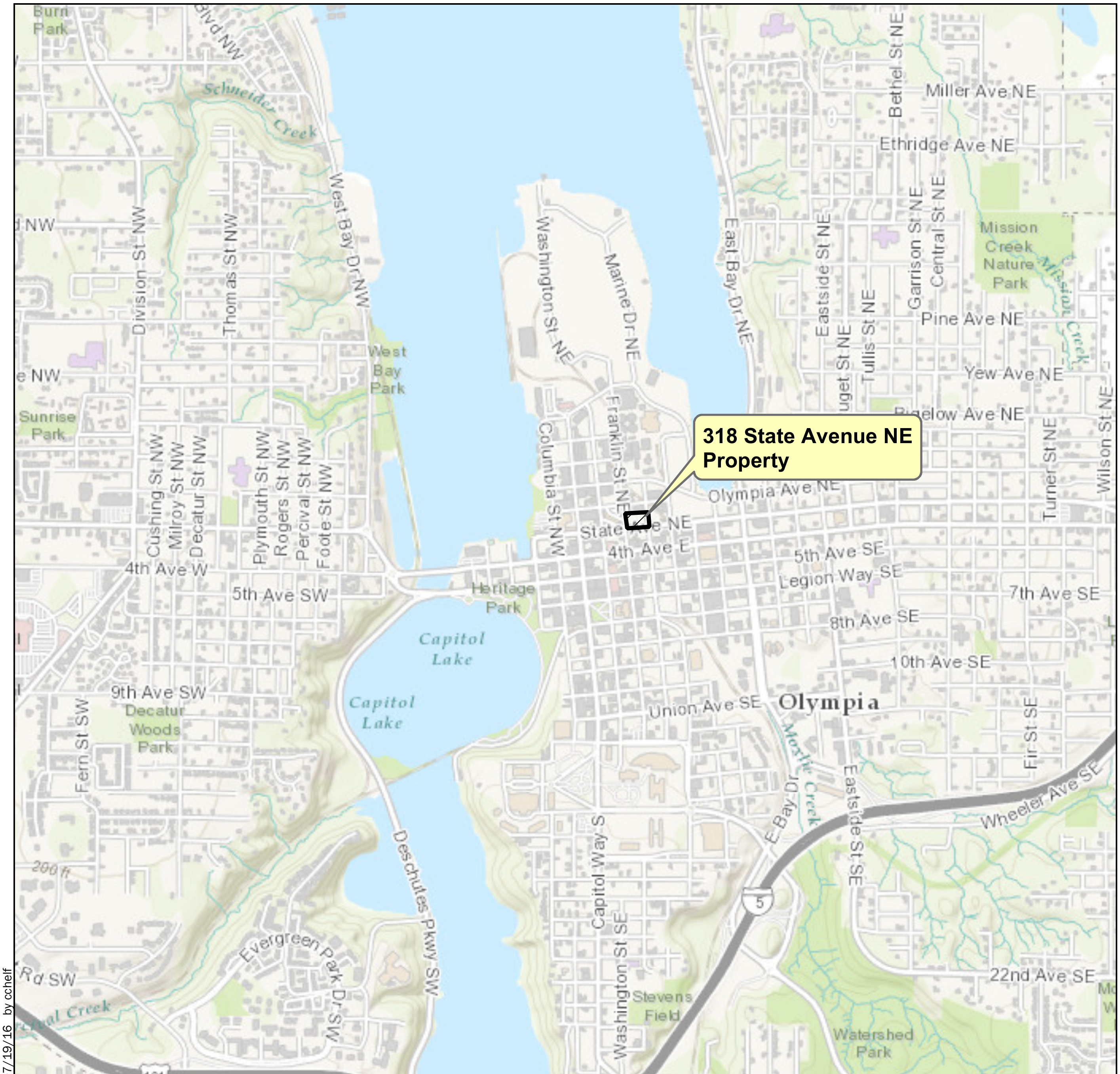
NTU = nephelometric turbidity unit

NC = Not collected

ft btoc = feet below the top of monitoring well casing

J = Analyte concentration is estimated

U = The analyte was not detected at a concentration greater than the identified reporting limit



N
W E
S

3,000 0 3,000

Feet

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Mapbox Open Street Map, 2016

Projection: WGS 1984 Web Mercator Auxiliary Sphere

Vicinity Map

318 State Avenue NE Property
Olympia, Washington

GEOENGINEERS

Figure 1

P:\0\0415049\GIS\MXDs\041504903_Figure1_VicinityMap.mxd Date Exported: 07/19/16 by cchelf

Map Revised: 28 June 2016 cchelf

Path: P:\0\0415049\GIS\MXDs\041504906_F02_PropertyMap.mxd

Office: TAC

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Sources: Approximate Property Boundary from Thurston County parcels (revised by GeoEngineers). Aerial photograph 2013 from ESRI. Data Frame Rotated 356 degrees.

Projection: NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet
Datum: D_North_American_1983

Property Map

318 State Avenue NE
Olympia, Washington

GeoEngineers

Figure 2

MW-1 7.89 — GeoEngineers Monitoring Well Location, ID and Groundwater Elevations (May 25, 2011) based on mean sea level

Approximate Property Boundary

Remediation Areas

Parcel Boundary

Approximate Groundwater Flow Direction

Reference: Approximate Property Boundary from Thurston County parcels (revised by GeoEngineers). Parcels from Thurston County.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

70 0 70
Feet

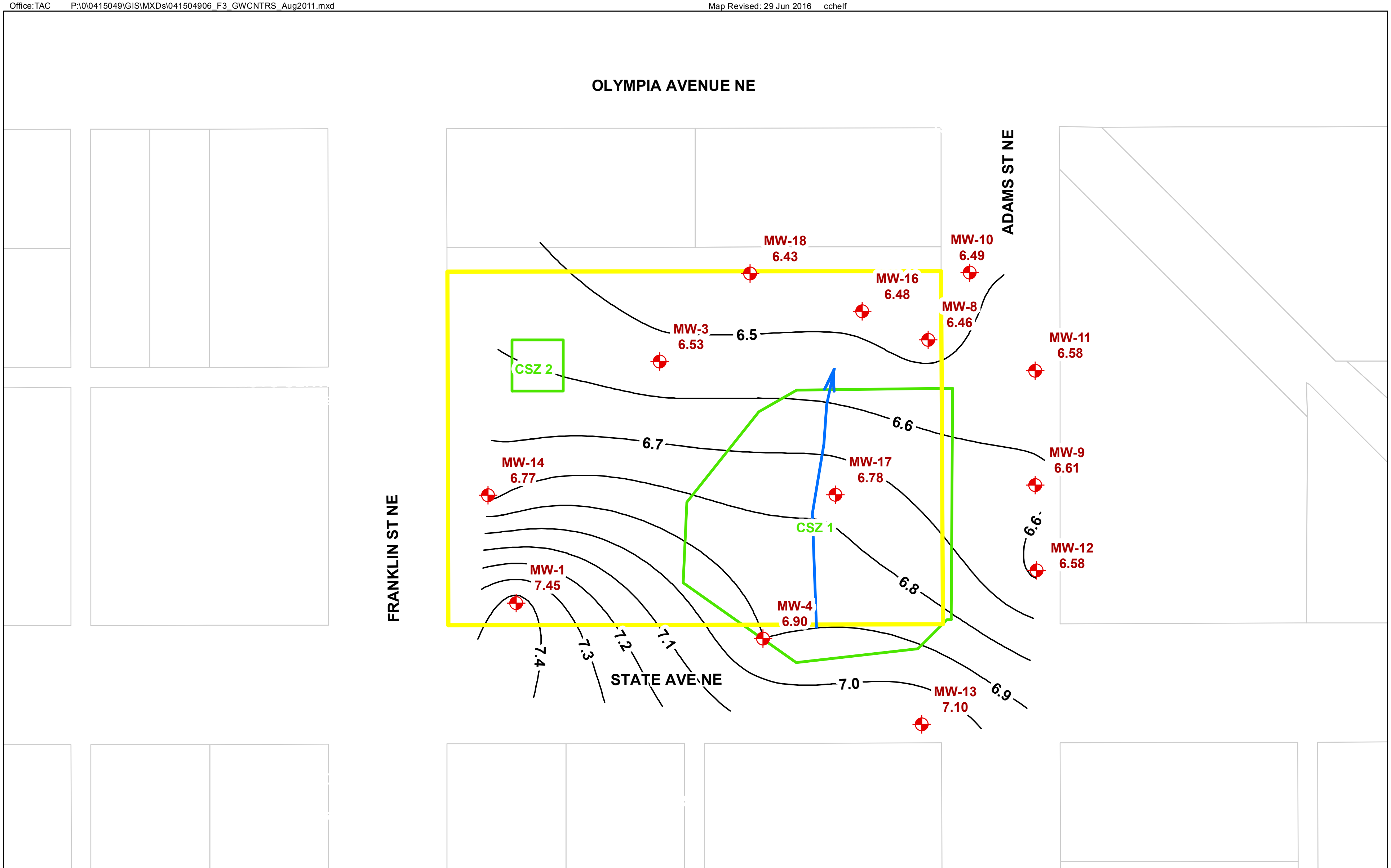
Potentiometric Surface Map - May 25, 2011 Measurements

318 State Avenue NE
Olympia, Washington

GEOENGINEERS

Figure 3

Office:TAC P:\0\0415049\GIS\MXDs\041504906_F3_GWCNTRS_Aug2011.mxd Map Revised: 29 Jun 2016 cchelf



MW-1
7.45

GeoEngineers Monitoring Well Location, ID and Groundwater Elevations (August 24, 2011) based on mean sea level

Approximate Property Boundary

Remediation Areas

Parcel Boundary

Approximate Groundwater Flow Direction

70 0 70

Feet

Reference: Approximate Property Boundary from Thurston County parcels (revised by GeoEngineers). Parcels from Thurston County.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

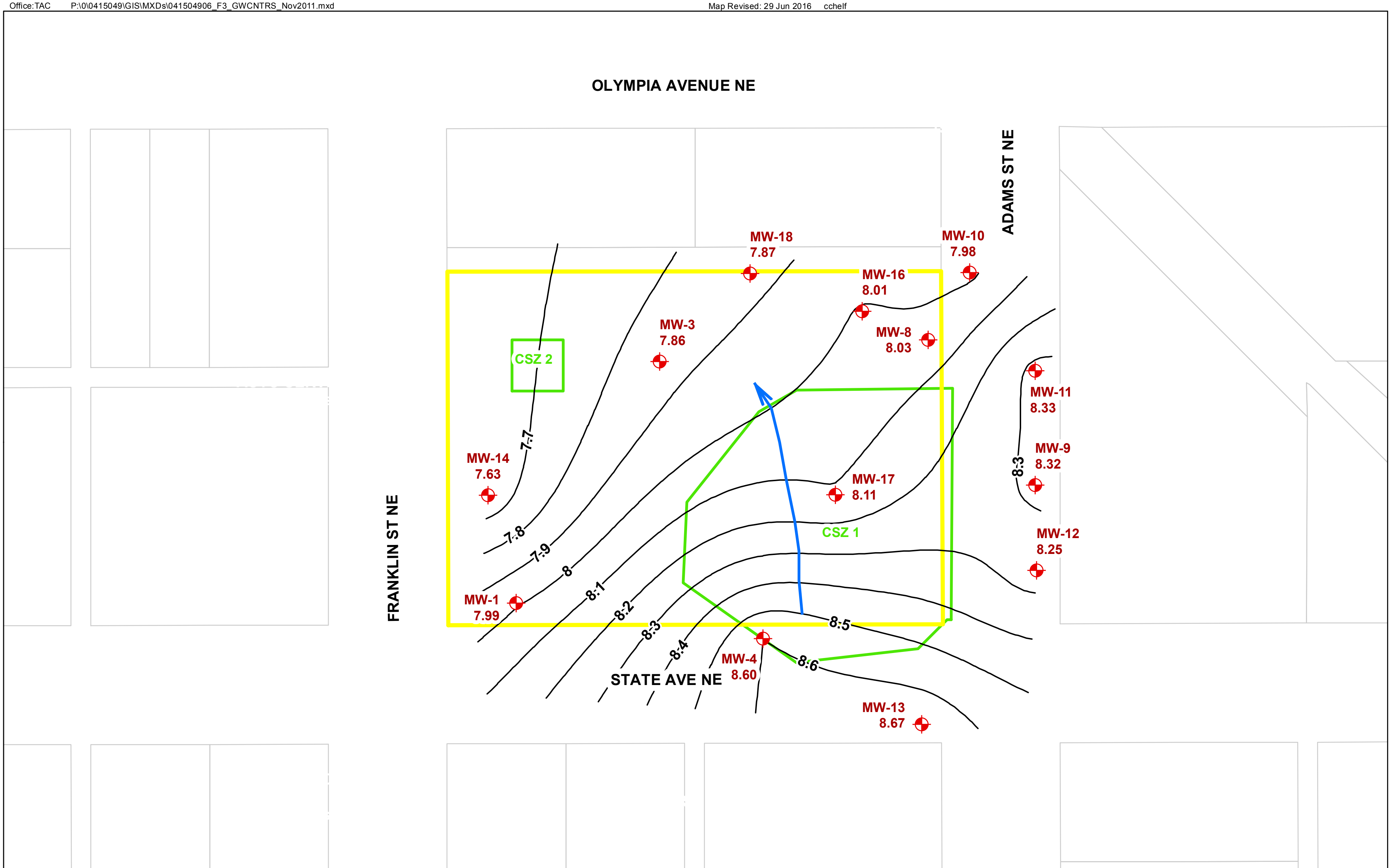
Potentiometric Surface Map - August 24, 2011 Measurements

318 State Avenue NE
Olympia, Washington

GEOENGINEERS

Figure 4

Office:TAC P:\0\0415049\GIS\MXDs\041504906_F3_GWCNTRS_Nov2011.mxd Map Revised: 29 Jun 2016 cchelf



MW-1
7.99

Monitoring Well Location and Groundwater Elevations (November 29, 2011) based on mean sea level

Approximate Property Boundary

Remediation Areas

Parcel Boundary

Approximate Groundwater Flow Direction

Reference: Approximate Property Boundary from Thurston County parcels (revised by GeoEngineers). Parcels from Thurston County.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

70 0 70
Feet

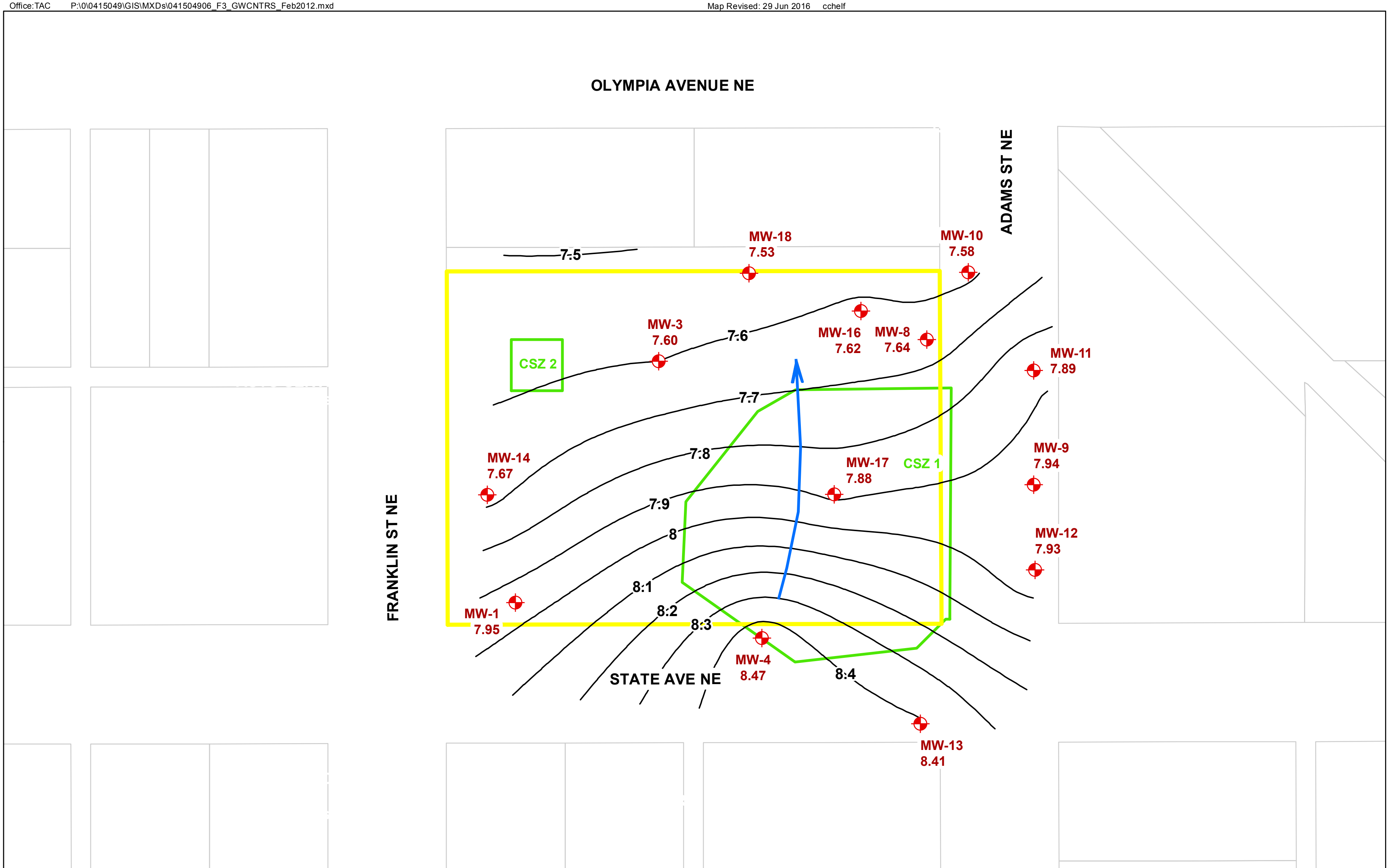
Potentiometric Surface Map - November 29, 2011 Measurements

318 State Avenue NE
Olympia, Washington

GeoEngineers

Figure 5

Office:TAC P:\0\0415049\GIS\MXDs\041504906_F3_GWCNTRS_Feb2012.mxd Map Revised: 29 Jun 2016 cchelf



MW-1 7.95 — Monitoring Well Location and Groundwater Elevations (February 28, 2012) based on mean sea level

Approximate Property Boundary

Remediation Areas

Parcel Boundary

Approximate Groundwater Flow Direction

Scale: 70 0 70 Feet

Reference: Approximate Property Boundary from Thurston County parcels (revised by GeoEngineers). Parcels from Thurston County.

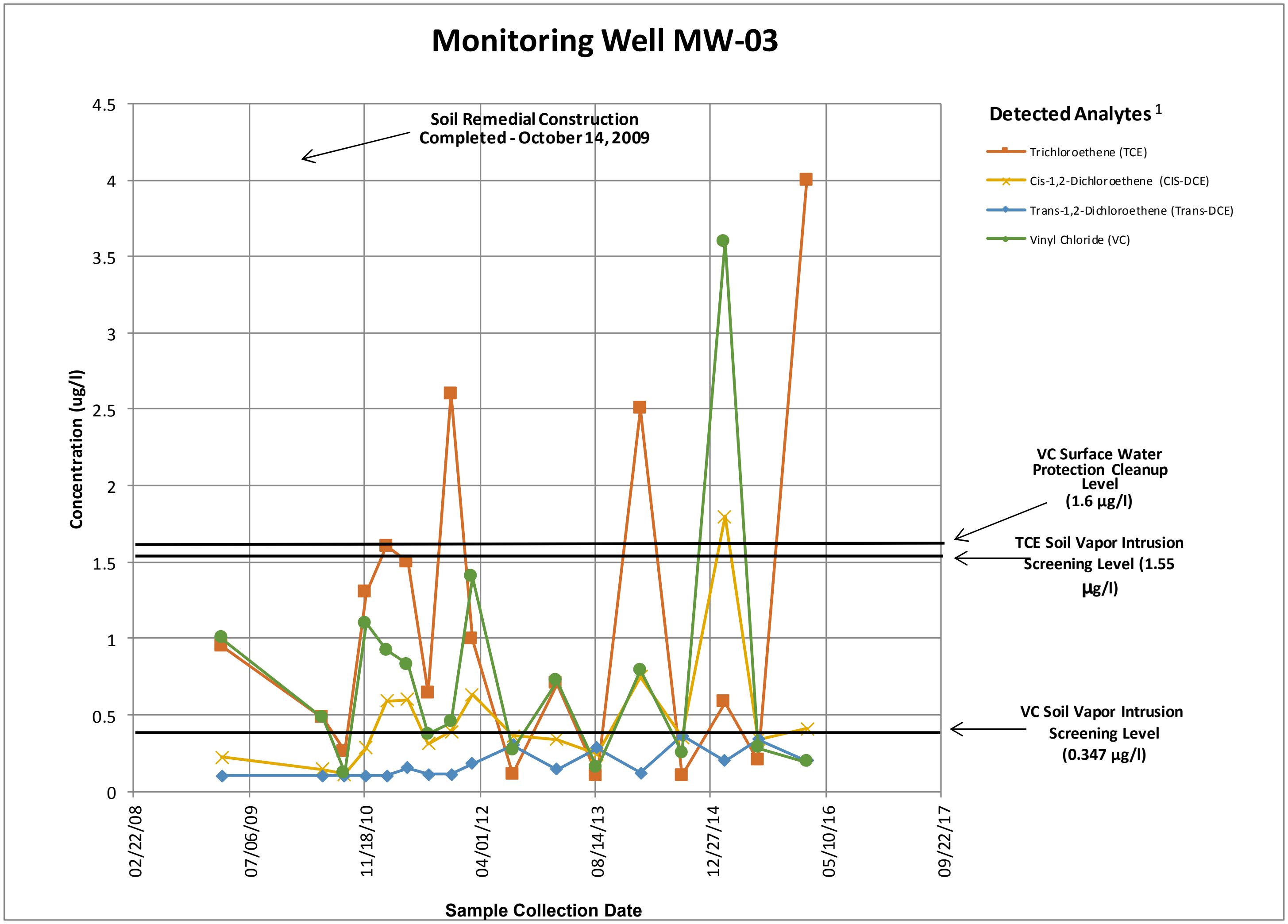
Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Potentiometric Surface Map - February 28, 2012 Measurements

318 State Avenue NE
Olympia, Washington

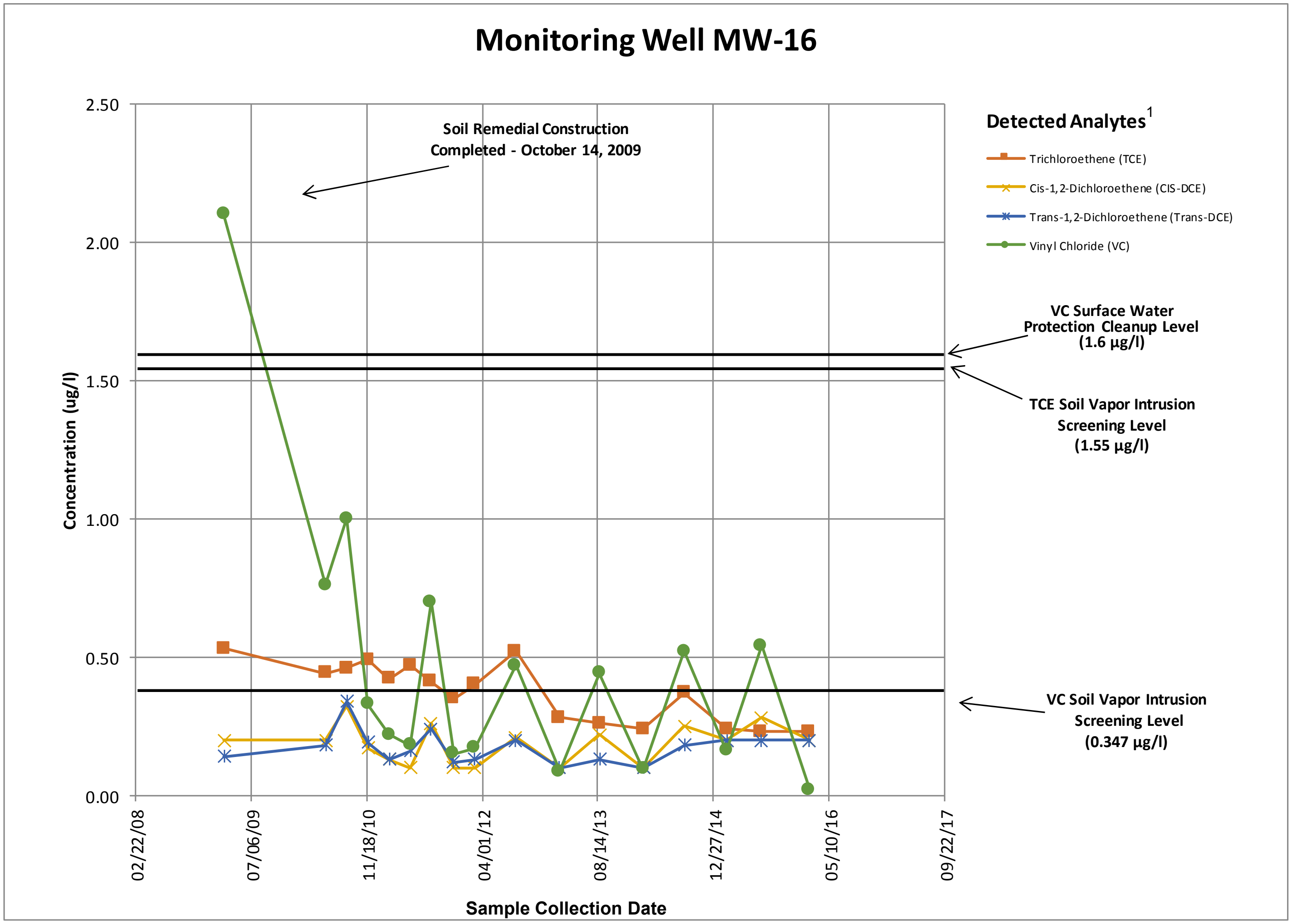
GeoEngineers

Figure 6



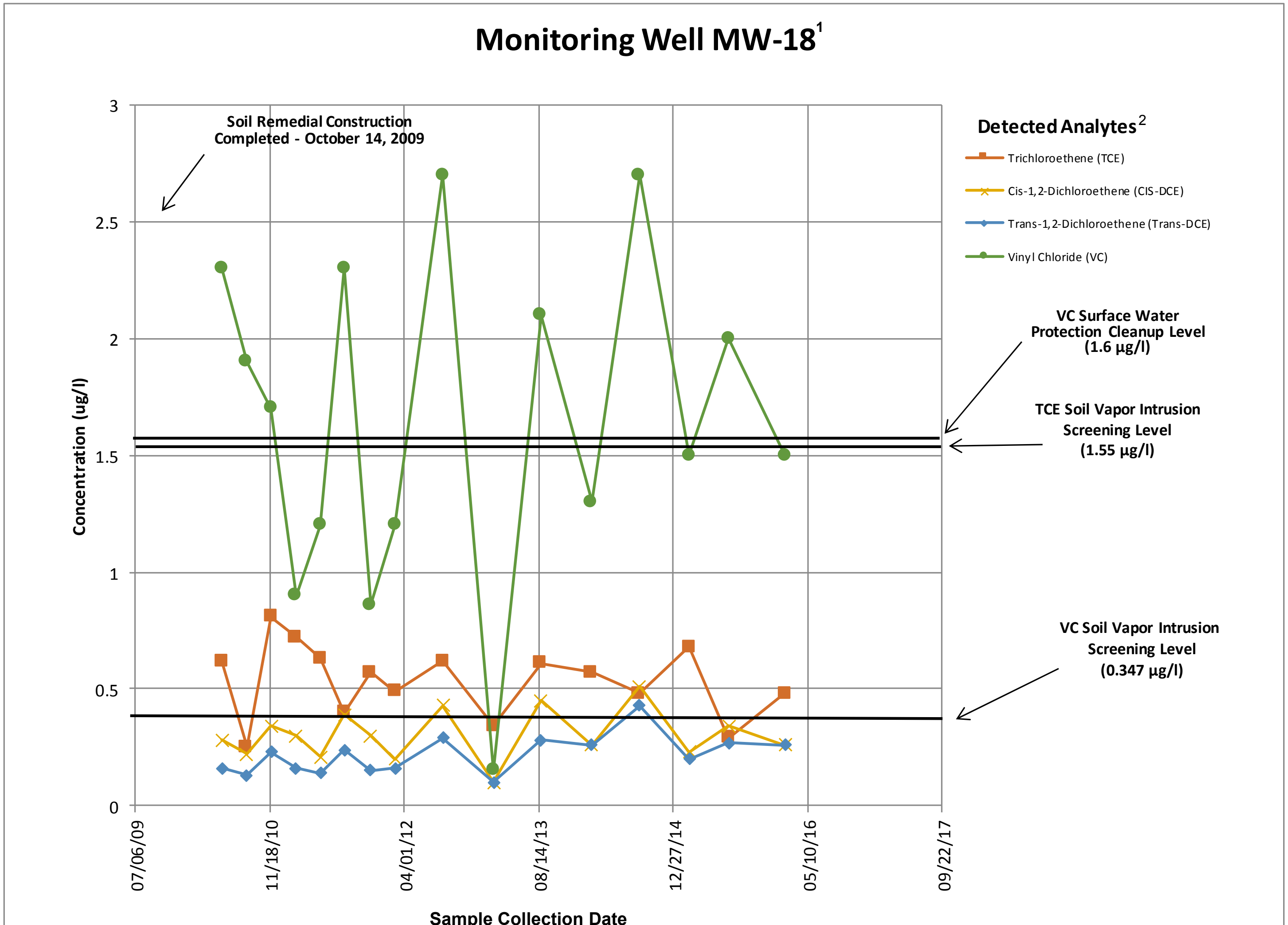
Note:
[1] See Table 1 for a comprehensive summary of the groundwater monitoring results and groundwater cleanup and screening levels.

Trend Analysis – MW-03	
318 State Avenue NE Olympia, Washington	
GeoEngineers	Figure 7



Note:
[1] See Table 1 for a comprehensive summary of the groundwater monitoring results and groundwater cleanup and screening levels.

Trend Analysis – MW-16	
318 State Avenue NE Olympia, Washington	
GeoEngineers	Figure 8



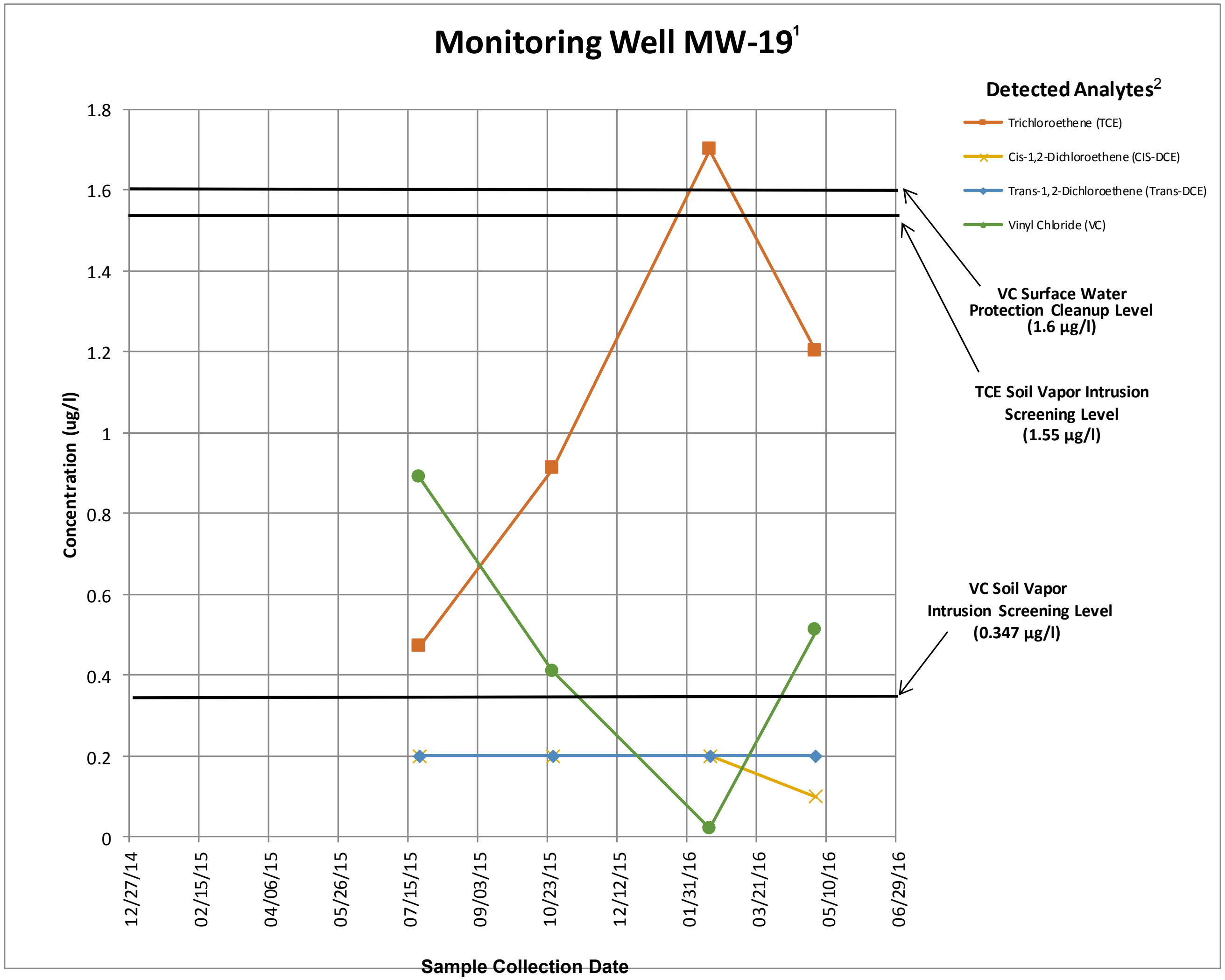
Notes:
[1] MW-18 was installed after remedial actions for soil were completed on October 14, 2009.
[2] See Table 1 for a comprehensive summary of the groundwater monitoring results and groundwater cleanup and screening levels.

Trend Analysis – MW-18

318 State Avenue NE
Olympia, Washington

GeoEngineers

Figure 9



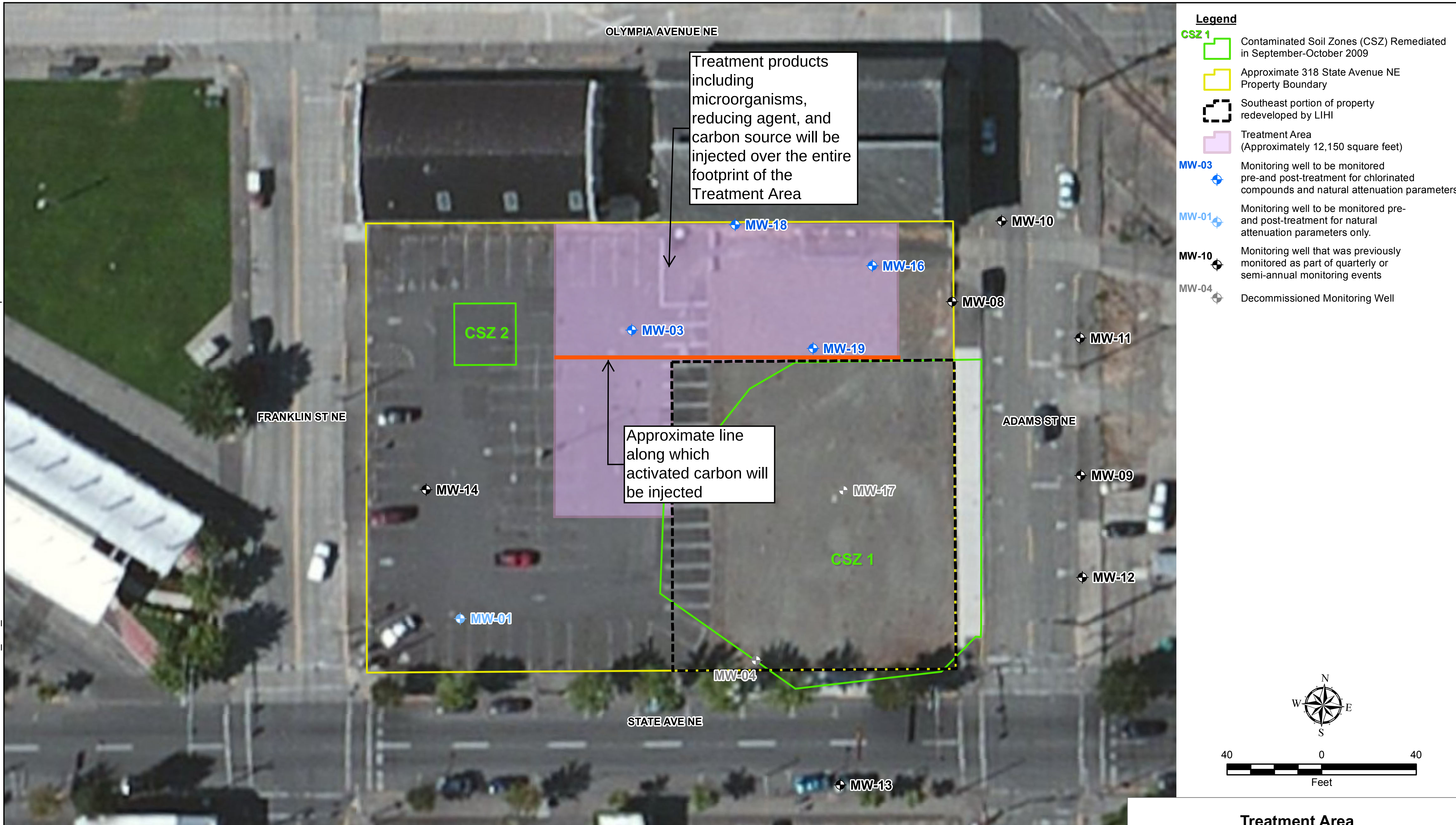
Notes:
[1] MW-19 was installed on July 16, 2015 as part of monitoring groundwater from the southeast portion of the property.
[2] See Table 1 for a comprehensive summary of the groundwater monitoring results and groundwater cleanup and screening levels.

Trend Analysis – MW-19

318 State Avenue NE
Olympia, Washington

GeoEngineers

Figure 10



Map Revised: 29 June 2016 cchelf

Path: P:\0\0415049\GIS\MXDs\041504906_F11_TreatmentArea.mxd

Office: TAC

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Sources: Approximate Property Boundary from Thurston County parcels (revised by GeoEngineers). Aerial photograph 2013 from ESRI. Data Frame Rotated 356 degrees.

Projection: NAD_1983_StatePlane_Washington_South_FIPS_4602_Feet
Datum: D_North_American_1983

Treatment Area

318 State Avenue NE
Olympia, Washington

GeoEngineers

Figure 11

APPENDIX A
Health and Safety Plan

Site Health and Safety Plan

318 State Avenue NE
Olympia, Washington

for
City of Olympia

July 2017

GeoEngineers

1101 South Fawcett Avenue, Suite 200
Tacoma, Washington 98402
253.383.4940

Table of Contents

GEOENGINEERS, INC.
SITE HEALTH AND SAFETY PLAN
318 STATE AVENUE NE
OLYMPIA, WASHINGTON
FILE NO. 0415-049-07

This HASP is to be used in conjunction with the GeoEngineers Safety Program Manual. Together, the written safety programs and this HASP constitute the site safety plan for this site. This plan is to be used by GeoEngineers personnel on this site and must be available on-site. If the work entails potential exposures to other substances or unusual situations, additional safety and health information will be included, and the plan will need to be approved by the GeoEngineers Health and Safety Manager. All plans are to be used in conjunction with current standards and policies outlined in the GeoEngineers Health and Safety Program Manual.

Liability Clause: If requested by subcontractors, this site safety plan may be provided for informational purposes only. In this case, Form C-3 shall be signed by the subcontractor. Please be advised that this Site Safety Plan is intended for use by GeoEngineers Employees only. Nothing herein shall be construed as granting rights to GeoEngineers' subcontractors or any other contractors working on this site to use or legally rely on this Site Safety Plan. GeoEngineers specifically disclaims any responsibility for the health and safety of any person not employed by them.

1.0 GENERAL PROJECT INFORMATION

Project Name:	318 State Avenue NE
Project Number:	0415-049-07
Type of Project:	Injection Monitoring and Groundwater Sampling
Start/Completion:	To Be Determined
Subcontractors:	To Be Determined

2.0 WORK PLAN

The work to be performed consists of monitoring the contractor during in situ treatment injection, and sampling monitoring wells pre- and post-injection.

2.1 Site Description and History

The Site is approximately 1.1 acres in size and is located within the City of Olympia, Thurston County, Washington. The property is generally situated between the southern end of the East and West Bays of Budd Inlet (Figure 1) and is bounded on the south by State Avenue, on the east by Adams Street and on the west by Franklin Street (Figure 2). The Site is bounded on the north by several commercial buildings and Olympia Avenue.

The Site is relatively flat, with ground surface elevations ranging from approximately 11 to 12 feet national geodetic vertical datum (NGVD). The western half of the property is paved with asphalt and the eastern half of the Site is exposed soil and gravel in the former location of a Transportation Data Office (TDO).

Remedial actions were performed at the Property in 2009 to remove soil and fill material containing volatile organic compounds (VOCs) including chlorinated solvents, metals and carcinogenic polycyclic aromatic compounds (cPAHs) at concentrations greater than the Model Toxics Control Act (MTCA) cleanup levels (CULs). A UST was also removed. Soil and fill was excavated from two remedial action areas, designated as contaminated soil zones CSZ 1 and CSZ 2. Clean imported fill soil was placed in CSZ 1 and CSZ 2 after excavation, and the Property was restored. Site contaminants of concern include VOCs including trichloroethylene (TCE), cis-1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE) and vinyl chloride.

The proposed work includes more than 50 direct push soil borings and chemical injections to remediate residual levels of the site contaminants. The contractor will be performing the drilling and injections, and GeoEngineers will be monitoring injection activities. GeoEngineers will also perform pre- and post-injection monitoring.

2.2 List of Field Activities

Check the activities to be completed during the project.

	Site reconnaissance		Field Screening of Soil Samples
X	Borings		Vapor Measurements
X	Construction Monitoring	X	Groundwater Sampling
	Surveying	X	Groundwater Depth Measurement
	Test Pit Exploration		Product Sample Collection
	Monitoring Well Installation		Soil Stockpile Testing
	Monitoring Well Development		Remedial Excavation
	Soil Sample Collection		Underground Storage Tank (UST) Removal Monitoring
	Remediation System Monitoring		Recovery of Free Product

3.0 LIST OF FIELD PERSONNEL AND TRAINING (TO BE DETERMINED)

Name of Employee on Site	Level of HAZWOPER Training (24-/40-hr)	Date of 8-Hr Refresher Training	Date of HAZWOPER Supervisor Training	First Aid/ CPR	Date of Other Trainings	Date of Respirator Fit Test

CHAIN of COMMAND	TITLE		NAME		TELEPHONE NUMBERS
1	Project Manager		Abhijit Joshi		206.239.3256
2	HAZWOPER Supervisor		Garrett Leque		253.312.7958
3	Field Engineer/Geologist		TBD		
4	Site Safety and Health Supervisor*		TBD		

CHAIN of COMMAND	TITLE		NAME		TELEPHONE NUMBERS
5	Client Assigned Site Supervisor		NA		NA
6	Health and Safety Program Manager		Wayne Adams		253.350.4387
N/A	Subcontractor(s)		To Be Determined		To Be Determined
	Current Owner		City of Olympia		360.753.8211

***Site Safety and Health Supervisor** – The individual present at a hazardous waste site responsible to the employer and who has the authority and knowledge necessary to establish the site-specific health and safety plan and verify compliance with applicable safety and health requirements.

4.0 EMERGENCY INFORMATION

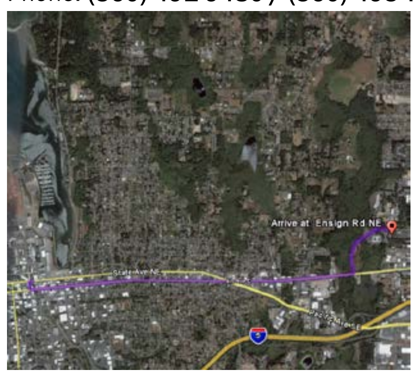
Hospital Name and Address: Providence St Peter Hospital
413 Lily Road NE
Olympia, Washington 98506

Phone Numbers [Main/ER (Automated)]: Phone: **(360) 491-9480 / (360) 493-7289**

Route to Hospital:

1. Go south on Franklin or Adams Streets, go 1 block
2. Turn left (east) on 4th Avenue east, go 1.6 miles
3. Continue on Martin Way 0.5 miles
4. Turn left at Ensign Road NE, 0.5 miles

Hospital is on your left.



Ambulance: 9-1-1

Poison Control: Seattle (206) 253-2121; Other (800) 732-6985
Police: 9-1-1
Fire: 9-1-1
Location of Nearest Telephone: Cell phones are carried by field personnel.
Nearest Fire Extinguisher: Located in the GeoEngineers vehicle on-site.
Nearest First-Aid Kit: Located in the GeoEngineers vehicle on-site.

4.1 Standard Emergency Procedures

Get help.

- Send another worker to phone 9-1-1 (if necessary)
- As soon as feasible, notify GeoEngineers' project manager

Reduce risk to injured person.

- Turn off equipment
- Move person from injury location (if in life-threatening situation only)
- Keep person warm

- Perform CPR (if necessary)

Transport injured person to medical treatment facility (if necessary) -

- By ambulance (if necessary) or GeoEngineers vehicle
- Stay with person at medical facility
- Keep GeoEngineers manager apprised of situation and notify Human Resources Manager of situation

5.0 HAZARD ANALYSIS

**Note: A hazard assessment will be completed at every site prior to beginning field activities. Updates will be included in the daily log. This list is a summary of hazards listed on the form.*

5.1 Physical Hazards

X	Drill rigs
	Backhoe
	Trackhoe
X	Heavy equipment
X	Pumps (pressurized liquids)
	Excavations/trenching (1:1 slopes for Type B soil)
	Shored/braced excavation if greater than 4 feet of depth
	Overhead hazards/power lines
	Tripping/puncture hazards (debris on-site, steep slopes or pits)
	Unusual traffic hazard – street traffic
	Heat/cold, humidity
X	Utilities/utility locate

- Utility checklist will be completed as required for the location to preventing drilling or digging into utilities. Note: These procedures should be added to the standard GeoEngineers utility checklist.
- Work areas will be marked with reflective cones, barricades and/or caution tape. Personnel wearing high-visibility vests; vests are mandatory to ensure personnel can be seen by vehicle and equipment operators.
- Field personnel will be aware at all time of the location and motion of heavy equipment in the area of work to ensure a safe distance between personnel and the equipment. Personnel will be visible to the operator at all times and will remain out of the swing and/or direction of the equipment apparatus. Personnel will approach operating heavy equipment only when they are certain the operator has indicated that it is safe to do so through hand signal or other acceptable means.
- Heavy equipment and/or vehicles used on this site will not work within 20 feet of overhead utility lines without first ensuring that the lines are not energized. This distance may be reduced to 10 feet depending on the client and the use of a safety watch. Working equipment around overhead power lines requires distance and a spotter.

- Keep a safe distance from energized parts which is a minimum of 10 feet for 50 kV and under. The minimum distance will be more for higher voltages (above 50kV). The only exception is for trained and qualified electrical workers using insulated tools designed for high voltage lines.
- Never touch an overhead line if it has been brought down by machinery or has fallen. Never assume lines are de-energized. When a machine is in contact with an overhead line, DO NOT allow anyone to come near or touch the machine. Stay away from the machine and summon outside assistance. Never touch a person who is in contact with a live power line.
- When mechanical equipment is being operated near overhead power lines, employees standing on the ground may not contact the equipment unless it is located so that the required clearance cannot be violated even at the maximum reach of the equipment.
- Personnel will avoid tripping hazards and other hazardous encumbrances.
- Heat stress control measures are being implemented according to the GeoEngineers, Inc. program with water provided on-site. See Additional Programs at end of this HASP.

5.2 Engineering Controls

__________ Trench shoring (1:1 slope for Type B Soils)

__________ Location work spaces upwind/wind direction monitoring

__________ Other soil covers (as needed)

__________ Other (specify)______________________________________

5.3 Chemical Hazards (Potentially Present at Site)

**Note: Remediation was performed at the Site as described in Section 2.1. Presumably contaminant concentrations in soil have been reduced to below MTCA Method A cleanup levels. To be conservative, the concentrations shown below are the maximum concentrations observed BEFORE remediation.*

Maximum Soil Chemistry (mg/kg)	Petroleum Products
	Naphthalenes or paraffins
	Aromatic hydrocarbons (benzene, ethylbenzene, toluene, xylenes [BETX])
	Gasoline
	Diesel fuel
	Waste oil
	Other petroleum fuels (list)_________________________
	Organic Compounds
2.3	Chlorinated hydrocarbons (TCE) (MTCA Method A is 0.3 mg/kg to compare)
	Carcinogenic Polycyclic aromatic hydrocarbons (cPAHs) (MTCA A = 0.1)
	Pesticides/Herbicides
	Other ____
	Metals

Maximum Soil Chemistry (mg/kg)	Petroleum Products
	Lead
	Copper
	Chromium
	Zinc
	Arsenic

5.3.1 Trichloroethene (TCE)

The PEL is 100 ppm (OSHA) or 50 ppm (ACGIH) for an 8-hour average. The PID will detect TCE. Central nervous system effects are the primary effects noted from acute inhalation exposure to trichloroethene in humans, with symptoms including sleepiness, confusion, and feelings of euphoria. Effects on the gastrointestinal system, liver, kidneys and skin have also been noted.

Trichloroethene absorption by inhalation, dermal, and oral exposure is very rapid. Trichloroethene is metabolized in humans and animals to a number of substances which themselves are known to be toxic: chloral hydrate, trichloroacetic acid, dichloroacetic acid and trichloroethanol.

TCE is very lipophilic; hence, all routes of exposure can contribute to TCE absorption. Inhalation is the most important route of TCE uptake by which absorption is very rapid. The initial rate of uptake of inhaled TCE is quite high, leveling off after a few hours of exposure.

TCE defats the skin and disrupts the stratum corneum, thereby enhancing its own absorption. The rate of absorption probably increases with greater dermal disruption. However, dermal route is generally not a significant route of exposure.

5.3.2 Other Hazards

Characteristics of other potential hazards are summarized in this section.

5.3.2.1 Biological Hazards and Procedures

Site personnel shall avoid contact with or exposures to potential biological hazards encountered.

	Hazard	Procedures
	Poison Ivy or other vegetation	
	Insects or snakes	
X	Used hypodermic needs or other infectious hazards	Do not pick up or contact
	Others	

5.3.2 .2 Additional Hazards (Update in Daily Report)

The Site is in a public area, and care should be taken to keep the public away from the work areas during injections and monitoring.

6.0 AIR MONITORING PLAN

Work upwind if at all possible.

Check instrumentation to be used:

X Photoionization Detector (PID)

______ Other (i.e., detector tubes): ____

Check monitoring frequency/locations and type (specify: work space, borehole, breathing zone):

______ 15 minutes - Continuous during soil disturbance activities or handling samples

______ 15 minutes

______ 30 minutes

X Hourly (in breathing zone during excavations, drilling, sampling)

Additional personal air monitoring for specific chemical exposure:

Action levels:

- The workspace will be monitored using a photoionization detector (PID). These instruments must be properly maintained, calibrated and charged (refer to the instrument manuals for details). Zero this meter in the same relative humidity as the area in which it will be used and allow at least a 10-minute warm-up prior to zeroing. Do not zero in a contaminated area. The PID can be tuned to read chemicals specifically if there are not multiple contaminants on-site. It can be tuned to detect one chemical with the response factor entered into the equipment, but the PID picks up all volatile organic compounds (VOCs) present. The ionization potential (IP) of the chemical has to be less than the PID lamp (11.7/10.6eV), and the PID does not detect methane. The ppm readout on the instrument is relative to the IP of isobutylene (calibration gas), so conversion must be made in order to estimate ppm of the chemical on-site.
- An initial vapor measurement survey of the site should be conducted to detect "hot spots" if contaminated soil is exposed at the surface. Vapor measurement surveys of the workspace should be conducted at least hourly or more often if persistent petroleum-related odors are detected. Additionally, if vapor concentrations exceed 5 ppm above background continuously for a 5-minute period as measured in the breathing zone, upgrade to Level C personal protective equipment (PPE) or move to a noncontaminated area.
- Standard industrial hygiene/safety procedure is to require that action be taken to reduce worker exposure to organic vapors when vapor concentrations exceed one-half the TLV. Because of the variety of chemicals, the PID will not indicate exposure to a specific PEL and is therefore not a preferred tool for determining worker exposure to chemicals. If odors are detected, then employees shall upgrade to respirators with Organic Vapor cartridges and will contact the Health and Safety Program Manager for other sampling options.

AIR MONITORING ACTION LEVELS

Contaminant	Activity	Monitoring Device	Frequency of Monitoring Breathing Zone	Action Level	Action
Organic Vapors	Environmental Remedial Actions	PID	Start of shift; every 60 minutes and in event of odors	Background to 5 ppm in breathing zone	Use Level D or Modified Level D PPE
Organic Vapors	Environmental Remedial Actions	PID	Start of shift; every 60 minutes and in event of odors	5 to 25 ppm in breathing zone	Upgrade to Level C PPE
Organic Vapors	Environmental Remedial Actions	PID	Start of shift; every 60 minutes	> 25 ppm in breathing zone	Stop work and evacuate the area. Contact Certified Industrial Hygienist (CIH) for guidance.
Combustible Atmosphere	Environmental Remedial Actions	PID	Start of shift; every 60 minutes	>10% LEL or >1,000 ppm	Depends on contaminant. The PEL is usually exceeded before the lower explosive limit (LEL).

7.0 SITE CONTROL PLAN

The Site is currently vacant. The general public may access the Site. Use cones and/or flagging to secure a work zone that is approximately a 15-foot radius around your vehicle and equipment. If approached by any individual, use necessary precautions to keep them safe and away from the work area. Practice the buddy system with equipment operators and helpers (see Section 7.3). At the safety tailgate meeting, discuss an appropriate means of communicating during emergencies and establish a safe zone (see Section 7.4). Discuss the hospital/hospital route with drillers at the safety tailgate meeting (see Section 4.0).

7.1 Traffic or Vehicle Access Control Plans

The Site is not well cordoned off from the public, and people could walk or drive onto the Site. Use caution.

7.2 Site Work Zones

Hot zone/exclusion zone: Within 15 feet of boring.

	Method of delineation/ excluding non-site personnel
	Fence
X	Survey Tape (optional)
X	Traffic Cones (required)
	Other

The contamination reduction zone should be between the equipment and your vehicle.

The decontamination zone should be at your tailgate; decontaminate before you eat, smoke or leave the Site (see Section 7.5).

7.3 Buddy System

Personnel on-site should use the buddy system (pairs), particularly whenever communication is restricted. If only one GeoEngineers employee is on-site, a buddy system can be arranged with subcontractor/ contractor personnel.

7.4 Site Communication Plan

Positive communications (within sight and hearing distance or via radio) should be maintained between pairs on site, with the pair remaining in proximity to assist each other in case of emergencies. The team should prearrange hand signals or other emergency signals for communication when voice communication becomes impaired (including cases of lack of radios or radio breakdown). In these instances, you should consider suspending work until communication can be restored; if not, the following are some examples for communication:

- Hand gripping throat: Out of air, can't breathe.
- Gripping partner's wrist or placing both hands around waist: Leave area immediately, no debate.
- Hands on top of head: Need assistance.
- Thumbs up: Okay, I'm all right: or I understand.
- Thumbs down: No, negative.

7.5 Decontamination Procedures

Decontamination consists of removing outer protective Tyvek clothing and washing soiled boots and gloves using bucket and brush provided on-site in the contamination reduction zone. Inner gloves will then be removed, and respirator, hands and face will be washed in either a portable wash station or a bathroom facility in the support zone. Employees will perform decontamination procedures and wash prior to eating, drinking or leaving the site.

7.6 Waste Disposal or Storage

PPE disposal (specify): Used PPE to be placed disposed of as indicated below.

______ On-site, pending analysis and further action

______ Secured (list method) ____

X Other (describe destination, responsible parties): In bag into GeoEngineers dumpster

8.0 PERSONAL PROTECTIVE EQUIPMENT

Level D Personal Protective Equipment (PPE).is required at this Site. Be prepared to upgrade to level C in the event that air monitoring indicates the need to do so (see Section 6.0). Inspect PPE before work. Properly store and maintain your PPE. Wash clothes after working at this Site.

Air monitoring will be conducted for establishing the level of respiratory protection.

- Half-face combination organic vapor/high efficiency particulate air (HEPA) or P100 cartridge respirators will be available on-site to be used as necessary. P100 cartridges are to be used only if PID measurements are below the site action limit. P100 cartridges are used for protection against dust, metals and asbestos, while the combination organic vapor/HEPA cartridges are protective against both dust and vapor. Ensure that the PID or TLV will detect the chemicals of concern on-site.
- Level D PPE will be worn at all times on the site. Potentially exposed personnel will wash gloves, hands, face and other pertinent items to prevent hand-to-mouth contact. This will be done prior to hand-to-mouth activities including eating, smoking, etc.
- Adequate personnel and equipment decontamination will be used to decrease potential ingestion and inhalation.
- Individual PELs or action limits are not expected to be exceeded given the planned activities. If there are waste oil contaminants in the soil and conditions are damp, airborne dust is not likely to be an issue. If conditions are dry and dust is visible during site activities, personnel will use P100 cartridges on their respirators.

After the initial and/or daily hazard assessment has been completed, select the appropriate PPE to preserve worker safety. Task-specific levels of PPE shall be reviewed with field personnel during the pre-work briefing conducted prior to the start of site operations.

Check applicable personal protection gear to be used:

X Hardhat (if overhead hazards, or client requests)

X Steel-toed boots (if crushing hazards are a potential or if client requests)

X Safety glasses (if dust, particles, or other hazards are present or client requests)

X Hearing protection (if it is difficult to carry on a conversation 3 feet away)

X Rubber boots (if wet conditions)

Gloves (specify):

X Nitrile

_______ Latex

_______ Liners

_______ Leather

X Other (specify) _As necessary_________________________________

Protective clothing:

X	Tyvek as needed
	Saranex (personnel shall use Saranex if liquids are handled or splash may be an issue)
X	Cotton
X	Rain gear (as needed)
X	Layered warm clothing (as needed)

Inhalation hazard protection:

X	Level D
X	Level C (have your respirator with organic vapor/HEPA or P100 filters)

8.1 Limitations of Protective Clothing

PPE clothing ensembles designated for use during site activities shall be selected to provide protection against known or anticipated hazards. However, no protective garment, glove or boot is entirely chemical-resistant, nor does any PPE provide protection against all types of hazards. To obtain optimum performance from PPE, site personnel shall be trained in the proper use and inspection of PPE. This training shall include the following:

- Inspect PPE before and during use for imperfect seams, non-uniform coatings, tears, poorly functioning closures or other defects. If the integrity of the PPE is compromised in any manner, proceed to the contamination reduction zone and replace the PPE.
- Inspect PPE during use for visible signs of chemical permeation such as swelling, discoloration, stiffness, brittleness, cracks, tears or other signs of punctures. If the integrity of the PPE is compromised in any manner, proceed to the contamination reduction zone and replace the PPE.
- Disposable PPE should not be reused after breaks unless it has been properly decontaminated.

8.2 Respirator Selection, Use and Maintenance

If respirators are required, site personnel shall be trained before use on the proper use, maintenance and limitations of respirators. Additionally, they must be medically qualified to wear a respiratory protection in accordance with 29 CFR 1910.134. Site personnel who will use a tight-fitting respirator must have passed a qualitative or quantitative fit test conducted in accordance with an OSHA-accepted fit test protocol. Fit testing must be repeated annually or whenever a new type of respirator is used. Respirators will be stored in a protective container.

8.3.1 Respirator Cartridges

If site personnel are required to wear air-purifying respirators, the appropriate cartridges shall be selected to protect personnel from known or anticipated site contaminants. The respirator/cartridge combination shall be certified and approved by the National Institute for Occupational Safety and Health (NIOSH). A cartridge change-out schedule shall be developed based on known site contaminants, anticipated contaminant concentrations and data supplied by the cartridge manufacturer related to the absorption capacity of the cartridge for specific contaminants. Site personnel shall be made aware of the cartridge change-out schedule prior to the initiation of site activities. Site personnel shall also be instructed to change respirator cartridges if they detect increased resistance during inhalation or detect vapor breakthrough by smell, taste or feel, although breakthrough is not an acceptable method of determining the change-out schedule. At a minimum, cartridges should be changed at least once daily.

8.3.2 Respirator Inspection and Cleaning

Inspect your respirator at the project site before and after use, if used. Site personnel shall inspect respirators prior to each use in accordance with the manufacturer's instructions. In addition, site personnel wearing a tight-fitting respirator shall perform a positive and negative pressure user seal check each time the respirator is donned, to ensure proper fit and function. User seal checks shall be performed in accordance with the GeoEngineers respiratory protection program or the respirator manufacturer's instructions.

9.0 ADDITIONAL ELEMENTS

9.1 Heat Stress Prevention

List all the site-specific procedures for preventing heat stress.

- Drink water and pay attention to the signs of heat stress. Take breaks and add or subtract clothing layers as necessary to avoid heat stress.
- State and federal OSHA regulations provide specific requirements for handling employee exposure to heat stress. GeoEngineers' program complies with these requirements and will be implemented in all areas where heat stress is identified as a potential health issue.
- General requirements for preventing heat stress apply to outdoor work environments from May 1 through September 30, annually, only when employees are exposed to outdoor heat at or above an applicable temperature listed in the table below. To determine which temperature applies to each worksite, select the temperature associated with the general type of clothing or PPE each employee is required to wear.

HEAT STRESS

Type of Clothing	Outdoor Temperature Action Levels
Nonbreathing clothes including vapor barrier clothing or PPE such as chemical resistant suits	52°
Double-layer woven clothes including coveralls, jackets and sweatshirts	77°
All other clothing	89°

Keeping workers hydrated in a hot outdoor environment requires that more water be provided than at other times of the year. GeoEngineers is prepared to supply at least one quart of drinking water per employee per hour. When employee exposure is at or above an applicable temperature listed in Table 1, Project Managers shall ensure that:

- A sufficient quantity of drinking water is readily accessible to employees at all times; and

- All employees have the opportunity to drink at least one quart of drinking water per hour.

9.2 Emergency Response

Indicate what site-specific procedures you will implement.

- Personnel on-site should use the "buddy system" (pairs).
- Visual contact should be maintained between "pairs" on-site, with the team remaining in proximity to assist each other in case of emergencies.
- If any member of the field crew experiences any adverse exposure symptoms while on-site, the entire field crew should immediately halt work and act according to the instructions provided by the Site Safety and Health Supervisor.
- Wind indicators visible to all on-site personnel should be provided by the Site Safety and Health Supervisor to indicate possible routes for upwind escape. Alternatively, the Site Safety and Health Supervisor may ask on-site personnel to observe the wind direction periodically during site activities.
- The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated should result in the evacuation of the field team, contact of the PM, and reevaluation of the hazard and the level of protection required.
- If an accident occurs, the Site Safety and Health Supervisor and the injured person are to complete, within 24 hours, an Accident Report for submittal to the PM, the Health and Safety Program Manager and Human Resources. The PM should ensure that follow-up action is taken to correct the situation that caused the accident or exposure.

10.0 SAMPLING AND MONITORING PLAN FOR DRUMS AND CONTAINERS

10.1 Site Control Measures

See Section 7.0.

10.2 Spill Containment Plans (Drum and Container Handling)

The drums containing soil (drill cuttings) and water (purge/decontamination water) will be stored in a secured (fenced and locked) area on-site to be determined, pending proper disposal.

10.3 Standard Operating Procedures for Sampling, Managing and Handling Drums and Containers

Drums and containers used during the sampling meet the appropriate Department of Transportation (DOT), OSHA and United States Environmental Protection Agency (EPA) regulations for the waste that they contain. Site operations shall be organized to minimize the amount of drum or container movement. When practicable, drums and containers shall be inspected and their integrity shall be ensured before they are moved. Label all drums. Before drums or containers are moved, all employees involved in the transfer operation shall be warned of the potential hazards associated with the contents.

Drums or containers and suitable quantities of proper absorbent shall be kept available and used where spills, leaks or rupture may occur. Major spills are not anticipated to occur given the small volume of soil and water generated and the fact that the drums will be placed in a locked, fenced area.

10.4 Personnel Medical Surveillance

GeoEngineers employees are not in a medical surveillance program because they do not fall into the category of "Employees Covered" in OSHA 1910.120(f)(2), which states a medical surveillance program is required for the following employees:

(1) All employees who are or may be exposed to hazardous substances or health hazards at or above the permissible exposure limits or, if there is no permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year;

(2) All employees who wear a respirator for 30 days or more a year or as required by state and federal regulations;

(3) All employees who are injured, become ill or develop signs or symptoms due to possible overexposure involving hazardous substances or health hazards from an emergency response or hazardous waste operation; and

(4) Members of HAZMAT teams.

10.5 Sanitation

Local businesses could be utilized for sanitation.

10.6 Lighting

All work will be performed during daylight hours.

11.0 DOCUMENTATION TO BE COMPLETED FOR HAZWOPER PROJECTS

The following forms are required for Hazardous Waste Operations and Emergency Response (HAZWOPER) projects:

- Field Log
- Health and Safety Plan acknowledgment by GeoEngineers employees (Form 2)
- Contractors Health and Safety Plan Disclaimer (Form 3)
- Conditional forms available at GeoEngineers office: Accident Report

NOTE: The Field Report is to contain the following information:

- Updates on hazard assessments, field decisions, conversations with subcontractors, client or other parties, etc.;

- Air monitoring/calibration results, including: personnel, locations monitored, activity at the time of monitoring, etc.;
- Actions taken;
- Action level for upgrading PPE and rationale; and
- Meteorological conditions (temperature, wind direction, wind speed, humidity, rain, snow, etc.).

12.0 DOCUMENTATION EXPECTED TO BE COMPLETED

NOTE: The Field Log is to contain the following information:

- Updates on hazard assessments, field decisions, and conversations with subconsultants, client or other parties
- Actions taken
- Meteorological conditions (temperature, wind direction, wind speed, humidity, rain, snow, etc.)

Required forms:

- Field Log
- Form 1 Health & Safety Meeting
- Form 2 Site Safety Plan – GeoEngineers' Employee Acknowledgment
- Form 3 Subcontractor and Site Visitor Site Safety Form

13.0 APPROVALS

1.	Plan Prepared	Garrett Leque Signature	July 25, 2016 Date
2.	Plan Approval	Iain Wingard PM Signature	July 25, 2016 Date
3.	Health & Safety Officer	Wayne Adams Health & Safety Program Manager	July 25, 2016 Date

FORM 1
HEALTH AND SAFETY PRE-ENTRY BRIEFING
318 STATE AVENUE NE
FILE NO. 0415-049-07

Inform employees, contractors and subcontractors or their representatives about:

- The nature, level and degree of exposure to hazardous substances they're likely to encounter;
- All site-related emergency response procedures; and
- Any identified potential fire, explosion, health, safety or other hazards.

Conduct briefings for employees, contractors and subcontractors, or their representatives as follows:

- A pre-entry briefing before any site activity is started; and
- Additional briefings, as needed, to make sure that the Site-specific HASP is followed.

Make sure all employees working on the Site are informed of any risks identified and trained on how to protect themselves and other workers against the Site hazards and risks.

Update all information to reflect current sight activities and hazards.

All personnel participating in this project must receive initial health and safety orientation. Thereafter, brief tailgate safety meetings will be held as deemed necessary by the Site Safety and Health Supervisor.

The orientation and the tailgate safety meetings shall include a discussion of emergency response, Site communications and site hazards.

Company Employee

Date	Topics	Attendee	Name	Initials

FORM 2
SITE SAFETY PLAN – GEOENGINEERS' EMPLOYEE ACKNOWLEDGMENT
318 STATE AVENUE NE
FILE NO. 0415-049-07

All GeoEngineers' Site workers shall complete this form, which should remain attached to the Safety Plan and filed with other project documentation.

I hereby verify that a copy of the current Safety Plan has been provided by GeoEngineers, Inc., for my review and personal use. I have read the document completely and acknowledge an understanding of the safety procedures and protocol for my responsibilities on Site. I agree to comply with all required, specified safety regulations and procedures.

Print Name	Signature	Date

FORM 3
SUBCONTRACTOR AND SITE VISITOR SITE SAFETY FORM
318 STATE AVENUE NE
FILE NO. 0415-049-07

I verify that a copy of the current Site Safety Plan has been provided by GeoEngineers, Inc. to inform me of the hazardous substances on Site and to provide safety procedures and protocols that will be used by GeoEngineers' staff at the Site. By signing below, I agree that the safety of my employees is the responsibility of the undersigned company.

Print Name	Signature	Firm	Date

Appendix B
Groundwater Monitoring Quality Assurance Project Plan

APPENDIX B
QUALITY ASSURANCE PROJECT PLAN

The Quality Assurance Project Plan (QAPP) serves as the primary guide for the integration of quality assurance (QA) and quality control (QC) functions into monitoring activities. The QAPP presents the objectives, procedures, organization, functional activities and specific QA and QC activities designed to achieve data quality goals established for the project. This QAPP is based on guidelines specified in Washington Administrative Code (WAC) Chapter 173-340-820 and United States Environmental Protection Agency (EPA) Guidelines (EPA 1999 and 2004).

Throughout the project, environmental measurements will be conducted to produce data that are scientifically valid, of known and acceptable quality and meet established objectives. QA/QC procedures will be implemented so that precision, accuracy, representativeness, completeness and comparability (PARCC) of data generated meet the specified data quality objectives.

B.1 Project Organization and Responsibility

Descriptions of the responsibilities, lines of authority and communication for the key positions for QA and QC are provided below. The project organization facilitates the efficient performance of project work, allows for an independent quality review and permits resolution of any QA issues before submittal.

B.1.1 Project Leadership and Management

The Project Manager's duties consist of providing concise technical work statements for project tasks, selecting project team members, determining subcontractor participation, establishing budgets and schedules, adhering to budgets and schedules, providing technical oversight, and providing overall production and review of project deliverables. Abhijit Joshi is the Project Manager for treatment activities for shallow soil and groundwater at the Property. The Associate–in-Charge is responsible to the City of Olympia for fulfilling contractual and administrative control of the project. Iain Wingard is the Associate-in Charge.

B.1.2 Field Coordinator

The Field Coordinator is responsible for the daily management of activities in the field. Specific responsibilities include the following:

- Develops schedules and allocates resources for field tasks.
- Coordinates data collection activities to be consistent with information requirements.
- Collects field data and submits samples to the laboratory.
- Assures that data are correctly and completely reported.
- Implements field sampling in accordance with Treatment Work Plan requirements.
- Schedules sample delivery to the analytical laboratory.
- Assures that appropriate sampling, testing and measurement procedures are followed.
- Participates in QA corrective actions as required.

The Field Coordinator for activities at the Property will be Garrett Leque or Paul Robinette.

B.1.3 Quality Assurance Leader

The GeoEngineers project Quality Assurance Leader is Iain Wingard, who is responsible for the project's overall QA. The Project QA Leader is responsible for coordinating QA/QC activities as they relate to the acquisition of field data. The QA Leader has the following responsibilities:

- Serves as the official contact for laboratory data QA concerns.
- Responds to laboratory data, QA needs, resolves issues, and answers requests for guidance and assistance.
- Reviews the implementation of the QAPP and the adequacy of the data generated from a quality perspective.
- Maintains the authority to implement corrective actions as necessary.
- Reviews and approves the laboratory QA Plan.
- Evaluates the laboratory's final QA report for any condition that adversely impacts data generation.
- Ensures that appropriate sampling, testing, and analysis procedures are followed and that correct quality control checks are implemented.
- Monitors laboratory compliance with data quality requirements.

B.1.4 Laboratory Management

The Laboratory's QA Coordinator administers the Laboratory QA Plan and is responsible for QC. Specific responsibilities of this position include:

- Ensures implementation of the QA Plan.
- Serves as the laboratory point of contact.
- Activates corrective action for out-of-control events.
- Issues the final QA/QC report.
- Administers QA sample analysis.
- Complies with the specifications established in the project plans as related to laboratory services.
- Participates in QA audits and compliance inspections.

The chemical analytical laboratory QA Coordinator will be determined by the laboratory (Test America, Fife, Washington).

B.2 Data Quality Objectives

The QA objective for technical data is to collect environmental monitoring data of known, acceptable and reportable quality. The QA objectives established for the project are:

- Implement the procedures outlined herein for field sampling, sample custody, equipment operation and calibration, laboratory analysis, and data reporting that will facilitate consistency and thoroughness of data generated.
- Achieve the acceptable level of confidence and quality required so that data generated are scientifically valid and of known and documented quality. This will be performed by establishing criteria for PARCC parameters and by testing data against these criteria.

The sampling design, field procedures, laboratory procedures and QC procedures are set up to provide high-quality data for use in this project. Specific data quality factors that may affect data usability include quantitative factors (precision, bias, accuracy, completeness and reporting limits) and qualitative factors (representativeness and comparability). The measurement quality objectives (MQO) associated with these data quality factors are summarized in Tables A-1 and A-2, and are discussed below.

B.2.1 Analytes

The analytes for groundwater samples submitted to the laboratory during groundwater monitoring are shown in Table B-1 and include the following:

- Chlorinated compounds including PCE, TCE, 1,1-DCE, cis-DCE, trans-DCE, and VC using EPA Method 8260B;
- Nitrate and sulfate by EPA Method 300.0;
- Total and dissolved iron and manganese by EPA Method 200.8;
- Chemical oxygen demand (COD) by Method SM 5220C;
- Biochemical oxygen demand (BOD) by Method SM 5210B; and
- Dissolved gases (methane, ethane, ethene and carbon dioxide [CO2]) by Method RSK-175.

B.2.2 Detection Limits

Analytical methods have quantitative limitations at a given statistical level of confidence that are often expressed as the method detection limit (MDL). Individual instruments often can detect but not accurately quantify compounds at concentrations lower than the MDL, referred to as the instrument detection limit (IDL). Although results reported near the MDL or IDL provide insight to site conditions, quality assurance dictates that analytical methods achieve a consistently reliable level of detection known as the practical quantitation limit (PQL) or reporting limit (RL). The contract laboratory will provide numerical results for all analytes and report them as detected above the RL or undetected at the RL.

Achieving a stated detection limit for a given analyte is helpful in providing statistically useful data. Intended data uses, such as comparison to numerical criteria or risk assessments, typically dictate specific project target reporting limits (TRLs) necessary to fulfill stated objectives. For this project, the TRLs are values that are less than Model Toxics Control Act (MTCA) Method B cleanup levels for protection of surface water and the MTCA Method B groundwater screening level protective of indoor air provided in Ecology's Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State (Ecology 2009) as updated in April 2015 to revise the soil gas screening levels provided in Appendix B of the guidance document (Ecology 2015). The project analytes, applicable cleanup and screening levels, and laboratory TRLs are shown in Table B--2. The TRLs were obtained from Test America, Fife, Washington. The analytical methods and processes selected will provide RLs less than the TRLs under ideal conditions. Therefore, a particular TRL is considered a target because several factors may influence final RLs. Data users must be aware that high non-detect values, although correctly reported, can bias statistical summaries. Careful interpretation is required to correctly characterize site conditions.

B.2.3 Precision

Precision is the measure of mutual agreement among replicate or duplicate measurements of an analyte from the same sample and applies to field duplicate or split samples, replicate analyses, and duplicate spiked environmental samples (matrix spike duplicates) and laboratory control duplicates. The closer the measured values are to each other, the more precise the measurement process. Precision error may affect data usefulness. Good precision is indicative of relative consistency and comparability between different samples. Precision will be expressed as the relative percent difference (RPD) for spike sample comparisons and field duplicate comparisons. This value is calculated by:

$$RPD = 100[(Xs - Xd)/(Xs + Xd)]/2$$

Where:

RPD = relative percent difference
Xs = sample analytical result
Xd = duplicate sample analytical result

The RPD will be calculated for appropriate sample sets and compared to the applicable criteria. Precision can also be expressed as the percent difference (%D) between replicate analyses. Persons performing the evaluation must review one or more pertinent documents (EPA 1999 and 2004) that address criteria exceedances and courses of action. The relative percent difference goal for this effort is 50 percent in analyses, unless the duplicate sample concentrations are less than five times the reporting limit.

B.2.4 Accuracy

Accuracy is a measure of bias in the analytic process. The closer the measurement value is to the true value, the greater the accuracy. This measure is defined as the difference between the reported value versus the actual value and is often measured with the addition of a known compound to a sample. The amount of known compound reported in the sample, or percent recovery, assists in determining the performance of the analytical system in correctly quantifying the compounds of interest. Since most environmental data collected represent one point spatially and temporally rather than an average of values, accuracy plays a greater role than precision in assessing the results. In general, if the percent recovery is low, non-detect results may indicate that compounds of interest are not present when in fact these compounds are present. Detected compounds may be biased low or reported at a value less than actual environmental conditions. The reverse is true when recoveries are high. Non-detect values are considered accurate while detected results may be higher than the true value.

Accuracy will be expressed as the percent recovery of a surrogate compound (also known as “system monitoring compound”), a matrix spike result, or from a standard reference material where:

$$PR = 100(Xss - Xs)/T$$

Where:

PR = percent recovery
Xss = spike sample analytical result
Xs = sample analytical result
T = known spike concentration

Persons performing the evaluation must review one or more pertinent documents (EPA 1999 and 2004) that address criteria exceedances and courses of action. Accuracy criteria for surrogate spikes, matrix spikes and laboratory control spikes are found in Table B-1.

B.2.5 Representativeness, Completeness and Comparability

Representativeness expresses the degree to which data accurately and precisely represent the actual site conditions. The determination of the representativeness of the data will be performed by completing the following:

- Comparing actual sampling procedures to those specified in the Treatment Work Plan and QAPP.
- Comparing analytical results of field duplicates to determine the variations in the analytical results.
- Invalidating non-representative data or identifying data to be classified as questionable or qualitative. Only representative data will be used in subsequent data reduction, validation and reporting activities.

Completeness establishes whether a sufficient amount of valid measurements were obtained to meet project objectives. The number of samples and results expected establishes the comparative basis for completeness. Completeness goals are 90 percent useable data for samples/analyses planned. If the completeness goal is not achieved an evaluation will be made to determine if the data are adequate to meet study objectives.

Comparability expresses the confidence with which one set of data can be compared to another. Although numeric goals do not exist for comparability, a statement on comparability will be prepared to determine overall usefulness of data sets, following the determination of both precision and accuracy.

B.2.6 Holding Times

Holding times are defined as the time between sample collection and extraction, sample collection and analysis, or sample extraction and analysis. Some analytical methods specify a holding time for analysis only. Holding times for the analyses to be performed as part of groundwater monitoring are shown in Table B-3.

B.2.7 Blanks

According to the *National Functional Guidelines for Organic Data Review* (EPA 1999), "The purpose of laboratory (or field) blank analysis is to determine the existence and magnitude of contamination resulting from laboratory (or field) activities. The criteria for evaluation of blanks apply to any blank associated with the samples (e.g., method blanks, instrument blanks, trip blanks, and equipment blanks)." Trip blanks are placed with samples during shipment; method blanks are created during sample preparation and follow samples throughout the analysis process.

Analytical results for blanks will be interpreted in general accordance with *National Functional Guidelines for Organic Data Review* and professional judgment. Blanks are discussed further in Section B.6.

B.3 Sample Collection, Handling and Custody

B.3.1 Sampling Equipment Decontamination

Groundwater samples will be collected from each well using dedicated equipment. General decontamination procedures for any other equipment (e.g., the water level indicator) will consist of the following: (1) wash with non-phosphate detergent solution (Alconox and distilled water), (2) rinse with distilled water, and (3) second distilled water rinse. Field personnel will limit cross-contamination by changing gloves between sampling events or more frequently as needed. Wash water used to decontaminate the sampling equipment will be combined with well purge water in 55-gallon drums for proper off-site disposal.

B.3.2 Sample Containers and Labeling

The Field Coordinator will establish field protocol to manage field sample collection, handling and documentation. Samples obtained will be placed in appropriate laboratory-prepared containers. Sample containers and preservatives are listed in Table B-3.

Sample containers will be labeled with the following information at the time of collection:

- Project number,
- Sample name, and
- Date and time of collection.

Samples will be named according to the following example:

MW-19-072516-W

Where:

MW-19 = monitoring well number 19,
072516 = July 25, 2016 and,
W = water sample

The sample collection activities will be noted on field logs. The Field Coordinator will monitor consistency between the QAPP, sample containers/labels, field logs and the chain of custody.

B.3.3 Sample Storage

Samples will be placed in a cooler with "wet ice" immediately after they are collected. The objective of the cold storage will be to attain a sample temperature of 2 and 6 degrees Celsius. Holding times will be observed during sample storage.

B.3.4 Sample Shipment

The samples will be transported and delivered to the analytical laboratory in coolers. Field personnel will transport and hand-deliver samples to the laboratory or to a laboratory courier. All analyses for this project are anticipated to be performed using the Test America Fife laboratory, and sample shipping is not anticipated.

B.3.5 Chain-Of-Custody Records

Field personnel are responsible for the security of samples from the time the samples are collected until the samples have been received by the laboratory or courier. A chain-of-custody form will be completed at the end of the field day for samples being shipped to the laboratory. Information to be included on the chain-of-custody form includes:

- Project name and number.
- Sampler's name.
- Sample identification numbers.
- Date and time of sampling.
- Sample matrix and number of containers for each sample and preservatives used.
- Analyses to be performed.
- Names of personnel performing transfer of custody in transfer acknowledgment spaces.

The original chain-of-custody record will be signed by the field sample personnel and bear a unique tracking number. Field personnel shall retain carbon copies and place the original and remaining copies in a plastic bag, placed within the cooler or taped to the inside lid of the cooler before sealing the container for transport. This record will accompany the samples during transit by the field team member or courier to the laboratory.

B.3.6 Laboratory Custody Procedures

The laboratory will follow their standard operating procedures (SOPs) to document sample handling from time of receipt (sample log-in) to reporting. Documentation will include at a minimum, the analysts name or initial, and the time and date of analysis.

B.3.7 Field Documentation

Field documentation provides important information about sampling activities, sample characteristics, potential problems or special circumstances surrounding sample collection. Field personnel will maintain daily field logs while on site. The field logs will be prepared on field report forms. Entries in the field logs and associated sample documentation forms will be made in pencil on Rite-in-the-Rain logs or waterproof ink on standard paper and corrections will consist of line-out deletions that are initialed and dated. Individual logs will become part of the project files.

At a minimum, the following information will be recorded during the collection of each sample:

- Sample location and description
- Sampler's name
- Date and time of sample collection
- Type of sample
- Type of sampling equipment used
- Field instrument readings, as appropriate

- Field observations and details that are pertinent to the integrity/condition of the samples (e.g., weather conditions, performance of the sampling equipment, sample depth control, etc.)
- Sample preservation

In addition to the sampling information, the following specific information also will be recorded in the field log for each day of sampling:

- Names of field personnel
- Time of property arrival/departure
- Other personnel present at the property, as appropriate
- Summary of pertinent meetings or discussions with regulatory agency personnel
- Deviations from the Treatment Work Plan, Health and Safety Plan and QAPP procedures
- Changes in personnel and responsibilities with reasons for the changes
- Levels of safety protection
- Calibration readings for any equipment used and equipment model and serial number

The handling, use and maintenance of field logs are the field coordinator's responsibilities.

B.4 Calibration Procedures

B.4.1 Field Instrumentation

Equipment and instrumentation calibration facilitates accurate and reliable field measurements. Field and laboratory equipment used on the project will be calibrated and adjusted in general accordance with the manufacturer's recommendations. Methods and intervals of calibration and maintenance will be based on the type of equipment, stability characteristics, required accuracy, intended use and environmental conditions. The basic calibration frequencies are described below.

B.4.2 Laboratory Instrumentation

For analytical chemistry, calibration procedures will be performed in general accordance with the methods cited and laboratory standard operating procedures. Calibration documentation will be retained at the laboratory and readily available for a period of six months.

B.5 Data Reporting and Laboratory Deliverables

The laboratory will report data in electronic copy (and formatted hardcopy if requested). Analytical laboratory measurements will be recorded in standard formats that display, at a minimum, the field sample identification, the laboratory identification, reporting units, qualifiers, analytical method, analyte tested, analytical result, extraction and analysis dates, and detection limit. Each sample delivery group will be accompanied by sample receipt forms and a case narrative identifying data quality issues. Laboratory electronic data deliverables (EDD) will be established by GeoEngineers, Inc., with the contract laboratory. Final results will be sent to the Project Manager.

B.6 Internal Quality Control

Table B-4 summarizes the types and frequency of QC samples to be collected, including both field QC and Laboratory QC samples. The following sections describe field and laboratory QC samples.

B.6.1 Field Quality Control

Field QC samples serve as a control and check mechanism to monitor the consistency of sampling methods. The following sections provide a description of field QC samples.

B.6.1.1 Field Duplicates

In addition to replicate analyses performed in the laboratory, field duplicates can serve as a measure for precision. Field duplicates can be used to evaluate the consistency of the sampling techniques used by field personnel. Additionally, field duplicates can be used to evaluate the precision and consistency of laboratory analytical procedures and methods. One field duplicate, collected as a "split sample," will be collected during each monitoring round.

B.6.1.2 Trip Blanks

One trip blank will be placed in each cooler that contains samples to be analyzed for volatile organic compounds (VOCs) (i.e., chlorinated compounds and degradation products). The blank samples will be analyzed for the same VOCs as the parent sample.

B.6.2 Laboratory Quality Control

Laboratory quality control procedures will be evaluated through a formal data validation process. The analytical laboratory will follow standard method procedures that include specified QC monitoring requirements. These requirements will vary by method but generally include:

- method blanks
- internal standards
- calibrations
- matrix spike/matrix spike duplicates (MS/MSD)
- laboratory control spikes/spike duplicates (LCS/LCSD)
- laboratory replicates or duplicates
- surrogate spikes

The following sections provide a description of the laboratory QC samples.

B.6.2.1 Laboratory Blanks

Laboratory procedures employ the use of several types of blanks but the most commonly used blank for QA/QC assessments are method blanks. Method blanks are laboratory QC samples that consist of HPLC water. Method blanks are extracted and analyzed with each batch of environmental samples undergoing analysis. Method blanks are particularly useful during volatiles analysis since VOCs can be transported in the laboratory through the vapor phase. If a substance is found in the method blank then one (or more) of the following occurred:

- Measurement apparatus or containers were not properly cleaned and contained contaminants.

- Reagents used in the process were contaminated with a substance(s) of interest.
- Contaminated analytical equipment was not properly cleaned.
- Volatile substances in the air with high solubility or affinities toward the sample matrix contaminated the samples during preparation or analysis.

It is difficult to determine which of the above scenarios occurred if blank contamination occurs. However, it is assumed that the conditions that affected the blanks also likely affected the project samples. Given method blank results, validation rules assist in determining which substances in samples are considered "real," and which ones are attributable to the analytical process. Furthermore, EPA guidelines state, ". . . there may be instances where little or no contamination was present in the associated blank, but qualification of the sample is deemed necessary. Contamination introduced through dilution water is one example."

B.6.2.2 Calibrations

Several types of calibrations are used, depending on the method, to determine whether the methodology is "in control" by verifying the linearity of the calibration curve and to assure that the sample results reflect accurate and precise measurements. The main calibrations used are initial calibrations, daily calibrations and continuing calibration verification.

B.6.2.3 Matrix Spike/Matrix Spike Duplicates (MS/MSD)

MS/MSD samples are used to assess influences or interferences caused by the physical or chemical properties of the sample itself. MS/MSD data is reviewed in combination with other QC monitoring data to determine matrix effects. In some cases, matrix affects cannot be determined due to dilution and/or high levels of related substances in the sample. A matrix spike is evaluated by spiking a known amount of one or more of the target analytes ideally at a concentration of 5 to 10 times higher than the sample result. A percent recovery is calculated by subtracting the sample result from the spike result, dividing by the spiked amount, and multiplying by 100.

B.6.2.4 Laboratory Control Spikes/Laboratory Control Spike Duplicates (LCS/LCSD)

Also known as blanks spikes, LCS samples are similar to MS samples in that a known amount of one or more of the target analytes are spiked into a prepared media and a percent recovery of the spiked substances are calculated. The primary difference between a MS and LCS is that the LCS spike media is considered "clean" or contaminant free. For example, HPLC water is typically used for LCS water analyses. The purpose of an LCS is to help assess the overall accuracy and precision of the analytical process including sample preparation, instrument performance, and analyst performance. LCS data must be reviewed in context with other controls to determine if out-of-control events occur.

B.6.2.5 Laboratory Replicates/Duplicates

Laboratories often utilize MS/MSDs, LCS/LCSDs and/or replicates to assess precision. Replicates are a second analysis of a field-collected environmental sample. Replicates can be split at varying stages of the sample preparation and analysis process, but most commonly occur as a second analysis on the extracted media.

B.6.2.6 Surrogate Spikes

The purposes of using a surrogate are to verify the accuracy of the instrument being used and extraction procedures. Surrogates are substances similar to, but not one of, the target analytes. A known concentration of surrogate is added to the sample and passed through the instrument, noting the surrogate recovery. Each surrogate used has an acceptable range of percent recovery. If a surrogate recovery is low, sample results may be biased low and depending on the recovery value, a possibility of false negatives may exist. Conversely, when recoveries are above the specified range of acceptance a possibility of false positives exist, although non-detected results are considered accurate.

B.7 Data Reduction and Assessment Procedures

B.7.1 Data Reduction

Data reduction involves the conversion or transcription of field and analytical data to a useable format. The laboratory personnel will reduce the analytical data for review by the QA Leader and Project Manager.

B.7.2 Field Measurement Evaluation

Field data will be reviewed at the end of each day by following the QC checks outlined below. Field data documentation will be checked against the applicable criteria as follows:

- Sample collection information
- Field instrumentation and calibration
- Sample collection protocol
- Sample containers, preservation and volume
- Field QC samples collected at the frequency specified
- Sample documentation and chain of custody protocols
- Sample delivery

Cooler receipt forms and sample condition forms provided by the laboratory will be reviewed for out-of-control incidents. If anything is found to be out-of-control the project manager will implement corrective actions to ensure that additional out-of-control incidents do not occur. The final report will contain what effects, if any, the out-of-control incident may have on data quality. Sample collection information will be reviewed for correctness before inclusion in a final report.

B.7.3 Field Quality Control Evaluation

A field QC evaluation will be conducted by reviewing field logs and daily reports, discussing field activities with staff, and reviewing field QC samples (trip blanks and field duplicates). Trip blanks will be evaluated using the same criteria as method blanks.

B.7.4 Laboratory Data Quality Control Evaluation

The laboratory data assessment will consist of a formal review of the following QC parameters:

- Holding times
- Method blanks
- Matrix spike/spike duplicates
- Laboratory control spikes/spike duplicates
- Surrogate spikes

- Replicates
- Initial and continuing calibration

In addition to these QC mechanisms, other documentation such as cooler receipt forms and case narratives will be reviewed to fully evaluate laboratory QA/QC.

B.7.5 Corrective Action

Any deviation from the established criteria will be documented, and the data will be qualified, as appropriate. If significant quality assurance problems are encountered, appropriate corrective action as determined by GeoEngineers' project manager, GeoEngineers' associate/principle and/or the analytical laboratory will be implemented as appropriate.

B.8. References

EPA 1999. "Contract Laboratory Program National Functional Guidelines for Organic Data Review." October 1999.

EPA 2004. "Contract Laboratory Program National Functional Guidelines for Inorganic Data Review." October 2004.

Model Toxics Control Act (MTCA) Cleanup Regulations 2013. Washington Administrative Code, Chapter 173-340. Washington State Department of Ecology. Revised 2013.

TABLE B-1

MEASUREMENT QUALITY OBJECTIVES

318 STATE AVENUE NE

OLYMPIA, WASHINGTON

Laboratory Analysis	Reference Method	Check Standard (LCS) %R Limits[1]	Matrix Spike (MS) %R Limits[1]	Surrogate Standards (SS) %R Limits [2]	MS Duplicate Samples or Lab Duplicate RPD Limits[3]	Field Duplicate Samples RPD Limits[3]
VOCs	EPA 8260 B	60%-140%	60%-140%	60%-140%	≤30%	≤30%
Sulfate	EPA 300.0	50%-150%	50%-150%	35%-165%	≤30%	≤30%
Nitrate	EPA 300.0	90%-110%	90%-110%	NA	≤15%	≤30%
Metals[4]	200.8	85%-115%	70%-130%	NA	≤20%	≤30%
Chemical oxygen demand	SM 5220C	80%-120%	75%-125%	NA	≤20%	≤30%
Biochemical oxygen deman	SM 5210 B	85%-115%	NA	NA	≤20%	≤30%
Dissolved gasses[5]	RSK-175	80%-120%	46%-142%	62%-124%	≤30%	≤30%

Notes:

Method numbers refer to EPA SW-846 Analytical Methods.

[1] Recovery ranges are goals. Actual percent recovery limits are based on laboratory control limits. Limits will vary for individual analytes and may be outside of the limits shown.

[2] Surrogate standard limits are approximate. Actual percent recovery limits are based on laboratory control limits. Limits will vary for individual analytes and may be outside of the limits shown.

[3] RPD control limits are only applicable if the concentrations are greater than 5 times the method reporting limit (MRL). For results less than 5 times the MRL, the difference between the sample and duplicate must be less than the MRL.

[4] Metals include total and dissolved (field filtered) iron and manganese.

[5] Dissolved gasses include methane, ethane, ethene, and carbon dioxide

VOCs = Volatile organic compounds including tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene (DCE), cis-DCE, trans-DCE and vinyl chloride.

LCS = Laboratory Control Sample

%R = Percent Recovery

RPD = Relative Percent Difference

NA = Not Applicable

TABLE B-2

ANALYTES, CLEANUP LEVELS, AND TARGET REPORTING LIMITS

318 STATE AVENUE NE

OLYMPIA, WASHINGTON

Analyte	MTCA[1] Cleanup[2]/Screening[3] Levels	Laboratory Reporting Limit
Volatile Organic Compounds (µg/l)		
Tetrachloroethene	8.85/22.9	0.1
Trichloroethene	7/1.55	0.1
1,1-Dichloroethene	3.2/130	0.1
Cis-1,2-Dichloroethene	NA/NA	0.1
Trans-1,2-Dichloroethene	4,000/NA	0.1
Vinyl Chloride	1.6/0.347	0.1
Conventionals (mg/l)		
Sulfate	NA	1.2
Nitrate	NA	0.2
Iron	NA	0.2
Manganese	NA	0.01
COD	NA	10
BOD	NA	2
Gasses (mg/L)		
Methane	NA	0.005
Ethane	NA	0.005
Ethene	NA	0.005
Carbon Dioxide	NA	2

Notes:

[1] Model Toxics Control Act (MTCA) Cleanup Regulation Chapter 173-340 WAC.

[2] MTCA groundwater cleanup level protective of the highest beneficial use for groundwater. Ecology does not consider groundwater at the Property as a likely potable water source. Therefore, the highest beneficial use for groundwater is as marine surface water.

[3] MTCA Method B groundwater screening level protective of soil vapor intrusion provided in Ecology's Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State (Ecology 2009) as updated in April 2015 to revise the soil gas screening levels provided in Appendix B of the guidance document (Ecology 2015).

mg/l = milligram per liter

µg/l = microgram per liter

NA = Not applicable; cleanup level not established by Washington State Department of Ecology

TABLE B-3

TEST METHODS, SAMPLE CONTAINERS, PRESERVATION AND HOLDING TIME[1]

318 STATE AVENUE NE

OLYMPIA, WASHINGTON

Analysis	Method	Minimum Sample Size	Sample Containers	Sample Preservation	Holding Times
VOCs	EPA 8260B	120 mL	Three - 40 mL VOA Vials (no headspace)	0 to 6 degrees C HCl - pH<2	14 days preserved 7 days unpreserved
Sulfate + Nitrate	EPA 300.0	250 mL	250 mL poly	0 to 6 degrees C	28 days
Metals[2]	200.8	250 mL	250 mL poly with HNO3	0 to 6 degrees C	6 months
Chemical oxygen demand	SM 5220C	250 mL	250 mL poly with H2SO4	0 to 6 degrees C	28 days
Biochemical oxygen demand	SM 5210 B	1 L	1L Poly	0 to 6 degrees C	48 hours
Dissolved gasses[3]	RSK-175	120 mL	Three - 40 mL VOA Vials (no headspace)	0 to 6 degrees C HCl - pH<2	14 days preserved 7 days unpreserved

Notes:

[1] Holding Times are based on elapsed time from date of collection

[2] Metals include total and dissolved (field filtered) iron and manganese.

[3] Dissolved gasses include methane, ethane, ethene, and carbon dioxide

VOCs = Volatile organic compounds including tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene (DCE), cis-DCE, trans-DCE and vinyl chloride.

VOA = Volatile organic analysis

HCl = Hydrochloric Acid

HNO_3 = Nitric Acid

mL = milliliter

L = liter

TABLE B-4

QUALITY CONTROL SAMPLES TYPE AND FREQUENCY

318 STATE AVENUE NE

OLYMPIA, WASHINGTON

Parameter	Field Quality Control		Laboratory Quality Control			
	Field Duplicates	**Trip Blanks**	**Method Blanks**	**LCS**	**MS / MSD**	**Lab Duplicates**
VOCs	1 per round of monitoring	1/cooler	1/batch	1/batch	1 MS/batch	1/batch
Sulfate	1 per round of monitoring	NA	1/batch	1/batch	1 MS/batch	1/batch
Nitrate	1 per round of monitoring	NA	1/batch	1/batch	1/batch	N/A
Metals[4]	1 per round of monitoring	NA	1/batch	1/batch	1/batch	N/A
Chemical oxygen demand	1 per round of monitoring	NA	1/batch	1/batch	N/A	1/batch
Biochemical oxygen demand	1 per round of monitoring	NA	1/batch	1/batch	N/A	N/A
Dissolved gasses[5]	1 per round of monitoring	NA	1/batch	1/batch	1/batch	N/A

Notes:

An analytical batch is defined as a group of samples taken through a preparation procedure and sharing a method blank, LCS, and MS/ MSD (or MS and lab duplicate).

No more than 20 field samples can be contained in one batch.

[4] Metals include total and dissolved (field filtered) iron and manganese.

[5] Dissolved gasses include methane, ethane, ethene, and carbon dioxide

LCS = Laboratory control sample

MS = Matrix spike sample

MSD = Matrix spike duplicate sample

VOCs = Volatile organic compounds including tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene (DCE), cis-DCE, trans-DCE and vinyl chloride.