ESSENTIAL MANAGEMENT
SOLUTIONS

INTERMEDIATE AND SHALLOW GROUNDWATER ZONE REMEDIATION PILOT TEST REPORT

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700 Dexter Property

700 Dexter Avenue North

Seattle, Washington

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1.0 Introduction

This report describes pilot test activities completed for the evaluation of anaerobic reductive dechlorination at the 700 Dexter Avenue Project (Property) located at 700 Dexter Avenue North, Seattle, Washington. The Property is an inactive property located in the downtown Seattle metropolitan area that was a former Navy dry cleaning operations facility. The facility has been previously demolished and remaining subslab structures with partial walls to side streets. The Property is unoccupied and secured with chain link fence surrounding it. Previous environmental investigations have been conducted at the Property and identified constituents of concern (COC) comprised of chlorinated volatile organic compounds (CVOCs) consisting of tetrachloroethene (PCE) along with of biological degradation daughter products; trichloroethene (TCE), cis-1,2-dichloroethene (DCE) and vinyl chloride (VC). Soil and groundwater impacts were identified from the likely release of chlorinated solvents utilized in historical Property dry cleaning operations. Remedial activities have been completed on Property removing source material COC in soils and groundwater utilizing electrical resistivity heating (ERH) remedial technology. For the purpose of this report all Property history, Property characteristics, investigations, and interim remedial actions content will refer to previous Property reports: Remedial Investigation Report (SES, 2013a), Feasibility Study Report (SES, 2013b), (Interim Cleanup Action Plan (SES, 2013c), and Cleanup Action Plan (SES, 2014a), Technical Memorandum - Addendum to 700 Dexter Draft Cleanup Action Plan (SES, 2014b).

1.1 Project and Regulatory Background

The Property is regulated under the jurisdiction of the Washington State Department of Ecology (Ecology). Previous interim remedial actions consisting of ERH conducted at the Property indicate significant COC source area removal has been conducted and source area soils and groundwater have undergone treatment. Residual groundwater impacts reside consisting of PCE and its biological degradation daughter products TCE, DCE, and VC. Historical Property investigations indicate that three separate and confined groundwater bearing zones reside beneath the Property. For the purpose of this report the intermediate groundwater zone will be primarily discussed with some discussion of the overburden shallow groundwater zone. Currently FEM has an approved underground injection control permit for the Property from Ecology applicable to the shallow and intermediate groundwater zone.

FEM contracted Essential Management Solutions, LLC (EMS) to perform a groundwater remediation pilot test in the intermediate groundwater zone to identify and confirm design criteria towards the development of a full-scale intermediate groundwater remediation approach utilizing in-situ injection technology.

An intermediate groundwater zone injection pilot test was conducted on Property November 2 through 4, 2015 utilizing one injection point location to identify the design criteria. A subsequent expanded pilot test was implemented on Property January 11 through 17, 2016 to further evaluate the delivery and effectiveness of the groundwater remedy.

1.2 Organization

The remaining sections of this pilot test report provide a description of the Property groundwater remedy technical approach (Section 2.0), description of the initial ERD injection pilot test (Section 3.0), discussion of the expanded ERD biobarrier pilot test (Section 4.0), overview of a full scale injection work plan (Section 5.0), and references (Section 6.0)

2.0 Groundwater Remedy Technical Approach

The in-situ biological remediation approach selected for the groundwater remedy pilot testing is enhanced reductive dechlorination (ERD), whereby PCE will be degraded following the reductive dechlorination pathway (Freedman and Gossett, 1989):

$$\text{PCE} \Rightarrow \text{TCE} \Rightarrow \text{DCE} \Rightarrow \text{VC} \Rightarrow \text{Ethene and Ethane}$$

This naturally occurring process is enhanced through the addition of fermentable carbon compounds (carbohydrate substrate) that serve as "electron donors" for subsurface bacteria that use the PCE and its biological degradation products (chloroethenes) as "electron acceptors".

In practice, the technology involves amending groundwater with carbohydrate substrate that stimulate natural systems in the aquifer to increase rates of contaminant degradation by optimizing geochemical conditions. ERD in this case is applied in a manner through injection of carbohydrate substrate that establishes a zone of treatment through which groundwater flows. The injected carbohydrate substrate provides an electron donor (a biodegradable form of organic carbon such as vegetable oil, lactate, molasses, corn syrup, or ethanol) into the subsurface. When the electron donor is added to groundwater, naturally-occurring bacteria begin metabolic processes and oxidize the carbon, resulting in the depletion of dissolved oxygen (DO). The reduction of DO transitions aerobic and mild anoxic groundwater aquifer conditions to an anaerobic aquifer state conducive to reduction processes. Following the depletion of oxygen, the bacteria begin the successive utilization of alternative electron acceptors (such as nitrate, ferric iron, sulfate, and carbon dioxide) to support metabolism. Several types of bacteria have the capacity to achieve dechlorination (generally through co-metabolic processes) and in most systems act as a consortium to dechlorinate contaminants under highly reducing conditions. These processes result in the sequential removal of chloride atoms and the transformation of chlorinated contaminants into innocuous non-chlorinated end products that are readily biodegradable.

The biological degradation reactions of chloroethenes such as PCE may occur under three different reductive dechlorination processes as follow:

- Direct anaerobic reductive dechlorination reaction where bacteria gain energy and grow as one or more chlorine atoms on a chloroethene molecule and are replaced with hydrogen molecule under anaerobic conditions. Within this chemical reaction the chlorinated compound serves as the electron acceptor and hydrogen is the direct electron donor that is supplied from the carbohydrate substrate as it is fermented. This reaction may also be referred to as halorespiration or dehalorespiration (USEPA, 2000a).
- Cometabolic anaerobic reductive dechlorination is a reaction in which a chlorinated compound is reduced by a non-specific enzyme or co-factor produced during microbial metabolism of another compound (i.e., the primary substrate) in an anaerobic environment. By definition, cometabolism of the chlorinated compound does not yield any en-

ergy or growth benefit for the microbe mediating the reaction (USEPA, 2000a). For the cometabolic process to be sustained, sufficient primary substrate is required to support growth of the transforming microorganisms.

- Abiotic reductive dechlorination is a chemical degradation reaction, not associated with biological activity, in which a chlorinated hydrocarbon is reduced by a reactive compound. Addition of an organic substrate and creation of an anaerobic environment may create reactive compounds, such as metal sulfides, that can degrade chloroethenes (e.g., Butler and Hayes, 1999; Lee and Batchelor, 2002). In this case, substrate addition may indirectly cause and sustain abiotic reductive dechlorination

The reductive dechlorination processes of chloroethenes using hydrogen as an electron donor are typically based on the following two half reactions:

$$H_2 \Rightarrow 2H^+ + 2e-$$

$$2e- + H^+ + R\text{-}C\text{-}Cl \Rightarrow R\text{-}C\text{-}H + Cl-$$

These half reactions can be combined and balanced to produce the following generalized complete reaction:

$$H_2 + R\text{-}C\text{-}Cl \Rightarrow R\text{-}C\text{-}H + H^+ + Cl$$

Where C-Cl represents a carbon-chloride bond in a chlorinated molecule, C-H represents a carbon-hydrogen bond, and R represents the remainder of the molecule. In these reactions, two electrons are transferred with molecular hydrogen (H_2) as the electron donor that is oxidized and the chlorinated molecule (R-C-Cl) as the electron acceptor that is reduced (AFCEE, 2004).

The following reaction examples are provided to further demonstrate how the ERD process and application is completed. Utilizing a carbohydrate edible oil substrate (EOS) solution example of EDR-ER (Tersus Environmental product) like all edible vegetable fats and oils (triglycerides) can anaerobically ferment to hydrogen and low-molecular weight fatty acids by common subsurface microorganisms. Under anaerobic fermentation, a two-step process occurs where the ester linkages between the glycerol and the fatty acids are hydrolyzed releasing free fatty acids and glycerol to solution. The released glycerol degrades to 1,3-propanediol and subsequently to acetate. The saturated fatty acids further breakdown by beta-oxidation resulting in the formation of two molecules of hydrogen (H_2), and one molecule of acetate ($C_2H_3O^{2-}$). The original molecule of acid appears as a new acid derivative with two less carbon atoms (Sawyer et al., 1994).

$$C_nH_{2n}O_2 + 2H_2O \Rightarrow 2H_2 + C_2H_3O^{2-} + H^+ + C_{n-2}H_{2n-4}O_2$$

This produced hydrogen is then used in the reductive dechlorination process of chloroethenes with the electron donor (reduction) half reactions provided below:

PCE (C_2Cl_4) reductive dechlorination to TCE (C_2HCl_3)

$$H_2 + C_2Cl_4 \Rightarrow C_2HCl_3 + HCl$$

TCE (C_2HCl_3) reductive dechlorination DCE ($C_2H_2Cl_2$)

$$H_2 + C_2HCl_3 \Rightarrow C_2H_2Cl_2 + HCl$$

DCE ($C_2H_2Cl_2$) reductive dechlorination VC (C_2H_3Cl)

$$H_2 + C_2H_2Cl_2 \Rightarrow C_2H_3Cl + HCl$$

VC (C_2H_3Cl) reductive dechlorination to ethene

$$H_2 + C_2H_3Cl \Rightarrow C_2H_4 + HCl$$

Additionally, increases in the microbial populations during ERD application result in the production of natural cosolvent surfactants that can solubilize contaminant mass sorbed onto the soil, increasing the amount of contaminant dissolved in groundwater and available for biodegradation. This secondary effect from ERD is important for treatment of mass in soil within the saturated one as it allows active treatment of sorbed-phase contaminant mass. This additional aspect of ERD can shorten treatment times especially source areas relative to other physical and chemical remedial strategies that rely only on diffusion to access the sorbed-phase mass and eliminate the potential for rebound of contaminant concentrations after active remediation.

Property groundwater sampling results historical, post ERH, and prior to initial pilot test activities indicate detectable concentrations of TCE, DCE, and VC indicating that reductive dechlorination of PCE has been occurring naturally at the Property. Tables 1 and 2 provided historical groundwater analytical data. Additionally Property groundwater generally exhibits low DO levels and oxidation reduction potentials (ORP) that fall in the range of iron reduction. Dissolved iron, nitrate, manganese, and sulfate levels are in relative low concentrations in the intermediate groundwater zone monitoring wells suggesting these organic materials are providing as electron donors of the reductive dechlorination process. Total organic carbon (TOC) groundwater samples collected from the intermediate groundwater zone also indicate low TOC concentrations suggesting that any available carbon sources have been utilized as part of the reductive dechlorination process. The presence of the inorganic compounds (TCE, DCE, and VC) represents that electron acceptors will consume reducing equivalents from organic carbon species if present in the groundwater.

The evidence of reductive dechlorination of organic constituents at the Property, the presence of reduced inorganic compounds and low concentrations of dissolved oxygen, provide the basis for selection of pilot testing the ERD technology at the Property.

2.1 Pilot Test Application

The pilot study was designed to enhance the naturally occurring reductive dechlorination processes and identify optimal design parameters for the ERD remediation technology to expedite the groundwater remedial timeframe. As part of the testing application, the design and selection of an ideal carbohydrate substrate injection amendment material to be utilized as an electron donor to facilitate the ERD process was evaluated. Edible oil substrate (EOS) a solution of biodegradable vegetable oil was selected as the injection amendment for its characteristics and properties that would be conducive to the Property specific ERD application. The EOS amendment substrate selected is a vegetable oil product (EDS-ER) consisting primarily of soybean oil manufactured for enhanced anaerobic bioremediation environmental applications by Tersus Environmental. The following lists EDS-ER criteria and product technical specifications are provided as Appendix A.

- Food grade carbon source that is 100 percent (%) fermentable and prepared for extended carbon donor release applications;
- Can provide a single application for controlled release of electron donors for periods of up to 3 to 5 years;
- Easily mixable and self emulsifies on contact with water;
- Exhibits low viscosity properties, ideal for injection distribution and expanded contact into lower permeable and sorb-phased formation applications;
- Contains low dissolved solids to comply with secondary water quality requirements for amendment with low salt content
- Conforms to the United States (US) Environmental Protection Agency Environmentally Preferable Purchasing and US Department of Agriculture biobased criteria;
- Green sustainable chemistry produced from renewable crop based oils.

The application of the EOS is performed by injection of a solution into the subsurface intermediate groundwater zone with a mixed blend of EDS-ER with water at a target dosing percent for optimal organic carbohydrate substrate distribution into the groundwater zone. The solution dosing is based upon Property specific soil and groundwater characteristics, COC concentrations, and general industry practice for carbohydrate substrate EOS total organic carbon (TOC) target concentration distribution into treatment zones at concentrations ranging from 100 to 500 mg/L.

Pilot test injection target volumes were estimated based upon an assumed injection radius of influence of 20 feet (ft), a saturated thickness of injection interval of approximately 20 ft, and a formation mobile porosity of 5%. Based upon these parameters an estimated target injection volume of 10,000 gallons was established for pilot testing. EOS dosing calculations that incorporate the target injection volume, CVOC concentrations, and additional Property characteristics estimated that an approximate 0.5% EOS dosing was required to complete the entire reductive dechlorination process at a safety factor of 2. To provide a higher level of confidence with carbohydrate substrate distribution the safety factor was increased to 10 bringing the dosing percent within a typical industry practice range dosage of approximately 2.3% towards achieving target TOC concentrations between 100 to 500 mg/L within the ERD pilot test area.

2.2 Pilot Test Objectives

Objectives of the groundwater remediation pilot test are implement remediation injections in the intermediate groundwater zone to identify and confirm design criteria towards the development of a full-scale intermediate groundwater remediation approach utilizing in-situ injection technology. Design criteria include identifying the following:

- Determine whether Property indigenous reductive dechlorination processes could be further enhanced through the selected pilot test injection groundwater remedy amendment;
- Evaluate the effectiveness of the ERD remediation technology and application;
- Determine the ability to effectively inject into the intermediate groundwater zone;
- Define injection parameters required for optimal injection distribution of carbohydrate substrate solution;
- Identify the achievable injection influence of carbohydrate substrate solution;
- Develop a basis for full-scale Property ERD application.

3.0 Initial ERD Pilot Test

The initial ERD pilot test was completed November 2 through 4, 2015 at one injection point IW-01 located on the Property (Figure 1). The following sections discuss the pilot test implementation to include injection point drilling, temporary injection well completion, injection testing, monitoring, injection point plugging and abandonment, testing results, and conclusions.

3.1 Injection Location Drilling

A pilot test borehole for injection well (IW-01) was drilled with a continuous core sonic drill rig, utilizing a dual cased 4 to 6 inch sized casing. The drill rig core barrel was advanced through the existing 6 to 8 inch concrete sub-slab pulling a continuous core in 5 (ft) core barrel runs to total depth. Following core logging, borehole core cuttings were placed in 55 gallon drums for investigation derived waste Property storage. The borehole outer conductor casing was advanced to 40 ft below ground surface (bgs) and the core barrel was advanced to a total depth of 66 ft bgs on November 2, 2015. The 40 to 66 ft open borehole was verified to remain open overnight into November 3, 2015 with minor sloughing into borehole up to approximately 63 ft. The soughing material was drilled and removed. The following lithology characteristics were observed during drilling from core samples. Fill material was observed in the boring to approximately 12 ft bgs, from approximately 15 to 30 ft bgs light gray and brown silty, clayey sands to sandy silts and clays were observed. Lithology density increased below approximately 30 ft bgs and was dominated by light gray sandy silts with lenses of higher sand content noted at approximate depth intervals of 45 to 50 ft and 53 to 55 ft bgs. Appendix B provides a detailed borehole log and photo log of core samples collected during drilling.

3.2 Temporary Injection Well Completion

A temporary 2 inch injection well was completed in the open borehole (IW-01) with stainless steel wire wrap screen set from 50 to 65 ft bgs, followed by a 3 ft casing riser section to 47 ft with an attached 5 ft inflatable packer set in open borehole from approximately 42 to 47 ft. Well casing riser attached to the packer was completed to above ground surface for connection during injection testing. Prior to injection the inflatable packer was inflated to a pressure of 300 pounds per square inch (psi) expanding into the open borehole at the 42 to 47 ft interval sealing off the below target injection zone from the upper formation.

3.3 Injection Testing

The pilot test injection was competed over a 2 day time period from November 3 through November 4, 2015. The selected injection groundwater remedy carbohydrate substrate amendment solution of EOS solution consists of a 100% soybean oil product that emulsifies during the dosing/mixing of EOS and water in the injection process. The EOS was selected as an ideal extended release electron donor that is designed to release bio-available hydrogen over a period of 3 to 5 years. During the bioremediation microbial metabolic degradation process, the carbohydrate substrate carbon source of EOS is fermented releasing hydrogen, which acts as a preferred electron donor and bacteria reduce electron acceptors resulting in the release of chlorine atoms and subsequent degradation of chloroethene compounds (PCE and its biological degradation daughter products TCE, DCE, and VC) through the ERD process.

A City of Seattle Water Department fire hydrant was utilized to supply water during the injection process. Water was supplied to a dosing pump that mixed water and EOS solution prior to injection well location. An injection pump controlled by a variable frequency drive controller allowing the adjustment of injection pressure and flow pumped mixed injection solution to the injection well. A pressure gauge and flow meter/totalizer were placed in line prior to injection well to monitoring injection well pressures, flow rates, and injection totals.

Injection testing began with procedures at lower injection pressures and flows increased over time to identify optimal injection criteria, observe for any subsurface formation break through or subsurface formation fracturing, and meet objectives of target injection volumes. Injection pressures started at approximately 50 psi with an observed average flow rate of 3 gallons per minute (gpm) over time. Pressure was increased to the fire hydrant average pressure rate of 85 psi that yielded an approximate injection flow of 6.8 gpm. Over the course of testing injection pressure and flows were gradually increased to determine an ideal injection pressure and flow. A target flow of 20 gpm was established based upon a target injection volume of up to 10,000 gallons of EOS solution. On November 3, 2015 injection pilot testing pressures ranged from 50 up to a maximum of 180 psi, at flows of 2.7 to 22.6 gpm, respectively. Injection data for November 4, 2015 indicated similar results with pressures ranging from 44 to 170 psi at flows of 3.6 to 20.4 gpm, respectively. In each instance as pressures were increased and flows increased the pressure would stabilize quickly, remain steady or slowly begin to drop over time. Appendix C provides graphs of injection pressure and flow over time and injection volume, pressure, and flow over time. Injection data results collected during testing indicate that pressures and flows depict correlating linear trends. Essentially as the injection pressure is increased the injection flow increases. This trend is typical of lithological formations that are more permeable or contain more permeable flow paths. As discussed in Section 3.1, sandy silts with lenses of higher sand content were noted at approximate depth intervals of 45 to 50 ft and 53 to 55 ft bgs located across the injection well screen interval of 50 to 65 ft bgs. The injection data pressure and flow linear trends on the graphs suggest that any formation break through was nominal and that the formation was amendable to higher flows and pressure without observed subsurface fracturing. Fracturing is observed to occur when high pressure spikes are observed that drop off dramatically with typical correlated increased flows at the same time. The testing data did not yield this condition.

Over the course of injection pilot test a total injection volume of 11,281 gallons at an average 2.3 % EOS solution was injected at an overall average pressure of 117 psi and flow of 14.2 gpm.

3.4 Injection Test Monitoring

Pilot test injection monitoring entailed a selected number of close proximity intermediate groundwater and shallow groundwater zone wells to assess for injection influence. Depth to groundwater (DTGW) elevations, total organic carbon (TOC) and CVOC concentrations, and field parameters of pH, temperature, conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP) were collected from a select number of monitoring well locations. Intermediate groundwater zone wells included W-MW-01, W-MW-02, MW-107, and MW-111. W-MW-01 and MW-111 were monitored for DTGW elevation changes. W-MW-02 and MW-107 were monitored for pre and post injection TOC and CVOC analysis, DTGW, and field parameters. Shallow monitoring wells included J15, G12, and M15 with monitoring of DTGW.

3.5 Injection Point Decommissioning and Abandonment

Following pilot test injection completion, the temporary injection well casing, packer, and screen along with conductor casing advanced to 40 ft bgs were removed from the borehole. The borehole was decommissioned and abandoned on November 5, 2015 in accordance with Ecology well decommissioning and abandonment guidelines.

3.6 Pilot Test Results

Pilot testing injection influence and groundwater remedy effectiveness was assessed by evaluating collected injection field data parameters and analytical data results from target monitoring well locations. The following summarizes the results of intermediate and shallow groundwater monitoring well locations.

3.6.1 Intermediate Wells W-MW-01 and MW-111

Monitoring wells W-MW-01 and MW-111 were monitored for DTGW elevation changes. Monitoring location distances from IW-01 are approximately 85 ft (W-MW-01) and 205 ft (MW-111). Well screen intervals for both wells are 70 to 80 ft bgs. During pilot testing on November 3 and 4, 2015 a maximum elevation rise at W-MW-01 of 4.6 and 3.4 ft, respectively was observed utilizing a down well pressure data logger. No elevation increase was observed at MW-111. In general the elevation increases observed at a distance of 85 ft towards W-MW-01 correlated to injection results indicate a positive injection influence at a much greater distance than anticipated. No EOS solution was visually observed during extraction of pressure data logger on November 5, 2015.

3.6.2 Intermediate Well W-MW-2

Monitoring well W-MW-02 resides approximately 25 ft to the northeast of IW-01 and is an intermediate groundwater zone well screened from 70 to 80 ft bgs. W-MW-02 was observed to have a direct connection to injection well IW-01. Groundwater elevation increased significantly at the beginning of injections on November 3, 2015 and surfacing of EOS solution was observed coming out of W-MW-02 after approximately 30 minutes of injecting 425 gallons of solution. Injections were stopped and a well seal cap with pressure gauge was applied to W-MW-02.

Well pressure was monitored over the course of the remaining injection pilot test. On November 4, 2015 a wellhead pressure of 17 psi was observed after injection start up and approximately 150 gallons were injected into IW-01. Wellhead pressure was observed increasing over time during injections and an average steady state pressure of approximately 32 psi was observed over the course of both days at W-MW-02 as injection pressures and flows were increased. Once daily injections were completed the wellhead pressure began to decline back to 0 psi.

Pre injection groundwater baseline samples were collected on October 20, 2015 and analyzed for CVOCs and TOC. Subsequent post injection event groundwater performance samples were collected on November 10, 2015, one week following pilot test injecting. Overall analytical laboratory results indicate a substantial decline in CVOC constituents of concern. PCE and TCE concentrations were both below Method A Cleanup Levels (MTCA) with reductions of <5 ug/L to <1 ug/L and <5 ug/L to 3.4 ug/L, respectively post injection event. DCE and VC indicated the greatest reductions in concentrations from 12,000 ug/L to 480 ug/L and 1,700 ug/L to 110 ug/L, respectively. Post analytical laboratory results indicate a 96% reduction in DCE and 94% reduction in VC concentrations. TOC concentrations showed an increase of 85% with pre injection concentration of 28.9 mg/L up to 99 mg/L post injection. Analytical laboratory data results are presented in Tables 1 and 2.

Field parameters during injection were not able to be collected due to capping the well. However comparison of baseline groundwater sampling results to post injection sampling indicate a decrease in DO concentrations supportive of the fermentation of carbohydrate substrate. Decreasing or more negative ORP levels were observed generally indicative of a more reductive environment conducive to ERD processes following EOS injections. Field observations of groundwater during post injection sampling noted a milky white color indicative of EOS solution during purging. Pre and post groundwater sampling monitored natural attenuation (MNA), geochemical, and field parameter data are provided in s 3.

Injection pilot test results from W-MW-02 indicate successful and positive remedial results. The direct connection and immediate influence observed at W-MW-02 during injections confirm that a minimum 25 ft injection radius of influence can be achieved (Figure 2). The injection interval targeted from approximately 47 to 65 ft has a direct influence in the intermediate groundwater zone interval of 70 to 80 ft bgs. Groundwater analytical laboratory results pre and post injection signify CVOCs are being reduced and field parameters indicate a more reductive environment is present promoting ERD processes.

3.6.3 Intermediate Well MW-107

Monitoring well MW-107 resides approximately 25 ft to the southeast of IW-01 and is an intermediate groundwater zone well screened from 35 to 45 ft bgs. Groundwater elevations were observed to increase during both days of the injection testing at MW-107. Maximum groundwater elevation increases were observed on November 3, 2105 of 3.01 ft and November 4, 2015 of 6.03 ft (Figure 2).

Pre and post injection groundwater samples were collected on the same dates as W-MW-02 and analyzed for both CVOCs and TOC. Analytical laboratory results indicated a similar positive reduction in both PCE and TCE as observed in W-MW-02. PCE and TCE concentrations declined from 2,300 ug/L to 620 ug/L and 5,100 ug/L to 3,800 ug/L, respectively. Demonstrating a reduction in concentrations of 73% for PCE and 25% for TCE. DCE and VC concentrations increased slightly from 3,600 ug/L to 4,400 ug/L (DCE) and 27 ug/L to 31 ug/L (VC), however this trend is supportive of the ERD process as PCE degrades to its daughter products of TCE, DCE, and VC. TOC concentrations only increased slightly following post injection with concentrations increasing from 30.0 mg/L to 36.8 mg/L. Analytical laboratory data results are presented in Table 2.

Field parameters collected during the injection event indicate an increasing trend in temperature and conductivity, along with a decreasing trend in ORP suggesting EOS solution was effectively being distributed outwards and influencing MW-107. Pre and post field parameter data comparison show a decline in both DO and ORP supportive of a more reductive environment conducive to ERD following EOS injections. Similar to field observations at W-MW-02, MW-107 groundwater post injection sampling noted a milky white color indicative of EOS solution during purging of well for sampling. Pre and post groundwater sampling field parameter data are provided in Table 3.

MW-107 injection pilot test monitoring results suggest successful and positive remedial results. Injection influence and distribution of EOS solution were confirmed with DTGW elevation rise, visual observation of EOS, field parameter trends promoting reductive environment, decreases in PCE and TCE concentrations, ERD process trends, and increase in TOC concentration. A minimum 25 ft injection radius of influence is further confirmed in the southeast direction of IW-01 and the injection interval targeted from approximately 47 to 65 ft has a direct influence in the vicinity intermediate groundwater zone interval from 35 to 45 ft bgs.

3.6.4 Shallow Wells J15, G12, and M15

Shallow monitoring well locations in the proximity of injection well IW-01 were monitored for DTGW elevation changes. Screen intervals for the shallow wells reside above the intermediate groundwater zone at approximate screen intervals from 10 to 40 ft bgs. Well location distances from IW-01 are approximately 27 ft (J15), 65 ft (G12), and 73 ft (M15). Elevation increases were noted in all three wells during both days of injections with maximum increases observed as follows: November 3, 2015 – J15 (2.04 ft), G12 (1.61 ft), and M15 (0.42 ft). November 4, 2015 – J15 (1.04 ft), G12 (0.8 ft), and M15 (1.22 ft). The increases in all shallow wells at the distances observed indicate a relative radial mounding (groundwater rise) in the immediate area occurring from the intermediate groundwater zone injection solution being effectively distributed beneath the shallow interval. No visual observations of EOS solution were identified at the shallow monitoring locations suggesting the intermediate groundwater zone injections were not directly influencing the shallow zone with carbohydrate substrate solution. The mounding effect observed in the shallow wells is attributable to the displacement of the exiting groundwater in the formation pore space and as injection solution is added the existing groundwater is pushed out radially. This can occur both horizontally and vertically. The limited groundwater elevation increases in the shallow as compared to the greater elevation increases in the intermediate groundwater zone suggests that some permeability or pathways have limited influence vertically. Notably the ERH points that reside on Property are installed to an approximate depth of 40 ft bgs on close spacing within the immediate vicinity of injection location. It is plausible that through less permeable formation between the target injection interval and ERH points that contain very permeable sand borehole materials that displaced water is susceptible to uplift through these locations. Figure 2 depicts the estimated injection elevation contours in the intermediate groundwater zone and water level rises for both intermediate and shallow groundwater zones.

3.7 Pilot Test Conclusions

DTGW elevation increases observed at IW-01 vicinity shallow wells of relative equal values generally support a radial distribution pattern of injection solution. The shallow groundwater zone did not experience significant groundwater elevation rise or any sub-surfacing of injection solution indicating solution was dispersed into the target intermediate groundwater zone.

DTGW elevation increases at IW-01 proximity intermediate wells showed significant water level rise at distances much greater than the anticipated radius of influence. Water level rise was observed up to 4 ft at W-MW-01 at a distance of 85 ft. Monitoring well MW-107 observed a 6 ft water level increase at a distance of 25 ft and W-MW-02 experienced surfacing of EOS solution also at a distance of 25 ft. The injection DTGW elevation data supports that the target injection interval of 47 to 65 ft can influence the formation and wells beyond 25 ft that are screened in both 35 to 45 ft and 70 to 80 ft intervals.

Groundwater analytical laboratory data collected pre and post injection shows a significant decrease in CVOC concentrations. W-MW-02 concentrations of PCE and TCE were reduced to below MTCA standards. DCE and VC indicated a dramatic reduction in concentrations reduced by 96% and 94%, respectively. TOC concentrations and carbon loading increased by 85% in injection vicinity. MW-107 similar to W-MW-02 results also showed a decrease in PCE and TCE concentrations of 73% and 25%, respectively. DCE and VC concentrations increased slightly as anticipated in part of the ERD process with higher observed PCE concentrations and the breakdown into daughter products of TCE, DCE, and VC occur. TOC concentrations increased slightly at MW-107. In summary the analytical laboratory data results conclude that EOS solution was effectively dispersed beyond the target 25 ft radius of influence and the ERD process is occurring with reductions and breakdown of CVOC COCs.

Field parameters collected pre, during, and post pilot test injection indicates EOS solution was visually observed both at W-MW-02 and MW-107. Both wells observed a decrease in DO and ORP post injection event that is supportive of a more reductive environment and conducive to ERD processes. Field parameter data results collected during injection indicate both wells were influenced with W-MW-02 having direct contact and surfacing of EOS. While MW-107 showed an increasing trend in temperature and conductivity, along with a decreasing trend in ORP supporting EOS solution was effectively being distributed outwards and influencing the area.

In summary the pilot test injection data results conclude injections into the intermediate groundwater zone can influence an area greater than a 25 ft radius of influence, effectively dispersing injection solution, and promote the reduction and degradation of groundwater CVOC COC.

Recommendations are to expand the intermediate groundwater zone injection program along the Property east and south property boundaries and further assess ERD performance at available monitoring locations.

4.0 Expanded ERD Biobarrier Pilot Test

4.1 Premise

The initial ERD pilot test results indicate that ERD processes are effectively occurring at the Property and supports the expansion of ERD biobarrier application along the east and south Property Boundaries. These positive results support the in-situ groundwater remedy approach of EOS injection and ERD CVOC destruction.

Groundwater performance sampling was conducted in December 2015 following the post injection sampling in November 2015. Target monitoring well locations W-MW-02 and MW-107 were evaluated and overall yielded positive results. Concentrations of PCE and TCE at W-MW-02 continued to remain below the MTCA, while DCE and VC concentrations were observed to increase. Both DO and ORP indicated a rise in concentrations and levels, however TOC concentrations had increased by a magnitude from 28.9 mg/L to 199 mg/L indicating effective carbohydrate substrate distribution. Results for MW-107 were relatively similar for DO and ORP levels with TOC concentrations only indicating a slight increase. PCE and TCE concentrations both increased above post injection sampling results, but continue to remain below pre injection and historical concentrations. DCE and VC concentrations remained relative to post injection sampling results. The data suggest that carbon sources are being utilized, sorb-phased CVOC mass is being solubilized, and ERD processes are progressing.

The expanded ERD biobarrier pilot test serves to further augment the intermediate groundwater zone along both the Property east and south property boundaries to expand carbohydrate substrate distribution. Additionally shallow groundwater zone injections were also conducted during the intermediate groundwater zone injections with carbohydrate substrate injections performed at former ERH points along the east and south property boundaries. The shallow injections will allow for substrate dispersion into the upper shallow groundwater zone targeting the 30 to 40 ft bgs interval area in proximity to the MW-107 screen interval (35 to 45 ft bgs).

4.2 Injection Application

As completed with the initial intermediate groundwater zone ERD pilot test, EOS solution consisting of EDS-ER was injected with the same target volumes, dosing, pressure, and flow parameters utilizing the same method and procedures for intermediate groundwater zone application.

Shallow groundwater zone injections were completed with lower pressure and flow application with less target injection volumes than intermediate groundwater zone injections. Initial target volumes ranged from 1,000 to 2,000 gallons and increased at varying locations due to low injection yields at others. Carbohydrate substrate dosing was performed at an approximate 4.5% TOC dose by volume. Shallow injections utilized a carbohydrate substrate food grade material sugar based product (dextrose) that comes as a solid-state form of powder type material. Dextrose product specifications are provided in Appendix A. The carbohydrate substrate dextrose works under the same principles as discussed in Section 2.0 as an electron donor similar to EOS. The dextrose substrate was chosen for shallow injections based upon shallow groundwater zone characteristics, faster metabolic reaction times, and project timeline objectives.

As provided for EOS EDS-ER substrate, the following electron donor half reaction example provided below demonstrates how the fermentation of the dextrose carbohydrate substrate produces hydrogen that is then used in the reductive dechlorination process of chloroethenes.

$$C_6H_{12}O_6 + 6\ H2O \Rightarrow 6\ CO^2 + 24\ H^+ + 24\ e-$$

4.3 Objectives

The objectives of the expanded ERD biobarrier groundwater remediation pilot test were to further augment and expand the extent of the ERD process to facilitate an ERD barrier across the Property east and south property boundaries. The biobarrier will provide for the degradation of PCE and its biological degradation products in these areas and limit COC migration off Property. The ERD expansion was performed by additional remediation injections in the intermediate and shallow groundwater zones that provide extended carbohydrate substrate dispersion and delivery of extended time controlled release of electron donor carbon material for ERD processes. Expanded pilot test objectives follow:

- Evaluate the effectiveness of the expanded ERD remediation technology and application at both the intermediate and shallow groundwater zones;
- Further define optimal injection parameters for distribution of carbohydrate substrate solution into the intermediate groundwater zone;
- Identify the achievable injection influence of carbohydrate substrate solution and optimal injection parameters in the shallow groundwater zone;
- Further define and develop a basis for full-scale Property ERD application.

4.4 Intermediate Injection Location Drilling and Temporary Injection Well Completion

The expanded ERD biobarrier injection pilot test estimated an additional 6-injection point locations (IW-02 through IW-07) located along the Property east and south property boundaries. The number of injection point locations with radius of injection influence determined from initial ERD pilot testing were plotted on a Property map to identify the most ideal locations to allow for optimal EOS injection distribution and overlapping coverage (Figure 1). As completed in the initial ERD pilot test, injection boreholes were drilled with a continuous core sonic drill rig, utilizing a dual cased 4 to 6 inch sized casing. The drill rig core barrel was advanced through the existing 6 to 8 inch concrete sub-slab pulling a continuous core in 5 ft core barrel runs to total depth. Cores were evaluated on Property for confirmation of target permeable zones within the injection screen interval. Only injection location IW-05 was prepared as a detailed boring log as provided in Appendix B. Temporary injection wells were completed in each borehole similar to the initial ERD pilot test.

Table 4 presents the injection borehole drilling depths, conductor casing depth, screen intervals, packer set points, and dates drilled. All borehole core cuttings were placed in 55 gallon drums for investigation derived waste Property storage. Injection wells IW-02 through IW-06 were all successfully drilled and injected into. Only IW-07 could not be drilled to complete depth due to drill equipment failure. The borehole was completed to 50 ft bgs, filled with sand material to 45 ft and then completed with bentonite chips to ground surface. The well will be injected into during future Property full scale in-situ groundwater remedy implementation.

4.5 Shallow Injection Locations

Shallow groundwater zone injections were completed at existing ERH locations. Injections were completed at well locations along the Property east and south property boundaries. Locations are shown on Figure 3.

4.6 Injection Testing

The expanded ERD biobarrier pilot test injections performed on the intermediate and shallow groundwater zones were initiated on January 12, 2016 and completed January 18, 2016. A City of Seattle Water Department fire hydrant was utilized to supply water during the injection process as with initial pilot test injections. For both intermediate and shallow injections water was supplied to a dosing pump that mixed water and EOS (intermediate) and dextrose (shallow) into a solution prior to injection well location. The following sections discuss the implementation and performance of the injections.

4.6.1 Intermediate Groundwater Zone

Intermediate groundwater zone injections were performed in a procedural manor that allowed for simultaneous drilling and injection operations at up to 2 injection point locations at the same time. Injection point locations were drilled in a staggered manor that allowed injections to be completed immediately after the temporary injection well was set and drilling would continue at the next designated location at a distance that injections would not disrupt the injection point drilling operations. Injection locations were drilled in the following sequence of IW-02, IW-04, IW-06, IW-03, IW-05, and IW-07.

Injections were completed in the same manor as the initial ERD pilot test injections utilizing a series of injection pumps controlled by variable frequency drive controllers that allowed the adjustment of injection pressures and flows pumping the EOS solution into injection wells. A pressure gauge and flow meter/totalizer were placed in line prior to injection well to monitor injection well pressures, flow rates, and injection totals.

Table 6 provides a summary of the injection point location average operational parameters including injection pump and wellhead pressures, flow rates and totals, and EOS dosing %. Detailed field log tables and graphs presenting injection pressure and flow over time and injection volume, pressure, and flow over time are included in Appendix C for each injection point location.

Overall injection results of the expanded ERD biobarrier pilot test were observed with similar success in comparison to initial pilot test operational parameters. Average injection pressures and flows were lower this event with all volume totals within range of target injection volumes and EOS dosing %. Most injections occurred over the course of 2 days and extended into 3 days for some locations dependent upon weather, drilling, and equipment delays. Injection operational parameter graphs prepared each day for injection locations depict similar linear trends as initial pilot test with the exception of IW-03 and IW-05, on their first days of injections indicate some minor pressure build up and release with increased flow attributable to nominal formation break through and not formation fracturing. The maximum pressures from both locations resided within 85 to 95 psi far less then initial pilot testing pressures.

The injection point locations volume totals, average wellhead pressures, flow rates, and EOS dose % follow respectively.

- IW-02 (10,017 gal, 47.4 psi, 20.0 gpm, 3.3%)
- IW-03 (13,374 gal, 44.7 psi, 7.0 gpm, 4.1%)
- IW-04 (11,070 gal, 60.5 psi, 10.5 gpm, 3.9%)
- IW-05 (11,949 gal, 34.4 psi, 8.6 gpm, 3.9%)
- IW-06 (8,060 gal, 58.4 psi, 12.2 gpm, 3.8%)

A total of 54,470 gallons of EOS solution at an average 3.8% dosage was injected in the intermediate groundwater zone along the Property east and south property boundaries.

4.6.2 Shallow Groundwater Zone

Shallow groundwater zone injections were completed at a total of 24 existing ERH well point locations. Injections were conducted simultaneously into 10 ERH well points at a time with varying pressure and flow rates based upon the injection location formation yield to accept dextrose solution. Injections were performed using the City of Seattle fire hydrant water pressure. A premixed batch of dextrose solution was prepared in a tank with combined water and dextrose at an approximate 28% dose concentration. Water from the fire hydrant and the high concentrate dextrose solution tank was feed to a dose pump that mixed both at an approximate 7% dose dextrose solution prior to injection into the ERH well point at 4 to 1 ratio (4 parts water, 1 part dextrose solution). Injection pressure was regulated at the dose pump and injection pressures for all wells did not exceed 15 psi. This maximum pressure was established to maintain the integrity of the ERH well point seal and to eliminate potential short circuiting of dextrose solution around the ERH well point casing to ground surface. Initial target injection volumes per well point of 1,000 to 2,000 gallons were established, however various ERH points would not accept injection volume at the maximum pressure. These injection locations were ceased and wells that did observe good injection yield were increased with additional dextrose solution volumes. ERH injection point locations were flushed with fresh water following injection volume to reduce any potential for bio-fouling with in the ERH well point location.

Table 5 presents shallow groundwater zone ERH well point location injection volumes, dextrose mass loading, and estimated % dosing rates per well. A total of 43,590 gallons of dextrose solution at an average 4.5% dosage was injected in the shallow groundwater zone along the Property east and south property boundaries.

4.7 Injection Test Monitoring

Pilot test injection monitoring entailed a selected number of close proximity intermediate groundwater and shallow groundwater zone wells to assess for injection influence. DTGW elevations, TOC and CVOC concentrations, and field parameters of pH, temperature, conductivity, DO, and ORP were collected from a select number of monitoring well locations. Intermediate groundwater zone wells included W-MW-01, W-MW-02, and MW-107. W-MW-01, W-MW-02, and MW-107 were monitored for pre and post injection TOC and CVOC analysis, DTGW, and field parameters. Shallow monitoring wells F9, F13, J5, J15, K8, M15, and N7 were monitored for DTGW, CVOC concentrations, and field parameters. Shallow wells F13, J15, M15, and N7 were additionally analyzed for TOC.

4.8 Injection Point Decommissioning and Abandonment

Following each intermediate injection point completion, the temporary injection well casing, packer, and screen along with conductor casing advanced to 40 to 45 ft bgs were removed from the borehole. All boreholes were decommissioned and abandoned between January 13 and 19, 2016 in accordance with Ecology well decommissioning and abandonment guidelines. No shallow injection points were abandoned at this time.

4.9 Pilot Test Results

Pilot testing injection influence and groundwater remedy effectiveness was assessed by evaluating collected injection field data parameters and analytical data results from target monitoring well locations. The following sections summarize the results of intermediate and shallow groundwater monitoring well locations.

4.9.1 Intermediate Wells

Intermediate groundwater zone monitoring wells W-MW-01, W-MW-02, and MW-107 were monitored for DTWG elevation changes to assess injection influence during injections. CVOC, TOC, and field parameters were collected and analyzed to assess for injection influence, carbohydrate substrate distribution, and ERD performance. Pre injection groundwater baseline samples were collected on January 8, 2016 and post injection event groundwater performance samples were collected on February 2, 2016.

4.9.1.1 W-MW-01

Monitoring well W-MW-01 observed a maximum DTGW elevation increase of 16.96 ft on January 12, 2015 during injections at IW-02 located at a distance of approximately 35 ft. DTGW elevations were observed to increase on all other days during injections with the exception of

January 15, 2016 ranging from 1.88 ft to 5.93 ft, results are provided on Table 7. CVOC concentrations for pre and post pilot test injections indicate PCE, TCE, and DCE are all below the respective MTCA. VC concentrations post injections were relative to pre injection results. Analytical data results are presented on Table 2. TOC concentrations post injection are relative to pre injection at 2.1 mg/L to 1.92 mg/L, respectively. Both DO and ORP concentrations and levels indicate a decline of DO and more negative ORP applicable to an increasing anaerobic environment and more conducive to the ERD processes. TOC and field parameter results are presented on Table 3.

4.9.1.2 W-MW-02

Monitoring well W-MW-02 screened from 70 to 80 ft bgs resides approximately 70 ft to the northeast of IW-02 and was observed to have a direct connection during injections on January 12, 2016. During injection DTGW elevations were observed to dramatically rise within the first 2 hours of injections and the well was capped with a pressure gauge to monitor pressure through the injection. A maximum pressure of 22 psi was observed that decreased over time to a steady state pressure of 18 psi. Injections conducted at additional locations indicated increased DTGW elevations at W-MW-02 that ranged from 0.02 ft to 12.66 ft (Table 7).

Overall analytical laboratory results indicate a continued trend of ERD processes. PCE and TCE concentrations remained both below MTCA while DCE indicated an increase in concentrations from 750 ug/L (pre injection) to 2,900 ug/L (post injection). The increase can be attributable to the ERD process and mobilization of soil sorb-phased mass contaminant. VC concentrations decreased from 7,500 ug/L (pre injection) to 2,800 ug/L (post injection). Analytical laboratory data results are presented in Table 2. TOC concentrations showed a significant increase by 2 orders of magnitude up from pre injection results of 2.08 mg/L to post injection 907 mg/L. The increase in TOC concentrations supports the greater dispersion of carbohydrate substrate in the area and supports the effective application of biobarrier. TOC analytical data results are presented in Table 3.

Field parameters trends observed pre and post injection are conducive to the ERD process. DO and ORP were both observed with a decline of DO and more negative ORP applicable to an increasing anaerobic environment as part of the ERD application. Field parameters are provided on Table 3. Additionally during groundwater sampling, field observations noted a milky white color indicative of EOS solution during purging of well.

Expanded ERD biobarrier pilot test results from W-MW-02 indicate successful and positive remedial results. A greater injection influence was observed then from previous initial ERD pilot test with the direct connection of injections from IW-02 to W-MW-02 at an approximate distance of 70 ft. The injection interval targeted in the immediate area from approximately 45 to 65 ft further indicates that there is a direct influence in the intermediate groundwater zone interval of 70 to 80 ft bgs at W-MW-02. Groundwater analytical laboratory results pre and post injection signify CVOCs are being reduced and field parameters indicate a more reductive environment is present promoting ERD processes.

4.9.1.3 MW-107

Monitoring well MW-107 is screened from 35 to 45 ft bgs within the intermediate groundwater zone. The greatest DTGW elevation increase was observed on January 16, 2016 during injections when groundwater was observed to reach top of well casing at ground surface while injection at locations IW-03 and IW-05 at distances of approximately 90 ft and 185 ft away, respectively. The well was capped with a pressure gauge to monitor pressure through the injection and no pressure was observed built up on the well casing. Groundwater elevations were observed to increase during all days of the injection testing ranging from 0.11 ft to 9.82 ft. The greatest elevation increases with exception to January 16, 2016 were observed on January 12, 2016 (9.26 ft) and January 17, 2016 (9.82), during injections at the follow locations IW-02 and IW-03/IW-05, respectively. Table 7 provides DTGW elevations recording during the expanded ERD biobarrier pilot testing.

Analytical laboratory results indicated a continued positive reduction in both PCE and. PCE and TCE concentrations declined from 1,000 ug/L to 61 ug/L and 3,600 ug/L to 220 ug/L, respectively. Demonstrating a reduction in concentrations of 94% for both PCE and TCE. DCE and VC concentrations increased from 3,900 ug/L to 10,000 ug/L (DCE) and 20 ug/L to 73 ug/L (VC), with a continued trend supportive of the ERD process as PCE degrades to its daughter products of TCE, DCE, and VC. Analytical laboratory data results are presented in Table 2. TOC concentrations increased following post injection with concentrations from 25.6 mg/L to 170 mg/L to within ideal concentrations conducive to the ERD processes. TOC concentrations are provided on Table 3.

Field parameters pre and post comparison show a decline in both DO and ORP similar to W-MW-02. Both DO and ORP were observed with a decline of DO and more negative ORP applicable to an increasing anaerobic environment and conducive to ERD processes. Groundwater sampling field observations noted a milky white color indicative of EOS solution during purging of well sampling. Pre and post groundwater sampling field parameter data are provided in Table 3.

MW-107 expanded ERD biobarrier pilot test monitoring results indicate successful and positive remedial results. Injection influence and distribution of EOS solution were confirmed with DTGW elevation rise, visual observation of EOS, field parameter trends promoting reductive environment, decreases in PCE and TCE concentrations, ERD process trends, and increase in TOC concentration.

4.9.2 Shallow Wells

Shallow monitoring wells F13, J15, G12, M15, and N7 were monitored for DTGW injection pilot testing. F13, J15, M15, and N7 were monitored for CVOC and TOC concentrations, and field parameters post injection testing on February 2, 2016.

4.9.2.1 F13, J15, G12, M15, N7

Shallow monitoring well locations were monitored for DTGW elevations during both the intermediate and shallow ground zone injections. DTGW elevation monitoring indicated a varying of water level rise ranging from -0.89 ft to 11.35 during dates levels were collected. The maximum DTGW water level of 11.35 ft was observed at N7 on January 15, 2016. Three of 5 well locations (J15, G12, and M15) averaged an approximate 1.43 ft elevation increase on January 12, 2016. Only 1 well of 4 (N7) indicated a notable elevation increase of 11.35 ft on January 15, 2016 and on January 16, 2016 3 of 5 wells (J15, G12, and M15) observed an average approximate 1.72 ft elevation increase. The DTGW elevation increases at monitoring well locations within the proximity of shallow injections at ERH point suggests that carbohydrate substrate is being distributed into the shallow groundwater zone.

CVOC analytical data results from post injections indicate reductions in all shallow wells sampled (F13, J15, M15, and N7) for both PCE and TCE since October 19, 2015. The greatest reduction was observed at N7 with a PCE reduction of 92% from 2,900 ug/L (October 19, 2015) to 230 ug/L (February 2, 2016) post injection. CVOC concentration trends for the wells indicate reductive dechlorination is in process, most notably with the large reduction in concentration of PCE at N7, an increase in DCE was observed supportive of the ERD application. Analytical laboratory data is presented in Table 1.

TOC groundwater samples collected on February 2, 2016 indicate ideal target carbohydrate substrate TOC concentrations at wells F13 (410 mg/L), J15 (180 mg/L), and N7 (270 mg/L). Table 3 presents shallow groundwater zone wells TOC analytical data.

Shallow groundwater zone monitoring wells data indicate that carbohydrate substrate was effectively distributed into the shallow groundwater zone and effecting nearby monitor locations from the following observations of DTGW elevation increases, increased TOC concentrations, and reduction of PCE and its biological degradation daughter products supporting the ERD process application.

4.10 Pilot Test Conclusions

Intermediate ground water zone monitoring well DTGW elevation increases at wells W-MW-01, W-MW-02, and MW-107 indicate that injection of carbohydrate substrate EOS can successfully influence the formation at distances beyond a 25 ft radius of influence that are screened in both 35 to 45 ft and 70 to 80 ft intervals.

CVOC groundwater analytical laboratory results from intermediate groundwater zone wells indicate that PCE and its biological degradation products are actively undergoing reductive dechlorination and EOS injections have promoted the ERD process by solubilizing soil contaminant mass and more rapidly degrading CVOC concentrations in groundwater and enhancing remedial timeframes.

TOC concentrations are observed increasing in the intermediate groundwater zone wells to ideal target concentrations conducive to the ERD processes. Elevated TOC concentrations in the property boundary wells W-MW-02 and MW-107 indicate that adequate carbohydrate substrate EOS has been effectively dispersed along the Property east and south boundaries creating an effective biobarrier to provide for long term ERD and limit off property migration of CVOCs in groundwater.

Field parameters for DO and ORP were observed with trends of declining DO concentrations and more negative ORP levels applicable to an increasing anaerobic environment and conducive to ERD processes in intermediate groundwater zone monitoring wells. Additionally field observations noted a milky white color indicative of EOS solution during purging of well sampling at W-MW-0 and MW-107 further supporting the effective distribution of carbohydrate substrate EOS beyond 25 ft of injection location providing adequate coverage and distribution for ERD biobarrier application.

Shallow groundwater zone monitoring wells data indicate that carbohydrate substrate was effectively distributed into the shallow groundwater zone and effecting nearby monitor locations from the following observations of DTGW elevation increases, increased TOC concentrations, and reduction of PCE and its biological degradation daughter products supporting the ERD process application.

5.0 Full Scale Injection Remedy Work Plan

The Property full scale intermediate and shallow groundwater zones remedy is proposed to expand the previously conducted and successfully implemented in-situ ERD technology application as completed in the initial ERD pilot test and expanded ERD biobarrier pilot test. ERD will be implemented on Property to provide full coverage of the in-situ remediation technology. The following work plan sections discuss the procedures of Property wide full scale ERD application in the intermediate and shallow groundwater zones.

5.1 Objectives

Objectives of the Property full scale intermediate and shallow groundwater remedy will be the following:

- Drill and install an additional 11 intermediate groundwater zone injection well locations to provide for further on Property intermediate groundwater zone injections that provide adequate coverage and distribution of carbohydrate substrate EOS to effectively and efficiently promote the ERD process;
- Provide a long term carbohydrate substrate source of EOS to the intermediate groundwater zone at optimal carbon dosing that allow for a 1 time injection event that provide for the complete reductive dechlorination process and destruction of COCs;
- Implement shallow groundwater zone injections at up to 28 additional ERH well point locations to provide distribution of carbohydrate substrate dextrose solution to effectively and efficiently promote the ERD process in the shallow groundwater zone.

5.2 Intermediate Groundwater Zone Full Scale ERD

Intermediate groundwater zone full scale on Property ERD application will be performed at 11 additional well locations. Locations and effective radius of influence depicting the carbohydrate substrate distribution area are shown on Figure 1.

5.2.1 Drilling Procedures

Intermediate groundwater zone injection point location procedures for borehole drilling and temporary injection well completions are detailed as follows:

- Injection wells will be drilled utilizing a continuous core sonic drill rig mounted on mobile tracked equipment. This tracked equipment will allow for maneuverability between the Property existing ERH points and obstructions.
- Continuous core drill injection wells, utilizing a dual cased 4-6 inch sized casing. The core barrel will advance through the existing 5-6 inch concrete sub-slab. If any obstructions are observed in advancing through slab or into formation that inhibit advancement to target injection interval at injection location the drill rig will be moved to a close proximity replacement borehole location determined at time of drilling.

- Core barrels will be advanced pulling a continuous core in 5 or 10 core barrel runs. Following core logging, borehole core cuttings will be placed in either 55 gallon drums or bulk storage containers as investigation derived waste Property storage for off Property disposal.
- 6 inch steel casing will be advanced, over the core barrel, and the core barrel will then be pulled and the soil core extracted. The core barrel will re-enter and advance to the next depth. The core extraction/ casing advancement process will continue until the target injection interval is reached.
- The depth interval for injections will be range approximately 45 to 65 ft bgs. The core barrel will be drilled to approximately 65 ft bgs with conductor casing advanced to approximately 40 to 45 ft bgs. Based upon results of previous pilot tests the open hole to 65 ft bgs should remain open. If sloughing of formation occurs then casing will be advanced to full depth and extracted as discussed below.
- Once borehole is cased to target depth, the core barrel will be removed, and the borehole will be tagged to insure the hole is clear. A clean-out core run will follow if needed.
- Injection screen will then be advanced down the core barrel to screen the depth interval of approximately 45 to 65 ft bgs. A pressure packer with an expansion and pressure capacity greater than the injection pump pressure will be placed in the casing string immediately above using either a 15 or 20 ft screen interval. The screen and packer will be advanced down well conductor casing with rigid pipe casing sections or attached wire line and injection hose. The packer will be deployed immediately below the conductor casing advanced to 40 to 45 ft bgs.
- When injection screen has tagged borehole bottom the conductor casing will be extracted back to the approximate 40 to 45 ft bgs interval if required, allowing packer inflation into conductor casing.
- The first injection event will then be performed and drilling will commence at the next injection location. Following injection completion the drilling injection screen and packer will be tripped out/removed from casing and the drilling casing and continuous core will be moved to the next injection location.
- The initial injection well location will then be plugged.
- Injection locations will be drilled in a staggered manor from one location to the next to allow acceptable distance between injection location to not disrupt drilling or injection operations and to eliminate any potential short-circuiting of EOS injection up boreholes being drilled.

5.2.2 Injection Procedures

Intermediate groundwater zone injection procedures are specified below:

- As specified in the drilling operations Section 5.2 an inflatable packer will be installed on the top of the injection screen and will be lowered to the total borehole depth with rigid pipe casing sections or attached wire line and injection hose
- Once the packer/screen assembly is in place, the outer sonic casing will be retracted if required due to borehole sloughing to expose the correct borehole interval. If open borehole is in place the packer/screen assembly will be installed with either 15 or 20 ft screen interval.
- The packer will then be inflated just below the conductor casing to approximately 125% of the anticipated injection pressure. Injection wellhead target pressures are anticipated to reside below 100 psi and are unlikely to exceed 200 psi based upon previous pilot test results.
- The injection assembly hose will be attached to the well rigid casing injection pipe or injection hose.
- Injection amendment will consist of previously injection carbohydrate substrate EOS. The EOS will be provided in a 275 gallon totes by Tersus Environmental and consists of the EDS-ER product. Injection amendment dosing will be completed at a targeted 2.5 to 3 % dosing solution consisting of a approximate 1:49 ratio of EOS to water per Tersus application. Appendix A provides a Tersus Environmental mixing application chart.
- Water for injection will be provided from a City fire hydrant located in the southwest proximity of the Property utilizing a permitted City water meter and backflow preventer.
- One to two Dosatron injection pumps with manifold will be connected to fire hose that will be supplied from the City fire hydrant and a suction a Dosatron feed line will be placed in an EOS tote. Dosatron pumps will be set for a 2.5 to 3% dosing application. Water flow and pressure feed from hydrant through the dosing pumps will provide the dosed EOS solution to injection pumps for delivery and injection to wells. Each Dosatron pump will be capable of mixing a dose percentage and volume equal to the capacity of target injection flows or injection pump specifications.
- An injection trailer and pumps for injections will be capable of delivering and monitoring pressures and flows of up to 200 psi and provided up to 20 gpm at injection locations independently.
- Injections will begin at lower pressures with constant monitoring of pressure and flow. Pressure will be increased incrementally until a flow is observed. Flows will be recorded based upon pilot test observed results and will start at 50 psi, then 85 psi (hydrant pressure) and increased incrementally over time until target flow is achieved.
- High injection pressures exceeding 100 psi should be increased slowly and accordingly to alleviate any short-circuiting to surface via potential ERH point locations. ERH point locations are all generally drilled on 20 to 30 centers to an approximate depth of 40 ft bgs. ERH points could likely be a short-circuiting point of least resistance for high pressure and flow injections. Cautious operations should be conducted when increasing in-

jection pressure to eliminate any potential injection short-circuiting of EOS solution occurring.

- If any short-circuiting is observed from any monitoring or ERH point location, wells/openings should be capped and injection pressure and flows decreased.
- During injection operations drilling of additional injection locations will be occurring simultaneously, if any short circuiting is observed in drilling locations, injections will be stopped until the well location drilling is completed and conductor casing installed. The injection well location will have a packer inserted and inflated and injections at other locations will then resume.
- Target volumes for each injection interval are approximately 10,000 gallons of 2.5 to 3% solution based upon a greater than 25 ft radius of influence observed during pilot testing with a 15 screen interval. Injection operations may vary per location with delivery and distribution. Minimum injection volumes should generally target no less than 8,000 gallons based upon injection location ability to accept solution flow and the injection timeframe. Injection locations may exceed greater than 10,000 gallons based upon performance of other injection locations that may have a lower injection yield based on field observations.
- As injection pressures are increased during the injection to achieve target flow, close monitoring will be conducted to observe any break through pressure. Pressure and flow measurements should be generally recorded every minute at start until flow is observed and then decline to every 5 minutes as flow stabilizes and times recorded extended to every 15 – 30 minutes after upon achieving target flow rates. For every pressure measurement a relative simultaneous flow measurement should be recorded.
- Upon completion of the target injection volume for injection location, the packer assembly will be deflated; the injection assembly with screen will be removed from the casing and the core barrel and conductor casing will removed for well plugging. The packer assembly and screen interval assembly will be placed in the next injection well and the injection process repeats.

5.2.3 Monitoring

Intermediate groundwater monitoring wells available on Property or in close vicinity of Property property boundaries will be utilized as performance monitoring points. Depth to groundwater and field parameters will be monitored through out injections to assess influence.

Depth to water will be monitored at injection well locations within close proximity on Property shallow monitoring ERH points to assess any shallow aquifer injection influence and potential for short-circuiting.

5.2.4 Well Decommissioning and Abandonment

All boreholes will be plugged in accordance with Ecology well decommissioning and abandonment guidelines following completion of injection and removal of all injection screen assembly and well conductor casing.

5.3 Shallow Groundwater Zone Full Scale ERD

Shallow groundwater zone full scale on Property ERD application will be performed at an additional 28 ERH point locations. Locations and effective radius of influence depicting the carbohydrate substrate distribution area are shown on Figure 3.

5.3.1 Injection Procedures

Shallow groundwater zone injections follow the generalized procedures:

- Designated ERH points will be fitted to allow connection of injection hoses. Each point connection will have a pressure gauge to allow for optimal injection pressure at each individual location. Close proximity ERH points will be fitted with caps as needed to plug and alleviate any potential for dextrose solution short-circuiting up ERH point casing to surface.
- A pre-constructed manifold with pressure and flow monitoring and adjustment capability for each ERH point location will be connected to a select number of ERH points on the discharge side and to either a Dosatron pump pressured by fire hydrant pressure or an injection pump on the inlet side.
- Water for injection will be provided from a City fire hydrant located in the southwest proximity of the Property utilizing a permitted City water meter and backflow preventer.
- Carbohydrate substrate dextrose solution will be premixed in tanks on Property prior to injections at a concentrate solution as determined by the number and size of tanks using fire hydrant water and dextrose.
- A target dextrose solution dosing of approximately 4.5 to 5% will be targeted for injections.
- Dextrose solution from premixed tanks will be supplied to either the Dosatron pumps for further dilution at target dosage and or directly injected from tanks mixed to the target dosage. Either injection procedure is valid and may be modified at time of injection application to implement in the most efficient and optimal manor.
- Injection pressures should not exceed 15 psi to maintain the
- Target volumes for each ERH shallow groundwater zone injection should target approximately 2,000 to 4,000 gallons of a 4.5 to 5% dextrose solution based upon a 20 ft radius of influence with a 10 ft screen interval for optimal carbohydrate substrate distribution.
- General ERH point location injection pressures should not exceed 15 psi. This maximum pressure is to maintain the integrity of the ERH well point seal and to eliminate

potential short-circuiting of dextrose solution around the ERH well point casing to ground surface.

- ERH injection point locations may be designated to the next close proximity location for injection due to low injection yields as observed during previous pilot testing. If an ERH point location is not capable of injection within the maximum injection pressure the location may be susceptible to field modification based upon the timeframe required to achieve the target injection volume and still maintain adequate distribution and coverage of carbohydrate substrate delivery.

5.3.2 Monitoring

Depth to water will be monitored at injection well locations within close proximity of Property shallow monitoring ERH points to assess any shallow aquifer injection influence and potential for short-circuiting.

5.3.3 ERH Point Decommissioning and Abandonment

Following completion of shallow groundwater injections, all ERH point casings and conductors utilized in the ERH process will be pulled from the ground. Boreholes will be re-drilled to remove the ERH backfill conductor material and then plugged in accordance with Ecology well decommissioning and abandonment guidelines.

6.0 References

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(Sawyer et al., 1994)	Chemistry for Environmental Engineering, Sawyer, C.N., P.L. McCarty, and G.F. Parkin. 1994.

TABLES

Table 1
Summary of On-Site Groundwater Analytical Data

Sample Location	Sample Date	Sampled By	Sampling Method	Analytical Results (micrograms per liter) PCE[4]	TCE[4]	cis-1,2-DCE[4]	trans-1,2-DCE[4]	Vinyl Chloride[4]
MTCA Cleanup Level				5[6]	5[6]	16[7]	160[7]	0.2[6]
Shallow Wells								
R-MW1 (33.78 to 23.78)	10/24/92	Roux	Unknown	<5	<5	--	<5	**100**
	10/24/92	DOF	Unknown	4.2	0.82	12[c]	--	**170**
	10/24/92	Roux	Unknown	2.3	<2	14	NA	**140**
	01/29/09	DOF	Peristaltic	**17.1**	4.26	1.60	<0.200	**0.630**
	06/02/11	SoundEarth	Peristaltic	**7.9**	2.7	1.9	<1	**0.68**
	09/05/12	SoundEarth	Peristaltic	**16**	3.6	2.1	<1	**2.2**
	Decommissioned							
R-MW2 (36.74 to 26.74)	10/24/92	Roux	Unknown	<5	<5	--	<5	**<5**
	10/24/92	DOF	Unknown	--	--	--	--	--
	01/29/09	DOF	Peristaltic	**5.05**	<0.200	<0.200	<0.200	<0.200
	06/02/11	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
	09/04/12	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
R-MW3 (34.74 to 24.74)	10/24/92	Roux	Unknown	<5	<5	--	<5	<5
	10/24/92	DOF	Unknown	--	--	--	--	--
	01/29/09	DOF	Peristaltic	4.26	<0.200	<0.200	<0.200	<0.200
	06/02/11	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
	09/04/12	SoundEarth	Peristaltic	**6.4**	<1	<1	<1	<0.2
G-MW2 (31 to 21)	07/24/01	GeoEngineers	Peristaltic	**176,000**	**237**[g]	**129**[g]	1.02	**0.457**
	01/29/09	DOF	Peristaltic	**59,000**[f]	**210**	**373**	1.33	<0.200
	06/02/11	SoundEarth	Peristaltic	**150,000**	<1,000	<1,000	<1,000	<200
	09/06/12	SoundEarth	Peristaltic	**150,000**	**320**	**260**	1.4	<0.2
	Decommissioned							
F5	07/19/13	SoundEarth	Peristaltic	**120,000**	**1,100**	**700**	5.2	**4.2**
	10/24/13	SoundEarth	Peristaltic	**21,000**	**1,200**	**1,000**	**1,000**	**<200**
F9	07/19/13	SoundEarth	Peristaltic	**140,000**	**3,400**	**1,100**	8.6	**78**
	06/16/15	SoundEarth	Peristaltic	3.7	1.8	**680**	12	**74**
	10/19/15	SoundEarth	Peristaltic	**15**	**6.6**	**840**	13	**75**
	02/01/16	SoundEarth	Peristaltic	2.9	<1	1.3	<1	**20**
F13	07/19/13	SoundEarth	Peristaltic	**2,900**	**280**	**370**	<100	**49**
	10/24/13	SoundEarth	Peristaltic	**7,300**	**3,100**	**490**	<50	**<10**
	11/18/13	SoundEarth	Peristaltic	**67,000**	**6,600**	**3,200**	85	**48**
	12/12/13	SoundEarth	Peristaltic	**1,100**	**340**	**670**	<10	**20**
	03/07/14	SoundEarth	Peristaltic	**84**	**11**	**9.6**	<1	**0.36**
	06/16/15	SoundEarth	Peristaltic	**8.4**	<1	1.8	<1	**0.31**
	10/19/15	SoundEarth	Peristaltic	<1	2.0	**210**	2.3	**4.1**
	02/02/16	SoundEarth	Peristaltic	3.4	<1	<1	<1	**0.97**
G12	07/19/13	SoundEarth	Peristaltic	**64,000**	**3,100**	**9,200**	88	**130**
	10/24/13	SoundEarth	Peristaltic	**1,700**	**150**	<100	<100	**<20**
	11/18/13	SoundEarth	Peristaltic	**760**	**84**	**42**	<10	**<2**
J5	07/19/13	SoundEarth	Peristaltic	**46,000**	**660**	<100	<100	**<20**
	10/24/13	SoundEarth	Peristaltic	**48,000**	**13,000**	**1,400**	<100	**<20**
	06/16/15	SoundEarth	Peristaltic	**1,100**	**340**	**250**	51	**1.0**
	10/19/15	SoundEarth	Peristaltic	**1,400**	**470**	**890**	51	**1.3**
	02/02/16	SoundEarth	Peristaltic	**1,500**	**110**	**280**	14	**0.31**
Shallow Wells								
J15	07/19/13	SoundEarth	Peristaltic	**4,100**	**220**	**580**	6.8	**20**
	10/24/13	SoundEarth	Peristaltic	**10,000**	**1,100**	**680**	<100	**<20**
	03/07/14	SoundEarth	Peristaltic	**2,200**	**170**	**120**	<50	**<10**
	06/16/15	SoundEarth	Peristaltic	**9.0**	**12**	**310**	8.8	**3.1**
	10/19/15	SoundEarth	Peristaltic	3.6	<1	**110**	3.0	**1.7**
	02/02/16	SoundEarth	Peristaltic	2.4	<1	**35**	<1	**0.39**
K8	07/19/13	SoundEarth	Peristaltic	**8,700**	**330**	**1,400**	5.6	**6.3**
	06/17/15	SoundEarth	Peristaltic	**63**	**16**	**500**	67	**<2**
	10/19/15	SoundEarth	Peristaltic	**360**	**82**	**43**	3.2	**0.44**
	02/01/16	SoundEarth	Peristaltic	**250**	**44**	**82**	1.8	**0.31**

Table 1
Summary of On-Site Groundwater Analytical Data

Sample Location	Sample Date	Sampled By	Sampling Method	Analytical Results (micrograms per liter)				
				PCE[4]	TCE[4]	cis-1,2-DCE[4]	trans-1,2-DCE[4]	Vinyl Chloride[4]
MTCA Cleanup Level				5[6]	5[6]	16[7]	160[7]	0.2[6]
M15	07/19/13	SoundEarth	Peristaltic	**3,200**	**110**	**180**	1.7	**0.22**
	03/07/14	SoundEarth	Peristaltic	**2,100**	**190**	**290**	2.9	**2.6**
	10/24/13	SoundEarth	Peristaltic	**56,000**	**1,100**	**770**	<50	**<10**
	06/16/15	SoundEarth	Peristaltic	**58**	**44**	**76**	2.7	**1.1**
	10/19/15	SoundEarth	Peristaltic	**48**	**29**	**110**	2.3	**0.74**
	02/02/16	SoundEarth	Peristaltic	**11**	**10**	**84**	1.8	**0.39**
N7	07/19/13	SoundEarth	Peristaltic	**640**	**50**	**18**	<1	<0.2
	10/19/15	SoundEarth	Peristaltic	**2,900**	**99**	9.9	<1	<0.2
	02/02/16	SoundEarth	Peristaltic	**230**	**79**	**1,700**	2.9	**0.92**
Intermediate Wells								
W-MW-03 (-30.77 to -40.77)	02/03/12	Windward	Bladder	**5,300**	**220**	**160**	<20	**<20**
	09/06/12	SoundEarth	Peristaltic	**13**	2.6	**20**	<1	**120**
	Decommissioned							
W-MW-04[5] (-32.47 to -41.47)	02/03/12	Windward	Bladder	**5,400**	**160**	**54**	<20	**<20**
	09/06/12	SoundEarth	Peristaltic	**460**	**440**	**1,900**	4.0	**630**
	Decommissioned							
G-MW1 (9.01 to 4.01)	07/24/01	GeoEngineers	Peristaltic	**85,500**	**1,130**	**23.3**[g]	0.956	**74.5**[g]
	01/29/09	DOF	Peristaltic	**78,400**[f]	**1,160**	**34.4**	1.49	<0.200
	06/03/11	SoundEarth	Peristaltic	**78,000**	**1,100**	**22**	--	**33**
	09/06/12	SoundEarth	Peristaltic	**66,000**	**1,100**	**32**	1.5	**35**
	09/06/12 (dup)	SoundEarth	Peristaltic	**64,000**	**1,100**	**30**	1.4	**33**
	Decommissioned							
G-MW3 (13.55 to 3.55)	07/24/01	GeoEngineers	Peristaltic	**47,700**	**385**[g]	<0.200	3.71	**42.5**[g]
	12/10/04	DOF	Bailer	**220,000**	**1,200**	**570**	6	**19**
	01/29/09	DOF	Peristaltic	**64,000**[f]	**1,580**	**4,050**	13.9	<0.200
	06/02/11	SoundEarth	Peristaltic	**33,000**	**1,400**	**1,500**	<1,000	**290**
	09/06/12	SoundEarth	Peristaltic	**31,000**	**1,200**	**1,600**	5.9	**290**
	Decommissioned							
Deep Well								
MW101 (-65.51 to -75.51)	07/20/12	SoundEarth	Bladder	<1	<1	<1	<1	<0.2
	09/06/12	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
	Decommissioned							

NOTES:

Red denotes concentrations exceeding MTCA Cleanup Level.

[1]Analyzed by EPA Method 418.1 or 8015-M, NWTPH-HCID, or NWTPH-Gx.

[2]Analyzed by EPA Method 418.1 or 8015-M, NWTPH-HCID, or NWTPH-Dx.

[3]Analyzed by EPA Methods 8015, 8020, 8021B, 8240, 8260B, or 8260C.

[4]Analyzed by Purge and Trap Gas Chromatogram/Mass Spectrometry or EPA Method 601, 8010S, 8240, 8260B, or 8260C.

[5]Monitoring well was installed at a 25 degree angle from the vertical point of penetration.

[6]MTCA Method A Cleanup Levels, Table 720-1, Section 900, Chapter 173-340 of the WAC, revised November 2007.

[7]CLARC, Groundwater, Method B, Non Cancer, CLARC website - <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>. Revised May 2014.

Laboratory Notes:

[c]Reported as total 1,2,-DCE, which is sum of cis,-1,2- and trans,1-2-DCE isomers.

[E]Estimated value. The reported range exceeds the calibration range of the analysis.

[f]Analyte was detected in the associated method blank. Analyte concentration in the sample is greater than 10x the concentration found in the method blank.

[g]Estimated value. The reported range exceeds the calibration range of the analysis.

[qp]Hydrocarbon result partly due to individual peak(s) in quantitation range.

[x]The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

[Y]The GRPH result in the sample is due to a pattern of peaks that is consistent with the chlorinated volatiles detected by the 8260C analysis.

Table 2
Summary of Intermediate Zone Groundwater Analytical Data

Sample Location	Area Location	Sample Date	Sampled By	Sampling Method	Analytical Results (micrograms per liter) PCE[4]	TCE[4]	cis-1,2-DCE[4]	trans-1,2-DCE[4]	Vinyl Chloride[4]
MTCA Cleanup Level					**5[6]**	**5[6]**	**16[7]**	**160[7]**	**0.2[6]**
W-MW-01 (-25.12 to -35.12)	8th Avenue N ROW	02/02/12	Windward	Bladder	**46**	3.9	11	<0.2	**0.5**
		09/06/12	SoundEarth	Peristaltic	<1	<1	2.0	<1	**2.8**
		06/17/15	SoundEarth	Peristaltic	<1	<1	<1	<1	**0.46**
		10/20/15	SoundEarth	Peristaltic	<1	<1	<1	<1	**0.88**
		01/08/16	SoundEarth	Peristaltic	<1	<1	<1	<1	**2.5**
		02/01/16	SoundEarth	Peristaltic	<1	<1	<1	<1	**2.8**
W-MW-02 (-26.54 to -36.54)	8th Avenue Nnue N ROW	02/03/12	Windward	Bladder	**6,900**	**1,700**	**2,000**	<20	**120**
		08/13/12	SoundEarth	Peristaltic	**3,000**	**1,300**	**2,200**	4.1	**66**
		09/05/12	SoundEarth	Peristaltic	**2,600**	**1,300**	**2,800**	5.0	**69**
		01/03/14	SoundEarth	Peristaltic	**490**	**1,200**	**4,400**	7.3	**67**
		06/17/15	SoundEarth	Peristaltic	**<10**	**<10**	**13,000**	95	**2,400**
		10/20/15	SoundEarth	Peristaltic	<5[ht]	<5[ht]	**12,000[ht]**	97[ht]	**1,700[ht]**
		11/10/15	SoundEarth	Peristaltic	<1	3.4	**480**	3.6	**110**
		12/11/15	SoundEarth	Peristaltic	<1	4.9	**900**	6.2	**2,900**
		01/08/16	SoundEarth	Peristaltic	<1	3.1	**750**	26	**7,500**
		02/01/16	SoundEarth	Peristaltic	<1	4.6	**2,900**	35	**2,800**
W-MW-03 (-30.77 to -40.77)	Property	02/03/12	Windward	Bladder	**5,300**	**220**	**160**	<20	**<20**
		09/06/12	SoundEarth	Peristaltic	**13**	2.6	**20**	<1	**120**
		Decommissioned							
W-MW-04[5] (-32.47 to -41.47)	Property	02/03/12	Windward	Bladder	**5,400**	**160**	**54**	<20	**<20**
		09/06/12	SoundEarth	Peristaltic	**460**	**440**	**1,900**	4.0	**630**
		Decommissioned							
MW107 (8.81 to -1.18)	8th Avenue Nnue N ROW	12/21/12	SoundEarth	Peristaltic	**47,000**	**2,800**	**5,100**	41	**200**
		12/21/12 (dup)	SoundEarth	Peristaltic	**50,000**	**3,000**	**5,200**	44	**270**
		12/16/13	SoundEarth	Peristaltic	**32,000**	**2,400**	**4,000**	34	**76**
		06/17/15	SoundEarth	Peristaltic	**1,900**	**5,000**	**5,000**	<100	**40**
		10/20/15	SoundEarth	Peristaltic	**2,300**	**5,100**	**3,600**	60	**27**
		11/10/15	SoundEarth	Peristaltic	**620**	**3,800**	**4,400**	54	**31**
		12/11/15	SoundEarth	Peristaltic	**1,200**	**4,200**	**4,200**	57	**22**
		01/08/16	SoundEarth	Peristaltic	**1,000**	**3,600**	**3,900**	50	**20**
		02/01/16	SoundEarth	Peristaltic	**61**	**220**	**10,000**	33	**73**
MW108 (-7.22 to -17.22)	Alley Between 8th and 9th Avenue N	12/21/12	SoundEarth	Peristaltic	3.4	1.8	**400**	2.1	**210[pr]**
		12/17/13	SoundEarth	Peristaltic	3.8	4.6	**360**	3.6	**150**
		06/17/15	SoundEarth	Peristaltic	4.0	**11**	**370**	3.5	**260**
		10/20/15	SoundEarth	Peristaltic	3.0	**6.4**	**220**	1.8	**140**
		02/02/16	SoundEarth	Peristaltic	**15.0**	**7.9**	**290**	1.8	**180**
MW109 (-0.03 to -10.03)	Alley Between 8th and 9th Avenue N	12/21/12	SoundEarth	Peristaltic	**91**	**64**	**18**	<1	**1.5**
		12/17/13	SoundEarth	Peristaltic	4.0	**18**	**310**	<1	**27**
		06/17/15	SoundEarth	Peristaltic	**370**	**890**	**520**	1.2	**26**
		10/20/15	SoundEarth	Peristaltic	**230**	**790**	**400**	<20	**22**
		02/02/16	SoundEarth	Peristaltic	**34**	**330**	**270**	<1	**19**
MW110 (4.67 to -5.33)	Alley Between 8th and 9th Avenue N	12/21/12	SoundEarth	Bladder	**1,100**	**220**	**470**	3.0	**33**
		12/19/13	SoundEarth	Peristaltic	**930**	**240**	**840**	3.9	**31**
		04/22/15	SoundEarth	Peristaltic	**1,000**	**210**	**340**	2.4	**1**
		06/17/15	SoundEarth	Peristaltic	**1,000**	**200**	**470**	<10	**12**
		10/20/15	SoundEarth	Peristaltic	**890**	**180**	**380**	2.2	**13**
		02/01/16	SoundEarth	Peristaltic	**1,300**	**290**	**460**	3.0	**1.1**
MW111 (-33.52 to -43.52)	Alley Between 8th and 9th Avenue N	12/21/12	SoundEarth	Bladder	**110**	**32**	**37**	<1	**1.8**
		12/17/13	SoundEarth	Peristaltic	<1	<1	4.7	<1	**17**
		04/22/15	SoundEarth	Peristaltic	<1	<1	1.7	<1	**18**
		06/17/15	SoundEarth	Peristaltic	<1	<1	1.5	<1	**20**
		10/20/15	SoundEarth	Peristaltic	<1	<1	<1	<1	**8.2**
		02/02/16	SoundEarth	Peristaltic	<1	<1	2.3	<1	**5.8**
MW112 (-17.51 to -27.51)	Dexter Avenue N ROW	12/21/12	SoundEarth	Bladder	<1	<1	<1	<1	<0.2
		12/26/13	SoundEarth	Bladder	<1	<1	<1	<1	<0.2

Table 2
Summary of Intermediate Zone Groundwater Analytical Data

Sample Location	Area Location	Sample Date	Sampled By	Sampling Method	Analytical Results (micrograms per liter) PCE[4]	TCE[4]	cis-1,2-DCE[4]	trans-1,2-DCE[4]	Vinyl Chloride[4]
MTCA Cleanup Level					5[6]	5[6]	16[7]	160[7]	0.2[6]
MW114 (10.84 to 0.84)	Adjacent to Mercer Street	12/21/12	SoundEarth	Peristaltic	**1,400**	**290**	**260**	<1	**14**
		12/18/13	SoundEarth	Peristaltic	**8,400**	**1,300**	**640**	<50	**22**
MW115 (-0.86 to -10.86)	9th Avenue N ROW	12/13/12	SoundEarth	Peristaltic	**15**	1.1	3.0	<1	**2.6**
		12/21/12	SoundEarth	Peristaltic	<1	3.0	**38**	<1	**16**
		12/19/13	SoundEarth	Peristaltic	<1	<1	<1	<1	**0.75**
		04/21/15	SoundEarth	Peristaltic	<1	**17**	**170**	<1	**20**
		06/25/15	SoundEarth	Peristaltic	<1	<1	<1	<1	**6.2**
		10/27/15	SoundEarth	Peristaltic	<1	<1	<1	<1	**0.31**
		02/03/16	SoundEarth	Peristaltic	<1	<1	<1	<1	**2.3**
MW116 (-3.64 to -13.64)	9th Avenue N ROW	12/07/12	SoundEarth	Peristaltic	**6.8**	<1	<1	<1	<0.2
		12/21/12	SoundEarth	Peristaltic	2.7	<1	<1	<1	<0.2
		12/19/13	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
		06/25/15	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
		10/27/15	SoundEarth	Perstaltic	<1	<1	<1	<1	<0.2
		02/03/16	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
MW117 (16.90 to 1.90)	Dexter Avenue N ROW	02/08/13	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
		12/18/13	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
MW118 (12.91 to 2.91)	South-Adjoining	03/25/13	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
		12/18/13	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
MW119 (2.35 to -7.65)	South-Adjoining	03/25/13	SoundEarth	Peristaltic	<1	<1	3.3	<1	<0.2
		12/19/13	SoundEarth	Peristaltic	<1	<1	2.5	<1	**0.76**
		04/21/15	SoundEarth	Peristaltic	**34**	**42**	**50**	<1	**3.1**
		06/17/15	SoundEarth	Peristaltic	4.9	**7.1**	**52**	<1	**2.7**
		10/20/15	SoundEarth	Peristaltic	**15**	**22**	**74**	<1	**0.45**
		02/02/16	SoundEarth	Peristaltic	**7.3**	**24**	**100**	<1	**0.45**
MW120 (0 to -10)	8th Avenue N ROW	12/19/13	SoundEarth	Peristaltic	2.8	2.3	**19**	<1	**9.6**
		06/16/15	SoundEarth	Peristaltic	<1	<1	4.3	<1	<0.2
		10/20/15	SoundEarth	Perstaltic	<1	1.1	5.2	<1	**0.94**
		02/01/16	SoundEarth	Peristaltic	1.3	1.6	6.7	<1	**1.1**
MW126 (-54.06 to -64.06)	Alley E of 800 Roy Street	01/03/14	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
MW127 (-0.96 to -10.96)	8th Avenue N ROW	01/03/14	SoundEarth	Peristaltic	<1	<1	<1	<1	**0.29**
		01/13/14	SoundEarth	Peristaltic	<1	<1	<1	<1	**0.30**
PW-1	Unknown	1997 (8 hour)	B & V	Bailer	1.0	ND	ND	ND	ND
		1997 (Final)	B & V	Bailer	ND	ND	ND	ND	ND
BB-5	South of Mercer Street ROW	11/17/97	B & V	Bailer	ND	ND	1.1	ND	ND
BB-7	Westlake Ave N ROW	11/17/97	B & V	Bailer	ND	ND	ND	ND	ND
BB-8 (13.69 to 3.69)	Roy Street ROW	06/24/97	B & V	Bailer	**11,000**	**1,500**	**4,200**	14	**280**
		01/29/09	DOF	--	**896**[f]	**258**	**441**	2.45	**1.48**
		05/03/10	SoundEarth	Peristaltic	**510**	**120**	**110**	<1	**0.27**
		06/02/11	SoundEarth	Peristaltic	**170**	**59**	**44**	<1	<0.2
		09/05/12	SoundEarth	Peristaltic	**200**	**41**	**28**	<1	<0.2
		12/29/13	SoundEarth	Bladder	**200**	**38**	**24**	<1	<0.2
		06/17/15	SoundEarth	Peristaltic	**170**	**40**	**37**	<10	**2.0**
MTCA Cleanup Level					5[6]	5[6]	16[7]	160[7]	0.2[6]
BB-10	Dexter Avenue N ROW	11/13/97	B & V	Bailer	ND	ND	ND	ND	ND
BB-12	9th Avenue N ROW	05/19/98	B & V	Bailer	ND	ND	**540**	ND	**380**
		05/02/10	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
BB-13	Westlake Ave N ROW	1998	B & V	Bailer	ND	ND	2.6	ND	**1.1**
		05/02/10	SoundEarth	Peristaltic	<1	<1	<1	<1	<0.2
BB-14	?	1998	B & V	Bailer	--	--	--	--	--

Table 2
Summary of Intermediate Zone Groundwater Analytical Data

Sample Location	Area Location	Sample Date	Sampled By	Sampling Method	**Analytical Results** (micrograms per liter)				
					PCE[(4)]	TCE[(4)]	cis-1,2-DCE[(4)]	trans-1,2-DCE[(4)]	Vinyl Chloride[(4)]
MTCA Cleanup Level					5[(6)]	5[(6)]	16[(7)]	160[(7)]	0.2[(6)]

NOTES:

Red denotes concentrations exceeding MTCA Cleanup Level.

[(1)]Analyzed by EPA Method 418.1 or 8015-M, NWTPH-HCID, or NWTPH-Gx.

[(2)]Analyzed by EPA Method 418.1 or 8015-M, NWTPH-HCID, or NWTPH-Dx.

[(3)]Analyzed by EPA Methods 8015, 8020, 8021B, 8240, 8260B, or 8260C.

[(4)]Analyzed by Purge and Trap Gas Chromatogram/Mass Spectrometry or EPA Method 601, 8010S, 8240, 8260B, or 8260C.

[(5)]Monitoring well was installed at a 25 degree angle from the vertical point of penetration.

[(6)]MTCA Method A Cleanup Levels, Table 720-1, Section 900, Chapter 173-340 of the WAC, revised November 2007.

[(7)]CLARC, Groundwater, Method B, Non Cancer, CLARC website - <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>. Revised May 2014.

ROW = right-of-way

SoundEarth = SoundEarth Strategies, Inc.

TCE = trichloroethylene

Urban = Urban Redevelopment

WAC = Washington Administrative Code

Windward = Windward Environmental LLC

Laboratory Notes:

[f]Analyte was detected in the associated method blank. Analyte concentration in the sample is greater than 10x the concentration found in the method blank.

[J]Estimated concentration.

[ht]The analysis was performed outside the method the method or client-specified holding time requirement.

[pr]The sample was received with incorrect preservation. The value reported should be considered an estimate.

[x]The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

[Y]The GRPH result in the sample is due to a pattern of peaks that is consistent with the chlorinated volatiles detected by the 8260C analysis.

Table 3
Summary of Groundwater MNA and Geochemical Parameter Data

Well ID	Middle of Well Screen Depth	Sample Date	Analytical Results (mg/L) Chloride[1]	Alkalinity[2]	Nitrate[3]	Sulfate[4]	Total Manganese[5]	Total Iron[5]	Ferrous Iron[6]	Ferric Iron[7]	Dissolved Methane[7]	Dissolved Ethane[7]	Dissolved Ethene[7]	Lactic Acid[1]	Acetic Acid[9]	Propionic Acid[9]	TOC[10]	pH[11]	Specific Conductivity[11] (mS/cm)	Turbidity[11] (NTU)	Temperature[11] (°C)	ORP[11] (mV)	Dissolved Oxygen[11] (mg/L)
W-MW-01	75	09/06/12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.90	0.435	38.5	18.9	-130.9	0.85
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.95	0.532	2.43	21.47	-98.0	1.50
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.22	0.516	2.50	23.10	-9.4	1.13
		01/08/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.92	8.93	0.650	44.0	17.42	121.9	3.98
		02/01/16	26.0	230	<0.025	55.2	0.393	1.3	0.09	1.21	0.170	<0.010	<0.010	<0.5	<0.5	<0.5	2.1	7.68	0.624	34.6	16.43	-145.1	0.87
W-MW-02	75	09/04/12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.50	0.80	4.6	18.6	-97.4	0.94
		08/13/12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.32	0.5109	18.7	24.81	-174	0.45
		12/16/13	105	240	<0.025	101	0.676	0.672	0.87	0	0.00891	<0.00500	<0.00500	--	--	--	--	7.05	0.999	2.1	25.9	-84	0.30
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.04	1.59	19.9	33.78	-88	0.36
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.63	1.52	7.54	32.64	-111	0.69
		11/10/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	28.9	6.18	0.655	0.0	27.51	-140.0	0.0
		12/11/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	199	6.28	1.217	49.5	27.45	123.1	0.73
		01/08/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.08	5.48	1.282	22.3	26.71	52.5	3.11
		02/01/16	81.6	600	<0.025	11.5	7.07	83.6	70.5	13.1	3.50	<0.010	<0.010	<0.5	110	<0.5	970	5.72	2.23	10.5	25.15	-19	0.54
MW103	108	12/18/13	48.8	380	<0.025	0.99	1.10	1.14	1.39	0	0.0675	0.0135	0.00914	--	--	--	--	10.45	0.735	7.1	11.22	267.3	0.26
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.11	0.63	7.5	18.5	-172.8	0.13
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.35	0.618	38.5	18.13	-226	0.76
		02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.62	0.220	11.1	13.84	-72.6	0.80
MW104	124	12/17/13	28.9	310	<0.025	23.1	0.757	5.45	5.03	0.42	0.0254	<0.00500	<0.00500	--	--	--	--	8.49	0.591	>200	15.80	244.9	0.48
		10/27/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.20	0.488	7.01	26.42	164.2	1.45
		02/02/16	12.9	210	<0.025	10.2	0.508	0.585	0.04	0.545	0.019	<0.010	<0.010	<0.5	<0.5	<0.5	--	7.72	0.463	2.26	27.12	-187.1	0.58
MW105	135	12/29/13	48.3	440	0.716	29.3	1.24	2.91	2.01	0.90	0.0445	0.00614	<0.00500	--	--	--	--	7.49	1.165	3.0	13.51	215.8	1.26
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.04	0.827	41.8	20.41	-111.9	1.30
		10/27/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.53	0.860	27.5	15.29	80.3	0.64
		02/03/16	28.3	340	<0.025	28.5	1.27	4.57	0.19	4.38	0.034	<0.010	<0.010	<0.5	<0.5	<0.5	--	9.04	0.726	7.2	14.56	-137	0.52
MW106	135	10/27/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10.61	0.838	>200	15.75	-37.3	0.29
		02/02/16	27.9	320	<0.025	21.7	1.07	6.47	0.21	6.26	0.057	<0.010	<0.010	<0.5	<0.5	<0.5	--	7.75	0.742	out of range	14.39	-134.4	0.66
MW107	40	12/21/12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.90	1.157	11.9	13.15	-70	0.39
		12/16/13	70.8	340	<0.025	165	0.358	1.35	0.43	0.92	0.00869	<0.00500	<0.00500	--	--	--	--	6.62	0.90	320	25.7	22	1.14
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.94	1.321	5.24	36.10	-26.0	0.43
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.91	1.303	5.16	32.40	-42	0.88
		11/10/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	30.0	6.94	1.40	13.2	26.93	-105	0.0
		12/11/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	36.8	9.78	1.446	1.38	28.28	117.9	0.30
		01/08/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	25.6	7.96	1.503	3.28	26.02	87.7	2.80
		02/01/16	89.2	290	<0.025	8.97	0.643	13.4	10.2	3.2	1.10	<0.010	<0.010	<0.5	34.7	<0.5	170	6.01	0.995	12.8	24.83	-62.1	0.42
MW108	45	12/17/13	25.8	600	0.075	12.5	1.96	17.5	21.7	0	2.11	<0.00500	0.0228	--	--	--	--	6.36	1.57	337	15	-72	0.50
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.76	1.19	9.7	17.6	-25.0	1.94
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.82	1.316	255	18.32	-83	0.39
		02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.81	1.422	0.1	15.99	-73.8	0.33
MW109	40	12/17/13	16.1	670	<0.025	34.6	4.04	12.6	16.2	0	1.40	<0.00500	0.00589	--	--	--	--	6.68	1.54	977	16.1	-78	0.31
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.83	1.36	15.5	17.8	-58.1	2.14
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.95	1.358	169	17.83	-109	0.89
		02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.93	1.280	0.3	16.87	-98.4	0.48
MW110	40	12/19/13	20.4	390	0.603	158	3.28	0.079	0.04	0.04	0.00766	<0.00500	<0.00500	--	--	--	--	8.82	0.888	29.7	12.56	290.6	0.52
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.90	0.96	6.4	18.2	20.4	1.15
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.09	1.06	4.0	17.2	-100.7	0.41
		02/01/16	26.0	400	0.063	84.4	4.31	0.424	0.06	0.364	<0.005	<0.010	<0.010	<0.5	<0.5	<0.5	--	7.25	1.090	10.2	14.21	-32	0.40
MW111	75	12/17/13	47.3	170	<0.025	4.73	0.135	0.168	0.18	0	0.0147	<0.00500	<0.00500	--	--	--	--	7.58	0.498	47.0	15.9	-99	1.19
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.97	0.56	14.1	19.4	-108.7	0.34
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.15	0.520	138	17.18	-199	0.28
		02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.31	0.540	0.9	12.62	-105	0.42
MW112	80	12/26/13	12.3	160	0.064	44.9	0.106	0.560	0.23	0.33	<0.00500	<0.00500	<0.00500	--	--	--	--	7.79	0.378	39.7	8.05	222.9	2.58
MW113	75	12/19/13	23.5	96	0.280	17.4	0.0248	0.119	0.03	0.09	<0.00500	<0.00500	<0.00500	--	--	--	--	10.00	0.267	14.4	13.68	263.5	0.26
		06/25/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.35	0.832	6.89	17.42	-2.4	1.55
		10/27/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.87	1.233	4.04	16.63	142.0	0.36
		02/03/16	70.1	580	<0.025	46.8	0.999	9.56	5.82	3.74	2.10	<0.010	0.080	<0.5	<0.5	<0.5	--	6.74	1.323	1.72	15.51	-45.7	0.40
MW114	40	12/18/13	31.2	190	0.032	98.8	0.629	0.075	0.03	0.05	<0.00500	<0.00500	<0.00500	--	--	--	--	7.49	0.651	<1	14.5	-8	0.77
MW115	40	12/19/13	22.1	580	<0.025	3.35	1.44	6.24	6.69	0	2.55	<0.00500	<0.00500	--	--	--	--	6.80	1.22	37.1	16.3	-61	0.71
		06/25/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.67	1.009	4.27	17.80	37.7	0.94
		10/27/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.01	0.915	1.44	16.76	126.3	0.92
		02/03/16	29.0	550	<0.025	12.2	1.77	8.68	0.20	8.48	2.70	<0.010	<0.010	<0.5	<0.5	<0.5	--	7.38	0.842	0.0	15.98	-80	0.24

Table 3
Summary of Groundwater MNA and Geochemical Parameter Data

Well ID	Middle of Well Screen Depth	Sample Date	Analytical Results (mg/L)															pH[11]	Specific Conductivity[11] (mS/cm)	Turbidity[11] (NTU)	Temperature[11] (°C)	ORP[11] (mV)	Dissolved Oxygen[11] (mg/L)
			Chloride[1]	Alkalinity[2]	Nitrate[3]	Sulfate[4]	Total Manganese[5]	Total Iron[5]	Ferrous Iron[6]	Ferric Iron[7]	Dissolved Methane[7]	Dissolved Ethane[7]	Dissolved Ethene[7]	Lactic Acid[1]	Acetic Acid[9]	Propionic Acid[9]	TOC[10]						
MW116	**40**	12/19/13	26.2	310	<0.025	14.5	1.14	2.48	2.65	0	1.75	<0.00500	<0.00500	--	--	--	--	6.84	0.498	295	15.5	75	0.67
		06/25/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.17	0.810	13.3	18.35	-56.7	2.01
		10/27/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.89	0.797	1.04	16.78	127.4	0.90
		02/03/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.21	0.722	2.29	15.61	-108.3	0.86
MW117	**45**	12/18/13	9.11	200	<0.025	56.3	0.344	1.49	2.03	0	<0.00500	<0.00500	<0.00500	--	--	--	--	6.94	0.90	978	16.1	-38	0.85
MW119	**40**	12/19/13	12.1	310	<0.025	3.34	2.55	19.4	18.6	0.8	3.45	<0.00500	<0.00500	--	--	--	--	9.56	0.579	74.4	12.80	295.0	0.34
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.41	0.849	123	16.55	-67.0	1.30
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.61	0.75	3.91	15.4	-94.8	0.84
		02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.13	0.718	0.0	13.45	-48.0	0.26
MW120	**45**	12/19/13	36.5	290	0.069	99.4	0.319	0.288	0.17	0.12	0.0101	<0.00500	<0.00500	--	--	--	--	6.63	0.743	387.0	15.1	-13	1.30
		06/16/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.84	0.619	72.4	20.02	43	0.82
		10/20/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.94	0.65	15.2	16.4	-55.3	0.37
		02/01/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.17	0.680	0.0	14.78	15	0.39
MW121	**20**	12/26/13	18.6	790	<0.025	200	6.47	2.39	1.90	0.49	0.346	<0.00500	<0.00500	--	--	--	--	6.89	1.610	2.6	15.37	-29.6	4.16
MW124	**115**	12/26/13	5.96	160	1.22	0.73	0.125	1.46	0.39	1.07	<0.00500	<0.00500	<0.00500	--	--	--	--	7.84	0.285	79.9	10.09	216.7	1.43
MW125	**22**	12/26/13	112	650	0.076	12.8	1.85	2.39	1.47	0.92	0.455	<0.00500	0	--	--	--	--	6.28	1.414	5.4	14.26	22.2	8.68
BB-8	**35**	12/29/13	12.6	270	3.68	84.6	0.252	0.085	0.01	0.08	<0.00500	<0.00500	<0.00500	--	--	--	--	6.56	8.56	2.54	12.86	224.0	0.72
		06/17/15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.79	0.821	58.2	19.40	60	0.47
MW-9	**14.5**	12/16/13	3.76	56	0.059	6.08	0.778	3.32	3.41	0	0.00624	<0.00500	<0.00500	--	--	--	--	6.72	0.132	22.5	14.38	262.5	0.20
F-13	**--**	02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	410	--	--	--	--	--	--
J-15	**--**	02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	180	--	--	--	--	--	--
M-15	**--**	02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17	--	--	--	--	--	--
N-7	**--**	02/02/16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	270	--	--	--	--	--	--

NOTES:

(1) Analyzed by EPA Method 300.0 or 325.1.

(2) Analyzed by Method SM 2320B.

(3) Analyzed by Method SM184500N03F or EPA 300.0 or EPA 353.2.

(4) Analyzed by Method SM184500SO4E or EPA 300.0.

(5) Analyzed by EPA Method 200.7 or 200.8.

(6) Analyzed by Method SM 3500 or SM3500FeD.

(7) Ferric Iron = Total Iron - Ferrous Iron. If Total Iron is less than ferrous, ferric is reported as 0.

(8) Analyzed by EPA Method RSK-175.

(9) Analyzed by EPA Method 300.0 Modified

(10) Analyzed by method SM 5310C or SM 5310B

(11) Parameter is measured in the field using water quality meter with flow-through cell. The reported value is the last reading prior to sampling groundwater.

-- = not analyzed or not measured

< = not detected at a concentration exceeding laboratory reporting limit

°C = degrees celsius

CLARC = Washington State Cleanup Levels and Risk Calculation

EPA = United States Environmental Protection Agency

mg/L = milligram per liter

mS/cm = millisiemens per centimeter

MTCA = Washington State Model Toxics Control Act

mV = millivolts

NTU = nephelometric turbidity units

ORP = oxidation-reduction potential

ROW = right-of-way

TOC = total organic carbon

WAC = Washington Administrative Code

Table 4

Intermediate Groundwater Injection Drilling and Well Completions

Well ID	Date Drilled	Total Drill Depth (ft)	Conductor Casing Depth (ft)	Screen Interval (ft)	Riser Interval (ft)	Packer Interval (ft)	Injection Interval (ft)
IW-01	11/3/15	65	40	65 - 50	50 - 47	47 - 43	65 - 45
IW-02	1/11-12/2016	65	40	65 - 50	50 - 47	47 - 42	65 - 45
IW-03	1/13-14/16	65	45	48.5 - 63.5	45.5 - 48.5	45.5 - 40.5	65 - 45.5
IW-04	1/13-14/17	62.5	40	63 - 48	48 - 45	45 - 40	63 - 43
IW-05*	1/16-17/18	75	55	73 - 58	58 - 55	55 - 50	75 - 55
IW-06*	1/15/19	75	50	69.5 - 54.5	54.5 - 51.5	51.5 - 46.5	72 - 52
IW-07	1/19/16	50	45	NA	NA	NA	NA

Notes:

*Ground surface on bench is approximately 10 feet in elevation above the ground surface of the other injection well locations.

Injection tooling is approximately 25 feet in length (2 ft of riser + 5 ft packer + 3 ft riser + 15 ft stainless steel screen).

Packer is 5 feet in length

Riser below packer is approximately 3 feet in length.

Riser above packer is approximately 2 feet in length.

Bottom of Packer to bottom of screen is approxumatly 18 feet in length.

Table 5
Intermediate Groundwater
Injection Summary

Well ID	Date	Solution Injected (gallons)	Average Pump Pressure (psi)	Average Flow Rate (gpm)	Average EOS Dose (%)	Average Wellhead Pressure (psi)
IW-01	11/3/16	3510.0	106.6	12.0	2.0	--
	11/4/16	7763.8	130.1	16.9	3.7	--
	Total	**11273.8**	**--**	**--**	**--**	--
	Averages	--	**118.4**	**14.5**	**2.9**	--
IW-02	1/12/16	10017.0	100.8	20.0	3.3	47.4
	Total	**10017.0**	**--**	**--**	**--**	--
	Averages	--	**100.8**	**20.0**	**3.3**	**47.4**
IW-03	1/16/16	6347.2	56.4	8.6	3.7	47.2
	1/17/16	3136.1	58.3	9.4	3.7	51.8
	1/18/16	3891.0	14.5	3.1	47.3	35.3
	Total	**13374.3**	**--**	**--**	**--**	--
	Averages	--	**43.0**	**7.0**	**18.2**	**44.7**
IW-04	1/12/16	1266.0	85.3	9.9	3.0	76.3
	1/13/16	5961.0	68.9	10.1	3.8	59.6
	1/14/16	3843.0	52.7	11.4	5.0	45.6
	Total	**11070.0**	**--**	**--**	**--**	--
	Averages	--	**69.0**	**10.5**	**3.9**	**60.5**
IW-05	1/16/16	566.0	54.1	3.2	3.0	48.2
	1/17/16	8367.0	51.0	11.9	3.8	35.8
	1/18/16	3016.0	35.9	10.6	5.0	19.3
	Total	**11949.0**	**--**	**--**	**--**	--
	Averages	--	**47.0**	**8.6**	**3.9**	**34.4**
IW-06	1/15/16	8060.0	77.7	12.2	3.8	58.4
	Total	**8060.0**	**--**	**--**	**--**	--
	Averages	--	**77.7**	**12.2**	**3.8**	**58.4**

Table 6
Shallow Groundwater Injection Summary

ERH Well Point	Injection Volume (gal)	Dextrose Mass Injected (lbs)	Dose %
C14	83	30	4.3%
D13	1069	391	4.4%
D14	97	36	4.5%
E14	15	5	4.0%
F15	2126	756	4.3%
G15	740	252	4.1%
H16	6	2	4.0%
J16	1938	710	4.4%
K17	4334	1587	4.4%
L17	4199	1537	4.4%
M18	3492	1279	4.4%
N17	3000	1098	4.4%
N18	2487	911	4.4%
P16	3844	798	2.5%
P17	4355	1595	4.4%
P7	1000	366	4.4%
R16	2500	915	4.4%
R8	4254	999	2.8%
S10	1000	366	4.4%
S11	8	3	4.5%
S12	2023	741	4.4%
S13	13	5	4.6%
S15	1000	366	4.4%
S9	7	3	5.1%
TOTAL	**43590**	**14751**	**--**
AVERAGE	**--**	**--**	**4.2%**

Table 7
Pilot Test Groundwater Elevation Summary

Date	Time	Monitoring Well ID Depth to Groundwater Elevation (ft)							
		F13	**J15**	**G12**	**M15**	**N7**	**W-MW-01**	**W-MW-02**	**MW107**
11/3/15	8:40	--	13.68	13.39	15.44	--	--	--	--
	9:00	--	--	--	--	--	--	20.07	--
	9:16	--	--	--	--	--	--	--	19.76
	11:30	--	--	--	--	--	--	0	--
	11:36	--	--	--	--	--	--	--	18.95
	12;32	--	--	--	--	--	--	o psi	--
	12:40	--	--	--	--	--	--	3 psi	--
	12:55	--	--	--	--	--	--	5 psi	--
	13:25	--	13.34	13.20	15.37	--	--	11 psi	19.23
	13:45	--	13.24	13.16	14.35	--	--	15 psi	18.76
	14:00	--	13.19	13.16	14.35	--	--	--	18.42
	14:15	--	13.09	13.08	14.33	--	--	--	18.01
	14:30	--	--	--	--	--	--	25 psi	17.90
	14:50	--	13.03	13.02	14.32	--	--	39 psi	17.76
	15:00	--	--	--	--	--	--	36 psi	17.53
	15:10	--	--	--	--	--	--	34 psi	--
	15:40	--	--	--	--	--	--	34 psi	17.53
	15:55	--	12.80	12.79	14.27	--	--	34 psi	17.41
	16:45	--	12.64	12.59	14.22	--	--	31 psi	16.75
Max Increase		**--**	**1.04**	**0.80**	**1.22**	**--**	**--**	**20.07**	**3.01**
11/4/15	8:13	--	13.28	13.05	14.17	--	--	0 psi	19.39
	9:18	--	13.06	12.98	14.13	--	--	17 psi	18.36
	10:00	--	12.89	12.87	14.11	--	--	29 psi	17.92
	10:51	--	12.60	12.65	14.07	--	--	31 psi	16.62
	11:37	--	12.32	12.43	14.02	--	--	--	15.78
	12:24	--	12.08	12.17	13.96	--	--	31 psi	14.97
	13:10	--	11.83	11.95	13.93	--	--	30 psi	14.42
	13:53	--	11.65	11.75	13.87	--	--	30 psi	14.05
	14:37	--	11.46	11.58	13.81	--	--	--	13.74
	15:16	--	11.24	11.44	13.75	--	--	--	13.36
	15:52	--	11.10	11.31	13.71	--	--	35 psi	12.89
Max Increase		**--**	**2.18**	**1.74**	**0.46**	**--**	**--**	**--**	**6.50**
1/12/16	8:40	6.48	7.63	7.75	8.30	19.59	26.14	12.82	14.40
	9:40	--	--	--	--	--	25.84	15.09	14.20
	10:15	--	--	--	--	--	25.31	5.50	14.20
	10:30	6.44	7.34	7.62	8.11	--	24.38	--	13.65
	10:45	--	--	--	--	--	22.53	9 psi	13.78
	11:00	--	--	--	--	--	21.50	18 psi	13.17
	11:15	--	--	--	--	--	20.80	21 psi	12.68
	11:40	--	--	--	--	--	19.82	22 psi	11.96
	12:55	6.26	5.83	6.90	7.54	18.28	16.11	20 psi	7.96
	13:20	--	--	--	--	--	14.84	18 psi	8.08
	14:15	--	--	--	--	--	14.21	18 psi	7.46
	15:10	--	--	--	--	--	11.66	--	6.54
	15:20	6.10	6.05	6.50	7.06	19.14	--	--	--
	16:25	6.03	6.08	6.38	6.92	19.05	10.22	18 psi	5.40
		--	--	--	--	--	9.18	18 psi	5.14
Max Increase		**0.45**	**1.55**	**1.37**	**1.38**	**0.54**	**16.96**	**12.82**	**9.26**

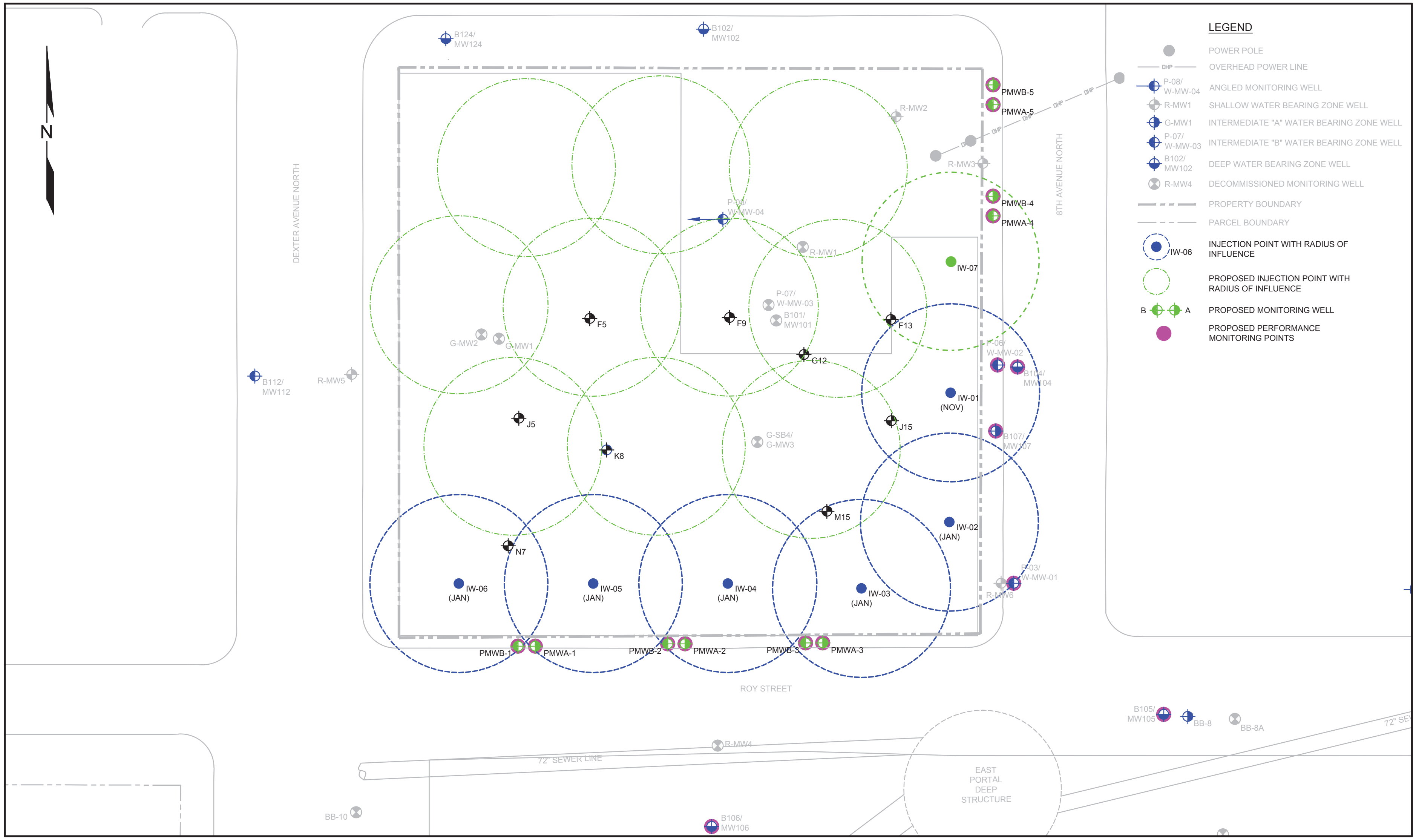
Table 7
Pilot Test Groundwater Elevation Summary

Date	Time	Monitoring Well ID Depth to Groundwater Elevation (ft)							
		F13	**J15**	**G12**	**M15**	**N7**	**W-MW-01**	**W-MW-02**	**MW107**
1/13/16	13:35	--	--	--	--	--	24.80	16.40	12.99
	13:05	--	--	--	--	--	25.21	15.50	12.94
	14:15	--	--	--	--	--	25.09	14.52	12.82
	15:15	--	--	--	--	--	24.32	13.59	12.67
	16:05	--	--	--	--	--	23.54	12.51	12.51
	17:05	--	--	--	--	--	22.92	11.82	12.30
Max Increase		--	--	--	--	--	**1.88**	**4.58**	**0.69**
1/14/16	8:25	--	--	--	--	--	25.24	16.10	13.06
	9:20	--	--	--	--	--	25.68	15.89	13.09
	10:10	--	--	--	--	--	25.92	15.26	13.02
	11:30	--	--	--	--	--	25.11	13.10	12.66
	12:30	--	--	--	--	--	24.34	12.31	12.47
	13:20	--	--	--	--	--	23.61	11.82	12.24
	14:20	--	--	--	--	--	22.61	11.33	12.11
	16:30	--	--	--	--	--	21.81	14.06	12.50
Max Increase		--	--	--	--	--	**3.43**	**2.04**	**0.56**
1/15/16	7:45	5.40	6.16	--	6.12	14.10	25.47	16.30	13.43
	14:15	5.40	5.70	--	6.12	6.48	25.70	16.40	13.43
	16:15	5.38	5.82	--	6.10	3.08	25.62	16.28	13.32
	17:15	--	--	--	--	2.75	--	--	--
Max Increase		**0.02**	**0.34**	--	**0.02**	**11.35**	**-0.15**	**0.02**	**0.11**
1/16/16	7:45	6.19	5.43	7.02	6.75	11.39	25.73	16.12	12.92
	8:10	--	--	--	--	--	25.86	16.10	12.84
	8:40	6.15	5.26	5.97	6.62	11.48	25.92	15.76	12.80
	9:40	--	--	--	--	--	25.50	14.47	12.64
	10:10	--	--	--	--	--	25.65	13.94	12.64
	10:40	6.10	5.85	5.80	6.12	11.54	24.89	13.07	12.28
	11:40	--	--	--	--	--	23.09	9.59	8.58
	12:15	--	--	--	--	--	22.65	8.38	6.22
	13:30	--	--	--	--	--	--	7.02	4.26
	14:00	--	--	--	--	--	21.62	0 psi	0 psi
	15:30	5.86	2.85	6.04	5.14	12.28	21.21	0 psi	0 psi
	16:30	--	--	--	--	--	20.48	3.74	0 psi
	17:30	--	--	--	--	--	19.88	3.35	0 psi
		--	--	--	--	--	19.80	3.46	0 psi
Max Increase		**0.33**	**2.58**	**0.98**	**1.61**	**-0.89**	**5.93**	**12.66**	**12.92**
1/17/16	8:00	--	--	--	--	--	24.95	15.48	12.28
	8:46	--	--	--	--	--	24.83	14.57	11.59
	9:35	--	--	--	--	--	24.22	12.25	9.30
	10:20	--	--	--	--	--	24.03	10.42	6.96
	12:50	--	--	--	--	--	21.78	6.14	2.46
Max Increase		--	--	--	--	--	**3.17**	**9.34**	**9.82**

Notes:

psi - Pounds per square inch pressure rating at welhead

FIGURES



PROJECT NAME:	700 DEXTER
PROJECT NUMBER:	0797-001
STREET ADDRESS:	700 DEXTER AVENUE NORTH
CITY, STATE:	SEATTLE, WASHINGTON

REGION:

0 20 40 80
APPROXIMATE SCALE IN FEET

FIGURE 1
PILOT INJECTION TEST LOCATIONS AND CONCEPTUAL INTERMEDIATE INJECTION POINTS FOR ERD

P:\0797 FRONTIER ENV MGMT\0797-001 700 DEXTER\0797-001-01 700 DEXTER\TECHNICAL\CAD\2016 RESPONSE LETTER\0797-001_2016_PT_IM.DWG
2/2/2016

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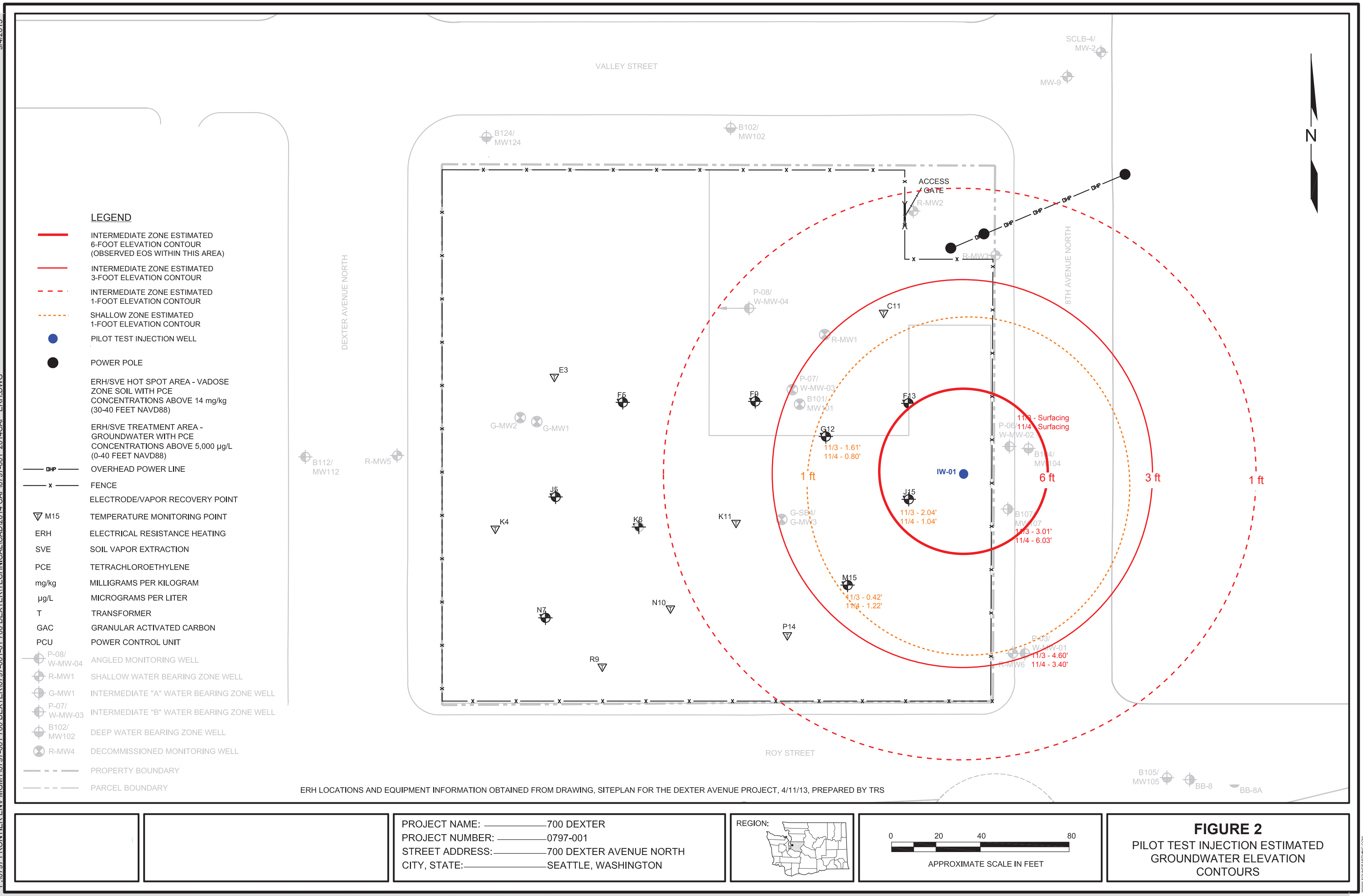
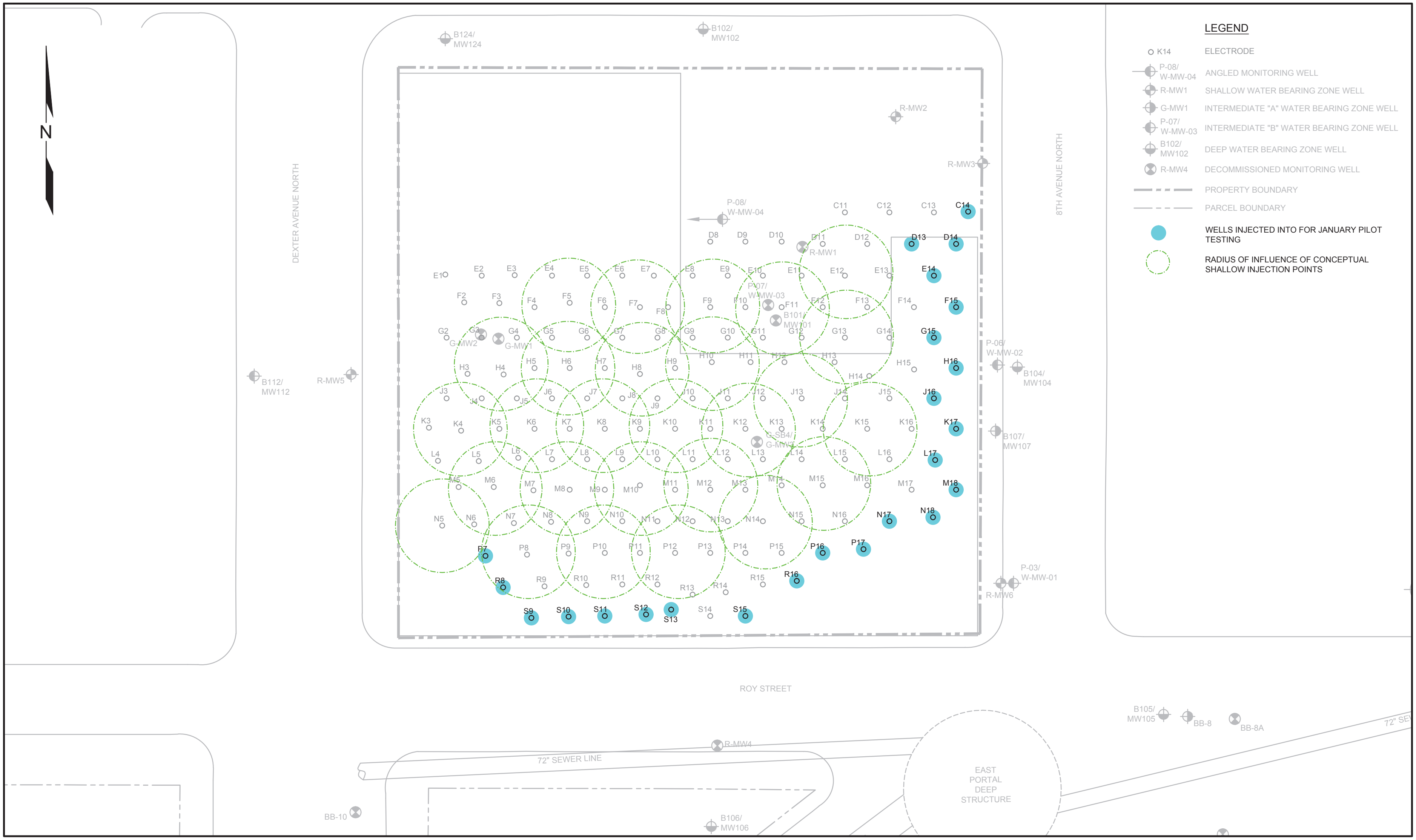


LEGEND
INTERMEDIATE ZONE ESTIMATED 6-FOOT ELEVATION CONTOUR (OBSERVED EOS WITHIN THIS AREA)
INTERMEDIATE ZONE ESTIMATED 3-FOOT ELEVATION CONTOUR
INTERMEDIATE ZONE ESTIMATED 1-FOOT ELEVATION CONTOUR
SHALLOW ZONE ESTIMATED 1-FOOT ELEVATION CONTOUR
PILOT TEST INJECTION WELL
POWER POLE
ERH/SVE HOT SPOT AREA - VADOSE ZONE SOIL WITH PCE CONCENTRATIONS ABOVE 14 mg/kg (30-40 FEET NAVD88)
ERH/SVE TREATMENT AREA - GROUNDWATER WITH PCE CONCENTRATIONS ABOVE 5,000 µg/L (0-40 FEET NAVD88)
OVERHEAD POWER LINE
FENCE
ELECTRODE/VAPOR RECOVERY POINT
M15 TEMPERATURE MONITORING POINT
ERH ELECTRICAL RESISTANCE HEATING
SVE SOIL VAPOR EXTRACTION
PCE TETRACHLOROETHYLENE
mg/kg MILLIGRAMS PER KILOGRAM
µg/L MICROGRAMS PER LITER
T TRANSFORMER
GAC GRANULAR ACTIVATED CARBON
PCU POWER CONTROL UNIT
P-08/ W-MW-04 ANGLED MONITORING WELL
R-MW1 SHALLOW WATER BEARING ZONE WELL
G-MW1 INTERMEDIATE "A" WATER BEARING ZONE WELL
P-07/ W-MW-03 INTERMEDIATE "B" WATER BEARING ZONE WELL
B102/ MW102 DEEP WATER BEARING ZONE WELL
R-MW4 DECOMMISSIONED MONITORING WELL
PROPERTY BOUNDARY
PARCEL BOUNDARY
VALLEY STREET
ROY STREET
DEXTER AVENUE NORTH
8TH AVENUE NORTH
ACCESS GATE
N
IW-01
1 ft
3 ft
6 ft
11/3 - Surfacing
11/4 - Surfacing
11/3 - 1.61'
11/4 - 0.80'
11/3 - 2.04'
11/4 - 1.04'
11/3 - 3.01'
11/4 - 6.03'
11/3 - 0.42'
11/4 - 1.22'
11/3 - 4.60'
11/4 - 3.40'
ERH LOCATIONS AND EQUIPMENT INFORMATION OBTAINED FROM DRAWING, SITEPLAN FOR THE DEXTER AVENUE PROJECT, 4/11/13, PREPARED BY TRS
PROJECT NAME: 700 DEXTER
PROJECT NUMBER: 0797-001
STREET ADDRESS: 700 DEXTER AVENUE NORTH
CITY, STATE: SEATTLE, WASHINGTON
REGION:
0 20 40 80
APPROXIMATE SCALE IN FEET
FIGURE 2
PILOT TEST INJECTION ESTIMATED GROUNDWATER ELEVATION CONTOURS
P:\0797 FRONTIER ENV MGMT\0797-001 700 DEXTER\0797-001-01 700 DEXTER\TECHNICAL\CAD\2014 CAP\0797-001_2014CAP_ERH.DWG
9/4/2015



2/2/2016

P:\0797 FRONTIER ENV MGMT\0797-001 700 DEXTER\0797-001-01 700 DEXTER\TECHNICAL\CAD\2016 RESPONSE LETTER\0797-001_2016_PT_SH.DWG

PROJECT NAME: 700 DEXTER
PROJECT NUMBER: 0797-001
STREET ADDRESS: 700 DEXTER AVENUE NORTH
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 20 40 80
APPROXIMATE SCALE IN FEET

FIGURE 3
PILOT INJECTION TEST LOCATIONS AND CONCEPTUAL SHALLOW INJECTION POINTS FOR ERD

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APPENDIX A

EDS-ER™

Water Mixable Oils for Enhanced Anaerobic Bioremediation

It is time to upgrade your emulsified vegetable oil (EVO) to EDS-ER, the next evolution in enhanced bioremediation. EDS-ER (electron donor solution – extended release) is long lasting water mixable oil, designed to release bio-available hydrogen over a period of 3 to 5 years. EDS-ER with a neutral pH has an expected shelf life in excess of two years. Unlike water-based EVO products, EDS-ER is not affected by freezing temperatures (Freezing Point -4 °F (-20 °C)).

Vegetable oils are hydrophobic and tend not to dissolve in or mix with water. To improve the distribution, some suppliers of electron donors add emulsifiers to the oil and mix the solution with water. The electron donor is packaged as an oil-in-water emulsion containing 25 to 50% water. As these EVO products are commonly sold on a $/lb basis, the buyer is purchasing water. To address sustainability concerns of shipping water to project sites, short shelf life and freeze thaw issues, Tersus Environmental has developed an electron donor family of water mixable oils.

Our Product

EDS-ER (electron donor solution – extended release) by Tersus Environmental is a vegetable oil based water mixable oil that self emulsifies on contact with water. EDS-ER contains no water (reduced shipping costs) and is 100% fermentable. There is no water within the formulation. The cost for shipping the electron donor to the project site may be reduced by as much as 50%. The benefit to you and your client is that we offer a lower cost solution to help you close the site.

Purpose

EDS-ER is a simple, safe, low-cost solution for the bioremediation of halogenated compounds (e.g., PCE, TCE, DCE, VC, TCA, CT, etc.), perchlorate, explosives such as aromatic nitrates, energetic munitions residuals, nitrates, acids, radionuclides, select oxidized heavy metals, and other contaminants.

Configuration

EDS-ER applications are easily configured and tailored to meet site-specific conditions. Configurations include applications in grids, barriers and excavations. Because of its low viscosity, EDS-ER can be applied to the subsurface with direct-push injection, hollow-stem auger, existing wells or re-injection wells.

Benefits

- 100% fermentable – contains no water
- Completely water mixable which minimizes the number of injection points for low permeability structures, reducing overall capital costs
- Easily mixes with water for economical application
- Controlled release of electron donors for up to five years
- Food-grade carbon
- Low total dissolved solids to comply with secondary water quality requirements for amendments with low salt content
- Conforms to EPA's EPP (Environmentally Preferable Purchasing) and USDA biobased criteria
- No operations and maintenance
- Clean, low-cost, non-disruptive application (e.g., direct-push, wells and excavations)
- Green sustainable chemistry, made from renewable crop-based oils
- Low cost transportation when compared to other electron donors
- Long shelf life - shelf life unrefrigerated > 2 years
- Freezing Point -4 °F (-20 °C)

Water Mixable Oils for Enhanced Anaerobic Bioremediation
EDS-ER™ by Tersus Environmental

Offers Cost Savings

Our EDS-ER technology has the potential to offer significant cost savings to the groundwater remediation industry. The passive nature of EDS-ER eliminates the large capital and operations/maintenance costs associated with active engineered systems. EDS-ER offers a faster and lower cost alternative to drawn out natural attenuation approach.

Longevity

A single EDS-ER application provides a controlled release of electron donors for periods of up to 3 to 5 years, under optimal conditions.

Field Applications

Because of its low viscosity and longevity, EDS-ER is an ideal substrate for injection using direct-push technology for source area, plume and reactive barrier applications. The low viscosity allows a greater volume of EDS-ER to be applied in a shorter period and increases the substrate delivery radius per point. The result is fewer injection points and overall shorter delivery time requirements per site. EDS-ER is also ideal for injection into the subsurface through injection wells or used in soil mixing and excavation projects.

Product Specifications

- Vegetable oil based, 100% fermentable – contains no water
- Neutral pH when mixed with water
- Shelf Life Unrefrigerated > 2 years

Packaging Options

- 55-gallon poly drums
- 275-gallon IBC containers
- 3,000 - 5,000 gallon tankers

Convergence of Gas inFusion Technology & *In Situ* Remediation Technologies

Adding hydrogen-enriched water can enhance the performance Tersus' EDS-ER and other electron donor substrates. Infusing hydrogen into water with the inVentures HiSOC or gPRO technology can reduce the demand for the carbon-based electron donor by as much as 50%. Simply add the hydrogen-infused water to EDS-ER for dilution, pre-conditioning, recirculation or chase water. Further, you can inject the hydrogen-enriched water with your bioaugmentation cultures.

About Us

What if we always settled for the first technology that came along?
Then we would have never gotten to where we are today.

We Develop & Market Innovative, Sustainable, Green Technologies. Tersus Environmental also provides global sales management and marketing services for inVentures Technologies' complete family of groundwater remediation products based on the worldwide-patented Gas inFusion technology, which allows for supersaturated levels of dissolved gas into liquids.

tersus environmental

Innovative Sustainable Green Technologies
Tel: 919.453.5577 • info@tersusenv.com
tersusenv.com

inVentures Technologies incorporated

Global Supplier of Gas inFusion Technology
Tel: 647.477.2394 • U.S. Tel: 646.688.4426
iSOCinfo.com • gPROinfo.com

Rev: 14 February 2013

EDS-ER™

Water Mixable Oils for Enhanced Anaerobic Bioremediation

As delivered, EDS-ER (electron donor solution – extended release) by Tersus Environmental is a significant change compared to the physical state of standard emulsified vegetable oil (EVO) products. Whereas EVO products are delivered as a concentrated emulsion containing water, EDS-ER is a water-mixable oil; it contains no water. Thus, the costs for shipping EDS-ER are about 50% less than conventional products.

Material Overview Handling and Safety

EDS-ER is a vegetable oil based water mixable oil that self emulsifies on contact with water. Packaging is available in 275-gallon totes, 55-gallon drums and bulk tankers.

- Each tote typically has a net weight of 2,100 pounds
- Each drum has a net weight of 415 pounds

At room temperature, EDS-ER is a liquid material with an appearance and viscosity roughly equivalent to vegetable oil. Unlike common EVO products, EDS-ER will not separate, will not freeze, and has a shelf life of 2 years without spoilage. EDS-ER is nontoxic, however field personnel should take precautions while handling and applying the material. Field personnel should use appropriate personal protection equipment (PPE) including eye protection. Gloves should be used as appropriate based on the exposure duration and field conditions. A Material Safety Data Sheet (MSDS) is provided with each shipment. Personnel who operate field equipment during the installation process should have appropriate training, supervision, and experience and should review the MSDS prior to site operations.

Design and Specifications

Designs for EDS-ER are similar to standard EVO products. We suggest the use of the Environmental Security Technology Certification Program (ESTCP) Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents to estimate the quantity of EDS-ER for a project.

Product Specifications:

- Vegetable oil based, 100% fermentable – contains no water
- Neutral pH
- Shelf Life Unrefrigerated > 2 years

EDS-ER should be diluted with water on a volume-to-volume (v:v) basis to produce the desired diluted emulsion fluid to inject at a site. Most typical concentrations range from 5 to 10% (v:v). More dilute concentrations can be easily produced using the water volumes provided in the table below.

Higher dilution rates are governed by the following technical considerations:

- Distribution requirements
- Site lithology
- Available application time (aquifer acceptance rate)

Product Application Suggestions

We believe that uniform distribution of an electron donor is the key to successfully enhancing an anaerobic bioremediation project. A uniform distribution of an amendment minimizes “hot spots" around injection points where excessive amounts of an amendment can create adverse conditions for bacterial growth or for ground water flow. Effective distribution also means that there is sufficient electron donor at the periphery of the radius of influence around injection points to insure adequate bioremediation.

Once emulsified, the oil in EDS-ER remains emulsified even at low concentrations and the diluted emulsion has a viscosity essentially that of water. Therefore, we suggest injecting a relatively dilute emulsion in a single step, as we are confident that the oil droplets move with the injected water. The dilution allows the oil in EDS-ER to be distributed over a much larger area around an injection well than would be the case with an injection of undiluted product. The oil droplets may remain suspended in the injection water for a few days to a few weeks after injection. Then the oil absorbs onto soil surfaces to act as a long-term source of electron donor.

EDS-ER can be diluted on site by adding the desired amount of product to a mixing tank and then simply adding water. The turbulence of the water flowing from a hose is enough for our product to emulsify. To eliminate the need for large mixing tanks on site, an on demand – Dosatron® Metering System that continuously mixes water and EDS-ER in a proportion desired by the user and then simultaneously inject the diluted mix into multiple points can also be used.

Injection points may be temporary or permanent wells or direct-push points.

The following table provides a quick reference to the dilution water necessary for some common application rates:

EDS-ER (%)	EDS-ER (mg/L)	EDS-ER (Gallons)	Clean Water (Gallons)	Resulting Volume (Gallons)
20	200,000	1	4	5
10	100,000	1	9	10
6	60,000	1	15.7	16.7
5	50,000	1	19	20
2	20,000	1	49	50
1	1,000	1	99	100

Water

EDS-ER is diluted with water prior to injection. A diluted mixture of 6% EDS-ER to 94% water is a typical injection blend. Once the blend is injected into the subsurface, it is chased with water to spread the resulting emulsion into the aquifer. The user should identify a suitable quantity of water at your project site. Natural site groundwater is an option and can be recirculated in the aquifer. For this option, the aquifer must yield a sufficient volume to be extracted in a relatively short period and regulatory approval may be required for re-injecting potentially contaminated groundwater. Potable water is another option to prepare and chase the emulsion. Pretreatment of the water with granular activated carbon (GAC) or air sparging to remove residual chlorinated disinfection byproducts and other contaminants may be needed.

Equipment Setup for Injection

EDS-ER is often injected using low pressure pumping equipment. Either connect a single hose from the supply pump to a manifold connecting all of the injection wells or supply the injection points in a daisy chain manner with a discharge hose extending from the pump to the first injection well first back to the dilution tank. Valves on each manifold serve to balance out flow rates.

Chase Water

After the design volume of EDS-ER is injected into the aquifer, additional chase water should be used to disperse the emulsion into the aquifer and flush out the injection point. In many cases, an injection well will later be used for a second injection or for monitoring (not recommended). Any electron donor, regardless of manufacturer, that remains in a well bore after injection will attract bacteria if other conditions conducive to growth are present. The result may be a well bore that will become clogged if it has not been properly flushed out. The purpose is **NOT** to chase EDS-ER farther into the aquifer, but to simply clear the well bore, screen, and pack so that the well will minimize the potential for biofoul.

Chase water can be added to the dilution tank after the emulsion has been pumped out with no changes in the equipment setup. In some cases, the water chase can be applied using water line pressure and no pump. Water should be applied until the calculated volume has been injected and then the valve on the wellhead or manifold is closed.

Recycling

Our clients have asked us many times if they can return a drum / tote and have it refilled with the same product. Unfortunately, three issues affect recycling drums. The issues are transport costs, documentation, and liability. Shipping empty containers is expensive. If a drum is returned, refilled, shipped back to the customer and then something goes wrong with the product it will be almost impossible to trace back what may have happened. Thus, many companies decide to "just throw them away".

We encourage our clients to us a recycling service. There are a number of drum / tote recycling companies located throughout the US. They make their revenues by collecting, prepping, and reselling used drums. Contacting one in your area and asking for help may allow you to evaluate some options. Depending on the number of containers, the pickup charge may be negligible.

tersus environmental

Innovative Sustainable Green Technologies
Tel: 919.453.5577 • info@tersusenv.com
tersusenv.com

Univar USA Inc Material Safety Data Sheet

MSDS No: CRN79936

Version No: 002 2012-11-21

Order No:

Univar USA Inc., 17425 NE Union Hill Rd., Redmond WA 98052
(425) 889 3400

Emergency Assistance

For emergency assistance involving chemicals call
Chemtrec - (800) 424-9300

Ingredion

MATERIAL SAFETY DATA SHEET

PRODUCT INFORMATION

Product Identity **Cerelose® Dextrose 020010**

Product Use Food-grade multipurpose dextrose

Company

Ingredion Incorporated
5 Westbrook Corporate Center
Westchester, IL 60154 USA
Info/Emergency Phone: (708) 551-2600
Fax: (708) 551-2510
Business Hours: Mon - Fri, 7:30 a.m. - 5:00 p.m. (Central Time)

405 The West Mall, Suite 600,
Etobicoke, Ontario M9C 0A1 Canada
Info/Emergency Phone: (416) 620-2300
Fax: (416) 620-4488
Business Hours : Mon – Fri. 7:30 a.m. – 6:00 p.m. (E.S.T)

COMPOSITION/INFORMATION ON INGREDIENTS

Substance	% or Range	CAS Number	EINICS Number	Toxicology Data
Dextrose (D-Glucose)	≤100	50-99-7	200-075-1	LD_{50}: 25800 mg/kg (oral – rat) LC_{50}: No data available

HAZARDS IDENTIFICATION

Toxicity Inhalation of dust may irritate the nose, throat, and upper respiratory tract. Skin contact is not known to be hazardous to health. Eye contact may cause mild transient irritation. Ingestion of quantities sufficient to produce health effects is not a plausible route of exposure in industrial use.

Reactivity Product is non-reactive under foreseeable conditions of use.

Flammability See *Fire* and *Explosion Hazards* and *Firefighting Measures*.

Corrosivity This product is non-corrosive

S Phrase(s) None designated

R Phrase(s) None designated.

FIRST AID MEASURES

Inhalation Remove the subject from the source of exposure.

Skin Contact Wash affected area with water.

Eye Contact Flush eyes with water for at least fifteen minutes. Seek medical assistance, if necessary.

Ingestion If the product is accidentally ingested, seek medical assistance.

FIRE AND EXPLOSION HAZARDS AND FIREFIGHTING MEASURES

Hazards High concentrations of product dust from this product may burn explosively if ignited by static charges or other ignition sources. The conditions under which this may occur are not readily predictable. Avoid open flames, electrical arcs, static electricity, and/or welding in areas of excessive dusting. Ensure that conveying and handling equipment is securely grounded. Fire and explosions may release carbon monoxide, smoke, and irritant combustion byproducts.

Extinguishing media Water, carbon dioxide, or dry chemical.

Fire and Explosion Hazards Data

Flashpoint:	No data available	**Autoignition temperature**:	No data available
Lower Explosive Concentration:	No data available	**Upper Explosive Concentration**:	No data available

MATERIAL SAFETY DATA SHEET

PREVENTIVE MEASURES

♦ Accidental Release Measures

Control Measures	Eliminate sources of ignition and static charge. Dry sweep spilled material to impervious containers. Avoid direct release to environmental media.
Personal Protection	Avoid contact with skin, eyes, and mucous membranes. Protective equipment is not required for clean up unless high dust levels exist. In such cases, wear respiratory protection appropriate for particulate matter in air, and that is approved and qualified.
Environmental Precautions	Dispose of residues in compliance with applicable national, state/provincial, and local regulations.

♦ Handling and Storage

Handling	Avoid contact with eyes and mucous membranes. Avoid creating dust clouds.
Storage	Store in a cool, dry place away from sources of ignition and incompatible materials (see Stability and Reactivity for incompatible materials).

♦ Exposure Controls and Personal Protection

Engineering Controls	Where use of the product may generate airborne dust, use appropriate measures such as local exhaust ventilation to maintain air concentrations of the components to within their respective exposure limits.
Respiratory Protection	If any exposure level exceeds a permissible limit, use a respirator having a configuration (class, face piece, filter, etc.) appropriate to the concentration and approved and qualified for the application.
Eye Protection	Wear appropriate eye protection such as goggles or glasses if there is the potential for eye contact with the product.
Skin Protection	Skin protection is not normally required. If it is desired, cloth or synthetic gloves are suitable.

PHYSICAL AND CHEMICAL PROPERTIES

Appearance	**Form:**	Powder	**Color/colour:**	White	**Odor/odour:**	None or faint cereal-like
Physical Data	**Moisture %:**	8.0 – 9.0	**Packing Density:**	≈0.64 g/cc (≈40 lbs./ft³)	**Water Solubility:**	Soluble
	pH Value:	Not applicable	**Odor/odour Threshold:**	No data available	**Vapor/vapour Pressure:**	None
			Minimum Ignition Energy :	>500 milliJoules (mJ)	**Minimum Ignition Temperature: (dust cloud)**	460-480°C

STABILITY AND REACTIVITY

Conditions to avoid	This product is stable under normal conditions of temperature and pressure.
Materials to avoid	Oxidizing/oxidising agents
Decomposition products	Carbon monoxide; carbon dioxide; irritant gasses, and smoke
Dangerous polymerization/polymerisation	Will not occur.
Dangerous reactions	None are known or reasonably foreseeable

MATERIAL SAFETY DATA SHEET

TOXICOLOGICAL INFORMATION

Health Hazards of Product	**Routes of Entry:**	Inhalation and ingestion. Not absorbed through skin or mucous membranes.		
	Acute Effects:	Inhalation may irritate the nose, throat, and respiratory tract. Eye contact may cause mild transient irritation. Ingestion of quantities sufficient to produce adverse health effects is not a plausible route of exposure in industrial use. Skin contact is not known to be hazardous.		
	Chronic Effects:	Adverse effects from chronic inhalation or ingestion are not known.		
Exposure Limits	**ACGIH TLVs, as Particulates Not Otherwise Classified:**	10 mg/m³ (inhalable fraction) 3 mg/m³ (respirable fraction)	**OSHA PELs, as Particulates Not Otherwise Regulated:**	15 mg/m³ (total dust) 5 mg/m³ (respirable fraction)
Carcinogencity	**IARC:**	No	**NTP (USA):**	No
	ACGIH:	No	**OSHA (USA):**	No
Reproductive Toxicity	Product is not classified as a reproductive toxin by any authoritative body or regulatory agency.			

TRANSPORT INFORMATION

Shipment of this product is not controlled by ICAO, USDOT, or Canadian TDG regulations.

ECOLOGICAL INFORMATION

In its intended manner of use, this product should not be released directly into environmental media. However, it is readily biodegradable in the natural environment.

REGULATORY INFORMATION

United States	TSCA:	All constituents are on EPA's TSCA inventory.
	CERCLA:	Contains no reportable quantity (RQ) substances per Sections 302/304 of EPA.
	SARA:	Contains no chemicals subject to the reporting requirements of Sections 311/312/313
	FDA:	Classified as *Generally Regarded as Safe* (GRAS).
Canada	WHMIS Classification(s):	Not applicable
	DSL:	Product is included.
	Food and Drug Act:	Product is regulated as a standard foodstuff.
Europe	Exempt from OECD (793/93/EEC) List for Evaluation of High Production Volume (HPV) Chemicals EU EINECS 200-075-1	
Elsewhere	Present on Australia (AICS), Philippines (PICCS) and China's Product Inventory Lists	

PREPARATION INFORMATION

Preparer/Responsible Party

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Canada

Revision Information

Date of revision: June 4, 2012
Supersedes previous MSDS dated: November 25, 2009

DISCLAIMER OF EXPRESSED OR IMPLIED WARRANTIES

Univar USA Inc Material Safety Data Sheet

For Additional Information contact MSDS Coordinator during business hours, Pacific time: (425) 889-3400

Notice

Univar USA Inc. (”Univar”) expressly disclaims all express or implied warranties of merchantability and fitness for a particular purpose, with respect to the product or information provided herein, and shall under no circumstances be liable for incidental or consequential damages.

Do not use ingredient information and/or ingredient percentages in this MSDS as a product specification. For product specification information refer to a product specification sheet and/or a certificate of analysis. These can be obtained from your local Univar sales office.

All information appearing herein is based upon data obtained from the manufacturer and/or recognized technical sources. While the information is believed to be accurate, Univar makes no representations as to its accuracy or sufficiency. Conditions of use are beyond Univar's control and therefore users are responsible to verify this data under their own operating conditions to determine whether the product is suitable for their particular purposes and they assume all risks of their use, handling, and disposal of the product, or from the publication or use of, or reliance upon, information contained herein.

This information relates only to the product designated herein, and does not relate to its use in combination with any other material or in any other process

APPENDIX B

SoundEarth Strategies

DRAFT

Project: 700 Dexter Property
Project Number: 0797-001-02
Logged by: CMP
Date Started: 11/02/15
Surface Conditions: Concrete
Well Location N/S: --
Well Location E/W: --
Reviewed by: --
Date Completed: 11/02/15

BORING LOG IW01

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling: -- feet bgs
Water Depth After Completion: ~10 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
0						Concrete		**Concrete surface.**	
			20			Fill		**Moist, sandy SILT with gravel. Brown and gray. Contains brick fragments. No hydrocarbon or solvent odor (60-30-10). Fill.**	
				0.0					
5						Fill		**Moist, sandy SILT with gravel. Contains pieces of asphalt. Mottled gray and orange. No hydrocarbon or solvent odor (60-30-10). Fill.**	
			40						
				0.0					
						SM		**Moist, silty SAND with gravel. Medium brown. No hydrocarbon or solvent odor (25-65-10).**	
				0.0					
10						SM		**Wet, silty coarse to medium SAND with gravel. Medium brown and gray. No hydrocarbon or solvent odor (30-60-10).**	▼

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	66	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:
(60-30-20): Estimated percentages by volume (clay/silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	CMP
Date Started:	11/02/15
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	11/02/15

BORING LOG **IW01**

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling -- feet bgs

Water Depth After Completion ~10 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
			75	0.1		SP		**Wet, SAND with silt. Light gray. No hydrocarbon or solvent odor (10-90-0).**	
						CL		**Wet, sandy SILT and CLAY. Gray. No hydrocarbon or solvent odor (85-15-0).**	
15						GP		**Moist, silty GRAVEL with sand. Light gray. No hydrocarbon or solvent odor (30-20-50).**	
				0.1		SM		**Moist, sandy SILT with gravel. Mottled gray and orange. No hydrocarbon or solvent odor (75-20-5).**	
						SM		**Moist to wet, silty fine to medium SAND with gravel. Light gray. No hydrocarbon or solvent odor (30-65-5).**	
				0.1		SM-SP		**Wet, silty medium to coarse SAND. Light gray. No hydrocarbon or solvent odor (20-80-0).**	
20			100			SM		**Wet, silty SAND with gravel. Light gray to brown. No hydrocarbon or solvent odor (25-65-10).**	
				0.3					
						SM		**Moist, silty SAND with gravel. Light gray. No hydrocarbon or solvent odor (25-65-10).**	

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	66	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(60-30-20): Estimated percentages by volume (clay/silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	CMP
Date Started:	11/02/15
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	11/02/15

BORING LOG IW01

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling: -- feet bgs
Water Depth After Completion: ~10 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
				0.7		SM		**Moist, sandy SILT with gravel. Light gray and brown. No hydrocarbon or solvent odor (20-70-10).**	
25			100			SM		**Dry to moist, very dense, silty SAND and sandy SILT with gravel. Light gray. No hydrocarbon or solvent odor (20-65-15)/(65-20-15).**	
				7.9		SM		**Dry to moist, gravelly SAND with silt. Light gray. No hydrocarbon or solvent odor (20-55-25).**	
				7.5					
30			100			SM		**Sluff: Wet, gravelly SAND with silt and silty SAND with gravel. Light gray. No hydrocarbon or solvent odor (20-55-25)/(30-55-15).**	
				8.2		ML		**Moist, dense, sandy SILT with clay and some gravel. Light gray. No hydrocarbon or solvent odor (35-60-5).**	
						SM		**Moist to dry, silty SAND with gravel. Light gray. No hydrocarbon or solvent odor (25-70-5).**	
				5.3					
35									
						SM		**Moist, silty to clayey SAND with gravel. Light gray.No hydrocarbon or solvent odor (30-65-5).**	

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	66	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:
(60-30-20): Estimated percentages by volume (clay/silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	CMP
Date Started:	11/02/15
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	11/02/15

BORING LOG IW01

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling: -- feet bgs
Water Depth After Completion: ~10 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
				7.3					
						SM		**Moist, silty SAND with some gravel. Light gray. No hydorcarbon odor (35-60-5).**	
40									
				10.9					
						ML		**Moist, dense, sandy SILT with gravel. Gray. No hydrocarbon or solvent odor (70-25-5).**	
				0.2					
45						SM		**Moist, dense, silty SAND with gravel. Light gray. No hydrocarbon or solvent odor (25-70-5).**	
				1.4					
						SM		**Moist, silty SAND with gravel. Light gray. No hydrocarbon or solvent odor (30-65-5).**	

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	66	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(60-30-20): Estimated percentages by volume (clay/silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	CMP
Date Started:	11/02/15
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	11/02/15

BORING LOG **IW01**

Site Address: 700 Dexter Avenue North, Seattle, WA

Water Depth At Time of Drilling -- feet bgs

Water Depth After Completion ~10 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
				3.0		SM		**Moist, gravelly SAND with silt. Light gray. No hydrocarbon or solvent odor (20-55-25).**	
50						SM		**Moist, silty SAND with gravel. Light gray. No hydrocarbon or solvent odor (35-60-5).**	
				0.5		ML		**Moist, dense, sandy SILT with gravel. Light gray. No hydrocarbon or solvent odor (60-30-10).**	
55				0.3		ML		**Moist, sandy SILT with gravel. Light gray. No hydrocarbon or solvent odor (70-20-10).**	
				0.3		ML		**Moist, dense, sandy SILT with gravel. Light gray. No hydrocarbon or solvent odor (70-25-5).**	
60				2.0					

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	66	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(60-30-20): Estimated percentages by volume (clay/silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	CMP
Date Started:	11/02/15
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	11/02/15

BORING LOG IW01

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling -- feet bgs

Water Depth After Completion ~10 feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
60								**No recovery**	
65						**ML**		**Moist, sandy SILT with gravel. Light gray. No hydrocarbon or solvent odor (60-30-10).**	
70									

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	66	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(60-30-20): Estimated percentages by volume (clay/silt-sand-gravel).

SoundEarth Strategies

PILOT INJECTION SONIC CORE PHOTOGRAPHS

700 Dexter

700 Dexter Avenue North

Seattle, Washington

Project No.:	0797-001-02
Date:	November 17, 2015
Drawn By:	CMS
Chk By:	**DRAFT**

Photograph 1. Sonic core of injection well IW01 from approximately 0 to 15 feet bgs.

Photograph 2. Sonic core of injection well IW01 from approximately 15 to 25 feet bgs.

Photograph 3. Sonic core of injection well IW01 from approximately 25 to 35 feet bgs.

Photograph 4. Sonic core of injection well IW01 from approximately 35 to 45 feet bgs.

Photograph 5. Sonic core of injection well IW01 from approximately 45 to 55 feet bgs.

Photograph 6. Sonic core of injection well IW01 from approximately 55 to 66 feet bgs.

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	GCF/CMP
Date Started:	01/13/16
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	01/15/16

BORING LOG IW06

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling 53.5 feet bgs

Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
0						**Concrete**		**Concrete surface.**	
				0.1		**Fill**		**Moist, SAND with gravel. Brown. No hydrocarbon or solvent odor (0-70-30). Fill.**	
5						**Fill**		**Moist, SAND with gravel. Brown. No hydrocarbon or solvent odor (0-70-30). Fill.**	
				0.3		**Fill**		**Moist, SAND with gravel and silt. Gray. No hydrocarbon or solvent odor (10-80-10).**	
10				0.1 0.9		**Fill**		**Moist, SAND with gravel and trace silt. Gray. No hydrocarbon or solvent odor (5-85-10).**	
15						**Fill**		**Moist, SAND with gravel and trace silt. Gray. No hydrocarbon or solvent odor (5-85-10).**	

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	75	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(10-70-20): Estimated percentages by volume (silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	GCF/CMP
Date Started:	01/13/16
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	01/15/16

BORING LOG IW06

Site Address: 700 Dexter Avenue North, Seattle, WA

Water Depth At Time of Drilling: 53.5 feet bgs

Water Depth After Completion: -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
				1.8					
20						SM		**Moist, silty SAND. Medium brown and gray. No hydrocarbon or solvent odor (10-90-0).**	
				0.0	IW06-25	SM		**Moist, silty fine to medium SAND with gravel. Medium brown and grayish. No hydrocarbon or solvent odor (20-70-10).**	
25									
						SM		**Moist, dense, silty SAND with gravel. Dark gray. No hydrocarbon or solvent odor (15-70-15).**	
				0.0	IW06-30				
30						SM		**Moist, dense, silty SAND with gravel. Dark gray. No hydrocarbon or solvent odor (20-70-10).**	

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	75	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(10-70-20): Estimated percentages by volume (silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	GCF/CMP
Date Started:	01/13/16
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	01/15/16

BORING LOG IW06

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling 53.5 feet bgs

Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
						SM		**Moist, dense, gravelly medium SAND with silt. Dark gray. No hydrocarbon or solvent odor (10-70-20).**	
				0.0					
35						SM		**Moist, gravelly SAND with silt. Becomes coarser with increasing depth. Dark gray. No hydrocarbon or solvent odor (10-65-25).**	
				0.0	IW06-40				
40									
						SM		**Moist, silty SAND with gravel. Dark gray. No hydrocarbon or solvent odor (20-70-10).**	
						SM		**Moist, silty fine to medium SAND with gravel. Dark gray. No hydrocarbon or solvent odor (25-65-10).**	
						SM		**Wet, medium to coarse SAND with silt and gravel. Dark gray. No hydrocarbon or solvent odor (10-80-10).**	
				0.0					
45									

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	75	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(10-70-20): Estimated percentages by volume (silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	GCF/CMP
Date Started:	01/13/16
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	01/15/16

BORING LOG IW06

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling 53.5 feet bgs

Water Depth After Completion -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
				0.0	IW06-50	SM		**Moist, dense, silty SAND with gravel. Light gray. No hydrocarbon or solvent odor (25-65-10).**	
50						ML		**Moist, sandy SILT with gravel. Dark gray. No hydrocarbon or solvent odor (60-30-10).**	
									▽ (53.5)
				0.0	IW06-55	SM		**Moist, silty SAND with gravel. Dark gray. No hydrocarbon or solvent odor (20-60-20).**	
55						SM		**Wet, SAND with silt and trace gravel. Dark gray. No hydrocarbon or solvent odor (10-85-5).**	
				0.0	IW06-60				
60						SM		**Moist, silty SAND with gravel. Dark gray. No hydrocarbon or solvent odor (20-65-15).**	

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	75	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(10-70-20): Estimated percentages by volume (silt-sand-gravel).

SoundEarth Strategies

DRAFT

Project:	700 Dexter Property
Project Number:	0797-001-02
Logged by:	GCF/CMP
Date Started:	01/13/16
Surface Conditions:	Concrete
Well Location N/S:	--
Well Location E/W:	--
Reviewed by:	--
Date Completed:	01/15/16

BORING LOG IW06

Site Address: 700 Dexter Avenue North
Seattle, WA

Water Depth At Time of Drilling: 53.5 feet bgs

Water Depth After Completion: -- feet bgs

Depth (feet bgs)	Interval	Blow Count	% Recovery	PID (ppmv)	Sample ID	USCS Class	Graphic	Lithologic Description	Well Detail/ Water Depth
				0.0	IW06-65				
65						SM		**Moist, silty SAND with gravel. Dark gray. No hydorcarbon odor (25-60-15).**	
				0.0	IW06-70				
70						SM		**Moist, silty SAND with gravel. Dark gray. No hydrocarbon or solvent odor (20-65-15).**	
						SM		**Wet, gravelly SAND with silt. Dark gray. No hydrocarbon or solvent odor (10-85-15).**	
						ML		**Moist, sandy SILT with gravel. Gray. No hydrocarbon or solvent odor (55-35-10).**	
					IW06-75				
75								**End of boring at 75 ft bgs. Temporary injection well IW06 installed to ~75 feet bgs. EOS injected into temporary well before the well was abandoned and backfilled with bentonite chips.**	
80									

Drilling Co./Driller:	Cascade/Zane	
Drilling Equipment:	Sonic Rig	
Sampler Type:	--	
Hammer Type/Weight:	--	lbs
Total Boring Depth:	75	feet bgs
Total Well Depth:	--	feet bgs
State Well ID No.:	--	

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

Notes/Comments:

(10-70-20): Estimated percentages by volume (silt-sand-gravel).

APPENDIX C

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Data Table

ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-01 **Personnel:** KS, DW, CS

Injection Interval: Intermediate groundwater aquifer zone (47' to 60')
Injection Packer Set 43'-47'/ Riser Pipe 47'-50' /
Stainless Steel Screen 50'-65'

Injection Method: High Pressure

Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)
	Start	End				
11/3/15	12:32		529.0	50.0	3.3	2.0
	12:35		538.0	50.0	3.1	2.0
	12:40		555.5	53.0	3.1	2.0
	12:45		568.0	54.0	3.2	2.0
	12:55		588.6	55.0	2.9	2.0
	13:00		611.0	55.0	2.8	2.0
	13:10		631.0	56.0	2.7	2.0
	13:11		640.0	85.0	7.1	2.0
	13:15		673.0	87.0	6.8	2.0
	13:22		715.5	87.0	6.8	2.0
	13:32		785.0	87.0	6.8	2.0
	13:44		859.0	85.0	6.8	2.0
	13:50		899.0	85.0	6.8	2.0
	13:55		935.0	85.0	6.8	2.0
	14:20		1101.0	80.0	6.8	2.0
	14:22		1120.0	85.0	7.3	2.0
	14:25		1140.0	85.0	7.4	2.0
	14:28		1175.0	100.0	10.3	2.0
	14:30		1209.0	100.0	10.5	2.0
	14:40		1314.0	92.0	10.6	2.0
	14:45		1352.0	92.0	10.6	2.0
	14:55		1468.0	90.0	10.6	2.0
	15:00		1518.0	90.0	10.5	2.0
	15:10		1619.0	90.0	10.5	2.0
	15:15		1680.0	100.0	12.1	2.0
	15:17		1700.0	100.0	12.0	2.0
	15:22		1760.0	100.0	12.0	2.0
	15:25		1788.0	100.0	12.1	2.0
	15:27		1817.0	110.0	13.5	2.0
	15:32		1868.0	108.0	13.5	2.0
	15:35		1920.0	107.0	13.6	2.0
	15:37		1958.0	121.0	15.1	2.0
	15:40		2005.0	119.0	15.1	2.0
	15:45		2069.0	118.0	15.1	2.0
	15:55		2213.0	117.0	15.1	2.0
	15:57		2254.0	130.0	16.8	2.0
	16:10		2483.0	127.0	16.7	2.0
	16:15		2544.0	126.0	16.7	2.0
	16:16		2582.0	140.0	18.2	2.0
	16:19		2635.0	140.0	18.2	2.0
	16:20		2660.0	150.0	19.2	2.0
	16:27		2784.0	147.0	19.0	2.0
	16:29		2824.0	158.0	20.3	2.0
	16:31		2871.0	157.0	20.4	2.0
	16:40		3062.0	155.0	20.3	2.0
	16:45		3140.0	180.0	22.7	2.0
	16:47		3195.0	180.0	22.6	2.0
	16:52		3319.0	178.0	22.6	2.0
		17:00	3510.0	177.0	22.6	2.0
Daily Totals / Averages			**3510.0**	**106.6**	**12.0**	**2.0**

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Data Table

ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-01 **Personnel:** KS, DW, CS

Injection Interval: Intermediate groundwater aquifer zone (47' to 60') Injection Packer Set 43'-47'/ Riser Pipe 47'-50' / Stainless Steel Screen 50'-65' **Injection Method:** High Pressure

11/4/15	8:08		3517.2	44.0	6.2	3.0
	8:30		3618.0	46.0	3.6	3.0
	8:33		3630.0	100.0	11.8	3.0
	8:35		3661.0	100.0	11.6	3.0
	8:45		3737.0	85.0	11.2	3.0
	8:47		3752.0	100.0	12.3	3.0
	8:55		3851.0	95.0	12.2	3.0
	9:18		4135.0	88.0	12.1	3.0
	9:28		4250.0	87.0	12.1	3.0
	9:35		4380.0	130.0	17.9	3.0
	9:48		4568.0	128.0	17.6	3.0
	10:00		4788.0	125.0	17.7	3.0
	10:03		4818.0	132.0	18.2	3.0
	10:05		4856.0	131.0	18.2	3.0
	10:20		5140.0	128.0	18.2	3.0
	10:35		5415.0	127.0	18.1	3.0
	10:55		5759.0	127.0	18.1	3.0
	11:00		5868.0	135.0	19.1	3.0
	11:20		6258.0	134.0	19.0	3.0
	11:25		6352.0	134.0	19.0	3.5
	11:38		6585.0	133.0	18.3	3.5
	12:00		6985.0	133.0	19.1	3.5
	12:17		7320.0	133.0	18.8	3.5
	12:45		7818.0	133.0	18.6	3.5
	13:10		8235.0	135.0	18.2	3.5
	13:47		8880.0	140.0	17.6	3.5
	13:55		9053.0	140.0	17.4	3.5
	14:00		9115.0	150.0	18.8	4.0
	14:05		9190.0	150.0	18.7	4.0
	14:10		9323.0	150.0	18.8	4.0
	14:30		9678.0	150.0	18.7	4.0
	14:35		9810.0	160.0	19.4	5.0
	14:45		9943.0	160.0	19.5	5.0
	14:47		10003.0	170.0	20.4	5.0
	14:50		10061.0	170.0	20.3	5.0
	14:55		10173.0	170.0	20.3	5.0
	15:05		10370.0	170.0	20.3	5.0
	15:15		10574.0	162.0	19.6	5.0
	15:25		10764.0	145.0	18.6	5.0
	15:30		10885.0	145.0	17.8	5.0
	15:50		11281.0	145.0	17.8	5.0
		16:50	11281.0	145.0	17.8	5.0
Daily Totals / Averages			**7763.8**	**130.1**	**16.9**	**3.7**
Injection Event Totals / Averages			**11273.8**	**118.4**	**14.5**	**2.9**

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

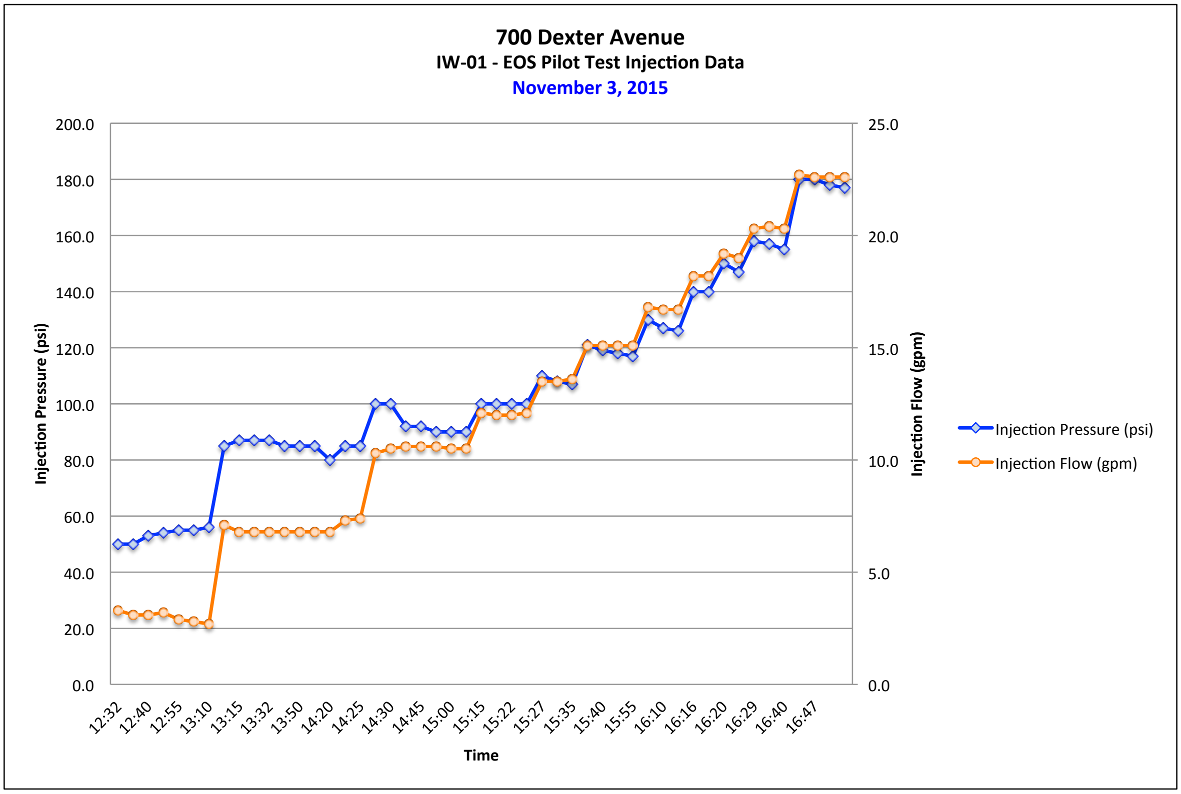
ESSENTIAL MANAGEMENT SOLUTIONS

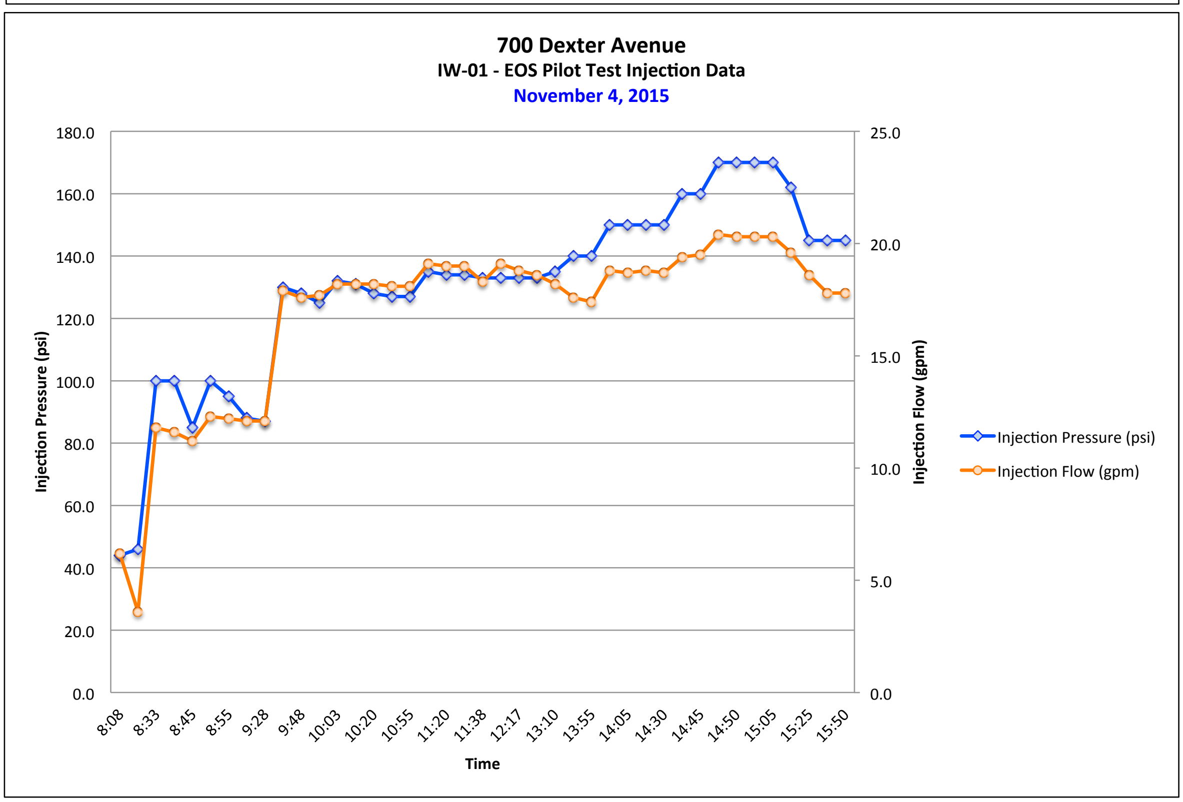
Well ID: IW-01

Personnel: KS, DW, CS

Injection Interval: Intermediate groundwater aquifer zone (47' to 60') Injection Packer Set 42'-47'/ Riser Pipe 47'-50' / Stainless Steel Screen 50'-65'

Injection Method: High Pressure





Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Volume, Pressure, and Flow Graphs

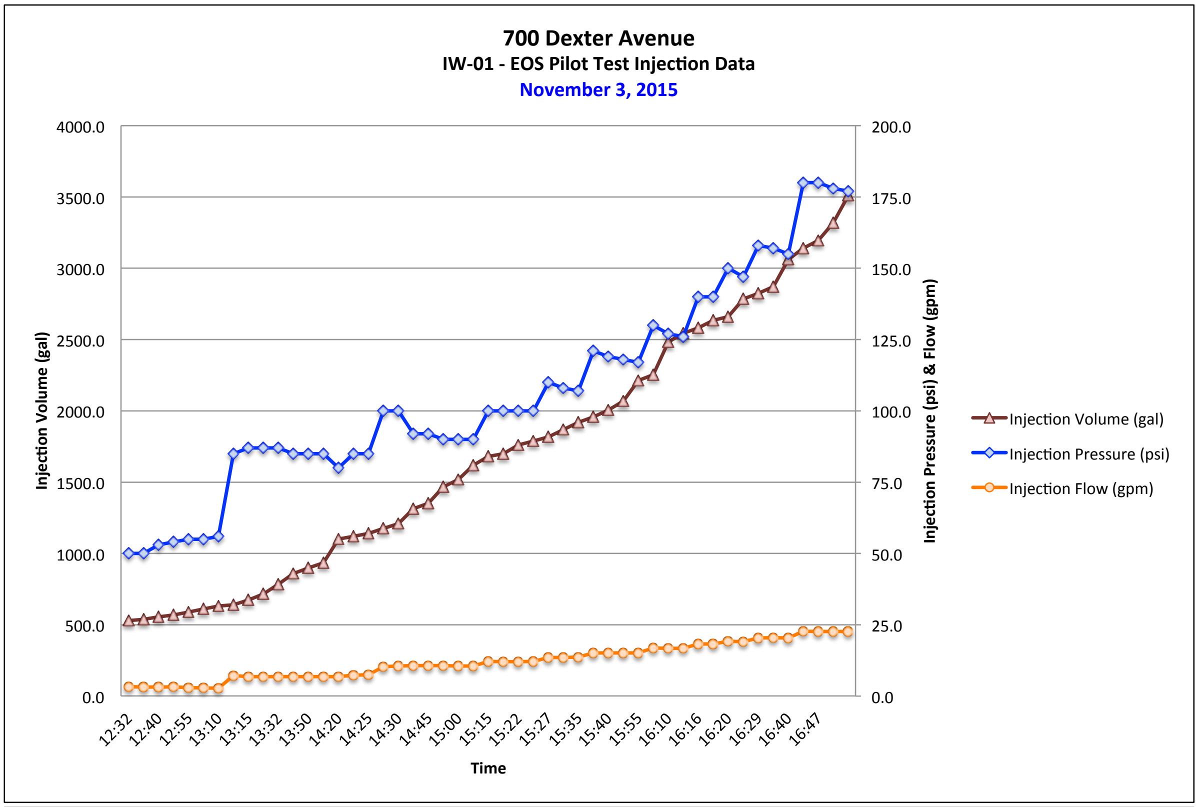
ESSENTIAL MANAGEMENT SOLUTIONS

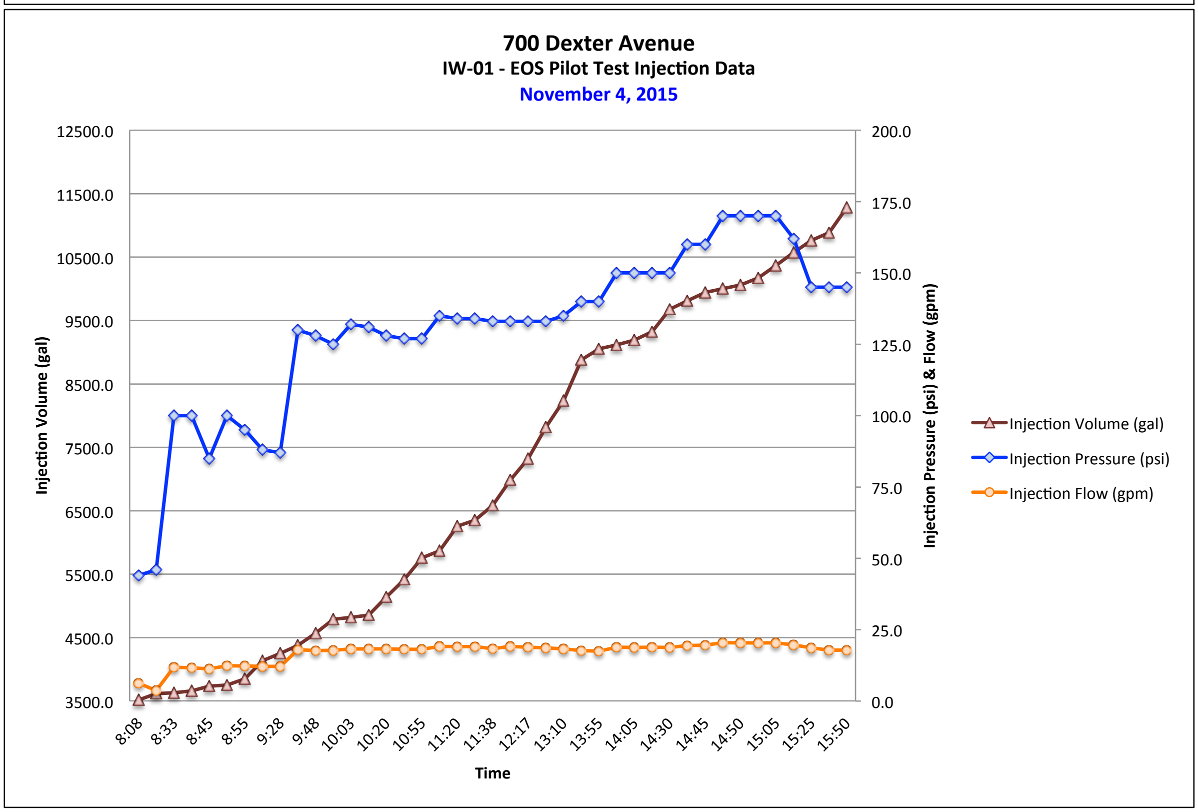
Well ID: IW-01

Personnel: KS, DW, CS

Injection Interval: Intermediate groundwater aquifer zone (47' to 60')
Injection Packer Set 42'-47'/ Riser Pipe 47'-50' /
Stainless Steel Screen 50'-65'

Injection Method: High Pressure





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Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Data Table

Well ID: IW-02

Personnel: KS

Injection Interval: Intermediate groundwater aquifer zone (47' to 60')

Injection Method: High Pressure

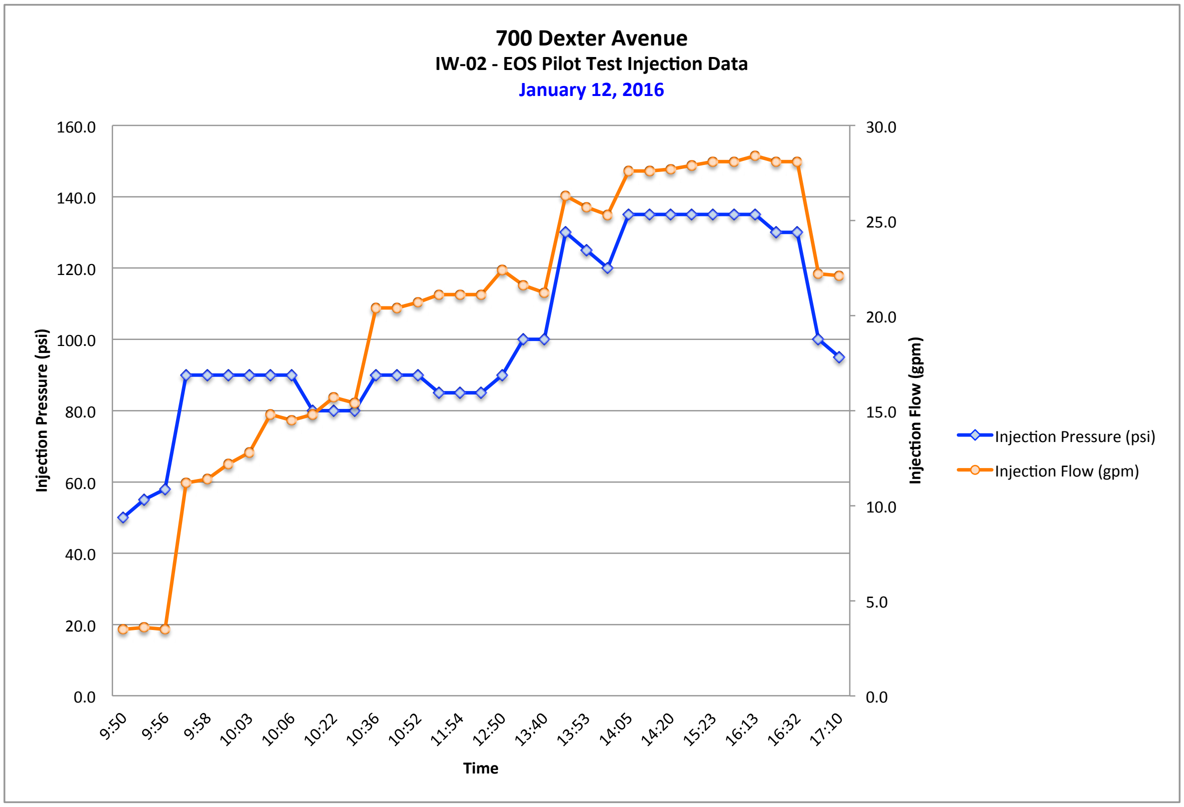
Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/12/16	9:50		0.0	50.0	3.5	3.0	0.0
	9:52		17.8	55.0	3.6	3.0	50.0
	9:56		28.8	58.0	3.5	3.0	56.0
	9:57		41.5	90.0	11.2	3.0	80.0
	9:58		52.0	90.0	11.4	3.0	80.0
	10:01		81.2	90.0	12.2	3.0	--
	10:03		108.5	90.0	12.8	3.0	65.0
	10:04		133.9	90.0	14.8	3.0	--
	10:06		154.4	90.0	14.5	3.0	60.0
	10:09		196.0	80.0	14.8	3.0	55.0
	10:22		363.0	80.0	15.7	3.0	50.0
	10:35		525.0	80.0	15.4	3.0	50.0
	10:36		554.0	90.0	20.4	3.0	50.0
	10:40		634.0	90.0	20.4	3.0	45.0
	10:52		894.0	90.0	20.7	3.0	43.0
	11:35		1776.0	85.0	21.1	3.0	--
	11:54		2195.0	85.0	21.1	3.0	40.0
	12:00		2335.0	85.0	21.1	3.0	40.0
	12:50		3377.0	90.0	22.4	3.0	40.0
	13:15		3633.0	100.0	21.6	3.0	--
	13:40		4184.0	100.0	21.2	3.0	40.0
	13:42		4239.0	130.0	26.3	3.0	44.0
	13:53		4557.0	125.0	25.7	3.0	43.0
	14:00		4743.0	120.0	25.3	3.0	42.0
	14:05		4891.0	135.0	27.6	3.0	43.0
	14:10		4985.0	135.0	27.6	3.0	43.0
	14:20		5320.0	135.0	27.7	3.0	--
	14:55		6337.0	135.0	27.9	3.0	42.0
	15:23		7025.0	135.0	28.1	3.0	42.0
	15:44		7592.0	135.0	28.1	3.0	42.0
	16:13		8384.0	135.0	28.4	3.0	--
	16:30		8880.0	130.0	28.1	5.0	--
	16:32		8940.0	130.0	28.1	5.0	--
	17:00		9587.0	100.0	22.2	5.0	--
	17:10		9800.0	95.0	22.1	5.0	--
		17:20	10017.0	95.0	22.2	5.0	--
Injection Event Totals / Averages			**10017.0**	**100.8**	**20.0**	**3.3**	**47.4**

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-02 **Personnel:** KS

Injection Interval: Intermediate groundwater aquifer zone (47' to 60') **Injection Method:** High Pressure



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Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

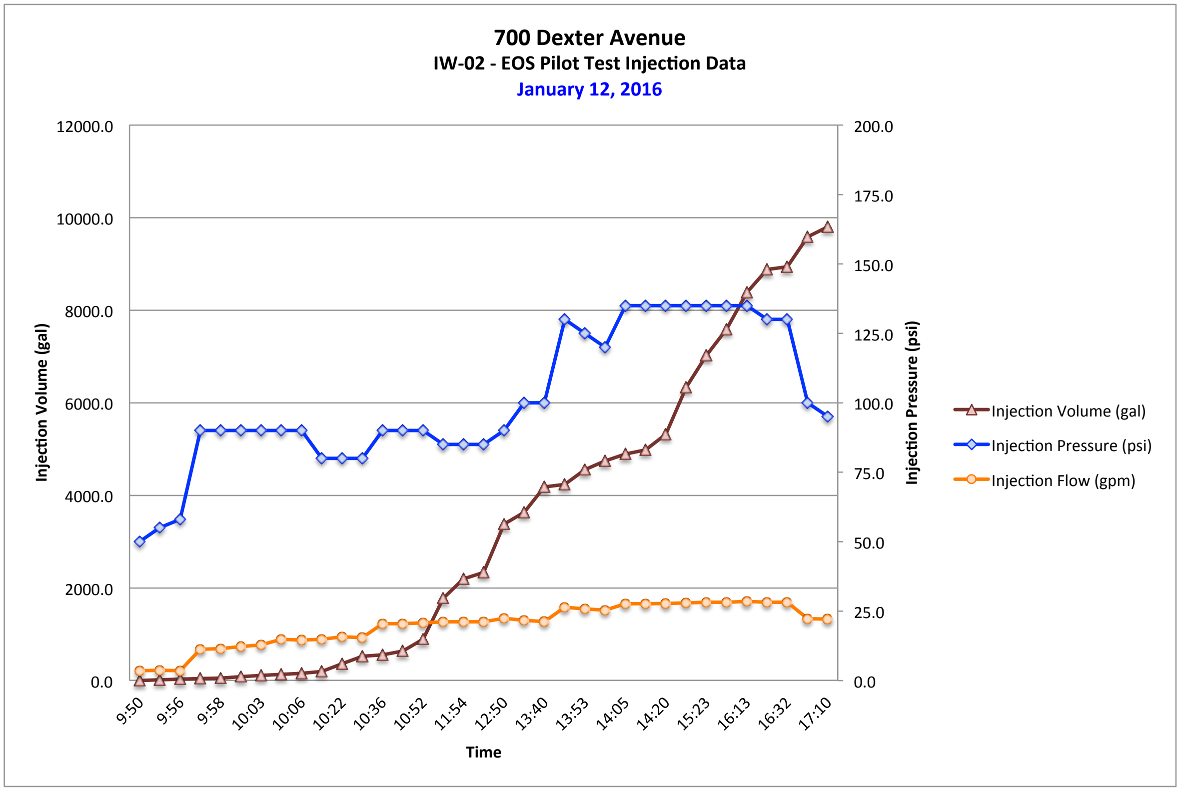
ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-02

Personnel: KS

Injection Interval: Intermediate groundwater aquifer zone (47' to 60')

Injection Method: High Pressure



Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Data Table

ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-03 **Personnel:** KS

Injection Interval: 45-60' **Injection Method:** High Pressure

Packer set at 43' inside casing

Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/16/16	7:30		0.0	35.0	1.5	3.0	30.0
	7:40		11.0	70.0	1.2	3.0	80.0
	7:44		14.6	85.0	1.0	3.0	80.0
	7:46		18.7	70.0	1.8	3.0	70.0
	7:50		25.6	70.0	2.4	3.0	60.0
	7:56		41.8	60.0	3.1	3.0	55.0
	8:10		80.8	55.0	3.3	3.0	50.0
	8:21		125.0	52.0	3.4	3.0	50.0
	8:34		171.7	50.0	3.4	3.0	60.0
	9:04		269.8	45.0	3.4	3.0	60.0
	9:25		379.8	60.0	9.9	4.0	60.0
	10:10		825.1	55.0	10.5	4.0	40.0
	10:00		1034.0	55.0	10.6	4.0	40.0
	11:00		1325.0	55.0	10.9	4.0	40.0
	11:36		1700.9	55.0	10.6	4.0	40.0
	12:15		2098.9	55.0	10.5	4.0	40.0
	12:40		2398.0	50.0	10.6	4.0	40.0
	13:30		2995.0	55.0	12.4	4.0	40.0
	13:50		3191.0	55.0	12.4	4.0	40.0
	14:00		3462.0	55.0	12.5	4.0	40.0
	14:24		3612.0	55.0	12.4	4.0	40.0
	14:45		3881.0	55.0	12.4	4.0	40.0
	15:13		4229.0	55.0	12.4	4.0	40.0
	15:54		4732.0	55.0	12.2	4.0	40.0
	16:14		4966.0	55.0	12.4	4.0	40.0
	16:35		5206.0	55.0	12.5	4.0	40.0
	17:16		5757.0	55.0	12.0	4.0	40.0
	17:31		5913.0	55.0	12.5	4.0	40.0
	18:00		6235.5	55.0	12.5	4.0	40.0
		18:04	6347.2	55.0	12.6	4.0	40.0
Daily Totals / Averages			**6347.2**	**56.4**	**8.6**	**3.7**	**47.2**
1/17/16	7:49		6365.6	75.0	3.3	4.0	75.0
	7:52		6378.2	75.0	3.4	4.0	75.0
	8:02		6415.4	65.0	3.7	4.0	65.0
	8:10		6442.4	70.0	5.5	4.0	65.0
	8:15		6474.4	70.0	6.9	4.0	65.0
	8:20		6511.0	65.0	7.6	4.0	60.0
	8:25		6557.2	60.0	7.9	4.0	60.0
	8:30		6590.8	65.0	9.8	4.0	60.0
	8:55		6844.0	60.0	10.5	4.0	50.0
	9:10		6996.9	60.0	10.5	4.0	50.0
	9:20		7099.9	55.0	9.8	4.0	45.0
	9:55		7437.7	55.0	9.8	4.0	40.0
	10:15		7630.0	55.0	9.8	4.0	40.0
	10:45		7890.1	55.0	9.9	4.0	40.0
	11:20		8376.1	60.0	13.9	4.0	45.0
	11:48		8758.0	55.0	13.9		40.0
	12:10		8894.8	55.0	13.8	2.0	40.0
	12:32		9375.3	55.0	13.8	2.0	40.0
	12:40		9485.9	55.0	13.9	2.0	40.0
		12:42	9501.7	0.0	--	--	40.0
Daily Totals / Averages			**3136.1**	**58.3**	**9.4**	**3.7**	**51.8**

Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/18/16	10:53		0.0	70.0	11.5	5.0	20.0
	10:57		45.0	65.0	13.9	5.0	20.0
	11:00		83.0	55.0	12.6	5.0	20.0
	11:09		221.0	60.0	15.5	5.0	25.0
	11:17		317.0	60.0	15.3	5.0	45.0
	11:20		387.0	60.0	15.5	5.0	45.0
	11:30		611.3	60.0	15.5	5.0	48.0
	11:37		684.0	--	--	--	--
	11:59		702.0	50.0	9.4	5.0	--
	12:03		748.0	50.0	9.4	5.0	--
	12:08		806.0	55.0	9.4	5.0	40.0
	12:13		926.0	55.0	13.1	5.0	40.0
	12:30		1108.0	55.0	14.5	5.0	40.0
	12:45		1337.0	50.0	14.8	5.0	40.0
	13:15		1775.0	50.0	15.4	5.0	40.0
	17:30	17:30	3891.0	50.0	13.3	5.0	40.0
Daily Totals / Averages			**3891.0**	**56.3**	**13.3**	**5.0**	**35.3**
Injection Event Totals / Averages			**13374.3**	**57.0**	**10.4**	**4.1**	**44.7**

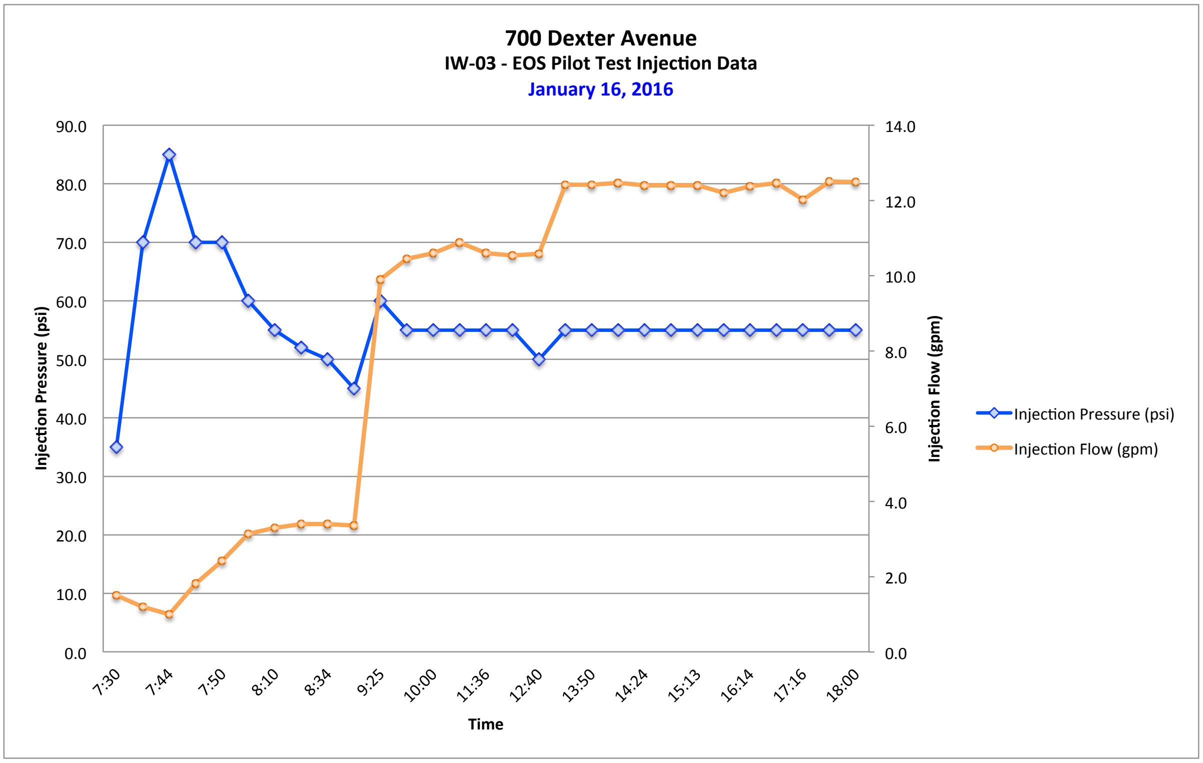
Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

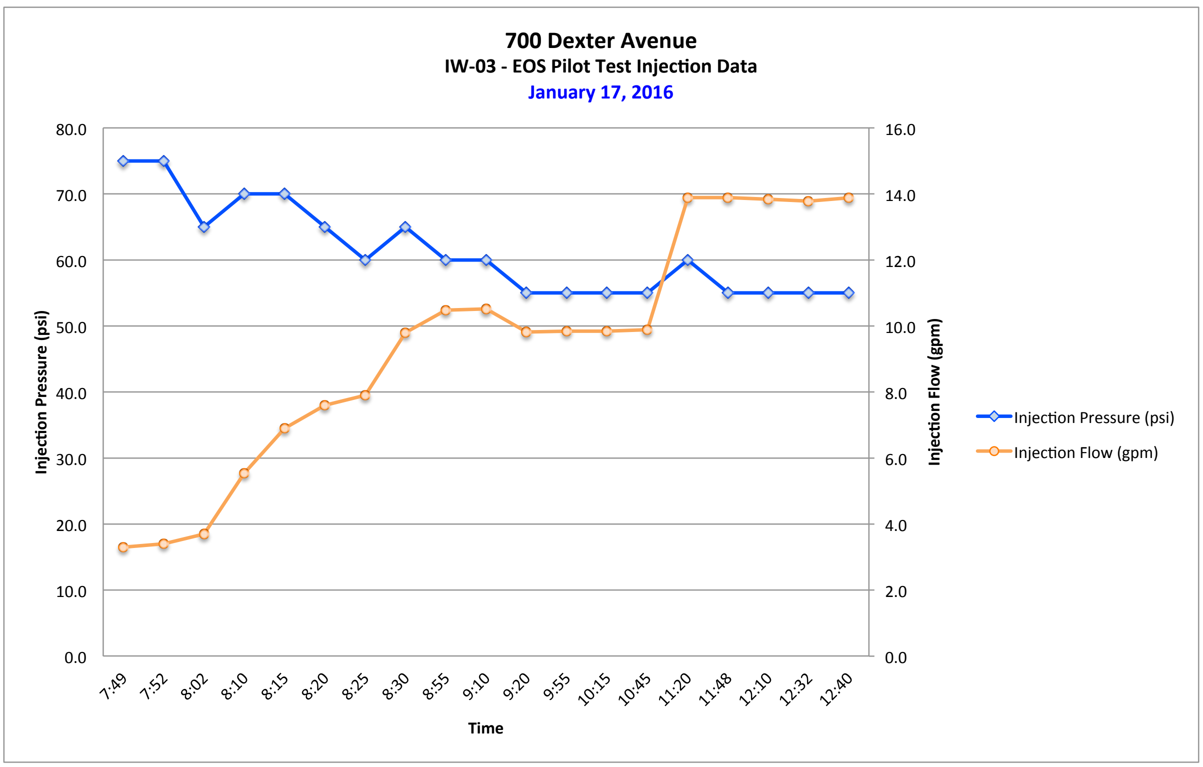
ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-03 **Personnel:** KS

Injection Interval: 45-60' **Injection Method:** High Pressure

Packer set at 43' inside casing





Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

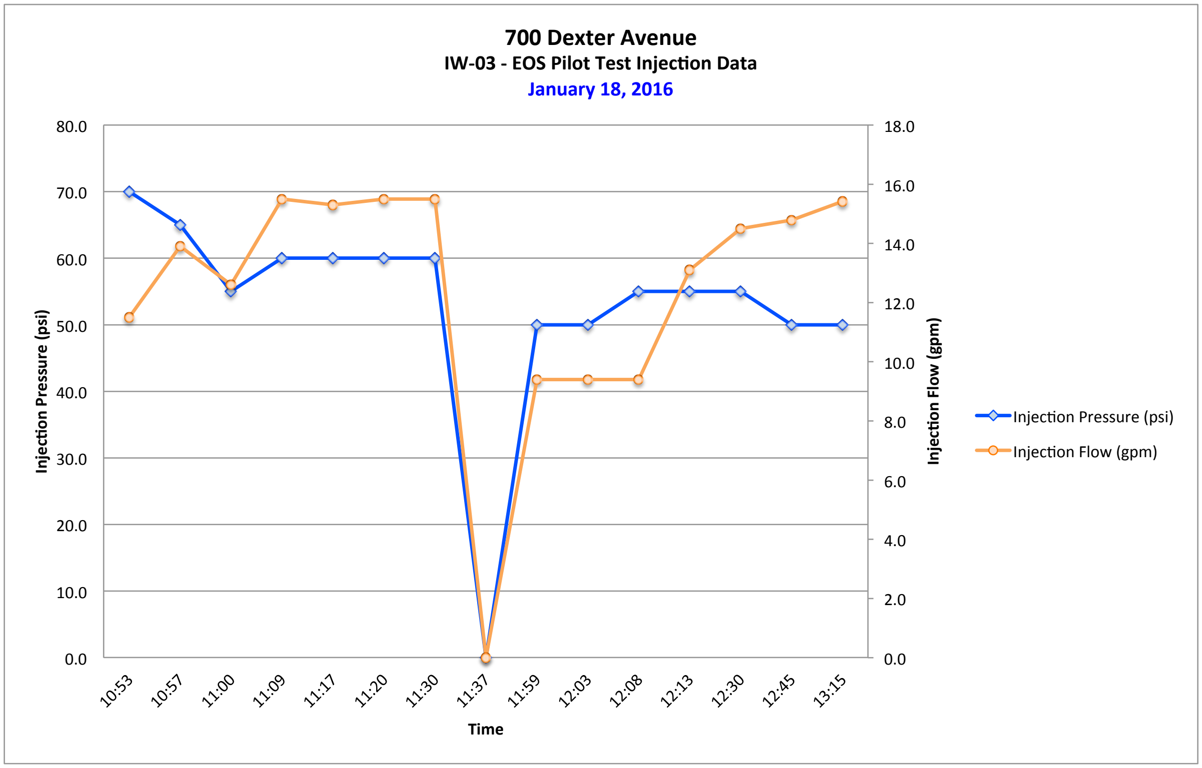
ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-03

Personnel: KS

Injection Interval: 45-60'
Packer set at 43' inside casing

Injection Method: High Pressure



Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

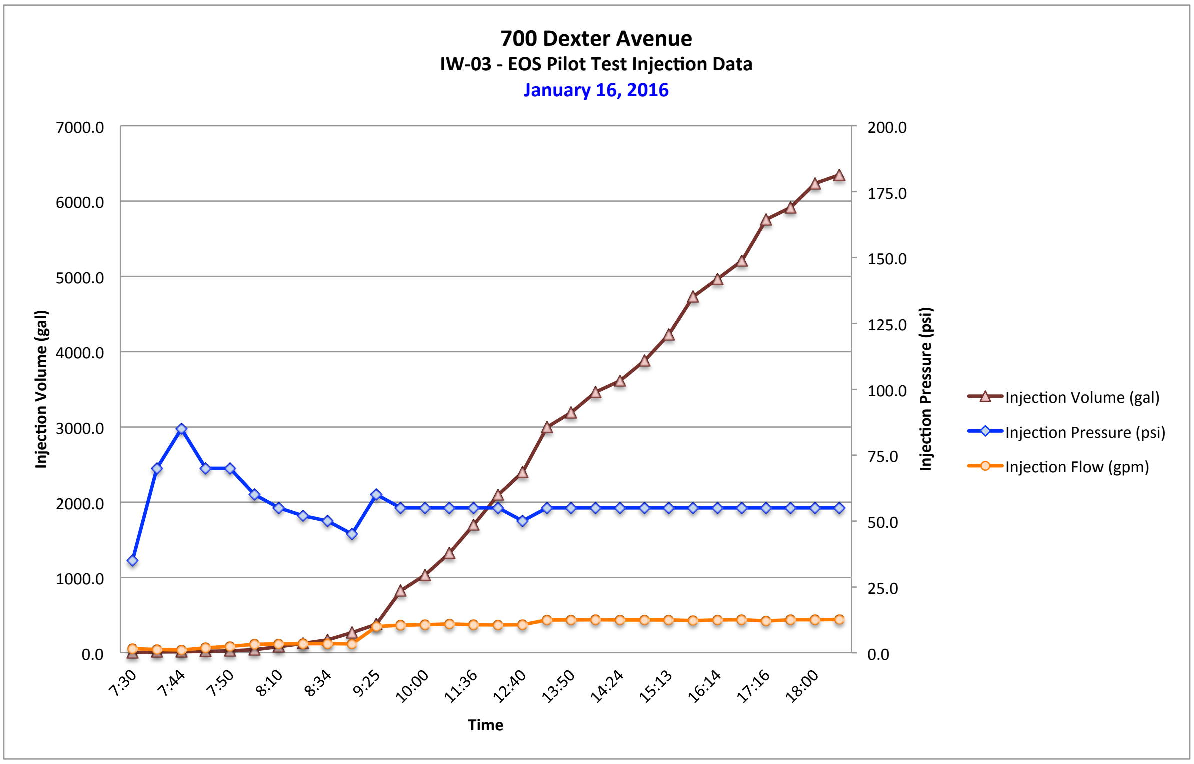
ESSENTIAL MANAGEMENT SOLUTIONS

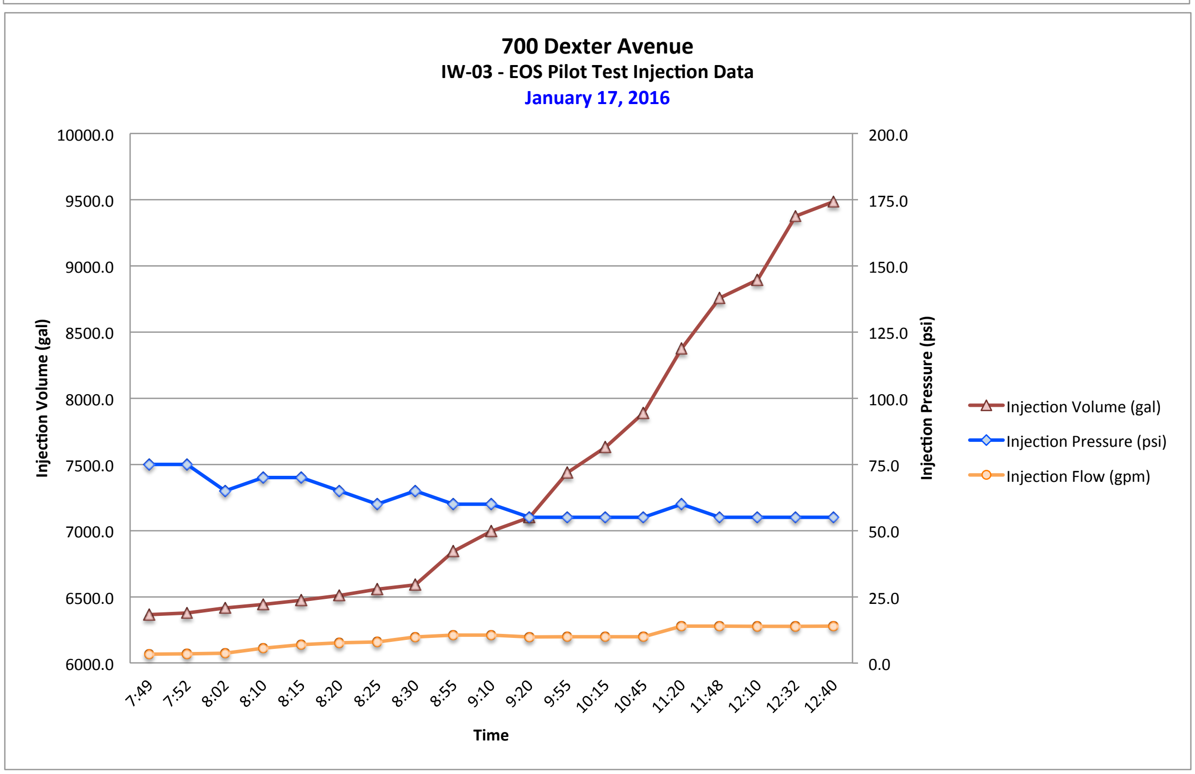
Well ID: IW-03

Personnel: KS

Injection Interval: 45-60'
Packer set at 43' inside casing

Injection Method: High Pressure





Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

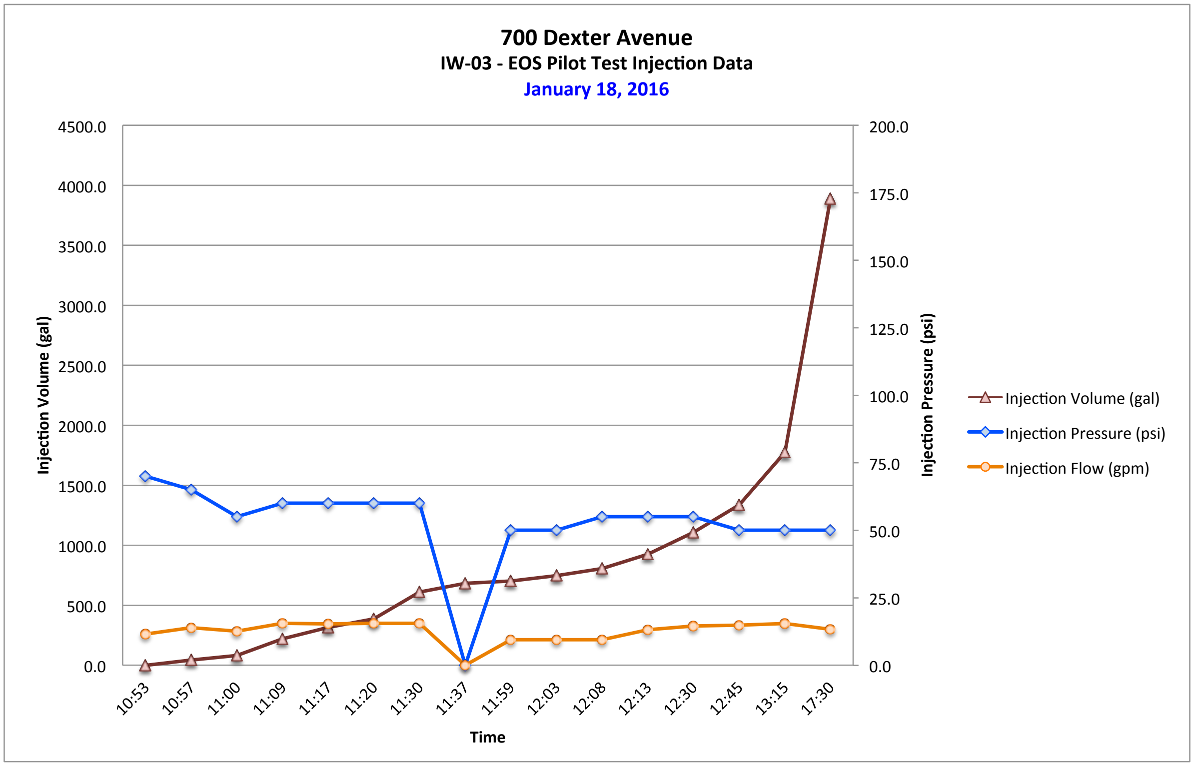
ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-03

Personnel: KS

Injection Interval: 45-60'
Packer set at 43' inside casing

Injection Method: High Pressure



Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Data Table

Well ID: IW-04 **Personnel:** KS

Injection Interval: 45-60' **Injection Method:** High Pressure
Interval 62.5 - 43' inside casing

Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/12/16	16:36		0.0	80.0	1.6	3.0	--
	16:39		0.0	85.0	1.2	3.0	--
	16:40		1.5	75.0	1.6	3.0	75.0
	16:43		3.8	75.0	2.2	3.0	75.0
	16:45		--	--	--	--	--
	16:52		23.2	100.0	8.2	3.0	80.0
	16:54		38.6	90.0	9.4	3.0	80.0
	16:56		61.7	85.0	8.9	3.0	75.0
	16:59		98.5	85.0	12.4	3.0	--
	17:02		134.0	85.0	12.6	3.0	--
	17:08		199.0	85.0	12.6	3.0	75.0
	17:12		260.0	85.0	12.6	3.0	--
	17:20		353.0	85.0	12.7	3.0	--
	17:21		371.0	85.0	13.2	3.0	75.0
	17:38		591.0	85.0	14.6	3.0	75.0
	18:01		931.0	90.0	14.4	3.0	--
	18:15		1151.0	90.0	15.0	3.0	--
		18:24	1266.0	85.0	15.2	3.0	--
Daily Totals / Averages			**1266.0**	**85.3**	**9.9**	**3.0**	**76.3**
1/13/16	7:45		1266	90.0	14.7	--	--
	8:09		1649	90.0	15.6	--	--
	8:23		1856	35.0	5.4	--	--
	8:35		1915	20.0	2.3	--	--
	9:30		--	--	--	--	--
	11:00		1970	90.0	1.3	3.0	--
	11:03		1974	85.0	1.4	3.0	--
	11:04		1976	85.0	1.5	3.0	90.0
	11:05		1978	85.0	1.8	3.0	85.0
	11:07		1981	80.0	1.8	3.0	80.0
	11:08		1984	80.0	2.1	3.0	80.0
	11:09		1990.0	95.0	6.2	3.0	90.0
	11:11		2000.0	80.0	7.3	3.0	
	11:13		2017.0	75.0	8.0	3.0	75.0
	11:15		2032.0	75.0	8.7	3.0	70.0
	11:19		2067.0	70.0	9.2	3.0	62.0
	11:21		2089.0	70.0	9.4	3.0	60.0
	11:25		2116.0	65.0	9.6	4.0	60.0
	11:26		2145.8	70.0	12.6	4.0	60.0
	11:28		2165.0	70.0	12.7	4.0	60.0
	11:32		2211.0	65.0	12.8	4.0	60.0
	11:34		2235.0	80.0	15.6	4.0	60.0
	11:35		2260.0	75.0	15.7	4.0	60.0
	12:00		2640.0	60.0	13.8	4.0	50.0
	12:30		3049.0	60.0	14.1	4.0	45.0
	13:10		3624.0	60.0	14.2	4.0	45.0
	13:13		3659.0	60.0	14.2	4.0	45.0
	13:20		3765.0	60.0	14.2	5.0	45.0
	13:55		4242.0	60.0	14.1	5.0	45.0
	14:27		4706.0	60.0	14.4	5.0	42.0
	15:20		5484.0	60.0	14.7	5.0	42.0
	16:00		6050.0	55.0	14.4	5.0	40.0
	16:30		6452.0	55.0	14.5	5.0	40.0
		17:21	7227.0	55.0	14.4	5.0	--
Daily Totals / Averages			**5961.0**	**68.9**	**10.1**	**3.8**	**59.6**

Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/14/16	8:00		7227.0	50.0	5.0	5.0	57.0
	8:25		7383.0	60.0	9.8	5.0	60.0
	9:00		7795.0	60.0	11.7	5.0	50.0
	9:30		8112.0	55.0	12.0	5.0	45.0
	10:00		8438.0	50.0	12.0	5.0	45.0
	10:30		8842.0	55.0	12.5	5.0	45.0
	11:30		9579.0	50.0	12.4	5.0	40.0
	12:00		9790.0	50.0	12.5	5.0	40.0
	12:30		10245.0	50.0	12.5	5.0	40.0
	13:00		10704.0	50.0	12.4	5.0	40.0
		13:36	11070.0	50.0	12.4	5.0	40.0
Daily Totals / Averages			**3843.0**	**52.7**	**11.4**	**5.0**	**45.6**
Injection Event Totals / Averages			**11070.0**	**69.0**	**10.5**	**3.9**	**60.5**

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

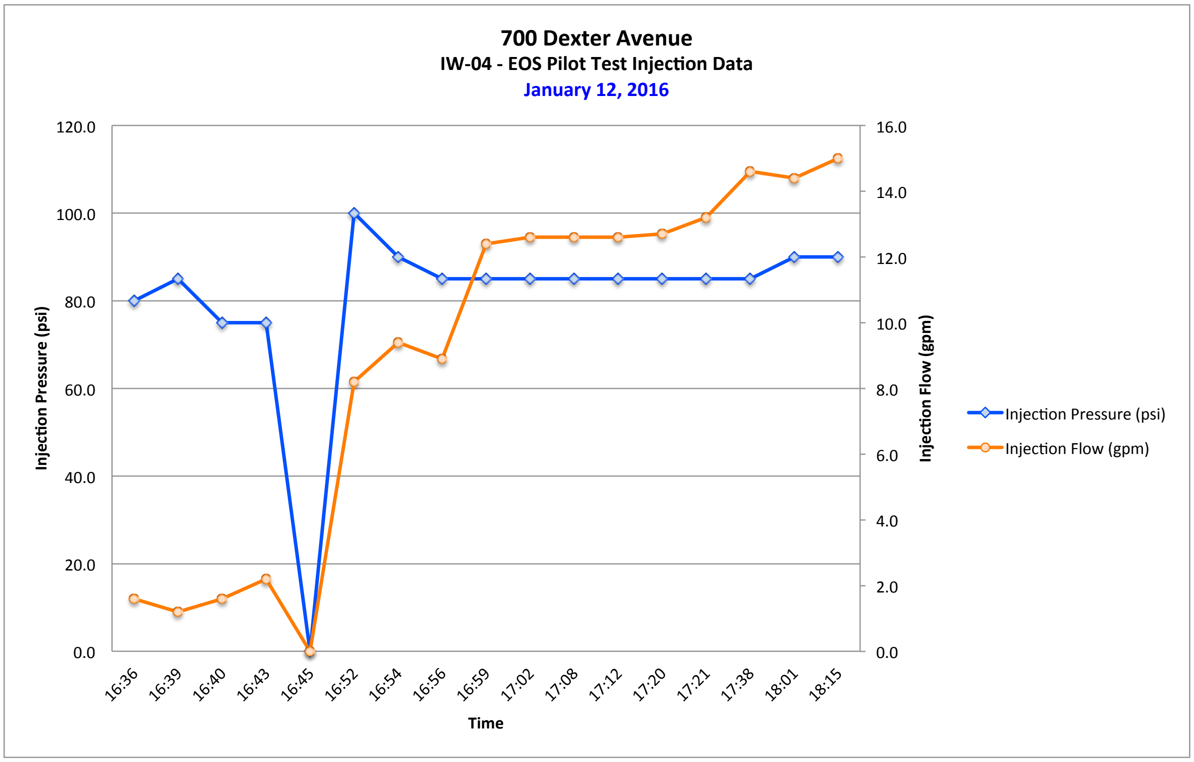
ESSENTIAL MANAGEMENT SOLUTIONS

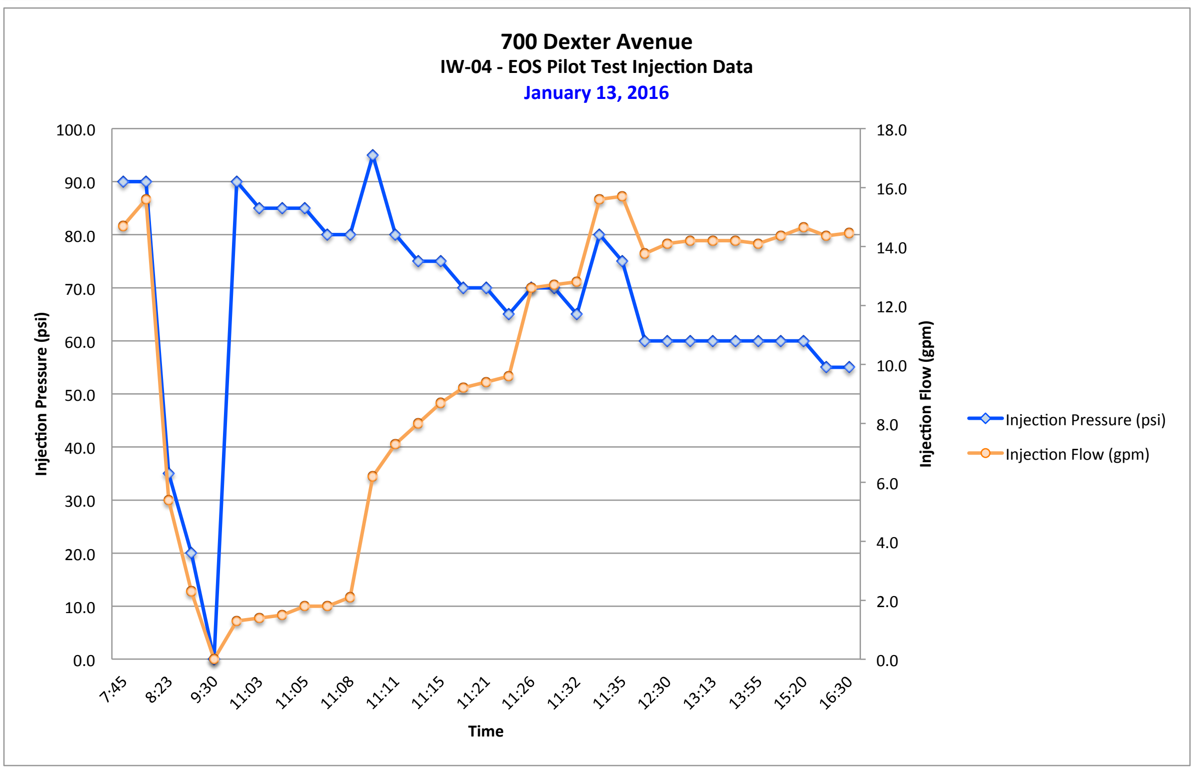
Well ID: IW-04

Personnel: KS

Injection Interval: 45-60'
Interval 62.5 - 43' inside casing

Injection Method: High Pressure





Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-04

Personnel: KS

Injection Interval: 45-60'
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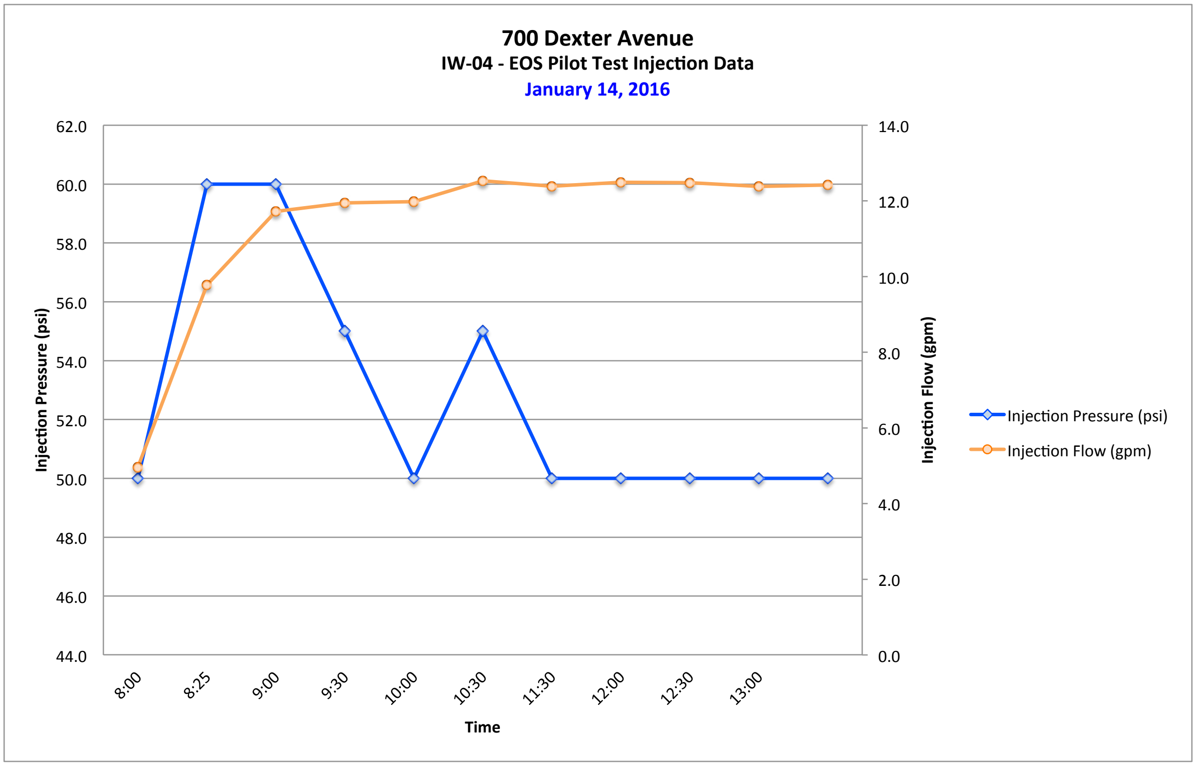
Injection Method: High Pressure



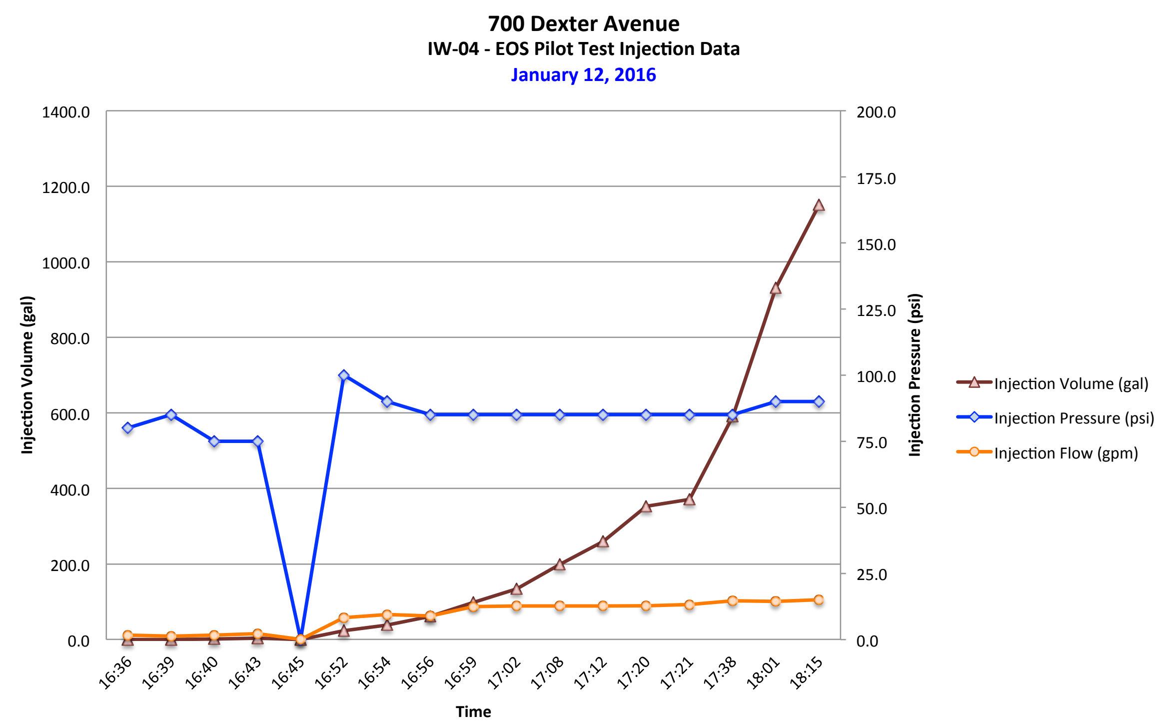
Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

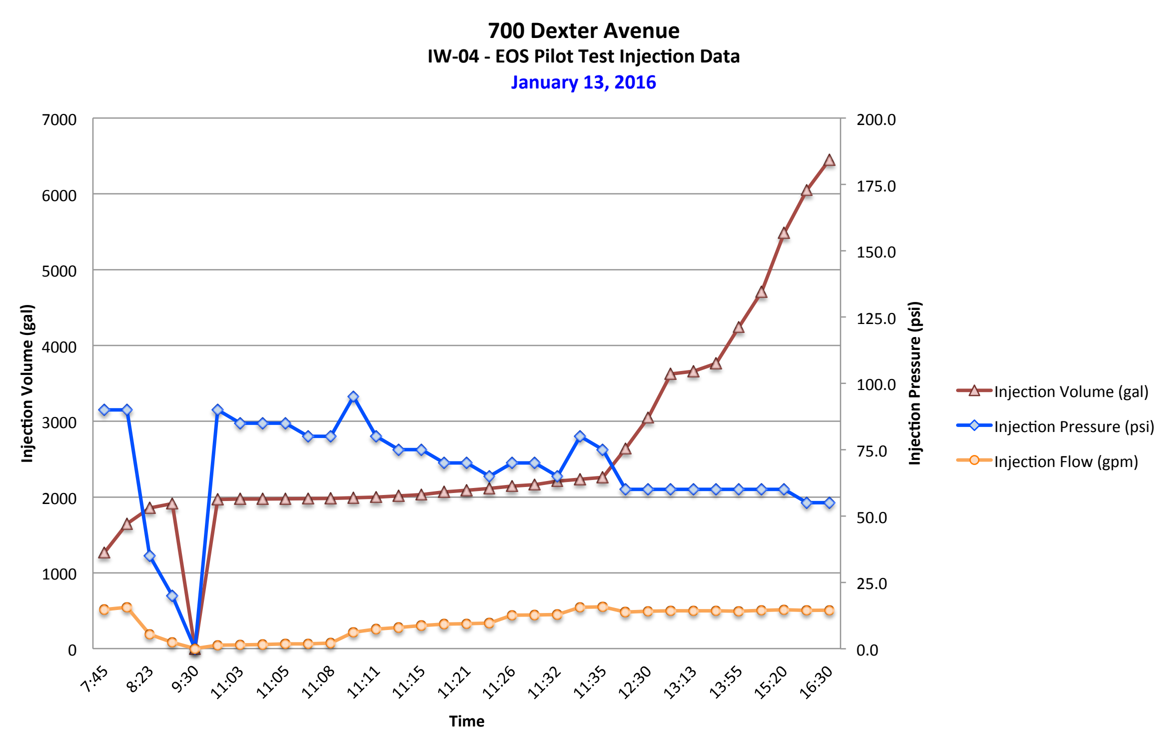
ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-04 **Personnel:** KS

Injection Interval: 45-60'
Interval 62.5 - 43' inside casing

Injection Method: High Pressure





Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

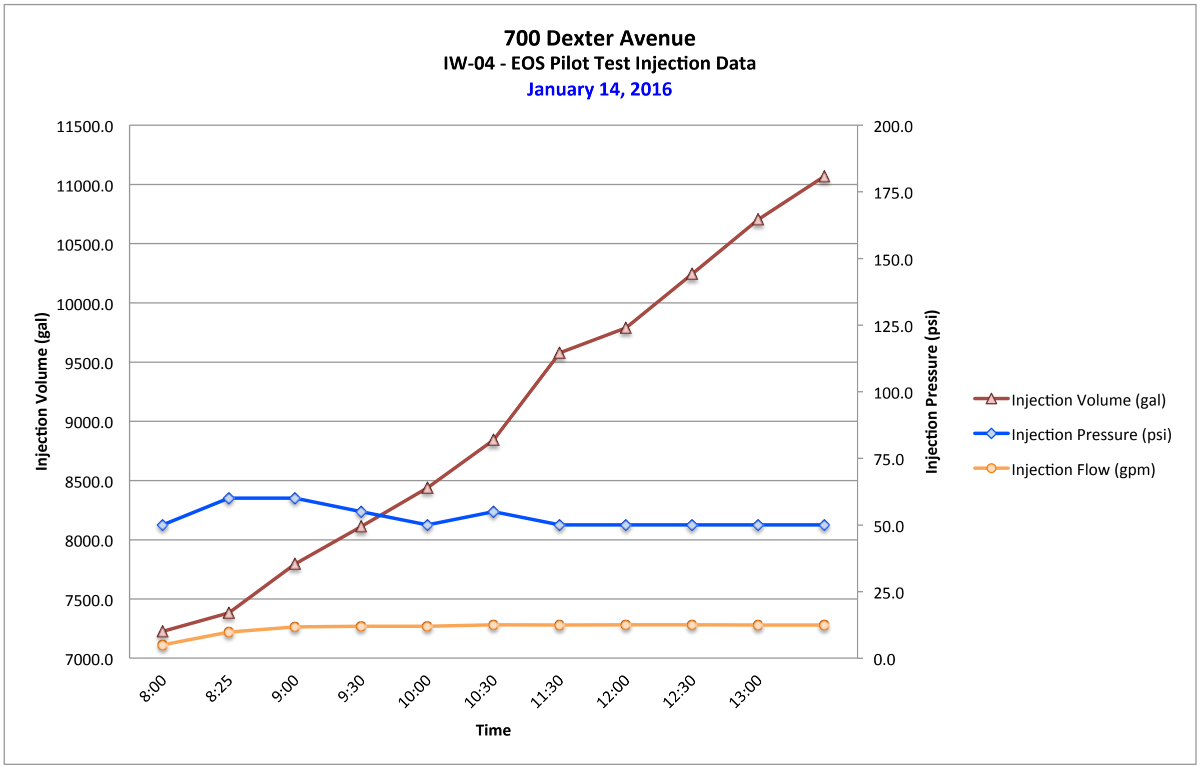
ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-04

Personnel: KS

Injection Interval: 45-60'
Interval 62.5 - 43' inside casing

Injection Method: High Pressure



Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Data Table

Well ID: IW-05 **Personnel:** KS

Injection Interval: 55-70' **Injection Method:** High Pressure
Packer set to 52' - 55' inside casing

Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/16/16	15:47		0.0	20.0	1.2	--	15.0
	15:51		--	90.0	0.3	3.0	50.0
	15:55		23.8	95.0	0.1	3.0	90.0
	16:07		27.0	90.0	1.1	3.0	90.0
	16:08		31.0	45.0	4.1	3.0	45.0
	16:13		50.7	45.0	4.1	3.0	45.0
	16:35		144.0	50.0	4.1	3.0	45.0
	17:15		348.0	40.0	4.4	3.0	40.0
	17:30		407.7	40.0	6.7	3.0	40.0
	18:00		530.3	40.0	4.8	3.0	35.0
		18:04	566.0	40.0	4.8	3.0	35.0
Daily Totals / Averages			**566.0**	**54.1**	**3.2**	**3.0**	**48.2**
1/17/16	7:49		590.0	45.0	7.1	3.0	35.0
	7:52		621.4	45.0	7.3	3.0	35.0
	8:02		705.1	45.0	8.2	3.0	35.0
	8:15		808.4	45.0	8.6	3.0	35.0
	8:20		855.7	45.0	9.5	3.0	35.0
	8:30		944.0	50.0	9.6	3.0	35.0
	8:55		1199	50.0	10.3	3.0	35.0
	9:10		1346.8	50.0	10.3	4.0	40.0
	9:20		1483.3	65.0	13.0	4.0	40.0
	9:55		1975.0	65.0	14.7	4.0	40.0
	10:15		2264.6	60.0	14.9	4.0	40.0
	10:45		2657.7	65.0	14.9	4.0	40.0
	11:20		3183.4	55.0	13.1	4.0	40.0
	11:48		3547.8	55.0	13.4	4.0	40.0
	12:00		3676.8	55.0	13.3	4.0	40.0
	12:32		4142.0	55.0	13.5	4.0	40.0
	13:00		4564.3	45.0	12.2	4.0	4.0
	13:34		4918.6	45.0	12.6	4.0	40.0
	13:55		5188.8	45.0	12.9	4.0	40.0
	14:15		5404.8	45.0	12.9	4.0	35.0
	14:30		5580.2	45.0	12.8	4.0	35.0
	15:00		6059.3	45.0	12.7	4.0	35.0
	15:31		6442.7	55.0	15.5	4.0	40.0
	16:00		6843.3	55.0	13.9	4.0	40.0
	16:15		7078.9	50.0	13.8	4.0	--
	16:30		7282.6	50.0	13.8	4.0	40.0
	17:09		7823.3	50.0	13.7	4.0	40.0
	17:32		8084.0	50.0	13.8	4.0	40.0
	18:01		8473.0	50.0	13.7	4.0	40.0
	18:29		8859.0	50.0	13.7	4.0	40.0
		18:36	8957.0	50.0	0.0	4.0	0.0
Daily Totals / Averages			**8367.0**	**51.0**	**11.9**	**3.8**	**35.8**

Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/18/16	10:10		0.0	15.0	3.9	5.0	5.0
	10:13		25.7	35.0	8.5	5.0	--
	10:15		42.6	40.0	13.0	5.0	20.0
	10:17		169.0	40.0	13.1	5.0	25.0
	10:28		501.0	40.0	13.6	5.0	25.0
	10:51		617.0	40.0	13.7	5.0	25.0
	11:00		741.0	40.0	13.1	5.0	25.0
	11:10		836.0	40.0	12.7	5.0	25.0
	11:15		873.0	40.0	11.2	5.0	25.0
	11:20		949.0	40.0	10.3	5.0	25.0
	12:00		1314.0	40.0	10.3	5.0	15.0
	12:09		1335.0	35.0	10.3	5.0	15.0
	12:12		1373.0	35.0	10.6	5.0	15.0
	12:30		1600.0	35.0	10.9	5.0	15.0
	12:45		1762.0	35.0	10.5	5.0	15.0
	13:15		2058.0	30.0	7.5	5.0	15.0
		17:30	3016.0	30.0	7.5	--	--
Daily Totals / Averages			**3016.0**	**35.9**	**10.6**	**5.0**	**19.3**
Injection Event Totals / Averages			**11949.0**	**47.0**	**8.6**	**3.9**	**34.4**

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

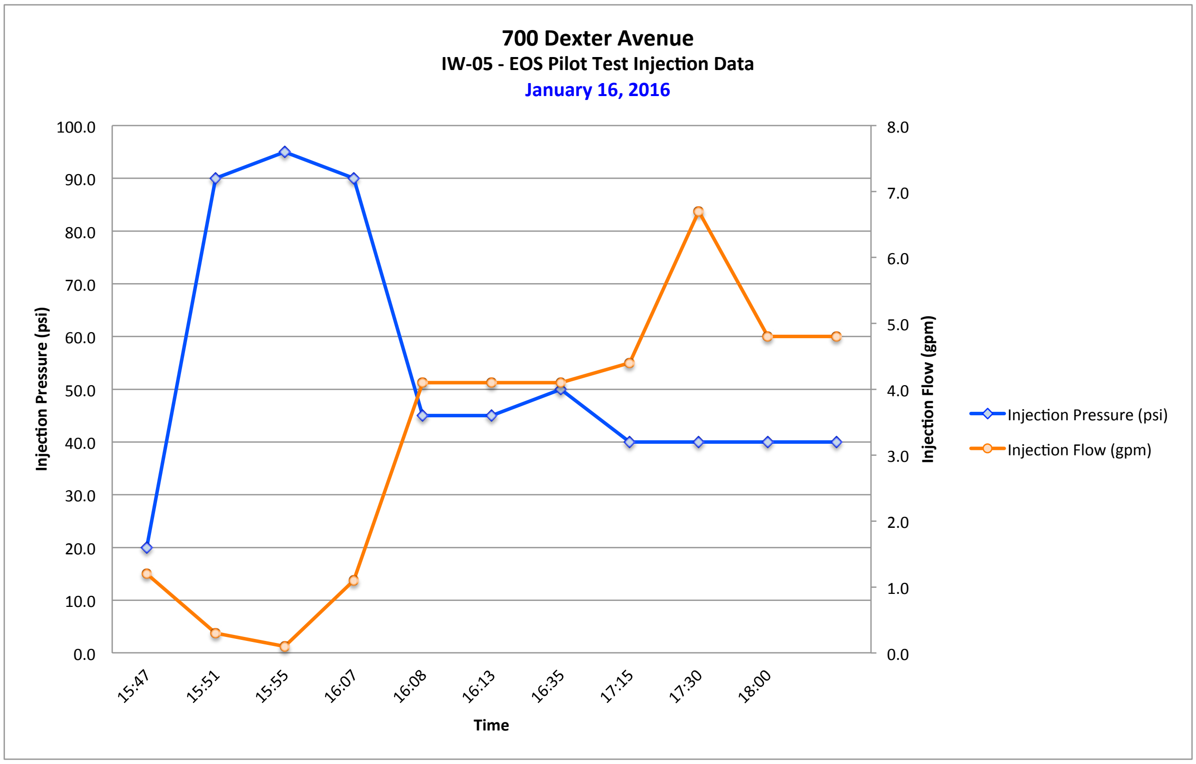
ESSENTIAL MANAGEMENT SOLUTIONS

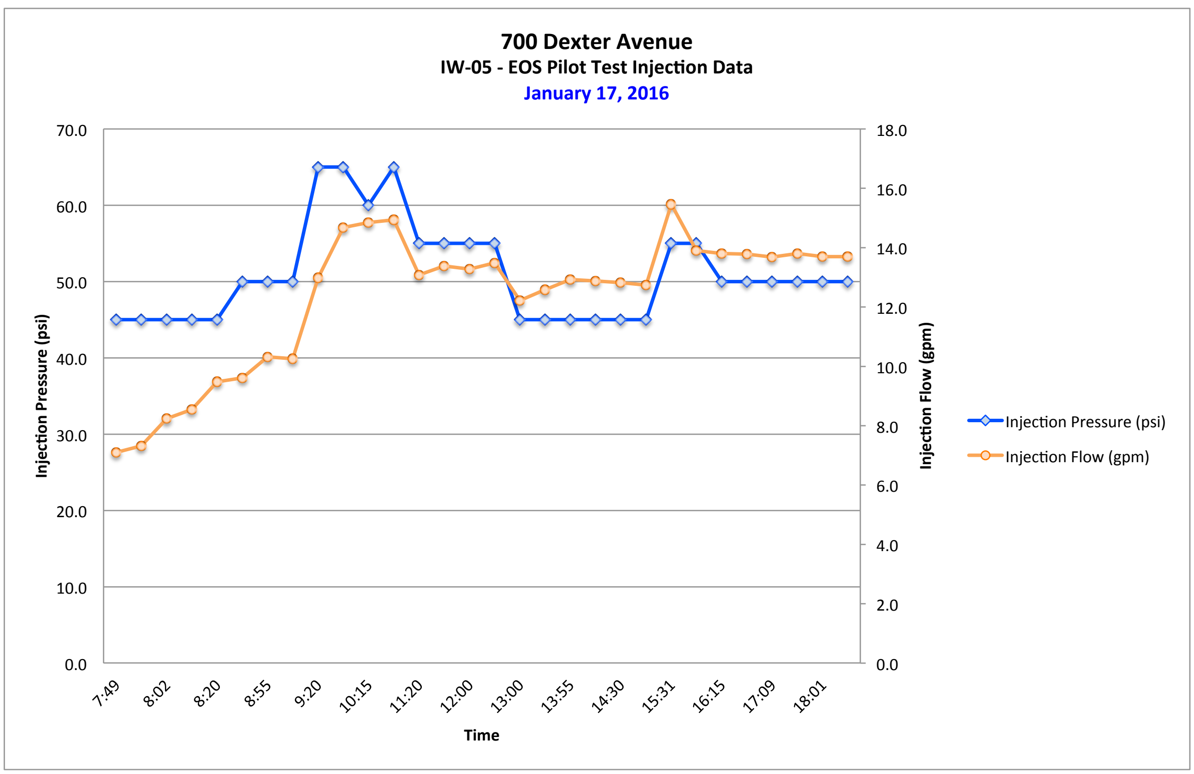
Well ID: IW-05

Personnel: KS

Injection Interval: 55-70'
Packer set to 52' - 55' inside casing

Injection Method: High Pressure

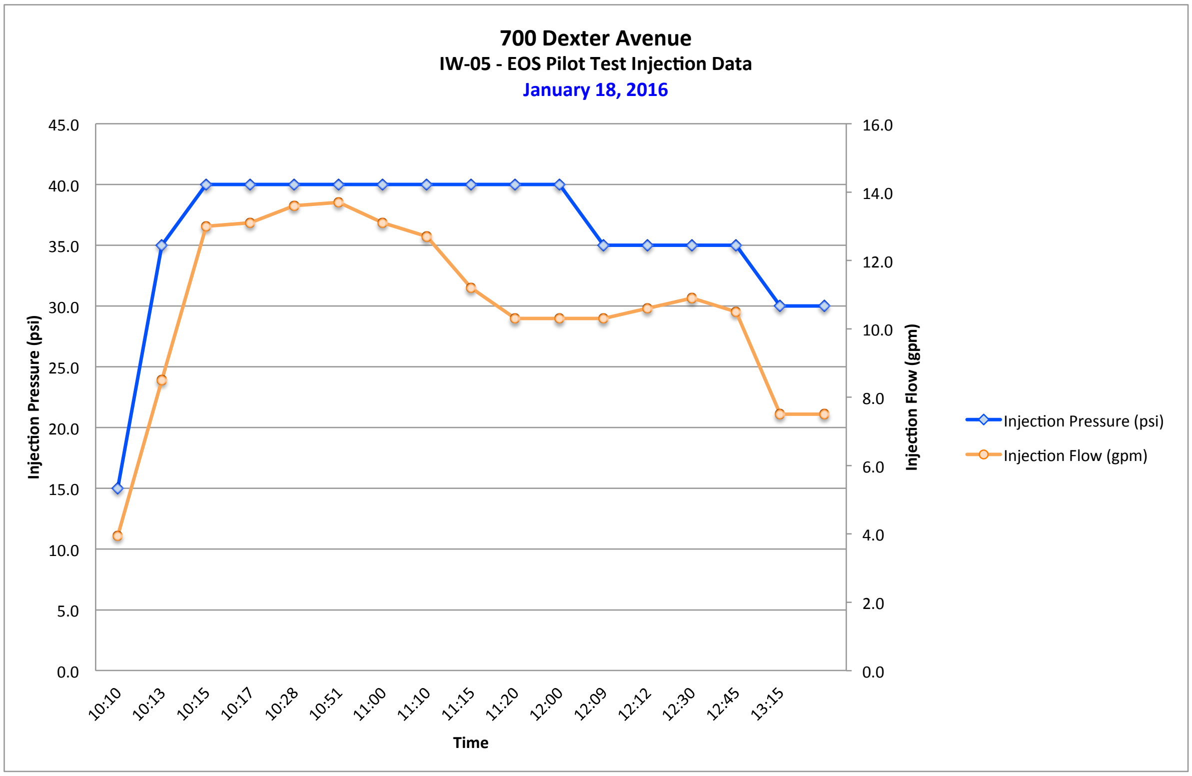




Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

ESSENTIAL MANAGEMENT SOLUTIONS

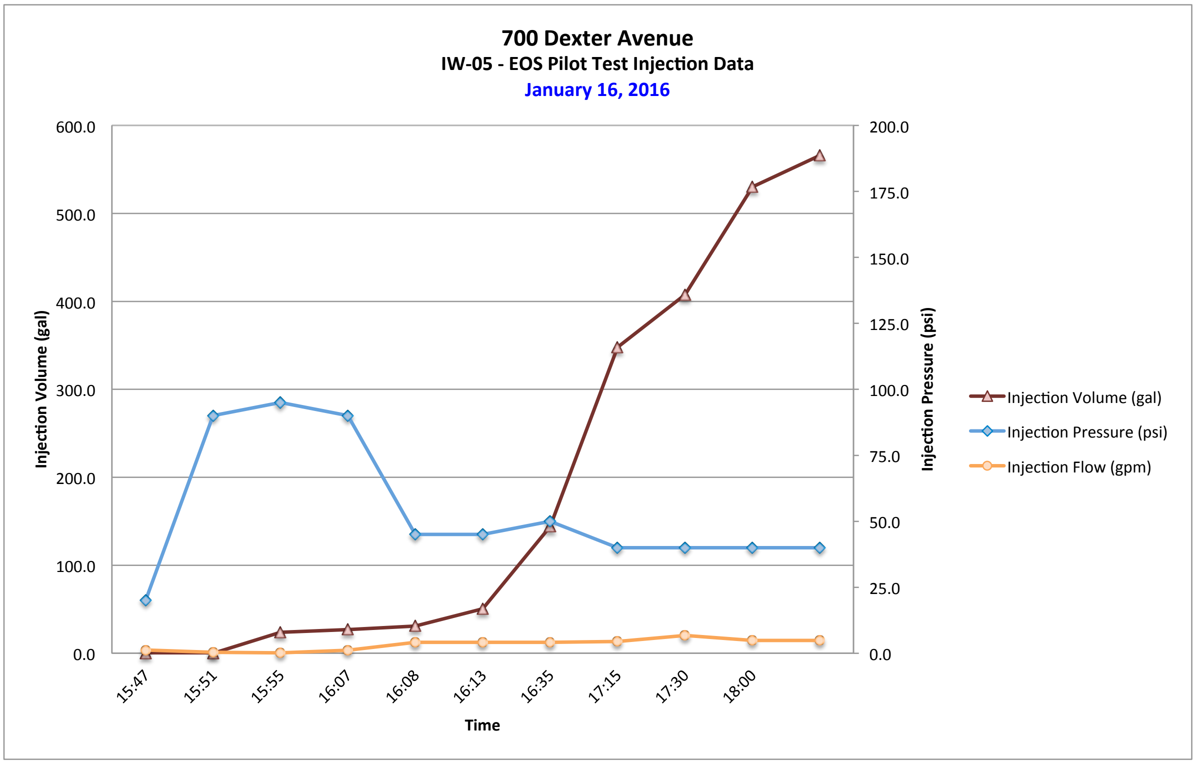
Well ID: IW-05
Personnel: KS
Injection Interval: 55-70'
Packer set to 52' - 55' inside casing
Injection Method: High Pressure

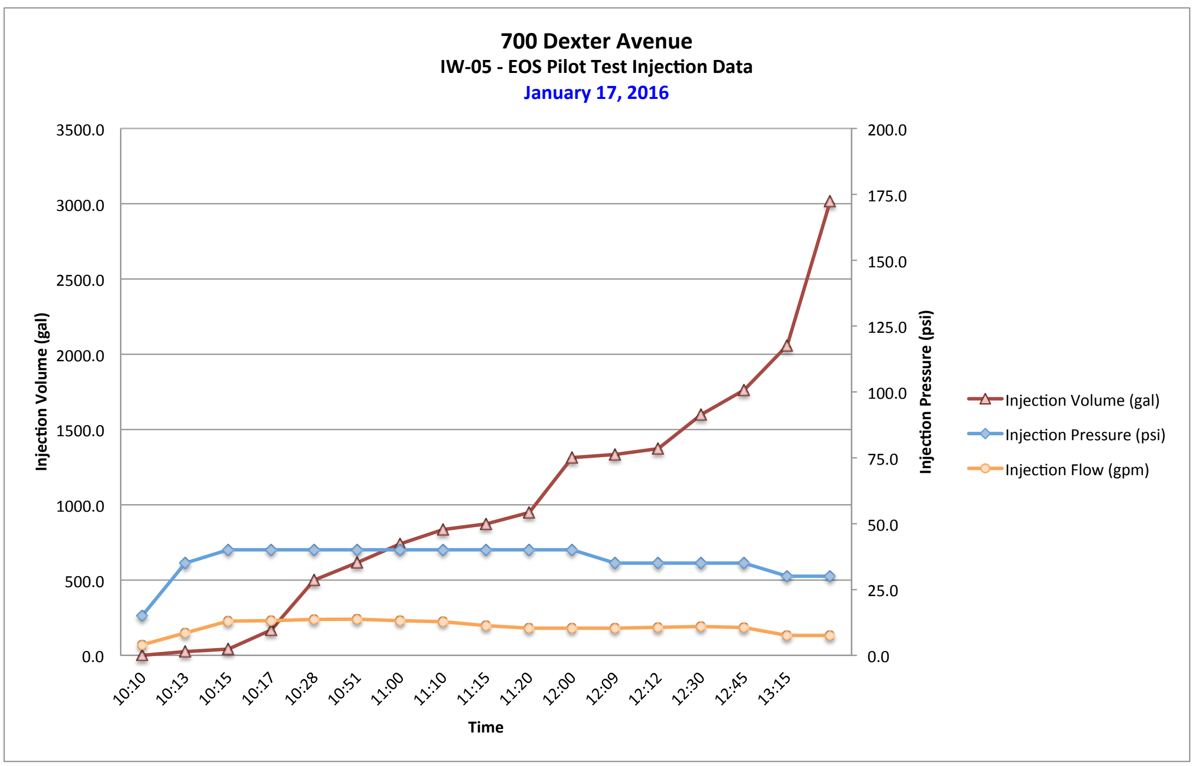


Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-05
Personnel: KS
Injection Interval: 55-70'
Packer set to 52' - 55' inside casing
Injection Method: High Pressure





DRAFT - Issued for Ecology Review

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

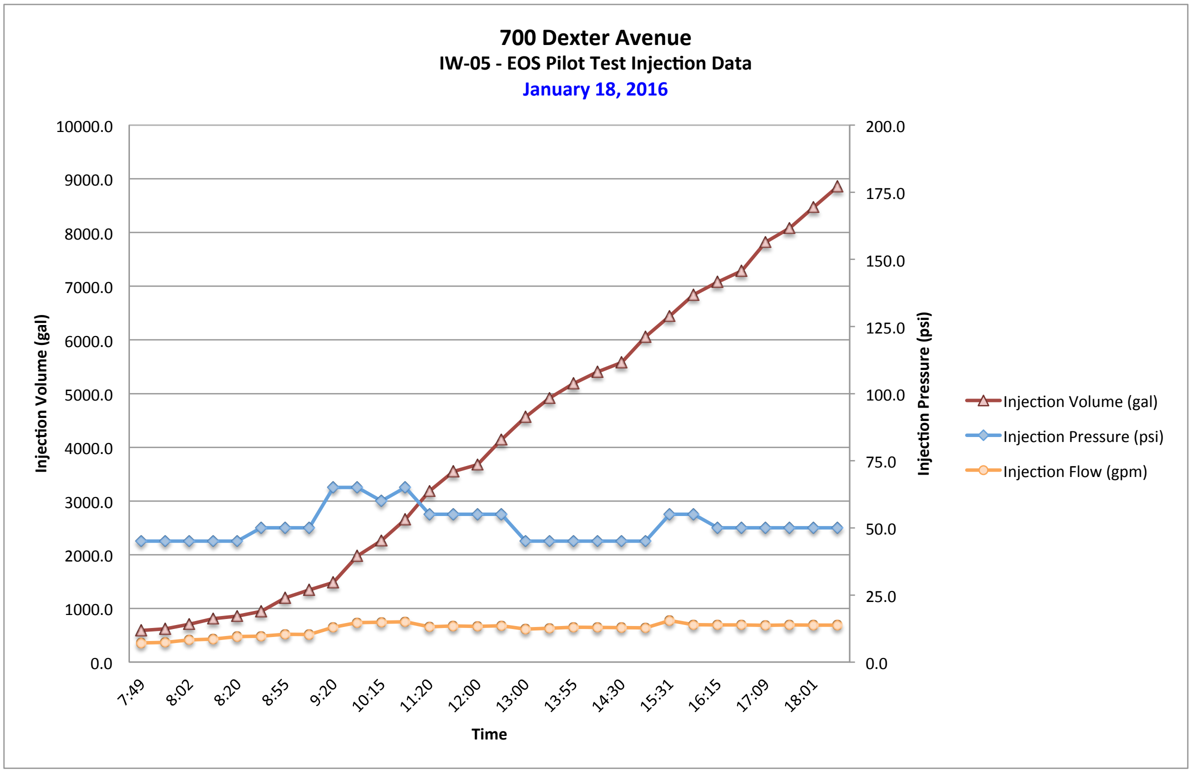
ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-05

Personnel: KS

Injection Interval: 55-70'
Packer set to 52' - 55' inside casing

Injection Method: High Pressure



Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Data Table

Well ID: IW-06 **Personnel:** KS

Injection Interval: 50 - 65' interval **Injection Method:** High Pressure
Packer set to 52-50' inside casing

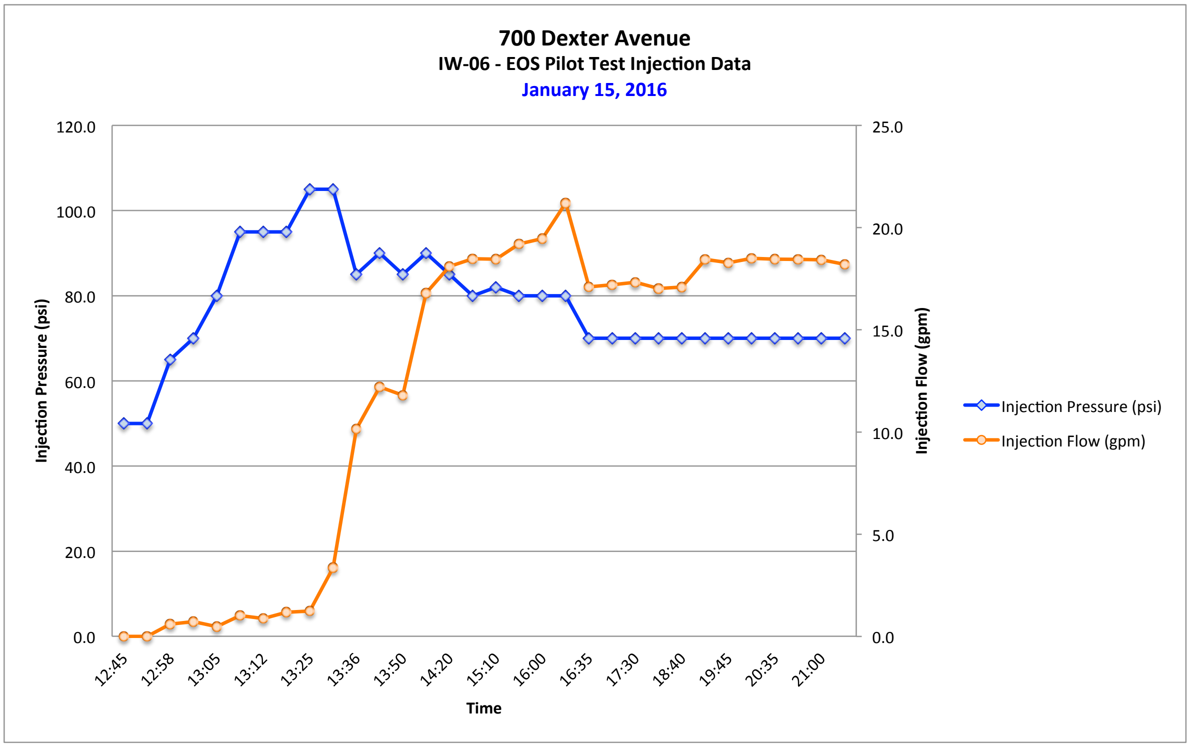
Date	Time		Totalizer (gallons)	Pump Pressure (psi)	Instant Flow Rate (gpm)	EOS Dose (%)	Wellhead Pressure (psi)
	Start	End					
1/15/16	12:45		0	50.0	0.0	3.0	--
	12:56		5.54	50.0	0.0	3.0	--
	12:58		6.16	65.0	0.6	3.0	60.0
	12:59		6.76	70.0	0.7	3.0	70.0
	13:05		9.25	80.0	0.5	3.0	75.0
	13:08		11.56	95.0	1.0	3.0	90.0
	13:12		14.1	95.0	0.9	3.0	93.0
	13:13		15.9	95.0	1.2	3.0	96.0
	13:25		26	105.0	1.2	3.0	95.0
	13:30		31	105.0	3.4	3.0	95.0
	13:36		135	85.0	10.2	3.0	90.0
	13:40		235	90.0	12.2	3.0	85.0
	13:50		307	85.0	11.8	3.0	60.0
	14:00		479	90.0	16.8	3.0	65.0
	14:20		907	85.0	18.1	3.0	60.0
	14:40		1169.0	80.0	18.5	4.0	50.0
	15:10		1780.0	82.0	18.5	4.0	45.0
	15:40		2466.0	80.0	19.2	4.0	45.0
	16:00		2714.0	80.0	19.5	4.0	40.0
	16:30		3335.0	80.0	21.2	4.0	40.0
	16:35		3414.0	70.0	17.1	4.0	40.0
	17:00		3993.0	70.0	17.2	4.0	40.0
	17:30		4370.0	70.0	17.3	4.0	40.0
	18:20		5227.0	70.0	17.0	4.0	40.0
	18:40		5560.0	70.0	17.1	4.0	40.0
	19:20		6300.0	70.0	18.4	5.0	40.0
	19:45		6719.0	70.0	18.3	5.0	40.0
	20:22		7385.0	70.0	18.5	5.0	40.0
	20:35		7627.0	70.0	18.5	5.0	40.0
	20:48		7793.0	70.0	18.4	5.0	40.0
	21:00		8024.0	70.0	18.4	5.0	40.0
		21:10	8060.0	70.0	18.2	5.0	--
Injection Event Totals / Averages			**8060.0**	**77.7**	**12.2**	**3.8**	**58.4**

Frontier Environmental Management
700 Dexter Avenue
Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

ESSENTIAL MANAGEMENT SOLUTIONS

Well ID: IW-06 **Personnel:** KS

Injection Interval: 50 - 65' interval
Packer set to 52-50' inside casing
Injection Method: High Pressure



DRAFT - Issued for Ecology Review

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Intermediate Zone Pilot Test Injection Pressure and Flow Graphs

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