In-Situ Treatment of Areas of Residual Contamination Pilot Study Results and Full-Scale Treatment Plan

Boomsnub/Airco Superfund Site
Hazel Dell, Washington

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June 2019
Revision: FINAL
Project No 15240.69

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µg/L	Micrograms per liter
AOC	Area of concern
bgs	Below ground surface
Ca	Calcium
COC	Contaminant of concern
COD	Chemical oxygen demand
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DVT	Design Verification Testing
EA	EA Engineering, Science and Technology, Inc., PBC
EPA	U.S. Environmental Protection Agency
Fe	Iron
ft	Foot/feet
gpm	Gallons per minute
Mg	Magnesium
mg/L	milligrams per liter
Mn	Manganese
mV	millivolts
ND	Non-detect
ORP	Oxidation Reduction Potential
PlumeStop	PlumeStop® Liquid Activated Carbon™ with AquaZVI™
psi	Pounds per square inch
Site	Boomsnub /Airco Superfund Site
TCE	trichloroethene
TOC	total organic carbon
VOC	Volatile Organic Compound
ZVI	Zero Valent Iron

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1. INTRODUCTION

This report presents the findings from the Phase I in-situ remediation of two areas of residual contamination at the Boomsnub/Airco Superfund Site (Site) located in Hazel Dell, Washington (Figure 1), and presents the design to scale up remediation using the tested technologies. This contaminated groundwater remedial action is consistent with the 2000 Record of Decision [(ROD) EPA 2000] for the site and the September 2015 Explanation of Significant Differences [(ESD) EPA 2015) which allows for in-situ treatment to augment the contaminated groundwater extraction and treatment system. The remedial action is being performed by Messer LLC (Messer) under a 2007 Consent Decree [(CD) EPA 2007] that requires U.S. Environmental Protection Agency (EPA) oversight. Messer's consultant is EA Engineering, Science, and Technology, Inc., PBC (EA) who is responsible for implementing field efforts and cleanup at the Site on behalf of Messer.

1.1 BACKGROUND

The groundwater at the Site is contaminated with volatile organic compounds (VOCs) and chromium, in a solute plume that extends approximately 2,600 feet (ft) downgradient from source areas. The primary contaminants of concern (COCs) at the site are trichloroethene (TCE) and hexavalent chromium. The COC plumes originally extended west approximately 4,500 ft downgradient of the source area. Significant efforts have been made to remediate the COCs. Since 1991 a groundwater extraction and treatment (pump and treat) system has been in operation. Research and experience have shown that the effectiveness of pump and treat systems decrease over time and other treatment methods are potentially needed to remove residual contamination in a timely manner.

The Toe-of-Plume Pilot Study (TOPPS), an *in situ* treatment test, was performed in 2006 to treat an area of recalcitrant TCE contamination. During this pilot study, a reducing agent consisting of ZVI and a carbon source (EHC®) was placed in the contaminated zone of the aquifer using direct push technology to determine its effectiveness at reducing residual contaminant concentrations to below established cleanup levels. The chromium and TCE concentrations in the TOPPS monitoring wells have remained below the cleanup level since that time, indicating that the TOPPS treatment was effective.

To accelerate cleanup at the site, EPA issued an Explanation of Significant Differences (ESD) to the Site Record of Decision (ROD) in September 2015 allowing the use of in-situ remediation to treat areas of residual contamination. In March 2018, the *Work Plan for the In-Situ Treatment of Areas of Residual Contamination* (EA 2018a) was completed and approved by the EPA in August 2018. The plan prescribed a phased approach and methods for implementation of in-situ remediation of two areas of residual contamination in groundwater.

The characterization and in-situ treatment work conducted in 2018 focused on two areas of concern (AOCs), AOC-1, adjacent to the VOC source area associated with Operable Unit 2, and AOC-2, which is located along the center of the plume (Figure 2). Both areas of residual

contamination contain TCE at concentrations exceeding the Site groundwater cleanup level of 5 micrograms per liter (µg/L). Chromium is only a consideration in AOC-2.

1.2 PROJECT OBJECTIVE AND APPROACH

The overall objective for the in-situ treatment is to achieve the groundwater cleanup levels in the two remaining areas of residual contamination, to reduce the overall size and strength of the plume and accelerate closure of the Site. The work plan presented the plan for testing in-situ treatment methods to be implemented at the full-scale design (EA 2018a). The work plan divided the work into in three phases: Design Verification Testing (DVT), Phase I Treatment (pilot testing), and Phase II Treatment (full-scale treatment).

The *Design Verification Testing Preliminary Report*, presenting the results from DVT, was submitted to EPA in November 2018 (EA 2018b) (Appendix A). The results of the DVT were used to establish the locations, depths, and quantities for the Phase I treatment, conducted in October 2018, which was essentially a field-scale pilot test that targeted a small, highly contaminated portion of the plume in AOC-1 and AOC-2. The results of the Phase I treatment have been used to develop the design for Phase II treatment presented later in this report, which is scheduled to be conducted in 2019 and 2020.

1.3 PROJECT SCOPE

This document is organized as follows:

- DVT is summarized in Section 2
- Phase I In-Situ Treatment is discussed in Section 3
- Performance Monitoring is discussed in Section 4
- Proposed Phase II In-Situ Treatment is discussed in Section 5
- Proposed Schedule is presented in Section 6.
- A list of references cited is provided in Section 7.

Appendix A provides the *Design Verification Testing Preliminary Report* which was submitted to EPA in November 2018 to present preliminary test results. Appendix B provides the AOC-1 summary report including details of field activities during the Phase I Treatment in AOC-1, and Appendix C provides the daily construction reports for the Phase I Treatment in AOC-2.

2. DESIGN VERIFICATION TESTING

DVT activities took place in Fall 2018 and included the following:

- Vertical concentration profiling of the plume using passive flux meters, passive diffusion bags, and collection of water samples from direct push boreholes.
- Horizontal delineation of contamination using direct push boreholes to establish areas of treatment.
- Installation of two wells for performance monitoring.

In general, the DVT results further defined the extent of contamination, and identified a couple of potential data gaps, most notably the horizontal extent of contamination in AOC-2, to the north and south. It should be noted that concentrations of contaminants in samples from direct push borings and passive flux meters do not correlate to concentrations that would be measured in a properly installed and developed well, sampled in accordance with an approved quality assurance sampling plan using low-flow sampling methodology, since they are discrete samples collected over narrow intervals versus a fully screened well. TCE concentrations measured in samples collected using direct push results will not be comparable to samples collected from wells using low flow sampling methods, but they are useful in identifying areas of contamination for future treatment.

In AOC-1, TCE concentrations in groundwater ranged from less than the method reporting limit to 95 µg/L. The highest concentrations vertically were found at approximately 35 ft below ground surface (bgs) (Figure 3). Contamination was bounded to the west (downgradient) at location AOC-1-GP-06, where reported TCE concentrations were below the established cleanup level of 5 µg/L. Historically, contamination to the north and south has been bounded by the monitoring wells along NE 47th Avenue, including monitoring well AMW-53A to the north, where TCE concentrations are fluctuating above and below the cleanup level, and well AMW-54A to the south.

In AOC-2, TCE concentrations in groundwater ranged from below detection to 456 µg/L. The results indicate that the highest concentrations of TCE vertically are generally between 149 ft and 169 ft elevation, or roughly 100-110 ft depth (Figure 4). The horizontal extent of the contamination was not defined during this round of sampling though this gap is mitigated by the planned expansion of in-situ injections.

Additional detail regarding the DVT is presented in Appendix A.

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3. PHASE I IN-SITU TREATMENT

Injections for the Phase I Treatment were conducted in October 2018 at AOC-1 and AOC-2 to test product application methods and rates, and to assess the effectiveness of the treatment. Direct push drilling was used at both sites to inject the selected treatment products into the aquifer, creating a permeable reactive zone. In AOC-1, PlumeStop® Liquid Activated Carbon™ (PlumeStop) with AquaZVI™ was used and EHC® Plus was used at AOC-2. The following provides a summary of the Phase I work.

3.1 AOC-1 INJECTIONS

Injections at AOC-1 were completed in October 2018. A summary report describing the injection activities is provided in Appendix B. At AOC-1, injections at seven in-situ injection points were completed in 4 days, averaging 3.5 hours per injection point (Figure 5). Treatment products were injected in a top-down fashion with an injection tip that directed the mixture horizontally. The mixture was injected using positive displacement pumps. Injection rates and injection pressures deviated slightly from the work plan goals of 10 gallons per minute (gpm) flowrate at injection pressures ranging between 30 to 60 pounds per square inch (psi), with generally lower injection flow rates and higher pressures, as shown in the table below. The deviations in flow rates and pressure occurred because the formation was tighter than expected.

AOC-1 Injection Parameter Summary

	Range
Injection Pressures	25 – 110 psi
Injection Flow Rates	2.0 – 5.5 gpm

The product was injected at the Site in a ratio of 1.4:1.6:1 PlumeStop® to PlumeStop S® to AquaZVI™. PlumeStop® and PlumeStop S® are both liquid activated carbon products, and AquaZVI™ consists of colloidal zero-valent iron (ZVI) coated with iron sulfide. The mixture was applied as a solution of product and water between the ranges of 4.4 percent and 7.5 percent. The injection design consisted of two rows of injection points that were staggered to achieve coverage perpendicular to the groundwater flow as shown in Figure 5. Seven injections points were placed 8.5 ft apart. Product was injected at depths between 30 ft bgs and 45 ft bgs using 3-ft-long screens. A total of 8,139 gallons of PlumeStop® and AquaZVI™ blend was mixed and applied over the treatment area.

Productivity was slower than expected due to surfacing of product in boreholes and monitoring wells. Surfacing was mitigated by turning the pump off, drilling to 15 ft into the respective location, and packing the borehole with an additional hydrated layer of bentonite. Additionally, the injected PlumeStop® product traveled upward through the well screen, spilling into the well vault of AOC-1-GP-01 while pumping on IP-1 and IP-7 (Appendix B). The few gallons of product that surfaced was allowed to drain back into the borehole, into the formation.

Monitoring well AOC-1-GP-01 was flushed with water to push the surfaced product into the surrounding formation, preventing a buildup of carbon particulates.

3.2 AOC-2 INJECTIONS

Injections at AOC-2 were completed between October 15, 2018 and October 30, 2018. Daily construction reports are provided in Appendix C. A total of 9,630 pounds of EHC® Plus (consisting of lecithin-based organic carbon donor, ZVI, and powdered activated carbon) was injected into 12 injection points. The injection design consisted of two rows of six injection points that were staggered to achieve coverage perpendicular to the groundwater flow (Figure 6). Additionally, each point was 14 ft apart under the assumption of a 7 ft radius of influence based on manufacturer's recommendations. At each injection point, product was injected in a bottom-up approach, every 2 ft at depths between 120 ft and 85 ft bgs. EHC® Plus was mixed with water and microbes and injected using a Geoprobe 7730DT direct push drill rig.

To distribute the solid slurry of EHC Plus (30 to 40% solids) into the formation, a narrow flow path is created to allow the slurry to flow through the target soils. The flow path is created by injecting at down hole injection pressure rates sufficient to overcome the natural matrix cohesion and overburden pressure. Using a dry soil weight of approximately 100 pounds per cubic foot, overburden pressure at 120 feet bgs is approximately 83 psi. Matrix cohesion was not determined, but for the purposes of this injection testing, the goal was to aim for injection pressures between 85 and 125 psi to initiate flow. Pressure drops as the slurry migrates out into the target soil. Distribution away from the injection point is controlled by the energy losses along its length, or in this case the time it takes to inject the target volume of EHC Plus at the design injection rates.

Gauge pressure during testing was measured and reported from a location between the injection pump and the drill rig. To determine the actual down hole pressure, the overburden pressure, pressure losses due the viscosity and flow rates of the slurry through the injection hose, DPT tooling and injection nozzle, need to be subtracted from the gauge pressure. At 120 feet bgs, which is typically where the highest pressure readings were observed, overburden pressure is 83 psi, pressure losses due the viscosity and flow rates of the slurry through the injection hose are approximately 58 psi, and the DPT tooling and injection nozzle require another 125 psi. The gauge pressures measured during testing typically ranged from 100 to 400 psi. After subtracting overburden pressure and pressures from equipment, actual downhole pressure at the injection point is estimated at 134 psi, which is just outside the test range stated in the work plan between 85 psi and 125 psi.

During testing, a few gauge pressure levels were reported as high as 600 psi which was attributed to momentary pressure spikes required from the added pressure to unclog the injection tip.

Production was slowed at AOC-2 due to problems with the drill rods and product surfacing. Because direct injection was pushed to 120 ft bgs, the drill rods were under extreme pressure.

While drilling at points 8 and 9, see Figure 6, rods broke while at depths between 84 ft and 95 ft bgs. The problem was resolved after new drill rods were purchased and disposable tips were used. Disposable tips do not close between injections which allows the treatment mixture to flow upwards through the rod and to surface.

During each injection, approximately 2 gallons of treatment mixture was lost due to surfacing. Additionally, product was lost when groundwater and the product mixture traveled up well MW-18E and gathered in the well vault after completing injections at points 4, 3, and 5 (Figure 6). The well vault required cleaning and injection flow rates were lowered to prevent further surfacing events. Approximately 200 gallons of lost injection product and groundwater was reinjected at various injection points. The injection product and groundwater mixture from the vault was reinjected at points AOC-2-TP-08 and AOC-2-TP-12. A total of 108 gallons was reinjected at AOC-2-TP-08 with each interval receiving an extra 6 gallons of product and a total of 90 gallons was reinjected at AOC-2-TP-12 with each interval receiving an extra 5 gallons of product. The remaining 50 gallons of surfaced product was not reinjected and was disposed.

3.3 RECOMMENDATIONS FOR FUTURE INJECTION

3.3.1 AOC-1

For full scale design it is recommended, based on problems that occurred during the Phase I injections, to increase the distance between injection points, as surfacing in adjacent injection points indicated product traveled further than the initial 8.5-ft design. Pressures will be more closely observed to limit applied pressures to the amount needed to open formation and allow product to be distributed away from the boring. Water levels will be monitored in adjacent wells to confirm.

Injection point distance is recommended to be increased from 8.5 ft to 10 ft. For scaling up the design, it is recommended retain the design ratio of 1.4:1.6:1 PlumeStop® to PlumeStop S® to AquaZVI™. PlumeStop® and PlumeStop S®.

3.3.2 AOC-2

Based on problems that occurred during Phase I injections, the following recommendations are made regarding direct push application.

- Drilling should be conducted using a rig equivalent to a Geoprobe 7730DT drill rig, or a more powerful rig.

- New rods should be purchased for the injections. The combination of integrally sound drill rods and a larger drill rig should reduce the probability of breaking rods and allow for a higher placement rate.

- To reduce the potential for product surfacing, it is recommended that a heavy spring-loaded injection tip be used, and to inject using a top down approach.

- Injection pressure and rate should be more closely monitored to ensure that reagent is injected into the formation pore space as uniformly as practical. Maintain downhole pressures < 135 psi except for momentary spikes that may be necessary to unplug the injection rods.

- Nearby water levels should be gauged during injection to monitor formation pressure.

4. PERFORMANCE MONITORING

Groundwater monitoring was conducted both before and after the Phase I product injections to assess the performance of the treatment relative to achieving Site groundwater cleanup levels and assist in scaling up the design. Sampling was also performed to monitor temporary water quality impacts associated with the injected treatment products.

4.1 MONITORING APPROACH

Samples were collected from downgradient performance monitoring wells in AOC-1 and AOC-2 in October 2018 (baseline pre-treatment sampling), January 2019, and February 2019. Specifically, monitoring wells AOC-1-GP-01 and AOC-1-GP-05, installed during the DVT, are being used to monitor the AOC-1 treatment area. Wells MW-18D and MW-18E are being used to monitor the AOC-2 treatment area. Groundwater samples were analyzed by ALS of Kelso, Washington. The sampling effort was designed to measure reductions in the primary contaminants of concern, to monitor impact on aquifer for evidence of biodegradation, and to monitor degradation products associated with the products tested, as described below.

4.2 AOC-1 MONITORING RESULTS

In AOC-1, samples were collected at two locations, AOC-1-GP-01 and AOC-1-GP-05. Well AOC-1-GP-01 is approximately 5 ft west (downgradient) of the more downgradient row of injection points and well AOC-1-GP-05 is approximately 30 ft west of the injection points (Figure 5).

4.2.1 AOC-1 Monitoring

The products tested in AOC-1, PlumeStop® and AquaZVI® contain activated carbon and ZVI. PlumeStop is composed of very fine particles of activated carbon which sorb to the aquifer matrix, removing contaminants from groundwater, while still permitting their degradation. Activated carbon does not produce by-products, but traps the TCE, which is then treated by the ZVI. The AquaZVI® promotes degradation of the TCE, primarily through beta-elimination, and does not have chlorinated intermediates. The following parameters monitored were used for the evaluation of the injections at AOC-1:

- TCE, to measure decrease in the primary COC at the site.
- DO, ORP, and metals to measure impacts on aquifer from ZVI.

4.2.2 AOC-1 Summary of Results and Discussion

TCE concentrations were less than the groundwater cleanup level of 5 µg/L in both wells sampled in AOC-1 in February 2019. In October 2018, concentrations of TCE at those locations exceeded the cleanup level. The TCE concentration in the downgradient monitoring point, AOC-1-GP-05, decreased from 15 µg/L in January to 4.2 µg/L in February. From October to

February, iron concentrations increased from 34 µg/L to 44,900 µg/L in AOC-1-GP-01 and from 519 µg/L to 3170 µg/L in AOC-GP-05. AquaZVI™ contains high concentrations of iron, so after injections the concentration of iron was expected to increase first in AOC-1-GP-01 and then in AOC-1-GP-05, as the product flowed further from the injection points. The AquaZVI™ also is intended to create reducing condition favorable for the breakdown of chlorinated organics, such as TCE, which is evidenced by decreasing concentrations of DO and ORP. In AOC-1-GP-01, DO decreased from 7.59 milligrams per liter (mg/L) to 0.1 mg/L and ORP decreased from 197.8 millivolts (mV) to -384 mV between October and February. Less change was observed over the same period farther downgradient in AOC-1-GP-05, as DO increased from 8.55 mg/L to 17.7 mg/L and ORP decreased from 200.6 mV to 79.6 mV. A summary of the AOC-1 monitoring results is presented in the following tables.

AOC-1 Monitoring Results

Sample Locations	Sample Date	Primary Parameter	Field Parameters		Secondary Parameter
		TCE (µg/L)	**DO** (mg/L)	**ORP** (mV)	**Iron** (µg/L)[1]
AOC-1-GP-01	Oct-18	71[2]	7.59	197.8	34
	Jan-19	--	0.47	-418.7	--
	Feb-19	ND	0.1	-384	44900
AOC-1-GP-05	Oct-18	40[2]	8.55	200.6	519
	Jan-19	15	3.33	8.1	--
	Feb-19	4.2	17.7[3]	79.6	3170

[1] Secondary parameters to represent baseline conditions (October 2018) at AOC-1 were sampled at nearby wells with AMW-53A and MW-1A. The average was used for comparison to future tests.
[2] From direct push boring, may be biased high.
[3] DO value is outside of range of water solubility. Meter was properly calibrated, so this is considered an anomalous reading.

When adding ZVI, TCE breaks down through a reductive pathway which does not produce the chlorinated intermediates found with biological breakdown such as cis-dichloroethane (DCS), trans-DCE and vinyl chloride (VC). To demonstrate, as shown in the following table, none of those chemicals are present in the most recent round of sampling conducted in February, yet the TCE concentrations had dropped to below the cleanup levels.

AOC-1 TCE Degradation Products

Sample Locations	Sample Date	Cis-DCE (µg/L)	Trans-DCE (µg/L)	Vinyl Chloride (µg/L)
AOC-1-GP-01	Oct-18	0.38 J	< 0.5	< 0.5
	Jan-19	--	--	--
	Feb-19	< 0.5	< 0.5	< 0.5
AOC-1-GP-05	Oct-18	0.79	< 0.5	< 0.5
	Jan-19	0.16 J	< 0.5	< 0.5
	Feb-19	< 0.5	< 0.5	< 0.5

Overall, the results to-date support that PlumeStop® is successfully working at remediating TCE. Monitoring supports this conclusion because of the reduced concentration of TCE over time, and the reductions in ORP and DO indicating a reducing environment around AOC-1-GP-01, which was placed just downgradient of the injection points, within the permeable reactive zone. These results support the use of this product in future injections.

4.3 AOC-2 MONITORING RESULTS

4.3.1 AOC-2 Monitoring

Samples were collected at AOC-2 at two sample locations, MW-18E and MW-18D. Well MW-18E was approximately 14 ft downgradient from the more downgradient row of injection points, and well MW-18D is approximately 30 ft downgradient from the injection points (Figure 6).

4.3.2 AOC-2 Summary of Results and Discussion

EHC® Plus consists of lecithin-based organic carbon donor, ZVI, and powdered activated carbon. The ZVI and activated carbon perform as described earlier. The organic carbon donor promotes another pathway for destruction of the TCE by providing an electron donor. The following parameters monitored were used for the evaluation of the injections at AOC-1:

- TCE, to measure decrease in the primary COC at the site.
- DO, ORP, and metals to measure impacts on aquifer from ZVI.
- Fatty Acids, dissolved gases, anions, carbon, and VOCs to predict future degradation and possible side effects of the injection product.

Prior to the Phase I injections, concentrations of TCE exceeded the cleanup level of 5 µg/L at MW-18D and MW-18E. TCE concentrations decreased at well MW-18E from 150 µg/L in October 2018 (before injections) to 2.7 µg/L in February 2019 (post-injections). TCE concentrations decreased at well MW-18D from 49 µg/L in October 2018 to 2.7 µg/L in February 2019. Chromium concentrations remained above the cleanup level in MW-18D and below the cleanup level in MW-18E in February 2019. It was expected that DO and ORP would decrease after injections, however DO concentrations remained stable in both well MW-18E and MW-18D. ORP decreased from 155.8 mV to 0.1 mV in MW-18D and remained relatively stable in MW-18E.

A summary of primary and field parameters results is shown in the following table.

AOC-2 Monitoring Results-Primary and Field Parameters

Sample Locations	Sample Date	Primary Parameters		Field Parameters	
		TCE (µg/L)	Cr (µg/L)	DO (mg/L)	ORP (mV)
MW-18D	Oct-18	49	127	3.2	155.8
	Jan-19	1.9	NA	1.96	7.9
	Feb-19	2.1	181	4.6	0.1
MW-18E	Oct-18	150	NA	0.01	-162.1
	Jan-19	2.4	NA	0.57	-85
	Feb-19	2.7	38.5	0	-174
NA: Samples not collected.					

Secondary parameters were monitored for evidence of chemical and/or biological degradation in the treated groundwater. Iron concentration was monitored to determine the extent that the treatment product reached, as EHC® Plus contains high concentrations of iron. Between October 2018 and February 2019, concentrations of iron increased in MW-18E from 1,450 µg/L to 330,000 µg/L and in MW-18D from 273 µg/L to 2,150 µg/L. Within the zone of influence of EHC® Plus, the reducing and anerobic conditions will favor the presence of ferrous iron. Groundwater at the Boomsnub site is predominantly aerobic. As soon as the ferrous iron migrates outside the zone of influence of EHC® Plus, it will get oxidized and precipitate out as ferric iron and will no longer impact the groundwater quality..

As seen in Table 2, fatty acids (Acetic Acid, Butyric Acid, and Formic Acid) increased in well MW-18E, which is expected with increased biological activity, as fatty acids are released as bacteria ferment the injected carbon. These data indicate that biological activity appears to be ongoing in the treated area. These volatile fatty acids are used by microorganisms as electron donors to bring about the reductive dichlorination of chlorinated CVOCs. The fatty acids are released over a period of two years but are short lived and are consumed relatively quickly to support the reductive dichlorination process. They are not likely to impact the water quality beyond two years post-injection.

The concentration of nitrate increased in MW-18E slightly from non-detect (ND) to 1.18 µg/L and sulfate decreased from 9.37 mg/L to 0.58 mg/L. Nitrate decreased in MW-18D from 18.9 mg/L to 6.93 mg/L and sulfate decreased from 18.9 mg/L to 6.93 mg/L between October and February. The overall increasing concentration trends of sulfate and nitrate is a favorable indicator since these compounds are used as electron acceptors signifying desired electron transfer.

Ethene concentrations increased in well MW-18E from 0.25 µg/L to 0.94 µg/L, but there has been no increase in ethene concentrations in well MW-18D, which supports that complete degradation of TCE has started to occur within a radius of 14 ft (distance to well MW-18E) from the first row of injection points but is not occurring further downgradient. Increases in ethene

show signs of TCE degradation, as ethene is the non-toxic end-product of TCE degradation by bacteria. An increase in methane concentrations in MW-18E from 24 µg/L to 24,000 µg/L shows evidence of methanogenesis, another common bacterial process in reducing environments that are conducive to TCE degradation.

AOC-2 Secondary Parameter Monitoring Results

Sample Location	Sample Date	Secondary Parameters								
		Iron (µg/L)	Nitrate (mg/L)	Sulfate (mg/L)	TOC (mg/L)	DOC (mg/L)	COD (mg/L)	Methane (µg/L)	Ethene (µg/L)	Ethane (µg/L)
MW-18D	Oct-18	273	6.08	18.9	ND	ND	ND	ND	ND	ND
	Feb-19	2,150	2.64	6.93	0.81	0.28 J	293	230	ND	ND
MW-18E*	Oct-18	1,450	ND	9.37	0.26 J	ND	ND	24	0.25	ND
	Feb-19	330,000	1.18	0.58	1,100	750	5,950	24,000	0.94	1.6

TCE breaks down anaerobically, with intermediate degradation products cis- and trans DCE, VC. As presented in the following table, none of those chemicals are present in the most recent round of sampling conducted in February in AMW-18D, however cis-DCE and VC are still present in MW-18E.

AOC-2 TCE Degradation Products

Sample Locations	Sample Date	Cis-DCE (µg/L)	Trans-DCE (µg/L)	Vinyl Chloride (µg/L)
MW-18D	Oct-18	0.7 J	<0.05	<0.05
	Jan-19	<0.05	<0.05	<0.05
	Feb-19	<0.05	<0.05	<0.05
MW-18E*	Oct-18	31	0.84	0.56
	Jan-19	19	0.15 J	0.83
	Feb-19	15	<0.05	1.4

Overall, the monitoring results show that EHC® Plus has started remediating the TCE in the vicinity of wells MW-18E and MW-18D as evidenced by the decreasing concentration of TCE over time, and secondary parameters showing evidence of reducing conditions and biological degradation in the permeable reactive zone. Monitoring will be continued at the site to support the findings of decreases in TCE due to the injection product and to verify that no harmful bioproducts are being formed, and that VC concentrations decline.

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5. PHASE II IN-SITU TREATMENT DESIGN

The results of the DVT and Phase I Treatment show that the in-situ treatments are effective at reducing COC concentrations downgradient of the permeable reactive zones. The pilot treatments for each of the areas can be expanded to accelerate remediation of the site. Based on the testing results, some modifications to the injection methodology are recommended to improve the effectiveness and make implementation of full-scale treatment more efficient.

5.1 AOC-1

The pilot test of PlumeStop® and AquaZVI™ in AOC-1 was conducted in an area with relatively low concentrations of TCE. One monitoring point was within the treatment area, and one downgradient monitoring point 30 ft from the test injection area. The pilot test showed adequate product distribution and evidence that the injected material was treating/trapping TCE as it migrates downgradient. Five months after the pilot study, ORP and DO remain depressed in GP-01, and TCE concentrations in the downgradient performance monitoring wells are less than the cleanup limit. Monitoring of degradation products indicated full degradation of TCE was occurring.

To scale up the AOC-1 treatment, two permeable reactive zones containing PlumeStop® and AquaZVI™ would be placed on each side of NE 48th Street, up to 220 ft in length, as shown on Figure 7. The flux data shows that contamination flux is fairly uniform from the top to the bottom of the screen interval on MW-1A with samples at 1.5-ft intervals from 31.1 ft to 38.3 ft bgs. Based on the passive flux meter data, the contaminant zone covers a minimum of 10 ft but is likely larger. In addition, extra vertical coverage will allow for fluctuation in the groundwater table. For these reasons the target treatment zone will be from approximately 28 ft to 43 ft bgs. Injection design is presented in the following table.

Injection Mix for Each Injection Interval: AOC-1

Injection Interval	28 to 35 ft bgs
Product Ratio	1.4:1.6:1 PlumeStop® to PlumeStop S® to AquaZVI™
Solution	4.4-7.5%
Injection Pressure	25-75 psi
Flow Rates	2 – 5.5 gpm

5.2 AOC-2

Based on reductions in TCE concentrations, and increases in organic acids, methane, ethene, ethane, and decreases in DO and ORP, there is strong evidence that reductive dechlorination is occurring in the area treated using EHC® Plus in AOC-2. Based on these results, it is expected that the groundwater plume in this area can be treated by placing permeable reactive zones containing EHC® Plus at eight locations, as shown on Figure 8. The table below provides the details for the 8 rows of injection points at AOC-2.

TCE in the groundwater will be treated by bacterial degradation and/or trapped by activated carbon as it flows through the aquifer. Specific parameters related to the design of these zones are provided in the tables that follow. The depths to be treated were determined by the DVT, and in areas outside of DVT testing, by the historical data collected from groundwater from existing wells.

Proposed Treatment Zone Locations and Design

	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8
Number of Rows	3	2	2	3	2	2	2	2
Length of Row (ft)	120	75	100	160	100	100	100	125
Number of Points	23	9	19	20	13	10	13	16
Start treatment (ft bgs)	75	75	75	75	95	95	95	95
End Treatment (ft bgs)	90	90	90	90	115	115	115	115
Volume product (pounds)	11,040	4,320	9,360	9,600	8,320	6,400	8,320	10,240
Row locations are shown on Figure 8.								

Injection Mix for Each Injection Interval: AOC-2

EHCPlus	64 lbs
Water (anaerobic)	23 gal
Innoculum	0.07 liters
Injection Pressure	< 100 psi
Flow Rates	8-12 gpm

Using the lessons learned from the pilot study, the scaled-up design at AOC-2 will be implemented as follows.

- Injection spacing will be increased to 16 ft on center
- Use a Geoprobe 7730DT or more powerful push-probe tool for injections
- New drill rods must be used at locations where injection will be deeper than 90 ft bgs
- Anaerobic water will be used to mix and inject product
- Spring loaded injection tip, top down injection approach
- Calculate estimated hydraulic fracture pressure prior to injection
- Use pressure gauge accurate to within 10 psi to continuously monitor injection pressure so that preferential pathways are not created, and reagent spreads evenly.
- Gauge surrounding monitoring wells during injection to evaluate formation pressure

6. PROPOSED SCHEDULE AND POST INJECTION MONITORING

6.1 Project Schedule

The full-scale injections will be completed in two phases as shown in the schedule provided in Figure 9. The goal is to complete as many injections possible in the Fall of 2019, before the ground becomes too wet to support the work. Typically, the rains begin in early October, which should allow injection in five of the proposed injections rows in AOC-2, the Padden Parkway area.

Prior to injections, extraction wells downgradient of each injection row will be shut off to prevent product from being drawn into the treatment system. Monitoring will be conducted three months after the 2019 injections, then in Spring and Fall of 2020.

6.2 Post Injection Monitoring

Samples will be analyzed for the primary contaminants of concern, potential degradation products, and in AOC-2, for evidence of microbial activity. If the COCs are less than the cleanup levels in wells downgradient of the treatment zones during the Fall 2020 sampling event, the groundwater treatment system will be turned off to allow the remained of the plume to be treated as it flows through the treatment zones. An addendum to the Site Quality Assurance Sampling Plan will be prepared to identify the specific sampling requirements.

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7. REFERENCES CITED

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EPA. 2015. Explanation of Significant Differences for the Boomsnub/Airco Superfund Site, Hazel Dell, Washington. Clark County. September.

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Figures

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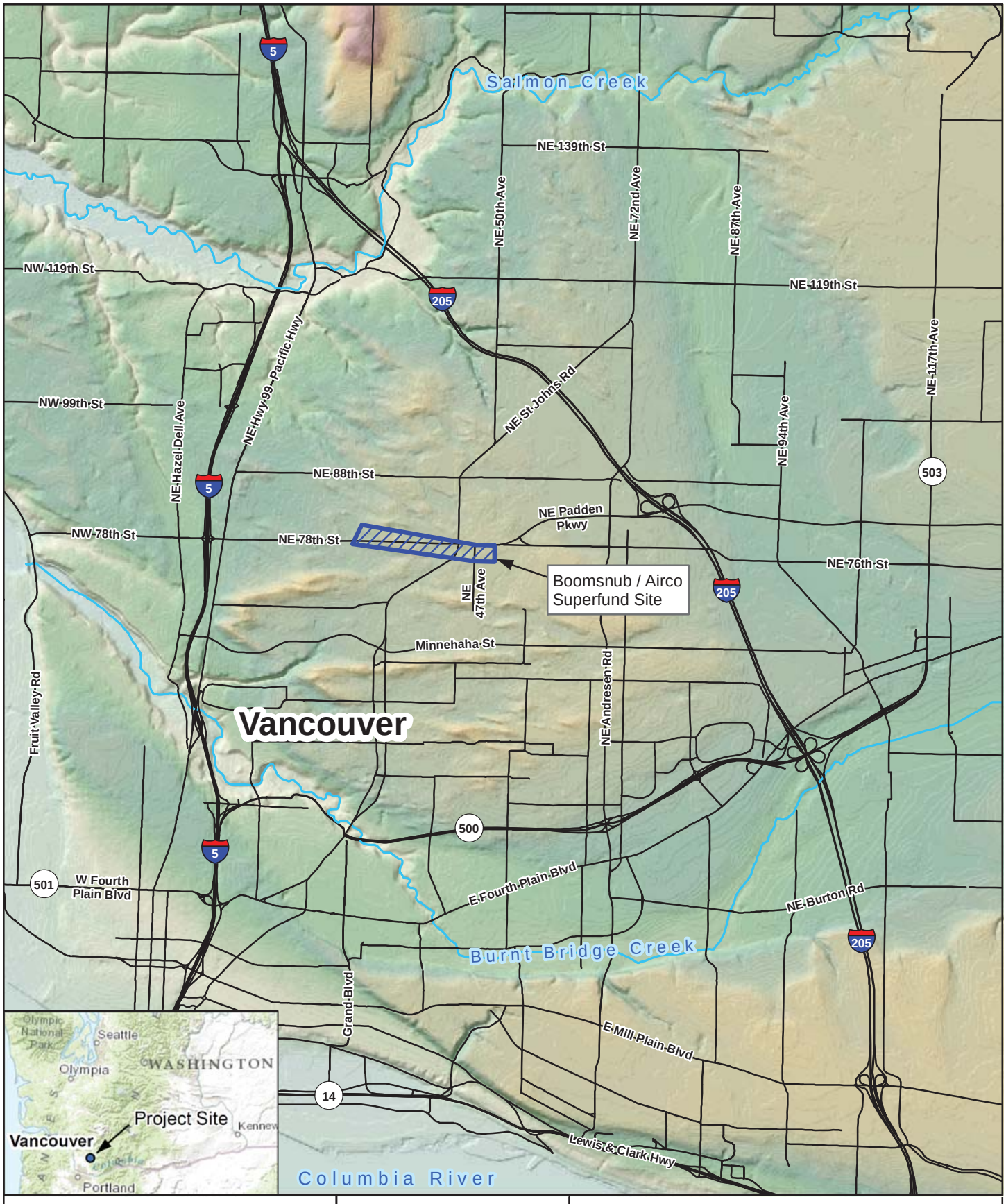

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FIGURE 1
SITE LOCATION MAP

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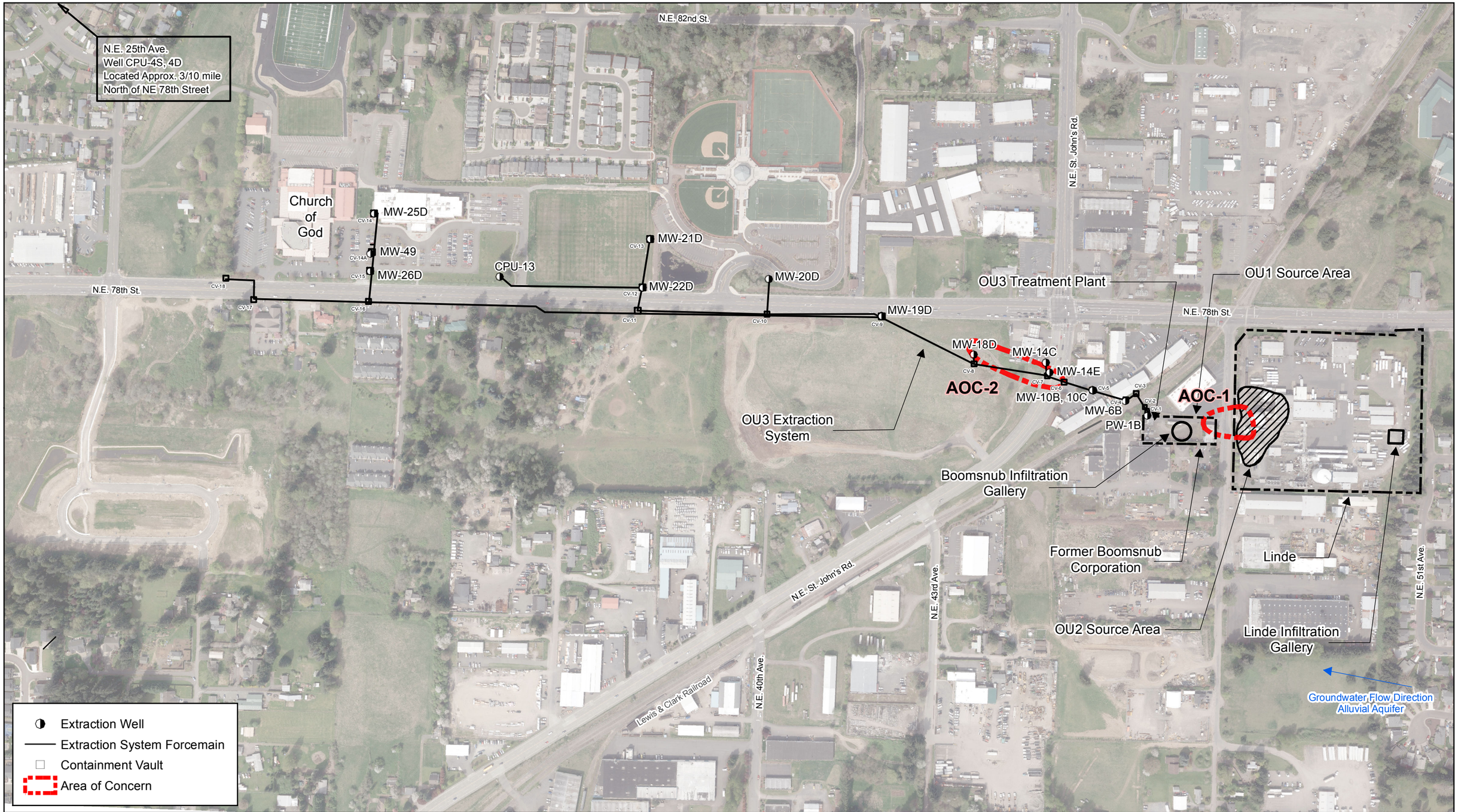

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EA Project No. 1524058
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FIGURE 2
OPERABLE UNITS, TREATMENT SYSTEM, AND AREAS OF CONCERN

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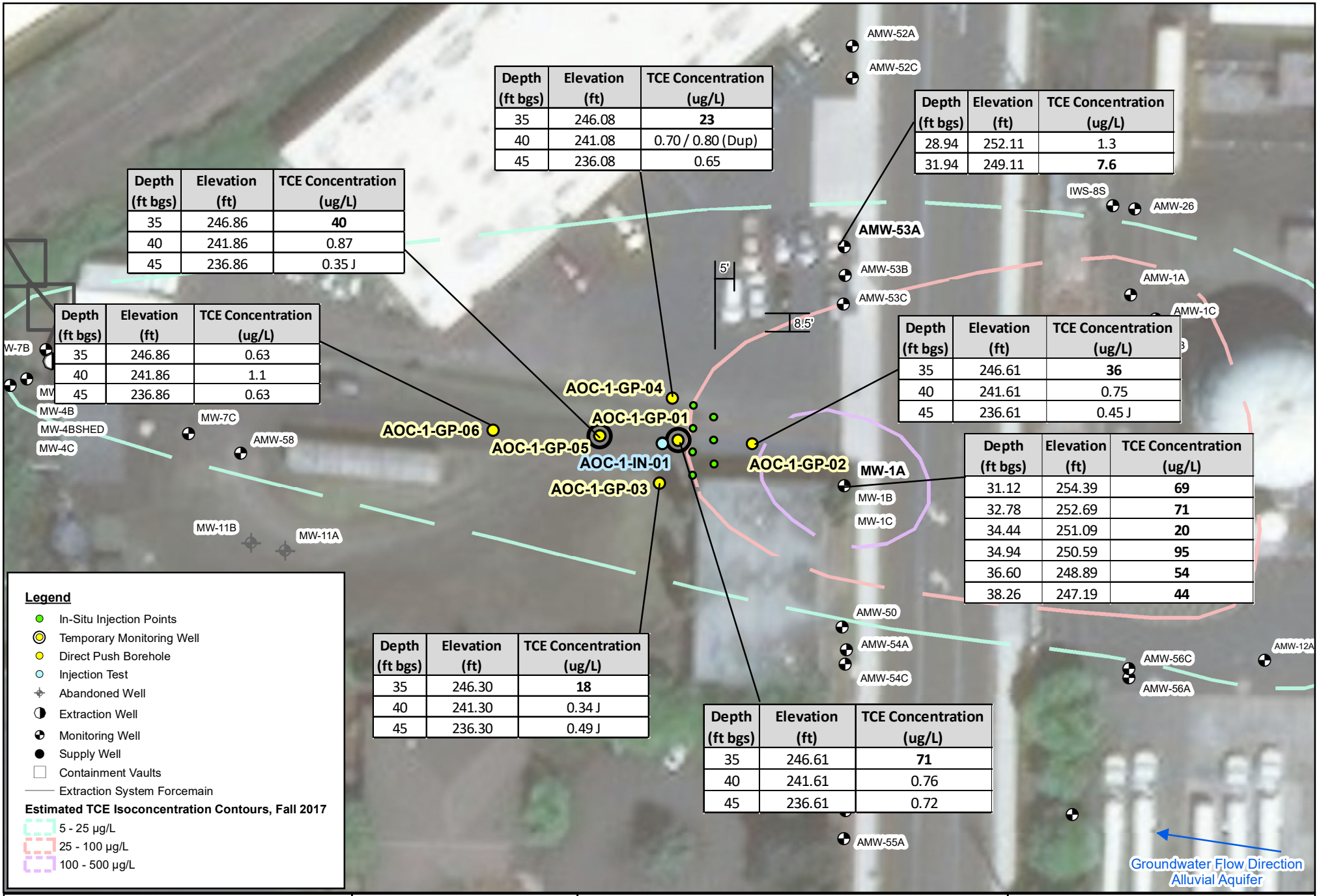

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.08	**23**
40	241.08	0.70 / 0.80 (Dup)
45	236.08	0.65

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
28.94	252.11	1.3
31.94	249.11	**7.6**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.86	**40**
40	241.86	0.87
45	236.86	0.35 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.86	0.63
40	241.86	1.1
45	236.86	0.63

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.61	**36**
40	241.61	0.75
45	236.61	0.45 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
31.12	254.39	**69**
32.78	252.69	**71**
34.44	251.09	**20**
34.94	250.59	**95**
36.60	248.89	**54**
38.26	247.19	**44**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.30	**18**
40	241.30	0.34 J
45	236.30	0.49 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.61	**71**
40	241.61	0.76
45	236.61	0.72

Legend

- In-Situ Injection Points
- Temporary Monitoring Well
- Direct Push Borehole
- Injection Test
- Abandoned Well
- Extraction Well
- Monitoring Well
- Supply Well
- Containment Vaults
- Extraction System Forcemain

Estimated TCE Isoconcentration Contours, Fall 2017

- 5 - 25 µg/L
- 25 - 100 µg/L
- 100 - 500 µg/L

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FIGURE 3
VERTICAL TCE PROFILE, AOC-1
August 2018

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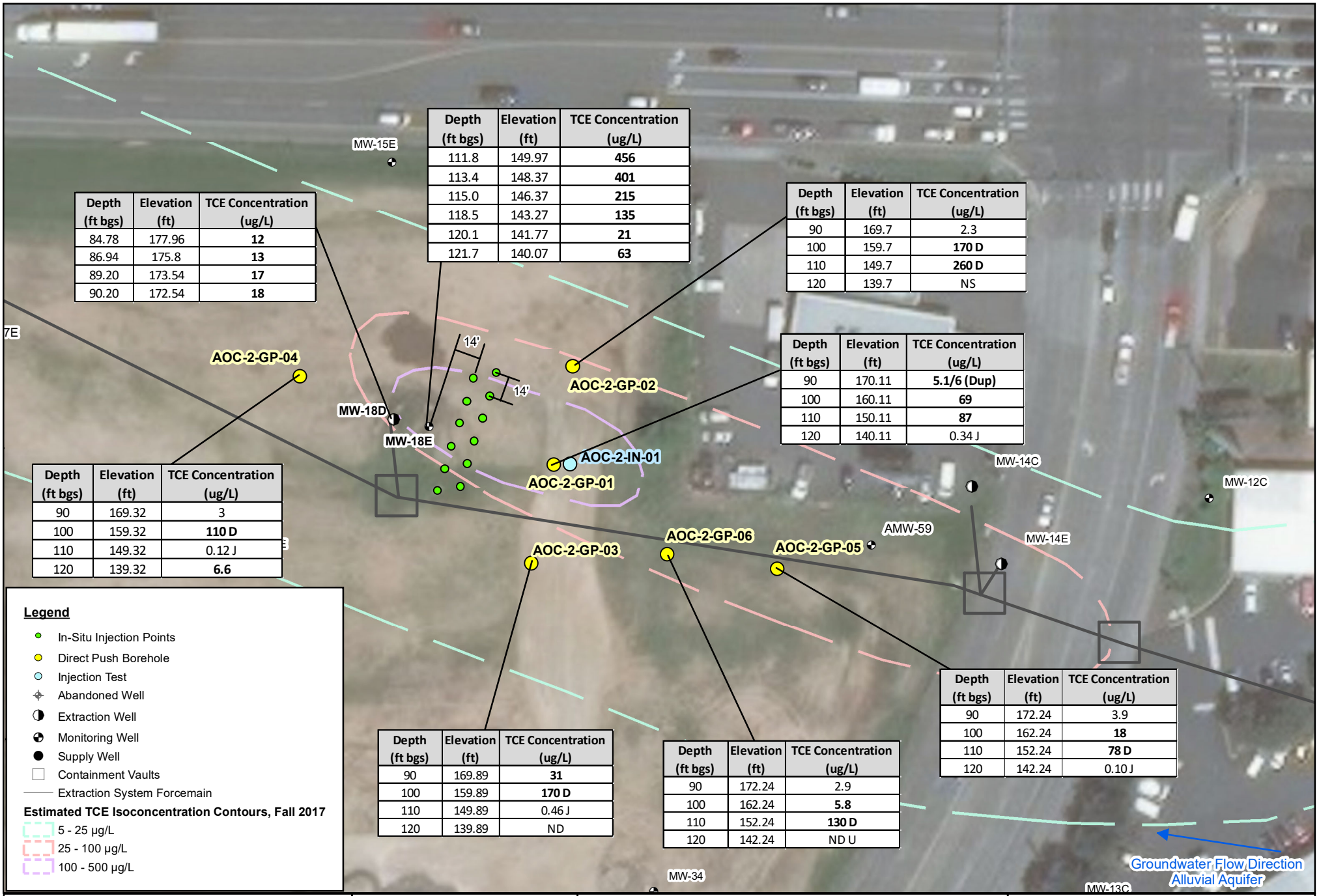

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
84.78	177.96	**12**
86.94	175.8	**13**
89.20	173.54	**17**
90.20	172.54	**18**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
111.8	149.97	**456**
113.4	148.37	**401**
115.0	146.37	**215**
118.5	143.27	**135**
120.1	141.77	**21**
121.7	140.07	**63**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	169.7	2.3
100	159.7	**170 D**
110	149.7	**260 D**
120	139.7	NS

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	170.11	**5.1/6 (Dup)**
100	160.11	**69**
110	150.11	**87**
120	140.11	0.34 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	169.32	3
100	159.32	**110 D**
110	149.32	0.12 J
120	139.32	**6.6**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	169.89	**31**
100	159.89	**170 D**
110	149.89	0.46 J
120	139.89	ND

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	172.24	2.9
100	162.24	**5.8**
110	152.24	**130 D**
120	142.24	ND U

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	172.24	3.9
100	162.24	**18**
110	152.24	**78 D**
120	142.24	0.10 J

Legend

- In-Situ Injection Points
- Direct Push Borehole
- Injection Test
- Abandoned Well
- Extraction Well
- Monitoring Well
- Supply Well
- Containment Vaults
- Extraction System Forcemain

Estimated TCE Isoconcentration Contours, Fall 2017

- 5 - 25 µg/L
- 25 - 100 µg/L
- 100 - 500 µg/L

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FIGURE 4
VERTICAL TCE PROFILE, AOC-2
August 2018

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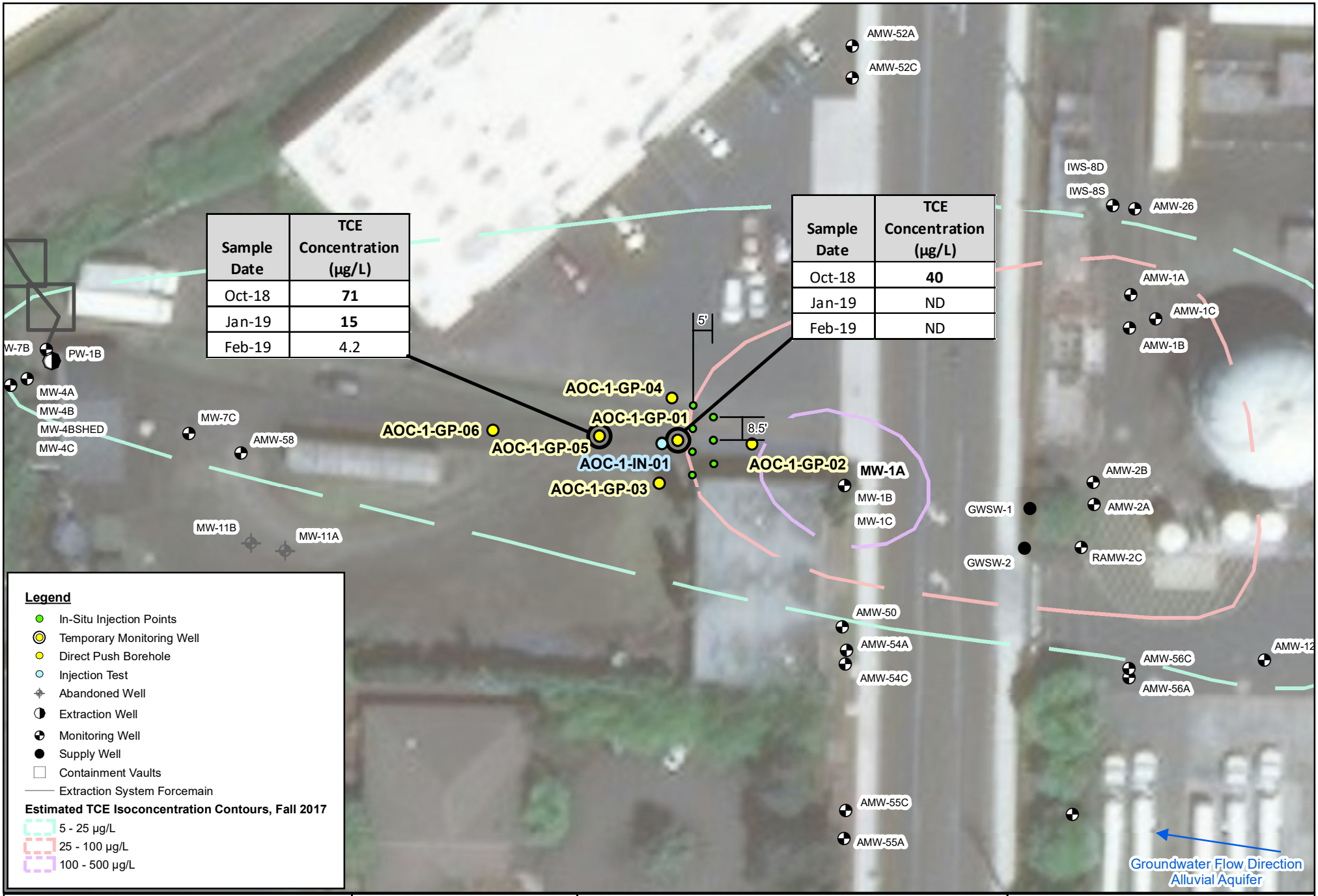

Sample Date	TCE Concentration (µg/L)
Oct-18	**71**
Jan-19	**15**
Feb-19	4.2

Sample Date	TCE Concentration (µg/L)
Oct-18	**40**
Jan-19	ND
Feb-19	ND

Legend

- In-Situ Injection Points
- Temporary Monitoring Well
- Direct Push Borehole
- Injection Test
- Abandoned Well
- Extraction Well
- Monitoring Well
- Supply Well
- Containment Vaults
- Extraction System Forcemain

Estimated TCE Isoconcentration Contours, Fall 2017

- 5 - 25 µg/L
- 25 - 100 µg/L
- 100 - 500 µg/L

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FIGURE 5
TCE CONCENTRATIONS OVER TIME IN PERFORMANCE ASSESSMENT WELLS, AOC-1

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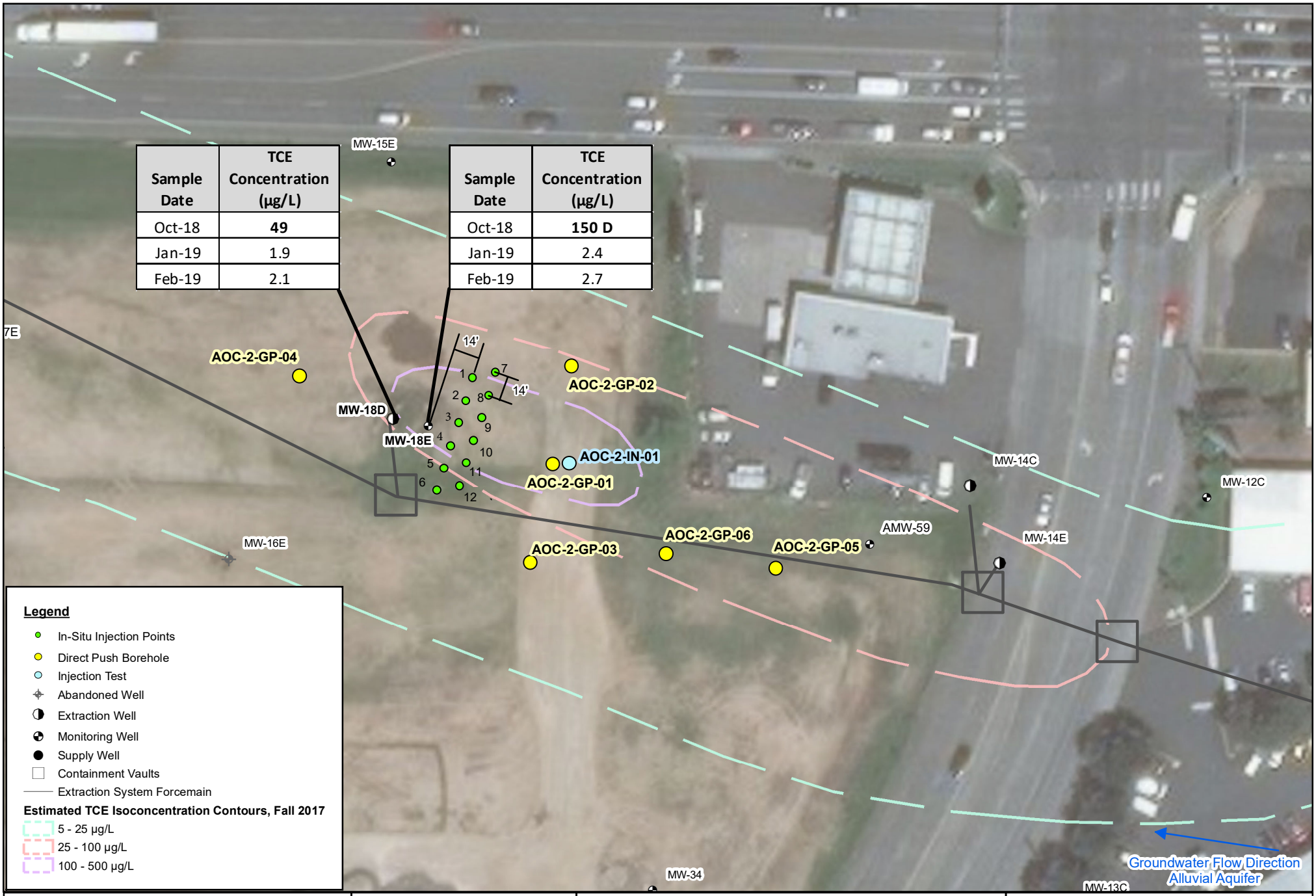

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FIGURE 6
TCE CONCENTRATIONS OVER TIME IN PERFORMANCE ASSESSMENT WELLS,, AOC-2

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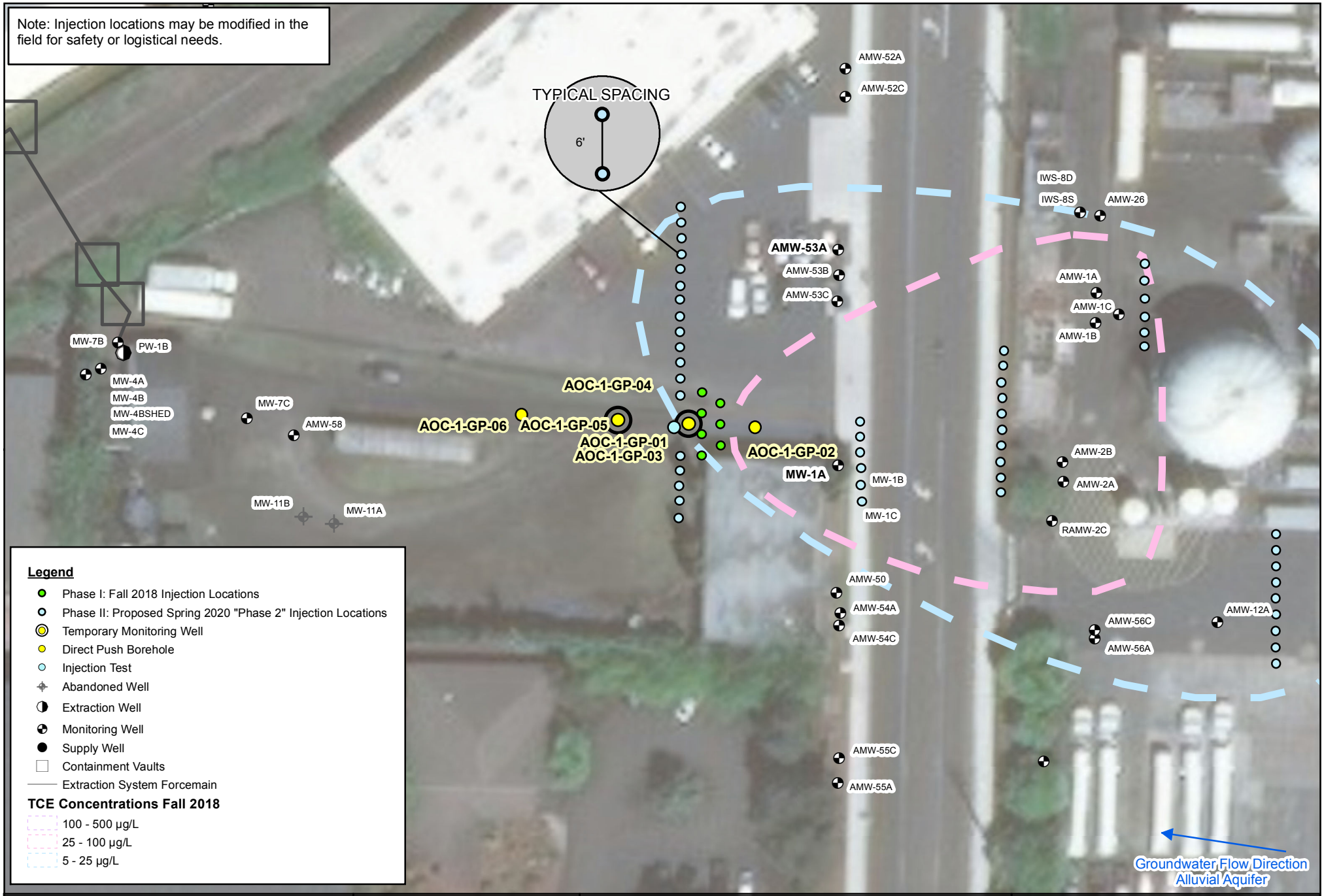

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FIGURE 7
PROPOSED PHASE II TREATMENT LOCATIONS, AOC-1

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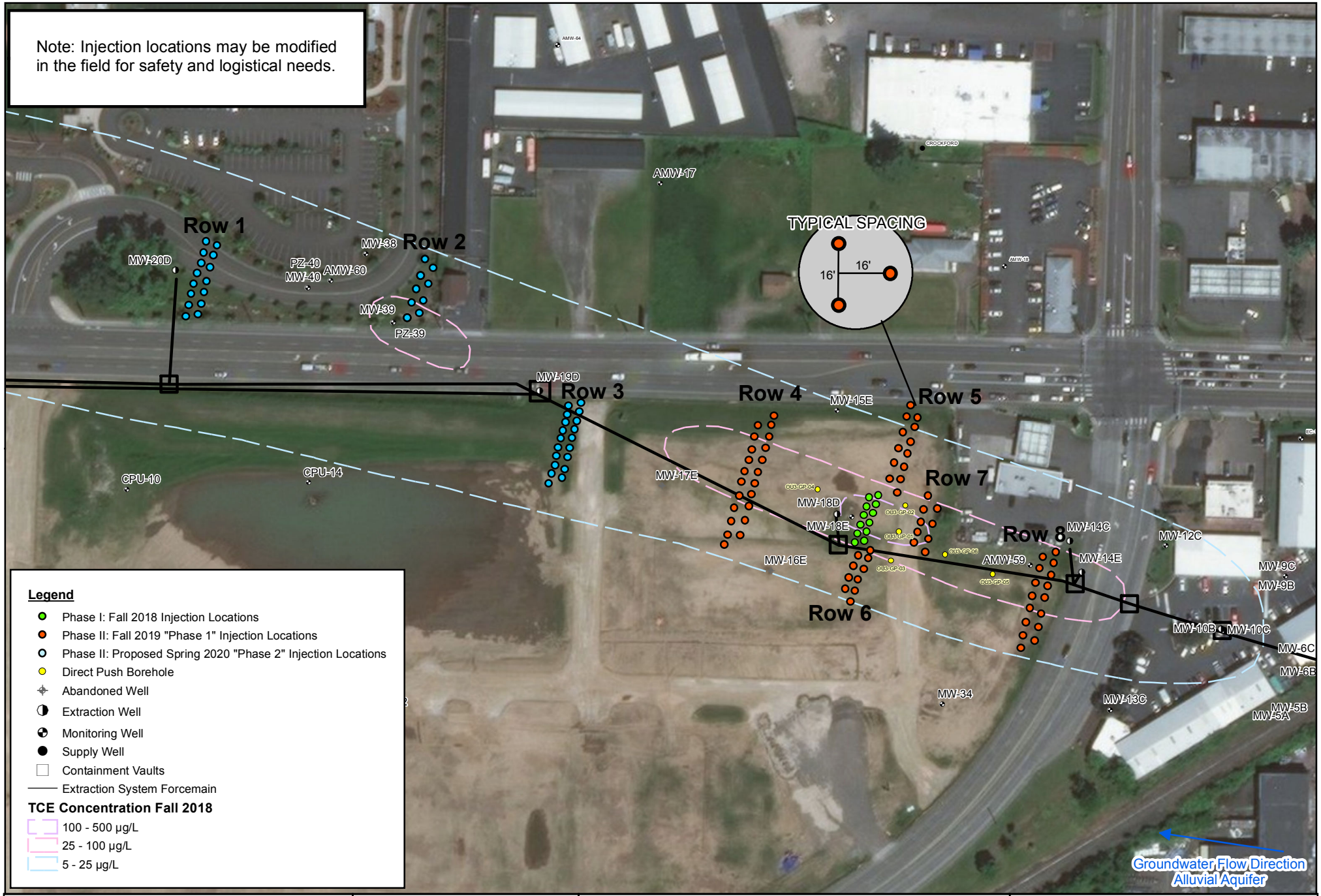

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FIGURE 8
PROPOSED PHASE II TREATMENT BARRIERS, AOC-2

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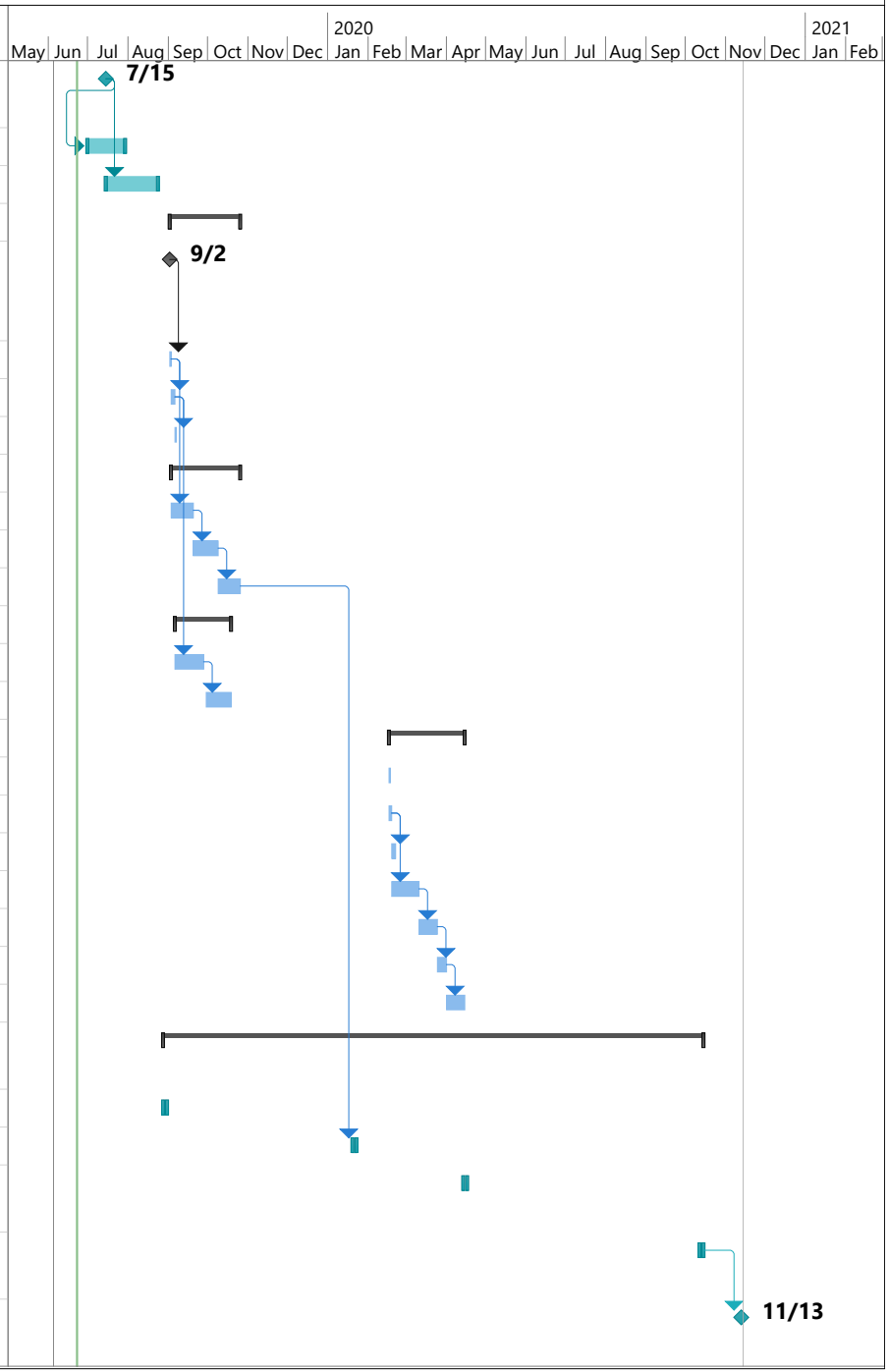
Figure 9. Propsed Schedule for In-Situ Remediation at the Boomsnub/Airco Superfund Site

Task Name	Duration	Start	Finish	Predecessors	Resource Names
Receive Approval from EPA to Proceed	**0 days**	**Mon 7/15/19**	**Mon 7/15/19**		
Driller Bids	21 days	Mon 7/1/19	Mon 7/29/19	1	
Order Product	**6 wks**	**Mon 7/15/19**	**Fri 8/23/19**	**1FS+10 days**	
Phase 1	**40 days**	**Mon 9/2/19**	**Fri 10/25/19**		
Shut off Extraction Wells MW-14C, MW-14E,	0 days	Mon 9/2/19	Mon 9/2/19		
Locates	1 day	Mon 9/2/19	Mon 9/2/19	5	
Mobilization	3 days	Tue 9/3/19	Thu 9/5/19	6	
Air Knife	1 day	Fri 9/6/19	Fri 9/6/19	7	
Rig 1	**39 days**	**Tue 9/3/19**	**Fri 10/25/19**		
Row 5	13 days	Tue 9/3/19	Thu 9/19/19	6	
Row 6	13 days	Fri 9/20/19	Tue 10/8/19	10	
Row 7	13 days	Wed 10/9/19	Fri 10/25/19	11	
Rig 2	**31 days**	**Fri 9/6/19**	**Fri 10/18/19**		
Row 8	16 days	Fri 9/6/19	Fri 9/27/19	7	
Row 4	15 days	Mon 9/30/19	Fri 10/18/19	14	
Phase 2	**42 days**	**Mon 2/17/20**	**Tue 4/14/20**		
Locates	1 day	Mon 2/17/20	Mon 2/17/20		
Mobilization	2 days	Mon 2/17/20	Tue 2/18/20		
Air Knife	3 days	Wed 2/19/20	Fri 2/21/20	18	
AOC-1	15 days	Wed 2/19/20	Tue 3/10/20	18	
Row 1	10 days	Wed 3/11/20	Tue 3/24/20	20	
Row 2	5 days	Wed 3/25/20	Tue 3/31/20	21	
Row 3	10 days	Wed 4/1/20	Tue 4/14/20	22	
Groundwater Monitoring	**296 days**	**Wed 8/28/19**	**Wed 10/14/20**		
Baseline	3 days	Wed 8/28/19	Fri 8/30/19		
Round 1	3 days	Mon 1/20/20	Wed 1/22/20	12FS+60 days	
Round 2 (correspond with	3 days	Tue 4/14/20	Thu 4/16/20		
Round 3 (correspond with	3 days	Mon 10/12/20	Wed 10/14/20		
Shut off remaining extraction wells	0 days	Fri 11/13/20	Fri 11/13/20	28FS+21 days	



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Tables

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Table 1. Summary of Monitoring Results

Sample Locations	Sample Date	Primary Parameters		Field Parameters		Secondary Parameters [1]																	
		TCE (µg/L)	Cr (µg/L)	DO (mg/L)	ORP (mV)	Ca (µg/L)	Fe (µg/L)	Mg (µg/L)	Mn (µg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	TOC (mg/L)	DOC (mg/L)	COD (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	Acetic Acid (mg/L)	Butyric Acid (mg/L)	Formic Acid (mg/L)	Methane (µg/L)	Vinyl Chloride (µg/L)	Ethene (ug/L)	Ethane (ug/L)
MW-18D	Oct-18	49	127	3.2	156	20500	273	11,200	14.5	5.0	6.1	18.9	ND	ND	ND	78	102	.29 J	0.11 J	1.9	ND	ND	ND	ND
	Jan-19	1.9	--	2.0	7.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Feb-19	2.1	181	4.6	0.1	16,900	2,150	7,760	337	3.0	2.6	6.9	0.8	.28 J	293	72	70.8	.37 J	ND	ND	230	ND	ND	ND
MW-18E	Oct-18	150	--	0.01	-162	62,100	1,450	17,400	632	9.0	ND	9.4	.26 J	ND	ND	232	252	0.34 J	ND	0.17 J	24.0	.56	0.3	ND
	Jan-19	2.4	--	0.6	-85	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Feb-19	2.7	38.5	0.0	-174	238,000	330,000	57,800	6330	16.4	1.2	0.6	1,100	750	5,950	1030	900	750	840	.61 J	24,000	1.4	0.9	1.6

Acronyms/Abbreviations:

-- Not Sampled
Ca Calcium
COD Chemical Oxygen Demand
DOC Dissolved Oxygen Content
Fe Iron
J The result is an estimated concentration that is less than the method reporting limit but greater than or equal to the method detection limit
Mg Magnesium
mg/L Milligrams per Liter
Mn Manganese
--ND Non-Detectable
TOC Total Organic Carbon
µg/L Micrograms per Liter
VOC Volatile Organic Carbon

Notes:

[1] Secondary parameters to represent baseline conditions (October 2018) at AOC-1 were sampled at nearby wells with AMW-53A and MW-1A. The average was used for comparison to future tests.
[2] TCE concentrations in AOC-1-GP-01 and AOC-1-GP-05 were collected using direct push, prior to well installation.

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Appendix A

Preliminary Design Verification Testing

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16 November 2018
15240.69

Mr. Jonathan Williams
U.S. Environmental Protection Agency
Region 10 (ECL-111)
1200 Sixth Avenue
Seattle, Washington 98101

Subject: Design Verification Testing Preliminary Report
Boomsnub/Airco Superfund Site
Hazel Dell, Washington – Revision 0
EPA Docket Number CO7-5163 FDB

Dear Mr. Williams:

On behalf of Linde LLC, EA Engineering, Science, and Technology, Inc., PBC (EA) is submitting this preliminary report to summarize the field activities and preliminary results from the design verification testing (DVT) at the Boomsnumb/Airco Superfund Site (Site). This preliminary report will be followed up in 2019 with a summary report, which will include groundwater analytical results and results from the Phase 1 treatment pilot test, as well as a proposed design for full scale treatment.

The design verification testing work was conducted in accordance with the final *Work Plan for In-Situ Groundwater Treatment for Areas of Residual Contamination for the Boomsnub/Airco Superfund Site*, Revision 0, which was revised based on comments received from you on 27 July 2018, and on discussions with you on 9 August 2018 regarding our response to comments.

Test activities were conducted from 18 August 2018 through 18 September 2018 and included the following activities:

- Vertical delineation of plume using passive flux meters (PFMs), passive diffusion bags (PDBs), and collection of water samples from direct push boreholes.
- Horizontal delineation of contamination using direct push boreholes.
- Installation of two wells for performance monitoring.
- Injection testing.

Figures 1 and 2 present the DVT locations for area of concern 1 (AOC-1) and AOC-2, respectively.

Passive Flux Meters

The PFMs were installed on 18 August 2018 to calculate the groundwater velocity and contaminant flux within the aquifer. In AOC-1, two PFMs were installed in series within well MW-1A to cover the 10-ft screened interval from approximately 28 ft below top of casing (btoc) to 38 ft btoc. In AOC-2, two PFMs were installed in series within well MW-18E to cover the 10-ft screened interval from approximately 112 ft btoc to 122 ft btoc.

The PFMs were pulled and sampled on 7 September 2018 after the 2-week (minimum) equilibration period. Three samples were collected from each of the 5-ft PFMs and were sent to EnviroFlux for analysis. Table 1 summarizes the results from the PFMs.

The PFMs provide information on contaminant concentration and flux. As shown in Table 1, higher trichloroethylene (TCE) concentrations were reported in AOC-2, with the greatest concentrations seen between elevations from approximately 150 to 143 ft. Darcy velocities ranged from 2.8 to 3.5 centimeter per day (cm/day) in AOC-1, and 6.9 to 14.9 cm/day in AOC-2. Contaminant flux in AOC-1 ranged from 0.8 to 2.9 milligram per meter squared per day ($mg/m^2/day$). Due to a larger range of TCE concentrations in AOC-2, this area had much more variability in TCE flux, which ranged from 2.5 to 53 $mg/m^2/day$.

Table 1. TCE Contaminant Flux and Concentration Results from Passive Flux Meters

Well_ID	Sample_ID	Depth	Elevation	Darcy Velocity	TCE	TCE Flux
		(ft btoc)	(ft)	(cm/day)	(µg/L)	($mg/m^2/day$)
MW-1A	**MW-1A-31.12**	31.1	254.39	2.9	69	2.0
	MW-1A-32.78	32.8	252.69	2.8	71	2.0
	MW-1A-34.44	34.4	251.09	3.8	20	0.8
	MW-1A-34.94	34.9	250.59	3.1	95	2.9
	MW-1A-36.6	36.6	248.89	3.5	54	1.9
	MW-1A-38.26	38.3	247.19	3.0	44	1.3
MW-18E	**MW-18E-111.8**	111.8	149.97	11.6	456	53.0
	MW-18E-113.4	113.4	148.37	7.8	401	31.4
	MW-18E-115.0	115.0	146.77	6.9	215	14.9
	MW-18E-118.5	118.5	143.27	7.9	135	10.7
	MW-18E-120.1	120.1	141.77	12.2	21	2.5
	MW-18E-121.7	121.7	140.07	14.9	63	9.5

Passive Diffusion Bags

Passive diffusion bags (PDBs) were installed on 18 August 2018. In AOC-1, two PDBs were installed in series within well AMW-53A to cover the 10-ft screened interval from 22 ft btoc to 32 ft btoc. In AOC-2, four PDBs were installed in series within well MW-18D to cover the interval from approximately 83 ft btoc to 93 ft btoc. The PDBs were retrieved and sampled on 7 September 2018 after the 2-week (minimum) equilibration period. The samples were collected and analyzed for volatile organic compounds (VOCs), including TCE. Results of this sampling are presented in Table 2. Contaminant concentrations were highest at approximately 32 feet below ground surface (bgs) (249.1 ft elevation) in AMW-53A, and concentrations increased with depth at MW-18D, with highest concentrations at 172.5 feet elevation.

Table 2. TCE Results from Passive Diffusion Bag

Well_ID	Sample_ID	Elevation (ft)	TCE (µg/L)
AMW-53A	**AMW-53A-28.94**	252.11	1.3
	AMW-53A-31.94	249.11	7.6
MW-18D	**MW-18D-84.78**	177.96	12
	MW-18D-86.94	175.80	13
	MW-18D-89.2	173.54	17
	MW-18D-90.2	172.54	18

Direct Push Boreholes

Direct push borings were advanced in AOC-1 and AOC-2 between August 27 and September 14, 2018. Upon completion of sampling activities, two of the boreholes at AOC-1 were finished as 2-in diameter temporary monitoring wells screened from 30 to 50 ft bgs. All other boreholes advanced in AOC-1 and AOC-2 were grouted and decommissioned by a licensed driller in accordance with Washington Administrative Code (WAC) 173-160, under EA oversight. The borehole locations were surveyed by a licensed surveyor. In AOC-1, six direct push borings were advanced to a depth of approximately 50 ft bgs. Soil cores were obtained from the wells to log soils; soils were logged within the expected treatment zone from 30 ft bgs to 50 ft bgs. The boring logs are included in Attachment 1. A direct push sampler with a retractable screen was also used to collect groundwater samples at each location. Groundwater samples were collected at depths of 35 ft, 40 ft, and 45 ft bgs. The samples were collected and sent to the lab to be analyzed for VOCs, including TCE. Analytical results are presented in Table 3.

Table 3. TCE Results from Direct Push Borings in AOC-1

Depth (ft btoc)	Elevation Range (ft)	AOC-1-GP-01	AOC-1-GP-02	AOC-1-GP-03	AOC-1-GP-04	AOC-1-GP-05	AOC-1-GP-06
35	246.08-246.86	**71**	**36**	**18**	**23**	**40**	0.63
40	241.08-241.86	0.76	0.75	0.34 J	0.80	0.87	1.1
45	236.08-236.86	0.72	0.45 J	0.49 J	0.65	0.35 J	0.63

Notes:
Results presented in µg/L If a duplicate sample was collected, the highest result is presented in this table.
Results in **bold** exceed established cleanup levels for TCE.
J: Estimated value (detected at concentrations less that method reporting limit).

In AOC-2, six direct push borings were advanced to a depth of approximately 120 ft bgs (Figure 2). Soil cores were obtained from one of the wells to log soils (AOC-2-GP-01); soils were logged from 70 ft bgs to 85 ft bgs. The boring log is included in Attachment 1. Obtaining soil cores beyond this depth was not feasible using direct push methods. Therefore, soil cores were not obtained from the other borings in AOC-2. A direct push sampler with a retractable screen was used to collect groundwater samples at each location. Groundwater samples were collected at depths of 90 ft, 100 ft, 110 ft, and 120 ft bgs, except at AOC-2-GP-02 where water could not be obtained from 120 ft bgs. The samples were collected and sent to the lab to be analyzed for analyzed for total chromium and VOCs, including TCE. The results of this sampling are shown in Table 4 for TCE and in Table 5 for chromium.

Table 4. TCE Results from Direct Push Borings in AOC-2

Depth (ft btoc)	Elevation Range (ft)	AOC-2-GP-01	AOC-2-GP-02	AOC-2-GP-03	AOC-2-GP-04	AOC-2-GP-05	AOC-2-GP-06
90	169.32-172.24	**6**	2.3	**31**	3	3.9	2.9
100	159.32-162.24	**69**	**170 D**	**170 D**	**110 D**	**18**	**5.8**
110	149.32-152.32	**87 D**	**260 D**	0.46 J	0.12 J	**78 D**	**130 D**
120	139.32-142.32	0.34 J	NS	ND	**6.6**	0.10 J	ND

Notes:
Results presented in µg/L. If a duplicate sample was collected, the highest result is presented in this table.
Results in **bold** exceed established cleanup level for TCE (5 µg/L).
D: The reported result is from a dilution.
J: Estimated value (detected at concentrations less than method reporting limit).
ND: The analyte was analyzed for but was not detected ("Non-detect") at or above the method reporting limit.
NS: No sample was collected from this elevation.

Table 5. Chromium Results from Direct Push Borings in AOC-2

Depth (ft btoc)	Elevation Range (ft)	AOC-2-GP-01	AOC-2-GP-02	AOC-2-GP-03	AOC-2-GP-04	AOC-2-GP-05	AOC-2-GP-06
90	169.32-172.24	1.3 J	16.3	7.2	37.3	78.4	53.3
100	159.32-162.24	4.8	0.9 J	ND	ND	0.7 J	**112**
110	149.32-152.32	ND	ND	ND	ND	ND	ND
120	139.32-142.32	ND	NS	ND	5.3	1.2 J	0.8 J

Notes:
Results presented in µg/L. If a duplicate sample was collected, the highest result is presented in this table.
Results in **bold** exceed established cleanup level for chromium (80 µg/L).
J: Estimated value (detected at concentrations less than method reporting limit).
ND: The analyte was analyzed for but was not detected ("Non-detect") at or above the method reporting limit.
NS: No sample was collected from this elevation.

Injection Testing

Injection testing was performed in both AOC-1 and AOC-2; Figures 1 and 2 show the locations of the injection tests. In AOC-1, a boring was advanced to a depth of approximately 50 ft bgs. Water was then injected bottom up from approximately 47 ft bgs in 5-ft intervals up to 32 ft bgs. In AOC-2, a boring was advanced to a depth of approximately 90 ft bgs. Water was injected top down from approximately 90 ft bgs and profiled in 10-ft segments down to 110 ft bgs. advanced approximately 10 ft between each injection point.

During the testing, the injection rate, injection pressure, and total volume of injected water was recorded. Additionally, the static water level in nearby monitoring wells were recorded throughout the test, if available. The injection test logs are included in Attachment 2. In general, water flowed into the formation at approximately 2.5 gallons per minute (gpm) in AOC-1, and approximately 3.1 gpm in AOC-2, with variations noted with depth.

Summary and Conclusions

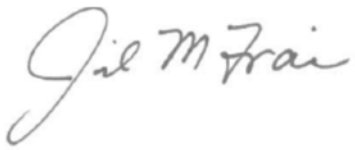
In general, the DVT results further defined extent of contamination, and also identified a couple of data gaps. It should be noted that concentrations of contaminants in samples from direct push borings do not correlate to concentrations that would be measured in a properly installed and developed well, sampled in accordance with an approved quality assurance sampling plan using low-flow sampling methodology. Typically, the direct push results tend to be higher, but they are useful in identifying areas of contamination for future treatment. Also note that the highest TCE concentrations measured were found in the passive flux meters, which collects TCE in absorbent media over a two-week period, which would bias samples high.

In AOC-1, TCE concentrations in groundwater ranged from estimated values, less than the method reporting limit, to 95 micrograms per liter (µg/L). Vertical extent of contamination was found at approximately 35 ft bgs. Contamination was bounded to the west (downgradient) at location AOC-1-GP-06, where reported TCE concentrations were below the established cleanup level of 5 µg/L. Historically, contamination to the north and south has been bounded by the monitoring wells along NE 47th Avenue, to the north at monitoring well AMW-53A, where TCE concentrations are fluctuating above and below the cleanup level, and to the south by monitoring well AMW-54A.

In AOC-2, TCE concentrations in groundwater ranged from below detection to 456 µg/L. The results indicate that the vertical extent of TCE contamination is generally between 149 ft and 169 ft elevation. The horizontal extent of the contamination was not defined during this round of sampling.

Please let me know if you have any questions regarding the test results. We look forward to compiling the results of the pilot test conducted in October 2018 and presenting a full-scale design in 2019.

Sincerely,
EA ENGINEERING, SCIENCE AND
TECHNOLOGY, INC., PBC

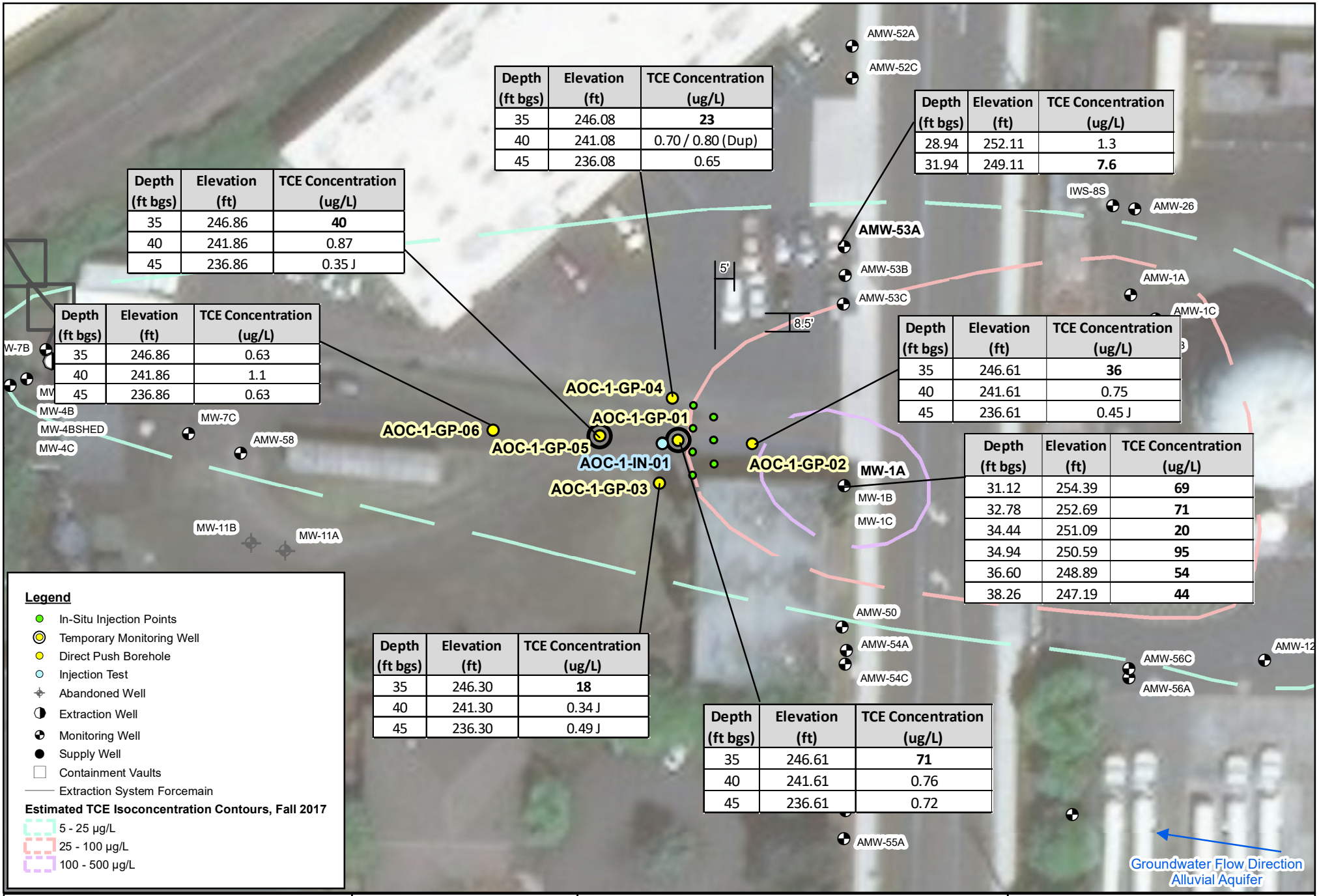


Jil Frain, P.E.
Project Coordinator

Figures
Attachment 1 – Boring Logs
Attachment 2 – Injection Test Logs

cc: Lee Thomas, EPA (electronic copy)

Figures



Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.08	**23**
40	241.08	0.70 / 0.80 (Dup)
45	236.08	0.65

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
28.94	252.11	1.3
31.94	249.11	**7.6**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.86	**40**
40	241.86	0.87
45	236.86	0.35 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.86	0.63
40	241.86	1.1
45	236.86	0.63

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.61	**36**
40	241.61	0.75
45	236.61	0.45 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
31.12	254.39	**69**
32.78	252.69	**71**
34.44	251.09	**20**
34.94	250.59	**95**
36.60	248.89	**54**
38.26	247.19	**44**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.30	**18**
40	241.30	0.34 J
45	236.30	0.49 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
35	246.61	**71**
40	241.61	0.76
45	236.61	0.72

Legend

- In-Situ Injection Points
- Temporary Monitoring Well
- Direct Push Borehole
- Injection Test
- Abandoned Well
- Extraction Well
- Monitoring Well
- Supply Well
- Containment Vaults
- Extraction System Forcemain

Estimated TCE Isoconcentration Contours, Fall 2017

- 5 - 25 µg/L
- 25 - 100 µg/L
- 100 - 500 µg/L

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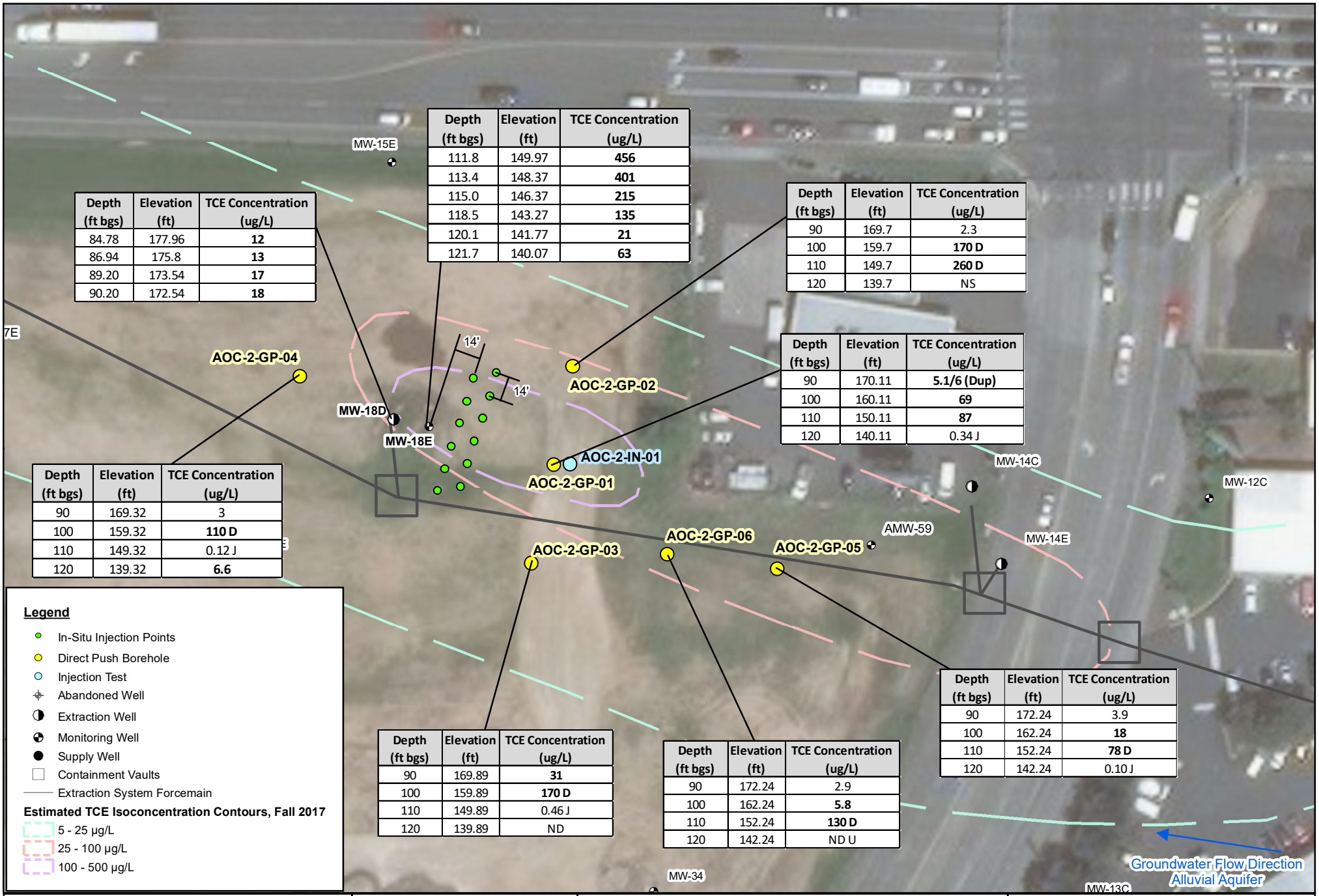
EA Project No. 1524069
File Location: \\seattlefp\Seattle\Projects\1524069 In Situ Treatment\DVT Letter\GIS\Fig_1_AOC-1_DVT_Results.mxd
File Name: Fig_1_AOC-1_DVT_Results

FIGURE 1
SAMPLING RESULTS, AOC-1



Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
84.78	177.96	**12**
86.94	175.8	**13**
89.20	173.54	**17**
90.20	172.54	**18**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
111.8	149.97	**456**
113.4	148.37	**401**
115.0	146.37	**215**
118.5	143.27	**135**
120.1	141.77	**21**
121.7	140.07	**63**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	169.7	2.3
100	159.7	**170 D**
110	149.7	**260 D**
120	139.7	NS

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	170.11	**5.1/6 (Dup)**
100	160.11	**69**
110	150.11	**87**
120	140.11	0.34 J

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	169.32	3
100	159.32	**110 D**
110	149.32	0.12 J
120	139.32	**6.6**

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	169.89	**31**
100	159.89	**170 D**
110	149.89	0.46 J
120	139.89	ND

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	172.24	2.9
100	162.24	**5.8**
110	152.24	**130 D**
120	142.24	ND U

Depth (ft bgs)	Elevation (ft)	TCE Concentration (ug/L)
90	172.24	3.9
100	162.24	**18**
110	152.24	**78 D**
120	142.24	0.10 J

Legend

- In-Situ Injection Points
- Direct Push Borehole
- Injection Test
- Abandoned Well
- Extraction Well
- Monitoring Well
- Supply Well
- Containment Vaults
- Extraction System Forcemain

Estimated TCE Isoconcentration Contours, Fall 2017

- 5 - 25 µg/L
- 25 - 100 µg/L
- 100 - 500 µg/L

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File Name: Fig_2_AOC-2_DVT_Results

FIGURE 2
SAMPLING RESULTS, AOC-2

Boring Logs

GP-01

BORING/WELL CONSTRUCTION LOG

Project:	Linde-Boomsnub In-Situ	Project Number: 15240.69	well
Drilling Company:	Cascade Drilling	Start Time/Date: 8/30/18 1140	8/31/18 0845
Drilling Rig/Bit:	Geoprobe 7720 DT	Completion Time/Date: 8/30/18 1600	8/31/18 1230
Driller:	Kyle Kemp	Final Depth: 50'	
Boring/Well ID:	AOC-1-GP-01	Logged By: M. Blomstrub	Page 1 of 1

Sample Type	Recovery (inches)	Sample Interva	PID Reading (ppmv)	USCS Soil Type	Depth, ft bgs	Soil Description (soil type, color, density/consistency, plasticity, moisture, grain size, angularity/minerology, other)
					1	
					2	Vacuum cleared
					3	
					4	
					5	
			0	SP/SM	6	Silty sand, 10YR 3/4, Sand fine 70%, med 10%, silt 20% Dry
					7	
				SP	8	Sand, 10YR 3/4, Sand fine 80%, med 15%, silt 5%, Dry
					9	
					10	
			0		11	
					12	
				SP	13	Sand, 10YR 3/4, Sand fine 90%, med 5%, silt 5% Dry
					14	
					15	
					16	
			0		17	
				SP	18	Sand, 10YR 3/3, Sand fine 30%, med 50%, coarse 20, Dry
					19	
					20	
					21	
			0		22	
				SP	23	
					24	Moist
				SP/SM	25	Silty sand, 10YR 3/3, Sand fine 75% med 5% silt 20%, wet slightly plastic, wet
			0		26	
					27	
					28	
					29	
				SP	30	Sand, fine 60%, med 35, silt 5%, wet.
			0		31	
					32	
					33	
				M	34	Silt, 10YR 4/4, silt 70%, fine sand 30%, wet. slightly plastic
				SP	35	Sand, fine 40%, med 40%, coarse 10%, silt 5%, wet, 10YR 4/3
			0		36	
					37	
				SP	38	
					39	
					40	
			0		41	
					42	
				SP	43	
					44	
					45	
			0	SP	46	
					47	
				SM	48	Silty sand, 10YR 3/3 Silt 70%, fine sand 30%, wet.
					49	
				SP	50	
					51	End
					52	
					53	
					54	
					55	

Boring and/or Well Details

3/8" Hole
Plug
Grout
Bentonite
Blank casing
Prepacked screens w/ 10/20 Sand
Cap

DTW = 27.10' @ 1345

DTW = 36.10 @ 1437

DTW = @

SS = Split Spoon CUT = Drill Cuttings

GP-02

BORING/WELL CONSTRUCTION LOG

Project:	Linde-Boomsnub In-Situ	Project Number:	15240.69
Drilling Company:	Cascade Drilling	Start Time/Date:	8/29/18 0840
Drilling Rig/Bit:	Geoprobe 7720 DT	Completion Time/Date:	8/29/18 1400
Driller:	Kyle King	Final Depth:	50'
Boring/Well ID:	AOC-1-GP-02	Logged By:	M. Blumb Page 1 of 1

Sample Type	Recovery (inches)	Sample Interval	PID Reading (ppmv)	USCS Soil Type	Depth, ft bgs	Soil Description (soil type, color, density/consistency, plasticity, moisture, grain size, angularity/minerology, other)	Boring and/or Well Details
					1–5	Vacuum cleared.	
					6–20		
			0	SP	21–22	Sand, Med/70% Fine 30% Dry 10YR 3/4	
				SP-SM	25	Sand w/silt, 80% fine, 10% med, 10% silt. Wet, Non-plastic.	
			0	SP	26		
				SP-SM	27–29	10YR 4/3	
				SP	30	Sand, Med 70%, fine 30%, wet 10YR 4/3,	
		0940	0	SP	31	Sand Med 20%, fine 80% wet " "	
				SP-SM	34–35	Sand w/Silt, Sand fine 90%, silt 10%, 10YR 3/4, Non-plastic	
		1022	0	SP	36	10YR 3/4, Sand 20% med, 80% fine, wet	
		1120	0	SP	41–45		
			0	SP-SM	48	Sand w/Silt, 10YR 3/4, Sand fine 90%, Silt 10%	
				SP	50	Sand as above. Med 20%, fine 80%	

31-35 ΔTW=31.20' bgs @0930

ΔTW=30.5' bgs @1018

ΔTW=32.3' bgs @

SS = Split Spoon CUT = Drill Cuttings

GP-03 BORING/WELL CONSTRUCTION LOG

Project: 1524069 Linde-Boomsnub In-situ DVT		Project Number: 15240.69	
Drilling Company: Cascade Drilling		Start Time/Date: 8/27/18	1535
Drilling Rig/Bit: GEOPROBE 7720		Completion Time/Date: 8/28/18	1105
Driller: KYLE KING		Final Depth: 50 FT BGS	ABANDONED
Boring/Well ID: AOC-1-GP-03		Logged By: ~~Mark Blinstrub~~ GARRETT LEE	Page 1 of 1

Sample Type	Recovery (inches)	Sample Interva	PID Reading (ppmv)	USCS Soil Type	Depth, ft bgs	Soil Description (soil type, color, density/consistency, plasticity, moisture, grain size, angularity/minerology, other)	Boring and/or Well Details
					1		
					2	VAC TRUCK	
					3		
					4		
					5	LARGE-SMALL, ANGULAR, SUBANGULAR	
	1			GP	6	GRAVEL, GP, MOIST 75% GRAVEL, 15% SAND, 10% SILT	
	PO				7		
				SM	8	BROWN, SM, SILTY SAND, 60% SAND, FINE, UNI	
					9	40% SILT, NON-PLASTIC	
					10		
1/2					11	LAYER OF GRAVEL (MED-SMALL)	
	9.5			SM	12		
					13	10YR 3/4 DARK-YELLOWISH BR.	
					14		
					15		
1 1/2					16	GRAVEL (MED-SMALL) - LAYER	
					17	SAND, MED-FINE, UNI 75% SAND, 25 SILT	
	8.5			SM	18		DRY
					19	SAND, FINE, UNI 70% SAND, 30 SILT	
					20		
1				SM	21	MED-FINE, UNI 75% SAND, 25 SILT	
				ML	22	MOIST, SILT, SLIGHTLY PLASTIC, 70% SILT	30% SAND
					23		
				SM	24	SAND, FINE, UNI 85% SAND, 15% SILT	
					25		
1 1/2					26		
				ML	27	MOIST, ML, SILT, SLIGHTLY PLASTIC, 80% SILT, 20 SAND FINE UNI	
					28		
				SP-SM	29	SAND, FINE, UNI, 10 YR 3/4, 90% SAND, 10% SILT (NON-PLASTIC)	
29.7 ▽					30	MOIST-WET	
					31		
DTW=30.0	10.0			SP-SM	32	WET SAND, FINE, UNI 90% FINE, 10% MED, 10 SILT	
GW SAMP					33		
				ML	34	WET ML SILT, NO PLASTIC, 10 YR 3/2 90% SILT, 10 SAND	
				SP	35		
					36		
DTW=37.25	10.0				37	WET, SAND, FINE, UNI 95% FINE, 10% MED, 5% SILT (NP) LESS SILT	
@ 930 GW					38		
SAMP					39	SAND, MED-FINE 10% 30% 5% SILT	
					40	10YR 3/2	
					41	SAND, FINE, UNI GRAVEL, SMALL ANG-SUBANG, 60% FINE, 15% MED 15% GRAVEL, 5 SILT	
DTW=39.12	10.0			SP	42		
@ 1010 GW					43	SAND, MED, FINE, UNI 85% FINE, 10% MED, 5% SILT	
SAMP					44		
					45	SAND, FINE, UNI 95% FINE, 5% SILT	
					46		
	10.0			SP	47	90% FINE SAND, 10 MED, 5 GRAVEL, 5 SILT	
					48	WET (UNI) (ANG) (SUB-ANG) (UNI)	
				SP-SM	49	90% FINE SAND, WET UNI, 10% SILT (NON-PL)	
				SC	50	85% FINE, WET, UNI 10 MED, 5 SILT (NP)	
					51		
					52		
					53		
					54		
					55		

SS = Split Spoon CUT = Drill Cuttings

BORING/WELL CONSTRUCTION LOG

Project: 154069 Linde-Boomsnub In-Situ		Project Number: 15240.69	
Drilling Company: Cascade Drilling		Start Time/Date: 1140 8/28/18	
Drilling Rig/Bit: GEOPROBE 7720		Completion Time/Date: 1700 8/28/18	
Driller: KYLE KING		Final Depth: 50' BGS, ABANDONED	
Boring/Well ID: AOC-1-GP-04		Logged By: M. BLINSTRUB, G. LEE	Page 1 of 1

Sample Type	Recovery (inches)	Sample Interval	PID Reading (ppmv)	USCS Soil Type	Depth, ft bgs	Soil Description (soil type, color, density/consistency, plasticity, moisture, grain size, angularity/minerology, other)	Boring and/or Well Details
					1		
					2		
					3		
					4		
					5		
					6		
					7	UAC TRUCK	
					8		
					9		
					10		
					11		
					12		
					13		
					14		
					15		
					16		
					17	w/ LOCKING	
					18		
					19	ARSW CO	
					20		
					21		
10 SW					22		
				SP	23	SAND, UNIF, FINE 90%, MED 10%, DRY 10 YR 3/4	
				SP	24	SAND, " DRY 10 YR 4/3	
WL=25.5' BGS				SP-SM	25	SAND, UNIF, FINE, 90%, SILT 10% (NP) MOIST 10 YR 3/4	
12 SW					26		
				SP-SM	27	WET	
					28		
					29		
				SP	30	SAND, UNIF, FINE 90%, MED 10%, WET 10 YR 3/4	
10 SW					31		
DTW=27.3' BGS				SP	32		
GW SAMPLE					33		
				SP-SM/SP	34	SAND, UNIF, FINE 90%, SILT 10% (NP) WET 10 YR 3/4	
					35		
DTW=26.58' BGS			0		36		
			0		37		
GW SAMPLE			0	SP	38	WET, FINE 90%, MED 10% 10 YR 3/4	
			0		39		
			0	SP	40	SAND, FINE 75%, MED 15%, COARSE 10% 10 YR 3/4	SAND GRAVEL 5% (NON-CONTRIB)
			0		41	SAND, FINE 90%, MED 10%	
			0	SP	42		
DTW=41.13' BGS			0		43	10 YR 3/4 WET	
			0		44		
GW SAMPLE			0	SP-SM	45	SAND, UNIF, FINE 90%, SILT 10% (NP) WET 10 YR 3/4	
			0		46		
			0	SP	47	SAND, FINE 90%, MED 10%, UNIF, WET 10 YR 3/4	
			0		48		
			0	SP-SM	49		
			0	SP	50		
					51		
					52		
					53		
					54		
					55		

SS = Split Spoon CUT = Drill Cuttings

GP-05

BORING/WELL CONSTRUCTION LOG

Project:	Linde-Boomsnub In-Situ	Project Number:	15240.69		Well
Drilling Company:	Cascade Drilling	Start Time/Date:	8/29/18 1415		8/31/18 1340
Drilling Rig/Bit:	Geoprobe 7720 DT	Completion Time/Date:	8/30/18 1050		9/4/18 1145
Driller:	Kyle King	Final Depth:	50' bgs		
Boring/Well ID:	AOC-1 / GP-05	Logged By:	M. Blinstrub	Page 1 of 1	

Sample Type	Recovery (inches)	Sample Interval	PID Reading (ppmv)	USCS Soil Type	Depth, ft bgs	Soil Description (soil type, color, density/consistency, plasticity, moisture, grain size, angularity/minerology, other)
			0		1–5	Vacuum cleared
			0	SM	6–8	10YR 3/3, Silty Sand, Silt 25%, Sand fine 60%, med 15%, Dry, slightly plastic
			0	SP	9–10	10YR 3/3, Sand, fine 95%, Silt 5%, Dry
			0	SP	11–15	10YR 3/3, Sand 75% fine, 20% med, 5% Silt, Dry
			0	SP	16–20	Sand fine 40%, med 20%, coarse 30%, Dry
			0	SP / SP-SM / SP	21–25	Silty sand, sand fine 60%, sand med 20% silt 20%, moist, 10YR 3/4
			0	SP / SP-SM / SP	26–30	Silty sand, sand fine 70%, med 10%, silt 20% wet. Sand, fine 60% med 30% coarse 5%, silt 5% 10YR 4/3 moist
			0	SP	31–34	Sand, fine 40, med 45, coarse 15%, silt 5% 10YR 4/3 wet.
				SP-SM	35	Silty sand, sand fine 70%, med 10%, silt 20%, wet.
			0	SP	36–40	Sand, fine 35% med 50%, coarse 10%, silt 5% wet. 10YR 4/3
			0	SP	41–45	
			0	SP / SP-SM / SP	46–50	Silty Sand, 10YR 4/3, Sand fine 70%, med 10%, Silt 20% wet. Sand, fine 35%, med 50%, coarse 10%, silt 5%, wet.
					51–55	

Boring and/or Well Details: Bentonite; Blank casing; Grout; Pea gravel; prepacked screen w/ 10/20 sand; sump

DTW = 30.70' bgs @ 1527

DTW = 31.90' bgs @ 825 8/30/18

DTW = 36.10' bgs @ 0920

SS = Split Spoon CUT = Drill Cuttings

GW SAMPLES FROM 31'-35', 36'-40', 41'-45'

INITIAL DTW
26.6 FT BGS

BORING/WELL CONSTRUCTION LOG

Project:	1624069 Linde-Boomsnub In-Situ	Project Number:	15240.69
Drilling Company:	Cascade Drilling	Start Time/Date:	8/22/19 1040
Drilling Rig/Bit:	7720	Completion Time/Date:	8/22/19 1325
Driller:	KYLE KING	Final Depth:	50' BGS ; ABANDONED
Boring/Well ID:	AOC-1-GP-06	Logged By:	GARRETT LEE Page 1 of 1

Sample Type	Recovery (inches)	Sample Interva	PID Reading (ppmv)	USCS Soil Type	Depth, ft bgs	Soil Description (soil type, color, density/consistency, plasticity, moisture, grain size, angularity/minerology, other)	Boring and/or Well Details
					1–25		
					26		
					27	▽ DEPTH TO WATER (INITIAL) = 26.6 FT BGS	
					28–30		
					31		
				SM	32–35	SAMPLE @ 1138 DTW = 26.6 FT BGS SILTY SAND; LIGHT BROWN; WET; FINE, UNIFORM SAND	
					36		
				ML	37–40	SAMPLE @ 1219 DTW = 28.1 FT BGS SANDY SILT; LIGHT BROWN; WET; FINE, UNIFORM SAND	
					41		
				ML	42–45	SAMPLE @ 1317 DTW = 31.1 FT BGS SILT, LIGHT BROWN, WET	
					46–55		

SS = Split Spoon CUT = Drill Cuttings

AOC-2
GP-01

BORING/WELL CONSTRUCTION LOG

Project:	Linde-Boomsnub In-Situ	Project Number:	15240.69
Drilling Company:	Cascade Drilling	Start Time/Date:	9/5/18
Drilling Rig/Bit:	7720DT / 7730DT	Completion Time/Date:	
Driller:	Kyle King	Final Depth:	
Boring/Well ID:	AOC-2-GP-01	Logged By:	Mr Blumstub Page ____ of ____

Sample Type	Recovery (inches)	Sample Interval	PID Reading (ppmv)	USCS Soil Type	Linear Feet	Soil Description (soil type, color, density/consistency, plasticity, moisture, grain size, angularity/minerology, other)	Boring and/or Well Details
					46		
					47		
					48		
					49		
					50		
					51		
					52		
					53		
					54		
					55		
					56		
					57		
					58		
					59		
					60		
					61		
					62		
					63		
					64		
					65		
					66		
					67		
					68		
					69		
					70		
				SP	71	10YR 4/3, sand, v. fine 60%, med sand 35%, silt 5%, wet	
					72		
					73		
					74		
				SM	75	10YR 4/3, silty sand, silt 50%, v fine sand 30%, fine 20%, wet.	
					76		
					77		
					78	No core.	
					79		
					80		
				SP	81	10YR 4/3, sand, v. fine 40%, fine sand 40%, med 15%, silt 5% wet	
					82		
					83	sand, v. fine 20%, fine 30%, med 45%, silt 5%, wet	
					84		
					85		
					86	stop soil cores. Not feasible with [redacted] probe.	
					87		
					88		
					89		
					90		

SS = Split Spoon CUT = Drill Cuttings

Injection Test Logs

Date 9/17/18 Page 1 of _____

Equipment Used 2½ inch internal screeded 5' injection point

Notes AOC-1-IN-01

To perform the injection test, a direct push tooling rod will begin injecting water at 50 feet bgs, in 3-ft segments until the water table (or top of screen) is reached. The static water level in the nearby monitoring well will be recorded before the start of the test. During the testing, the injection rate (gallons per minute [gpm]), injection pressure (pounds per square inch [psi]), total volume of injected water (gallons), and depth to water should be recorded every 3 minutes. The injection flow rate will remain between 2 to 10 gpm throughout the test, and the pressure within the 20 to 80 psi range. The flow rate and injection pressure should be varied throughout the test to measure the aquifer response to increases/decreases. After the injection testing is complete, the recovery of the water table within the monitoring well should be recorded for 30 minutes.

Time	Injection Depth	Injection Pressure	Flow Rate	Volume Injected	Water Level	Water Level
	feet bgs	psi	gpm	gal	Closest Well	Downgradient Well
					GP-01	GP-05
Baseline	--	--	--	--	26.12	26.56
11:25	47	110	3.5		26.11	26.56
11:32	47	90	3.1		26.08	26.56
11:35	47	50	3.1		26.08	26.56
11:38	47	75	3.1		26.08	26.56
11:41	47	60	3.1		26.08	26.56
11:44	47	35	3.1		26.08	26.56
11:47	47	40	3.1		26.08	26.56
11:50	47	42	3.1		26.08	26.56
11:53	47	45	3.1		26.09	26.56
11:56	47	45	3.1		26.09	26.56
11:59	47	45	3.1	110	26.09	26.56
12:15	42	100	2.5		26.10	26.56
12:18	42	80	2.0		26.10	26.56
12:21	42	90	1.5		26.10	26.56
12:24	42	100	1.5		26.10	26.56
12:27	42	60	1.5		26.10	26.56
12:30	42	60	1.5		26.10	26.56
12:33	42	80	2.0		26.10	26.56
12:36	42	60	1.5		26.10	26.56
12:39	42	60	1.5		26.10	26.56
12:50	42	90	1.5	65	26.10	26.56
13:52	37	80	3.5		26.10	26.56
13:57	37	80	3.5		26.10	26.56
14:02	37	90	3.6		26.10	26.56
14:07	37	100	3.6		26.10	26.56
14:22	37	100	3.5	106	26.10	26.56
14:30	32	100	2.4		26.10	26.56
14:35	32	100	2.35		26.10	26.56
14:40	32	100	2.35		26.10	26.56
14:45	32	125	2.20		26.10	26.56
14:50	32	100	2.03		26.10	26.56
14:55	32	100	1.55		26.10	26.56
15:00	32	80	1.50	62	26.10	26.56

243 gallons Total

Date 9/18/18 Page 1 of 1

Equipment Used 1 ½ inch internal screened 5' injection Point

Notes AOC-2-IN-01

To perform the injection test, a direct push tooling rod will begin injecting water at 50 feet bgs, in 3-ft segments until the water table (or top of screen) is reached. The static water level in the nearby monitoring well will be recorded before the start of the test. During the testing, the injection rate (gallons per minute [gpm]), injection pressure (pounds per square inch [psi]), total volume of injected water (gallons), and depth to water should be recorded every 3 minutes. The injection flow rate will remain between 2 to 10 gpm throughout the test, and the pressure within the 20 to 80 psi range. The flow rate and injection pressure should be varied throughout the test to measure the aquifer response to increases/decreases. After the injection testing is complete, the recovery of the water table within the monitoring well should be recorded for 30 minutes.

Time	Injection Depth	Injection Pressure	Flow Rate	Volume Injected	Water Level	Water Level
	feet bgs	psi	gpm	gal	Closest Well	Downgradient Well
					~~GP-01~~	~~GP-05~~
Baseline	--	--	--	--	N/A	N/A
13:00	90	130	4.6	↓		
13:05	90	120	4.5			
13:10	90	100	4.0		Surface	Water coming up Bore hole.
13:15	90	100	4.1	↓		
Push Rod to 100'				~~65~~ 65 RRR		
13:20	100	100	4.5	↓		
13:25	100	100	5.1			
13:30	100	100	4.9			
13:35	100	70	4.7	↓		
Pushed Rod to 110'				72		
13:50	110	130	0.5	↓		
13:55	110	130	0.87			
14:00	110	160	0.92			
14:05	110	150	0.53			
14:10	110	140	0.64	↓		
				10.5		
				147.5	Total	

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Appendix B

AOC-1 Summary Report

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November 7, 2018

REGENESIS Proposal No. ChL60819

Jil Frain
EA Engineering, Science, & Technology, Inc., PBC
2200 6th Avenue, Suite 707
Seattle, WA 98121

SUBJECT: Application Summary Report for Remedial Services at the Boomsnub/Airco Superfund Site

Dear Ms. Jil Frain,

REGENESIS Remediation Services (RRS) has recently completed an *in-situ* injection application of PlumeStop®, PlumeStop S®, and AquaZVI™ at the Boomsnub/Airco Superfund Site located at 7608 NE 47th Avenue, Vancouver, WA 98661. The goal of the remedial application was to rapidly address and prevent the VOC groundwater plume from migrating downgradient from OU2; TCE groundwater concentrations in the area of this pilot test are approximately 77 µg/L or less. RRS employed *in-situ* sorption and *in-situ* chemical reduction (ISCR) technologies to meet remediation goals.

RRS mobilized product, support pickup truck, injection trailer, and personnel to the site to begin work over four (4) days on October 16th through October 19th, 2018. RRS staffed this project with an experienced Project Supervisor who ensured a safe, successful injection application. Injection product was applied to the subsurface via direct push technology. After the remedial agent was applied, RRS flushed nearby AOC-1-GP-01 to ensure no particulate buildup occurs within the monitoring well.

Please review the attached application summary page, injection log, and photo log for more detail on the application.

RRS appreciates the opportunity to work at this site with EA Engineering, Science, & Technology, Inc., PBC (EA Engineering). RRS will be available to interpret the field data as it is collected or answer any questions. If you need additional information regarding the application process or attached field notes, please contact Andrea Maben at 949.899.0729 or Ashley Cedzo at 425.419.8266.

Sincerely,

Andrea Maben
West Region Project Manager
REGENESIS Remediation Services

Ashley Cedzo
Northwest District Technical Manager
REGENESIS Remediation Solutions

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Application Summary Page

OVERVIEW

Client: EA Engineering
Client PM: Jil Frain
RRS Project Manager: Andrea Maben
RRS Project Supervisor: Dominic Forlini

Site Address: 7608 NE 47th Avenue, Vancouver, WA
Project Name: Boomsnub/Airco Superfund Site
Project Dates: 10/16/18 to 10/19/18

TREATMENT TECHNOLOGY

RRS employed combined PlumeStop®, PlumeStop S®, and AquaZVI™ technologies to sorb, remediate, and prevent the VOC groundwater plume from migrating downgradient of the AOC-1 treatment area.

PlumeStop® Liquid Activated Carbon coats aquifer soils with very fine layer of carbon particles (1-2µm). Upon reagent injection, target contaminants partition out of the aqueous phase and into the reagent matrix, thereby removing mobile contaminants from the immediate risk pathway. The high surface area matrix is favorable for microbial colonization and growth, promoting contaminate biodegradation.

PlumeStop S® is a higher concentrated batch of PlumeStop® and behaves similar in remedial function.

AquaZVI™ is a colloidal zero-valent iron (ZVI) product in which the ZVI particles are coated with iron sulfide (FeS). ZVI provides a source of electrons that facilitate the electrochemical reduction of chlorinated contaminates to benign end products. The iron sulfide slows the reactivity of ZVI with water, extending the longevity of the ZVI. Additionally, the iron sulfide surface enhances the rate of reduction of common groundwater contaminants such as perchloroethene (PCE) and trichloroethene (TCE).

The established treatment will continue to clean up the pilot test area for an estimated 10 to 15 years with no scheduled maintenance.

RRS employed remediation design specifications as outlined in designs dated 7/2/2018.

DESIGN VERIFICATION AND RADIUS OF INFLUENCE (ROI) TESTING

The goal of the ROI field analysis is to inform field personnel and remediation design engineers on anticipated PlumeStop® application flow rates, pressures, and volumes. This empirical data gathered will provide value for real-time injection design adjustments for this pilot test and for future full-scale implementation.

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Testing began on the morning of October 16th by drilling a 3-foot retraction screen down to 45-feet below ground surface (bgs).The PlumeStop® and AquaZVI™ solution was injected through the probe rods at location IP-1, 5-feet away from the AOC-1-GP-01 monitoring well. Once head pressure was established, to prevent early stage tool clogging, the screen was raised 3-feet, exposing the screen, allowing for remedial product to be injected into the 45-42 ft bgs zone.

While injecting, RRS bailed water from AOC-1-GP 01 to monitor for the visual arrival of the remedial solution. Groundwater level and pH were also monitored for changes. Visually, the well water is moderately clear with silty residue present. Static groundwater level of AOC-1-GP-01 and AOC-1-GP-05 was 26.93 ft and 27.49 ft, respectively. Initial groundwater of AOC-1-GP-01 was slightly acidic at 6.86 pH. A total of 324 gallons of product solution was injected into ROI test point, IP-1. Application flow rates and pressures were observed between 3 to 4.25 gallons per minute (GPM) and 45 to 55 pounds per square inch (PSI). During the ROI test, AOC-1-GP-01 water level rose to 26.62 ft (+0.31 ft) and acidity decreased to 6.96 pH (+0.10 pH).

Observation of PlumeStop® occurred later than expected, however specific ROI well integration could not be precisely pinpointed during this test – in part, due to groundwater visual variety in the screened zone of the monitoring well (30-50 ft). The top portion of the monitoring well showed undeniable signs of PlumeStop® integration. The middle portion of the monitoring well had signs of PlumeStop® discoloration, but less intense than the top portion. The bottom portion of the monitoring well had no sign of PlumeStop® discoloration.

No deviations to the proposed design were made as a result of the injection testing in either the upgradient or downgradient areas.

APPLICATION

RRS applied the REGENESIS technologies PlumeStop® and AquaZVI™ by mixing the product in the RRS injection trailer and injecting through direct push borings drilled with a leading 1.5” retractable stainless steel injection screen (3-foot length) to a 490 ft^2 target treatment area. Mixing water was provided on-site by an EA Engineering reservoir transfer source. RRS used a dual-batch mixing system with 325-gallon tanks and pumped product using a positive displacement electrically powered pump. Soil borings were backfilled with sodium bentonite chips after injection to seal the boring. Injection pressures were observed generally between 25 and 75 PSI, with the exception of an instance of pressure spiking to 110 PSI at IP-2 from 45 to 42 ft bgs. Injection flow rates were observed generally between 2.0 and 5.5 GPM, with the exception of high pressure zones that limited initial flow rates to < 1.5 GPM. Injection was completed by pumping on up to three injection points at a time using the RRS injection trailer manifold system. Although a majority of sustained pressures were observed under 100 PSI, the RRS trailer is equipped with a pressure bypass valve that will re-route fluids back into the trailer tanks if downhole pressures reach 100 PSI in order to keep pressures at safe levels for field personnel.

REGENESIS
REMEDIATION SERVICES
Technology-Based Solutions for the Environment

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There were two surfacing events that originated from previous boreholes. These events were immediately mitigated by turning the pump off, drilling to 15 ft into the respective location with a fixed point, and packing the borehole with an additional hydrated layer of bentonite. These locations were monitored throughout the project.

Additionally, PlumeStop® injectate traveled upward through the well screen, spilling into the well vault of AOC-1-GP-01 while pumping on the 2 closest injection point locations: IP-1 and IP-7. Both injection point locations were drilled at a 5 ft linear distance away from the monitoring well. A well plug was attached to the well head, but was not tightened to prevent the buildup of excess pressure. This was alleviated by reducing point-specific flow rates and pressures, and by monitoring the groundwater level during the injection. A plugged compression fitting equipped with a pressure gauge was added to the well so that groundwater could be monitored safely.

After injection was completed, RRS flushed monitoring well AOC-1-GP-01 with 200 gallons of clear water at 1.25 GPM and 7 PSI per RRS standard operating procedure to prevent buildup of carbon particulates within the well and filter pack.

TREATMENT AREA 1 – AOC-1-GP-01

A total of 8,139 gallons of PlumeStop® and AquaZVI™ blend was mixed and applied to the treatment area. Total REGENESIS product applied was 1,200 lb of PlumeStop®, 1,600 lb of PlumeStop S®, and 1,000 lb of AquaZVI™.

Of the total applied product blend, 6,939 gallons applied as a 4.4% solution to injection locations further than 5 ft linear distance from the nearby monitoring well (IP-1 through IP-6). The remaining 1,200 gallons was applied as a 7.5% solution to injection locations 5 ft linear distance from AOC-1-GP-01 to reduce the overall probability of increased surfacing through the well (IP-1 & IP-7).

IP- 1 (ROI test point) received 4.4% solution at injection zone 45-39 ft, and 7.5% solution at injection zone 39-30 ft.

Application Method: Direct push drilling with retractable injection screens — 3-foot screens
Injection Depth: 45 to 30 feet below ground surface
Number of Injection Points: 7

Deviations From Proposal:

1. Injection volumes for locations 5 ft linear distance from the nearby monitoring well (IP-1 & IP-7) were decreased and concentrations increased. The application adjustment was made to prevent oversaturation of the zone and an increased probability of future surfacing events.

Please see attached Table 1 for details on injection flow rates and pressures observed.

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INJECTION POINT LOCATIONS – AOC-1-GP-01

PLUME STOP
Liquid Activated Carbon

EA Engineering - Boomsnub/Airco Superfund Site
Plumestop Injection Summary Log
AOC-1 Treatment Area
Table 1

REGENESIS
REMEDIATION SERVICES
Technology-Based Solutions for the Environment

Injection Point	Date	Time	Injection Depth (feet)	Injection Pressure (psi)	Flow Rate (gpm)	Volume Injected			Total Per Location (gal)	PlumeStop Injected Per Location (lb)	PlumeStop S Injected Per Location (lb)	Aqua ZVI Per Location (lb)	Comments	Injection Tooling	Refusal	Surfacing
						Beginning Flow Meter (gal)	Ending Flow Meter (gal)	Gallons Injected Per Interval								
IP-1	10/16/2018	11:53	45-42	45	3.10	0	22	22	964	171	229	143	Start at 11:45	3-Foot Screen		
		12:30		48	4.10	22	163	141								
		13:10		48	4.10	163	324	161					13:10 pause injection- PS in well at lower section (~5 foot interval)			
		14:25	42-39	-	-	324	411	87								
	10/17/2018	14:23		35	2.81	411	459	48					Pause injection - PS coming out of well GP-01 - 14:00			Yes
		17:46		30	2.17	459	514	55					Resume at 13:56			
	10/18/2018	11:46	39-36	60	2.86	0	20	20					**Reduce applied volume - 50 gal/ft**			
		12:32		50	3.04	20	150	130								
		14:40	36-33	22	3.10	150	203	53					Start at 11:36			
		15:07		25	3.42	203	300	97								
		15:35	33-30	25	3.32	300	365	65								
		16:00		15	3.18	365	450	85					End at 16:15			
IP-2	10/16/2018	14:02	45-42	110	3.22	0	10	10	1285	171	229	143	Start at 13:40	3-Foot Screen		
		14:23	43-40	75	4.01	10	100	90					No flow - pull 2-feet.			
		15:48		65	4.64	100	427	327								
		15:50	42-39	55	4.46	427	514	87								
		16:10	39-36	43	3.58	514	601	87					Stop at 16:32			
	10/17/2018	8:28		30	2.64	601	628	27					Start at 8:20			
		9:10		40	3.96	628	758	130								
		10:15	36-33	40	3.92	758	1020	262								
		11:01	33-30	40	4.92	1020	1175	155								
		11:24		40	4.49	1175	1285	110					End at 11:30			
IP-3	10/16/2018	13:55	45-42	72	2.11	0	15	15	1285	171	229	143	Start at 13:48	3-Foot Screen		
		14:23		70	2.40	15	72	57								
		15:15		65	4.35	72	257	185								
		15:17	42-39	50	4.38	257	514	257								
	10/17/2018	8:29	39-36	22	2.49	514	534	20					Start at 8:20			
		9:36		-	-	534	747	213								
		10:04	36-33	30	4.36	747	786	39								
		10:57		25	4.61	786	1032	246								
		11:17	33-30	25	4.30	1032	1122	90								
		11:54		25	5.00	1122	1285	163					End at 11:54			
IP-4	10/17/2018	9:18	45-42	80	3.50	0	18	18	1285	171	229	143	Start at 9:10. Rise in SWL - slowed GPM	3-Foot Screen		
		10:31		38	1.89	18	183	165								
		10:55		30	1.86	183	255	72								
		12:02	42-39	30	2.87	255	402	147					Stopped to pull rods at 12:00			
		13:05		30	3.34	402	514	112					Resume at 12:30			
		14:28	39-36	30	3.24	514	772	258								
		15:28	36-33	40	4.78	772	975	203								
		15:53		30	3.45	975	1028	53								
		16:10	33-30	40	5.48	1028	1100	72								
		16:42		30	6.56	1100	1285	185					Surfacing through previous borehole IP-2. Re-plugged.			Yes
IP-5	10/17/2018	12:48	45-42	70	2.97	0	17	17	1285	171	229	143	Start at 12:41	3-Foot Screen		
		14:02		50	3.60	17	262	245								
		14:45	42-39	-	-	262	296	34								
		15:59		25	3.16	296	514	218								
		16:24	39-36	20	2.71	514	583	69								
		16:30		20	2.56	583	589	6					Start at 8:00			
	10/18/2018	8:16		20	3.50	0	60	60								
		8:36	36-33	40	4.92	60	225	165								
		9:27		35	4.38	225	482	257								
		10:32	33-30	40	4.99	482	696	214								

PLUME STOP® Liquid Activated Carbon

EA Engineering - Boomsnub/Airco Superfund Site

Plumestop Injection Summary Log

AOC-1 Treatment Area

Table 1

REGENESIS® REMEDIATION SERVICES Technology-Based Solutions for the Environment

Injection Point	Date	Time	Injection Depth (feet)	Injection Pressure (psi)	Flow Rate (gpm)	Volume Injected			Total Per Location (gal)	PlumeStop Injected Per Location (lb)	PlumeStop S Injected Per Location (lb)	Aqua ZVI Per Location (lb)	Comments	Injection Tooling	Refusal	Surfacing
						Beginning Flow Meter (gal)	Ending Flow Meter (gal)	Gallons Injected Per Interval								
IP-6	10/17/2018	15:53	45-42	70	1.18	0	19	19	1285	171	229	143	Start at 15:34	3-Foot Screen		
		16:40		90	2.00	19	97	78								
	10/18/2018	8:15		20	2.32	0	22	22					Start at 8:06			
		9:17		75	2.13	22	160	138								
		10:18	42-39	40	4.56	160	417	257								
		10:37	39-36	40	4.90	417	473	56					At 9:10 PS filled GP-01 from 26.51 ft bgs to 3.08 ft bgs			
		11:14		43	5.00	473	674	201								
		12:38	36-33	35	5.45	674	748	74								
		13:10		35	5.52	748	935	187								
		13:24	33-30	35	5.52	935	1004	69								
		13:51		30	5.54	1004	1188	184								
IP-7	10/18/2018	11:47	45-42	50	2.10	0	24	24	750	171	229	143	Start at 11:36 - **Reduce applied volume - 50 gal/ft**	3-Foot Screen		
		14:28		55	1.70	24	150	126								
		14:40	42-39	40	2.89	150	179	29								
		15:34		45	2.66	179	300	121								
		15:52		40	3.01	300	341	41								
	10/19/2018	8:19	39-36	33	3.10	341	374	33					Start at 8:03			
		8:39		27	3.19	374	450	76					After 84 gallons - influence in GP-01 - water level rising			
		8:55	36-33	27	3.32	450	490	40								
		9:25		30	3.66	490	600	110								
		9:31	33-30	30	3.71	600	620	20								
		10:29		30	3.97	620	750	130								

Total Project Volume PlumeStop blend (gal)	Total Project Pounds PlumeStop	Total Project Pounds PlumeStop S	Total Project Pounds Aqua ZVI
8139	**1200**	**1600**	**1000**

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Photo Log – Boomsnub/Airco Superfund Site; October 2018 Injection

Photo 1: **General site environment and layout.**

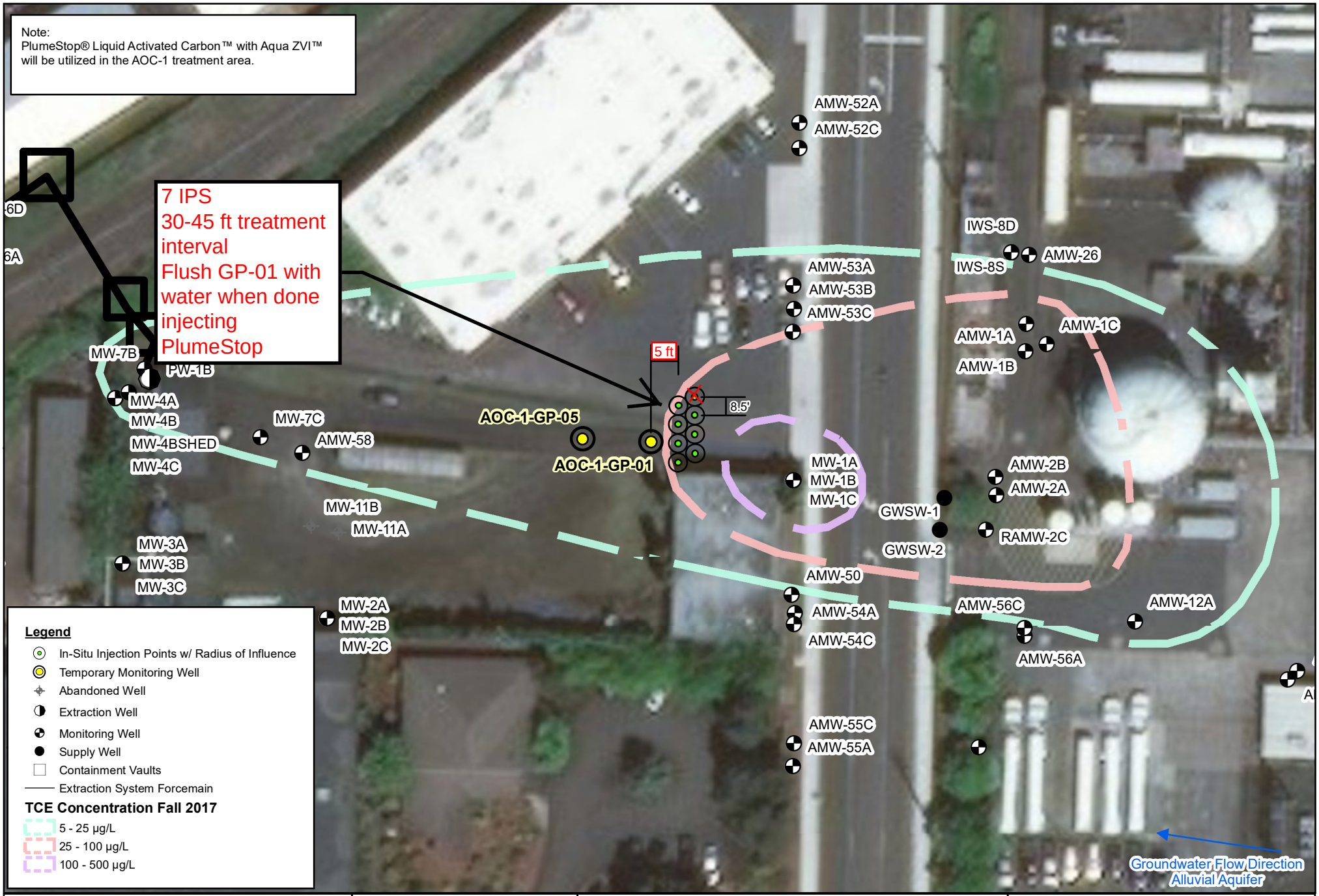
Photo 2: **Drill rig storage and injection trailer location – hose length setup.**

Photo 3: **Direct water source – fitted for fire hose to RRS trailer tanks.**

Photo 4: **Injection setup and water well monitoring equipment.**

Photo 5: **Injection cap and pressure relief bypass.**

Photo 6: **Monitoring well water flush – added compression fitting and pressure gauge.**



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Fax: (206) 443-7646

Feet
0 15 30 60

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BOOMSNUB / AIRCO SUPERFUND SITE
HAZEL DELL, WASHINGTON

EA Project No. 1524058
File Location: \\seattlefp\Seattle\Projects\1524069 In Situ Treatment\DVT Letter\GIS\Fig_3_AOC-1_In-situ.mxd
File Name: Fig_3_AOC-1_In-situ

FIGURE 3
PROPOSED IN-SITU TREATMENT LOCATIONS, AOC-1

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Appendix C

AOC-2 Daily Construction Reports

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DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/15/18** **DAY: Monday**	**Report #: 001**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Mostly Sunny**		
REPORT PREPARED BY: Garrett Lee		**TEMP.: 54 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 0 MPH**		
TIME ON-SITE: 1040	**TIME LEFT SITE: 1740**	**HUMIDITY: 50%**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Jesse Blakeny (Cascade), Ryan Galbreth (Cascade)

EQUIPMENT AT SITE (identify in use or idled):

EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

Geoprobe 7720DT drill rig, (2) 250-gal poly totes, ChemGrout mixer, forklift, generator

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Anaerobic water was premixed last week within the 1200-gal poly tank at AOC-2; EHC+ product and microbes delivered to the site

ACTIVITIES WORKED TODAY:

Cascade mobilized to AOC-2, set up construction fencing and work area, staged equipment, measured and laid out injection grid points, transported the EHC+ product to site, began setting up the pumping manifold and fittings

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/15/18	RPT #: 001	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

Confirm final dosing and amounts for anaerobic water, microbes, and EHC+ slurry mixture. Confirm target vertical treatment interval.

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

The first row of injection points was placed 14' away from MW-18E instead of 10' due to steep slopes at this distance. Confirmed with R. Read that all injection points are clear of the underground extraction pipeline.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/16/18** **DAY: Tuesday**	**Report #: 002**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Mostly Sunny / Clear**		
REPORT PREPARED BY: Garrett Lee		**TEMP.: 42 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 0 MPH**		
TIME ON-SITE: 0700	**TIME LEFT SITE: 1735**	**HUMIDITY: 90%**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Jesse Blakeny (Cascade), Ryan Galbreth (Cascade), Jil Frain (EA), Regenesis personnel

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift (idle), generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

Regenesis equipment and drill rig, generator (Regenesis), forklift (Regenesis)

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment

ACTIVITIES WORKED TODAY:

Cascade began drilling at AOC-2-TP-08, three rods broke during separate injection attempts delaying any injection progress

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/16/18	RPT #: 002	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

Need to determine why rods are breaking and how to not break rods during drilling/injections: is it the drilling action on the rods? Is it the pressure created by the slurry/pump? Are the rods old and failing?

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

Cascade will attempt top down injections, and will utilize new rods tomorrow to try and solve the breaking problem.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/17/18** **DAY: Wednesday**	**Report #: 003**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Mostly Sunny / Clear**		
REPORT PREPARED BY: Garrett Lee		**TEMP.: 41 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 0 MPH**		
TIME ON-SITE: 0700	**TIME LEFT SITE: 1515**	**HUMIDITY: 88%**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Cody Tucker (Cascade), Jil Frain (EA), Regenesis personnel

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift (idle), generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

None

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment, attempted drilling several points resulting in broken rods

ACTIVITIES WORKED TODAY:

Cascade grouted drilling attempt locations from yesterday, injected at AOC-2-TP-09 from 84 ft bgs to 94 ft bgs, encountered problems when attempting to drill to 96 ft bgs, determined the rod had broken

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/17/18	RPT #: 003	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

Cascade is bringing the larger drill rig and brand-new rods to the site tomorrow to try and solve the rod breaking problem.

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

We have used some anaerobic water at points that did not work, need to keep an eye on it and make sure we have enough to complete all the planned injection points.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-09	84	10 / 10	0.07	13.5	3	400
AOC-2-TP-09	86	10 / 10	0.07	13.5	3	400
AOC-2-TP-09	88	10 / 10	0.07	13.5	2.5	400
AOC-2-TP-09	90	10 / 10	0.07	13.5	.9	100
AOC-2-TP-09	92	10 / 10	0.07	13.5	.9	100
AOC-2-TP-09	94	10 / 10	0.07	13.5	.9	100

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/18/18** **DAY: Thursday**	**Report #: 004**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Mostly Sunny / Clear**		
REPORT PREPARED BY: Garrett Lee		**TEMP.: 57 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 2 MPH**		
TIME ON-SITE: 0830	**TIME LEFT SITE: 1515**	**HUMIDITY: 64%**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Cody Tucker (Cascade), Regenesis personnel at AOC-1

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift (idle), generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

150’ of new drill rod

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment, attempted drilling several points resulting in broken rods, injected at AOC-2-TP-09 from 84 ft bgs to 94 ft bgs

ACTIVITIES WORKED TODAY:

Cascade obtained new drill rods, continued at AOC-2-TP-09 and injected from 94 ft bgs to 120 ft bgs.

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/18/18	RPT #: 004	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

None

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

EPA onsite tomorrow. New rods seem to be working well. Cascade decided to return to bottom up approach to injections to minimize drill start and stop.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-09	94	10 / 10	0.07	13.5	6.1	350 – 150
AOC-2-TP-09	96	10 / 10	0.07	13.5	5.1	400 – 100
AOC-2-TP-09	98	10 / 10	0.07	13.5	4.2	350 – 100
AOC-2-TP-09	100	10 / 10	0.07	13.5	4.5	400 – 100
AOC-2-TP-09	102	10 / 10	0.07	13.5	4.9	400 – 50
AOC-2-TP-09	104	10 / 10	0.07	13.5	4.8	450 – 150
AOC-2-TP-09	106	10 / 10	0.07	13.5	5.2	400 – 200
AOC-2-TP-09	108	10 / 10	0.07	13.5	4.5	450 – 100
AOC-2-TP-09	110	10 / 10	0.07	13.5	5.0	600 – 100
AOC-2-TP-09	112	10 / 10	0.07	13.5	5.4	400 – 100
AOC-2-TP-09	114	10 / 10	0.07	13.5	4.4	500 – 100
AOC-2-TP-09	116	10 / 10	0.07	13.5	5.1	400 – 200
AOC-2-TP-09	118	10 / 10	0.07	13.5	5.3	400 – 100
AOC-2-TP-09	120	10 / 10	0.07	13.5	5.4	500 – 100

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/19/18** **DAY: Friday**	**Report #: 005**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Foggy**		
REPORT PREPARED BY: Garrett Lee		**TEMP.: 44 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 0 MPH**		
TIME ON-SITE: 0700	**TIME LEFT SITE: 1715**	**HUMIDITY: 100 %**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Cody Tucker (Cascade), Regenesis personnel at AOC-1, Jonathan Williams (EPA)

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

Prepared ~700 gallons of anaerobic water

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment, attempted drilling several points resulting in broken rods, injected at AOC-2-TP-09 from 84 ft bgs to 120 ft bgs

ACTIVITIES WORKED TODAY:

Drilled at AOC-2-TP-10 and injected from 120 ft bgs to 100 ft bgs.

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/19/18	RPT #: 005	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

Flow rates calculated for AOC-2-TP-09 need to be recalculated, did not include the flush water volume of 20 gal when originally calculated. **See following page for addendum which includes corrected flow rates for AOC-2-TP-09.**

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

Drilling was slow to start today due to very hard soils from approximately 105' bgs to 120' bgs. The consolidated silt clogged the injection point twice today, which results in all of the rod having to be pulled up so the point can be cleaned. Cascade decided to switch to a disposable point, so when they start to pull up from the bottom to inject, the point stays in the ground. The product injection occurs out of the open casing bottom. This method seems to work much better in terms of flow rate and no clogging issues. The tradeoff is that the opening doesn't close when the injection pump is stopped, so the pressures within the rod stay elevated and make it more difficult to change rods in between lifts.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-10	120	10 / 10	0.07	13.5	12.5	400 – 50
AOC-2-TP-10	118	10 / 10	0.07	13.5	13	200 – 50
AOC-2-TP-10	116	10 / 10	0.07	13.5	8.2	< 50
AOC-2-TP-10	114	10 / 10	0.07	13.5	10.5	< 50
AOC-2-TP-10	112	10 / 10	0.07	13.5	14.3	< 50
AOC-2-TP-10	110	10 / 10	0.07	13.5	12.4	400 – 100
AOC-2-TP-10	108	10 / 10	0.07	13.5	12.7	400 – 200
AOC-2-TP-10	106	10 / 10	0.07	13.5	11.3	400 – 100
AOC-2-TP-10	104	10 / 10	0.07	13.5	12.0	350 – 50
AOC-2-TP-10	102	10 / 10	0.07	13.5	12.3	200 – 100
AOC-2-TP-10	100	10 / 10	0.07	13.5	12.4	400 – 100

DAILY CONSTRUCTION REPORT

10/18/18 Addendum: Corrected Daily Construction Report

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/18/18** **DAY: Thursday**	**Report #: 004**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Mostly Sunny/Clear**		
REPORT PREPARED BY: Garrett Lee (Addendum prepared by Julia White)		**TEMP.: 57°F**		
PROJECT MANAGER: Jil Frain		**WIND: 2 MPH**		
TIME ON-SITE: 0830	**TIME LEFT SITE: 1515**	**HUMIDITY: 64%**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Cody Tucker (Cascade), Regenesis personnel at AOC-1

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift (idle), generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

150’ of new drill rod

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment, attempted drilling several points resulting in broken rods, injected at AOC-2-TP-09 from 84 ft bgs to 94 ft bgs

ACTIVITIES WORKED TODAY:

Cascade obtained new drill rods, continued at AOC-2-TP-09 and injected from 94 ft bgs to 120 ft bgs.

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/18/18	RPT #: 004	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

None

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

EPA onsite tomorrow. New rods seem to be working well. Cascade decided to return to bottom up approach to injections to minimize drill start and stop.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)*	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-09	94	10/10	0.07	13.5	**8.7**	350 – 150
AOC-2-TP-09	96	10/10	0.07	13.5	**7.3**	400 – 100
AOC-2-TP-09	98	10/10	0.07	13.5	**6.0**	350 – 100
AOC-2-TP-09	100	10/10	0.07	13.5	**6.4**	400 – 100
AOC-2-TP-09	102	10/10	0.07	13.5	**7.0**	400 – 50
AOC-2-TP-09	104	10/10	0.07	13.5	**6.8**	450 – 150
AOC-2-TP-09	106	10/10	0.07	13.5	**7.4**	400 – 200
AOC-2-TP-09	108	10/10	0.07	13.5	**6.4**	450 – 100
AOC-2-TP-09	110	10/10	0.07	13.5	**7.1**	600 – 100
AOC-2-TP-09	112	10/10	0.07	13.5	**7.7**	400 – 100
AOC-2-TP-09	114	10/10	0.07	13.5	**6.3**	500 – 100
AOC-2-TP-09	116	10/10	0.07	13.5	**7.3**	400 – 200
AOC-2-TP-09	118	10/10	0.07	13.5	**7.6**	400 – 100
AOC-2-TP-09	120	10/10	0.07	13.5	**7.7**	500 – 100

*** Flow rates recalculated using 20 gallons of flush water, which is the actual amount used in the field.**

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/22/18** **DAY: Monday**	**Report #: 006**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Sunny, Clear**		
REPORT PREPARED BY: Garrett Lee		**TEMP.: 53 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 4 MPH**		
TIME ON-SITE: 0700	**TIME LEFT SITE: 1730**	**HUMIDITY: 86 %**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Caleb Trusty (Cascade), Daniel Leigh (Peroxychem)

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

None

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment, attempted drilling several points resulting in broken rods, completed injection at AOC-2-TP-09, injected at AOC-2-TP-10 from 120 ft bgs to 100 ft bgs

ACTIVITIES WORKED TODAY:

Completed injection at AOC-2-TP-10 from 98 ft bgs to 86 ft bgs, and grouted closed. Drilled and completed injection at AOC-2-TP-04 from 120 ft bgs to 86 ft bgs.

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/22/18	RPT #: 006	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

Cascade seems to have the process down – today went generally very smooth and we were able to finish a point and a half.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-10	98	10 / 10	0.07	13.5	6.8	250 – 50
AOC-2-TP-10	96	10 / 10	0.07	13.5	9.6	200 – 100
AOC-2-TP-10	94	10 / 10	0.07	13.5	7.3	200 – 50
AOC-2-TP-10	92	10 / 10	0.07	13.5	10.5	200 – 100
AOC-2-TP-10	90	10 / 10	0.07	13.5	8.2	200 – 100
AOC-2-TP-10	88	10 / 10	0.07	13.5	8.4	100 – 50
AOC-2-TP-10	86	10 / 10	0.07	13.5	4.6	<50
AOC-TP-04	120	10 / 10	0.07	13.5	12.9	400 – 100
AOC-TP-04	118	10 / 10	0.07	13.5	12.0	350 – 50
AOC-TP-04	116	10 / 10	0.07	13.5	7.6	300 – 50
AOC-TP-04	114	10 / 10	0.07	13.5	11.2	300 – 50
AOC-TP-04	112	10 / 10	0.07	13.5	6.3	300 – 50
AOC-TP-04	110	10 / 10	0.07	13.5	9.3	250 – 100
AOC-TP-04	108	10 / 10	0.07	13.5	12.2	400 – 200
AOC-TP-04	106	10 / 10	0.07	13.5	8.8	250 – 50
AOC-TP-04	104	10 / 10	0.07	13.5	12.9	250 – 50
AOC-TP-04	102	10 / 10	0.07	13.5	8.4	300 – 50
AOC-TP-04	100	10 / 10	0.07	13.5	8.2	200 – 100
AOC-TP-04	98	10 / 10	0.07	13.5	13.4	300 – 100
AOC-TP-04	96	10 / 10	0.07	13.5	10.5	300 – 50
AOC-TP-04	94	10 / 10	0.07	13.5	15.9	200 – 50
AOC-TP-04	92	10 / 10	0.07	13.5	12.9	100 – 50
AOC-TP-04	90	10 / 10	0.07	13.5	15.2	350 – 150
AOC-TP-04	88	10 / 10	0.07	13.5	14.6	250 – 100
AOC-TP-04	86	10 / 10	0.07	13.5	11.6	100 – 50

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/23/18** **DAY: Tuesday**	**Report #: 007**	**PAGE** 1 **OF** 3
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Cloudy**		
REPORT PREPARED BY: Julia White		**TEMP.: 53 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 9 MPH**		
TIME ON-SITE: 0700	**TIME LEFT SITE: 1735**	**HUMIDITY: 76 %**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Garrett Lee (EA), Rick Read (EA), Julia White (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Caleb Trusty (Cascade),

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom, mixing truck (idle)

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

50’ of ROD. Filled potable water trunk.

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

None

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment, attempted drilling several points resulting in broken rods, completed injection at AOC-2-TP-09, injected at AOC-2-TP-10 from 120 ft bgs to 100 ft bgs. Completed injection at AOC-2-TP-10 from 98 ft bgs to 86 ft bgs, and grouted closed. Drilled and completed injection at AOC-2-TP-04 from 120 ft bgs to 86 ft bgs.

ACTIVITIES WORKED TODAY:

Completed grouting of AOC-2-TP-04. Drilled and completed injection at AOC-2-TP-05 from 120 ft bgs to 86 ft bgs. Drilled and completed injection at AOC-2-TP-03 from 120 ft bgs to 86 bgs.

ITEMS NEEDING ATTENTION:

Overflow of slurry mixer in Well MW-18E.

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/23/18	RPT #: 007	PAGE 2 OF 3
PROJECT: Boomsnub In-situ Treatment				

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

Cascade seems to have the process down – today went generally very smooth and we were able to finish two points. Lunch 30 mins. Cascade team member J.Tucker left site after lunch. Soon after injection was completed at AOC-2-TP-03, a black slurry mixer was noticed coming out of the well casing of well MW-18E.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-05	120	10 / 10	0.07	13.5	11.6	250 – 50
AOC-2-TP-05	118	10 / 10	0.07	13.5	11.2	200 – 100
AOC-2-TP-05	116	10 / 10	0.07	13.5	10.5	200 – 50
AOC-2-TP-05	114	10 / 10	0.07	13.5	12.4	100 – 50
AOC-2-TP-05	112	10 / 10	0.07	13.5	13.4	100 – 50
AOC-2-TP-05	110	10 / 10	0.07	13.5	13.4	100 – 50
AOC-2-TP-05	108	10 / 10	0.07	13.5	12.4	100 – 50
AOC-2-TP-05	106	10 / 10	0.07	13.5	12.8	100 – 50
AOC-2-TP-05	104	10 / 10	0.07	13.5	13.4	100 – 50
AOC-2-TP-05	102	10 / 10	0.07	13.5	11.5	100 – 50
AOC-2-TP-05	100	10 / 10	0.07	13.5	12.4	100 – 50
AOC-2-TP-05	98	10 / 10	0.07	13.5	12.4	100 – 50
AOC-2-TP-05	96	10 / 10	0.07	13.5	11.2	100 – 50
AOC-2-TP-05	94	10 / 10	0.07	13.5	12.4	100 – 50
AOC-2-TP-05	92	10 / 10	0.07	13.5	13.4	100 – 50
AOC-2-TP-05	90	10 / 10	0.07	13.5	11.9	100 – 50
AOC-2-TP-05	88	10 / 10	0.07	13.5	11.5	100 – 50
AOC-2-TP-05	86	10 / 10	0.07	13.5	13.4	100 – 50
AOC-TP-03	120	10 / 10	0.07	13.5	13.4	100 –50
AOC-TP-03	118	10 / 10	0.07	13.5	13.4	300 – 50
AOC-TP-03	116	10 / 10	0.07	13.5	13.1	300 – 50
AOC-TP-03	114	10 / 10	0.07	13.5	12.0	< 50
AOC-TP-03	112	10 / 10	0.07	13.5	10.5	300 – 50
AOC-TP-03	110	10 / 10	0.07	13.5	11.2	400 – 50
AOC-TP-03	108	10 / 10	0.07	13.5	9.8	400 – 100
AOC-TP-03	106	10 / 10	0.07	13.5	11.2	400 – 50
AOC-TP-03	104	10 / 10	0.07	13.5	12.0	100 – 50
AOC-TP-03	102	10 / 10	0.07	13.5	13.4	< 50
AOC-TP-03	100	10 / 10	0.07	13.5	10.2	< 50

AOC-TP-03	98	10 / 10	0.07	13.5	12.4	<50
AOC-TP-03	96	10 / 10	0.07	13.5	11.1	100 – 50
AOC-TP-03	94	10 / 10	0.07	13.5	11.1	300 – 100
AOC-TP-03	92	10 / 10	0.07	13.5	13.4	250 – 100
AOC-TP-03	90	10 / 10	0.07	13.5	11.6	200 – 50
AOC-TP-03	88	10 / 10	0.07	13.5	11.4	100 – 50
AOC-TP-03	86	10 / 10	0.07	13.5	10.4	200 – 50

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/24/18** **DAY: Wednesday**	**Report #: 008**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Cloudy**		
REPORT PREPARED BY: Julia White		**TEMP.: 59 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 3 MPH**		
TIME ON-SITE: 0700	**TIME LEFT SITE: 1715**	**HUMIDITY: 70 %**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Rick Read (EA), Julia White (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Caleb Trusty (Cascade), Daniel Leigh (Peroxychem), Ryan Galbreth (Cascade)

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7720DT drill rig, (2) 250-gal poly totes (1 idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom, mixing truck (idle)

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

Cascade switched out Geoprobe from 7720DT to 7730DT at end of day.

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

Safety issue in MW-18E vault. Possible risk of high pressure popping off cap. Restricted area with caution tape and avoided area around well casing.

ACTIVITIES COMPLETED TO DATE:

Premixed anaerobic water, Cascade mobilized to AOC-2 and staged equipment, attempted drilling several points resulting in broken rods, completed injection at AOC-2-TP-09, injected at AOC-2-TP-10 from 120 ft bgs to 100 ft bgs. Completed injection at AOC-2-TP-10 from 98 ft bgs to 86 ft bgs, and grouted closed. Drilled and completed injection at AOC-2-TP-04 from 120 ft bgs to 86 ft bgs. Completed grouting of AOC-2-TP-04. Drilled and completed injection at AOC-2-TP-05 from 120 ft bgs to 86 ft bgs. Drilled and completed injection at AOC-2-TP-03 from 120 ft bgs to 86 bgs.

ACTIVITIES WORKED TODAY:

Vacuumed out MW-18E. Grouted AOC-2-TP-05 and AOC-2-TP-03. Drilled and completed injection at AOC-2-TP-08 from 120 ft bgs to 86 ft bgs. Injected 108 gallons of overflow mixer from well MW-18E, injecting 6 gallons at each interval at AOC-2-TP-08. Prepared 1000 gallons of anaerobic water for tomorrow.

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/24/18	RPT #: 008	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

ITEMS NEEDING ATTENTION:

Additional cleanup of well MW-18E.

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

Slow start to the day due to issues with well MW-18E being addressed. Added in overflow from well to TP-08. No additional problems with overflow into nearby wells. Pressure gauge continues to be a problem, addressed issue by replacing broken gauge with a new one. High pressures at TP-08 which made transitions between rods longer and some mixture lost during those transitions.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-08	120	10 / 10	0.07	13.5	11.0	500 – 200
AOC-2-TP-08	118	10 / 10	0.07	13.5	10.4	600 – 200
AOC-2-TP-08	116	10 / 10	0.07	13.5	11	200 – 200
AOC-2-TP-08	114	10 / 10	0.07	13.5	11.6	200 – 200
AOC-2-TP-08	112	10 / 10	0.07	13.5	10.3	300 – 200
AOC-2-TP-08	110	10 / 10	0.07	13.5	9.2	400 – 250
AOC-2-TP-08	108	10 / 10	0.07	13.5	9.6	400 – 200
AOC-2-TP-08	106	10 / 10	0.07	13.5	12.4	200 – 50
AOC-2-TP-08	104	10 / 10	0.07	13.5	10.4	200 – 50
AOC-2-TP-08	102	10 / 10	0.07	13.5	10.4	200 – 50
AOC-2-TP-08	100	10 / 10	0.07	13.5	12.0	200 – 50
AOC-2-TP-08	98	10 / 10	0.07	13.5	10.3	200 – 50
AOC-2-TP-08	96	10 / 10	0.07	13.5	11.0	200 – 50
AOC-2-TP-08	94	10 / 10	0.07	13.5	10.4	200 – 50
AOC-2-TP-08	92	10 / 10	0.07	13.5	10.3	200 – 50
AOC-2-TP-08	90	10 / 10	0.07	13.5	11.6	200 – 50
AOC-2-TP-08	88	10 / 10	0.07	13.5	11.8	200 – 50
AOC-2-TP-08	86	10 / 10	0.07	13.5	9.6	200 – 50

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/25/18** **DAY: Thursday**	**Report #: 009**	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Rainy/Cloudy**		
REPORT PREPARED BY: Julia White		**TEMP.: 55 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 4 MPH**		
TIME ON-SITE: 0705	**TIME LEFT SITE: 1620**	**HUMIDITY: 87 %**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Rick Read (EA), Julia White (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Caleb Trusty (Cascade)

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7730DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom, mixing truck (idle)

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

Balor (Cascade) and twine (EA's) to remove overflow product from well MW-18E.

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

ACTIVITIES COMPLETED TO DATE:

Drilled, completed injection and grouted AOC-2-TP-04, AOC-2-TP-03, AOC-2-TP-05, AOC-2-TP-10, AOC-2-TP-09 and AOC-2-TP-08. Prepared 2100 gallons of anaerobic water to date. Vacuumed out MW-18E. Injected 90 gallons of overflow mixer from well MW-18E into AOC-2-TP-08.

ACTIVITIES WORKED TODAY:

Grouted closed AOC-2-TP-08. Drilled and injected at AOC-2-TP-12 from 120 ft bgs to 86 bgs. Injected 70 gallons of overflow mixture from MW-18E into AOC-2-TP-12. Started filling water tanker at end of day.

ITEMS NEEDING ATTENTION:

Additional cleanup of well MW-18E.

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

Waited for anaerobic water to reach a level of zero dissolved oxygen at the beginning of day slowed injection process by 40 mins. Overall there were no other problems.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-12	120	10 / 10	0.07	13.5	10.4	200 – 50
AOC-2-TP-12	118	10 / 10	0.07	13.5	9.2	200 – 50
AOC-2-TP-12	116	10 / 10	0.07	13.5	7.4	200 – 100
AOC-2-TP-12	114	10 / 10	0.07	13.5	10.4	200 – 100
AOC-2-TP-12	112	10 / 10	0.07	13.5	11.6	200 – 100
AOC-2-TP-12	110	10 / 10	0.07	13.5	11.0	200 – 100
AOC-2-TP-12	108	10 / 10	0.07	13.5	12.0	200 – 100
AOC-2-TP-12	106	10 / 10	0.07	13.5	10.4	200 – 50
AOC-2-TP-12	104	10 / 10	0.07	13.5	11.0	200 – 50
AOC-2-TP-12	102	10 / 10	0.07	13.5	12.8	200 – 50
AOC-2-TP-12	100	10 / 10	0.07	13.5	12.0	200 – 50
AOC-2-TP-12	98	10 / 10	0.07	13.5	11.7	200 – 50
AOC-2-TP-12	96	10 / 10	0.07	13.5	12.0	200 – 50
AOC-2-TP-12	94	10 / 10	0.07	13.5	12.8	200 – 50
AOC-2-TP-12	92	10 / 10	0.07	13.5	11.6	200 – 100
AOC-2-TP-12	90	10 / 10	0.07	13.5	11.9	200 – 100
AOC-2-TP-12	88	10 / 10	0.07	13.5	10.5	200 – 100
AOC-2-TP-12	86	10 / 10	0.07	13.5	8.6	200 – 100

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE: 10/26/18** **DAY: Friday**	**Report #: 010**	**PAGE** 1 **OF** 3
EA PROJECT No: 1524069		**LOCATION: AOC-2**		
CONTRACTOR: Cascade		**WEATHER: Cloudy**		
REPORT PREPARED BY: Julia White		**TEMP.: 59 °F**		
PROJECT MANAGER: Jil Frain		**WIND: 6 MPH**		
TIME ON-SITE: 0655	**TIME LEFT SITE: 1700**	**HUMIDITY: 87 %**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Rick Read (EA), Julia White (EA), Kyle King (Cascade), Jeff Tucker (Cascade), Caleb Trusty (Cascade)

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7730DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom, mixing truck (idle)

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

n/a

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

n/a

ACTIVITIES COMPLETED TO DATE:

Drilled, completed injection and grouted AOC-2-TP-04, AOC-2-TP-03, AOC-2-TP-05, AOC-2-TP-10, AOC-2-TP-09, AOC-2-TP-08, and AOC-2-TP-12. Prepared 2100 gallons of anaerobic water to date. Vacuumed out MW-18E. Injected 90 gallons of overflow mixer from well MW-18E into AOC-2-TP-08. Injected 70 gallons of overflow mixture from MW-18E into AOC-2-TP-12.

ACTIVITIES WORKED TODAY:

Grouted AOC-2-TP-12 close. Drilled and injected at AOC-2-TP-11 and AOC-2-TP-01. Premixed 900 gallons of anaerobic water.

ITEMS NEEDING ATTENTION:

Additional cleanup of well MW-18E.

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

Slow start to the day due to issues with geoprobe battery. Once geoprobe was running the rest of the day went well. Black injection mixture was noticed coming out of the MW-18E vault (on the outside), less than 1 gallon lost, after injection at AOC-2-TP-11 was finished. The cap on the well was still in place when the mixture was noticed coming from outside of the well and it's recommended to watch the well during future injections. During injection at AOC-2-TP-01 there was no additional overflow noticed coming from well MW-18E.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-11	120	10 / 10	0.07	13.5	11.2	200 – 100
AOC-2-TP-11	118	10 / 10	0.07	13.5	13.9	200 – 50
AOC-2-TP-11	116	10 / 10	0.07	13.5	11.6	200 – 50
AOC-2-TP-11	114	10 / 10	0.07	13.5	12.4	200 – 50
AOC-2-TP-11	112	10 / 10	0.07	13.5	12.4	150 – 50
AOC-2-TP-11	110	10 / 10	0.07	13.5	14.6	200 – 50
AOC-2-TP-11	108	10 / 10	0.07	13.5	11.2	200 – 50
AOC-2-TP-11	106	10 / 10	0.07	13.5	13.4	200 – 50
AOC-2-TP-11	104	10 / 10	0.07	13.5	13.4	200 – 100
AOC-2-TP-11	102	10 / 10	0.07	13.5	13.4	200 – 100
AOC-2-TP-11	100	10 / 10	0.07	13.5	15.2	200 – 100
AOC-2-TP-11	98	10 / 10	0.07	13.5	11.2	200 – 100
AOC-2-TP-11	96	10 / 10	0.07	13.5	11.2	200 – 100
AOC-2-TP-11	94	10 / 10	0.07	13.5	10.8	200 – 50
AOC-2-TP-11	92	10 / 10	0.07	13.5	11.2	200 – 100
AOC-2-TP-11	90	10 / 10	0.07	13.5	11.6	200 – 100
AOC-2-TP-11	88	10 / 10	0.07	13.5	12.4	200 – 100
AOC-2-TP-11	86	10 / 10	0.07	13.5	10.2	200 – 100

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-01	120	10 / 10	0.07	13.5	12.4	250 – 100
AOC-2-TP-01	118	10 / 10	0.07	13.5	14.6	200 – 100
AOC-2-TP-01	116	10 / 10	0.07	13.5	14.6	200 – 100
AOC-2-TP-01	114	10 / 10	0.07	13.5	14.6	250 – 100
AOC-2-TP-01	112	10 / 10	0.07	13.5	16.7	250 – 100
AOC-2-TP-01	110	10 / 10	0.07	13.5	15.2	250 – 100
AOC-2-TP-01	108	10 / 10	0.07	13.5	15.2	200 – 100
AOC-2-TP-01	106	10 / 10	0.07	13.5	15.2	200 – 100

AOC-2-TP-01	104	10 / 10	0.07	13.5	16.8	200 – 100
AOC-2-TP-01	102	10 / 10	0.07	13.5	16.0	200 – 100
AOC-2-TP-01	100	10 / 10	0.07	13.5	16.8	200 – 100
AOC-2-TP-01	98	10 / 10	0.07	13.5	12.4	200 – 100
AOC-2-TP-01	96	10 / 10	0.07	13.5	16.0	200 – 100
AOC-2-TP-01	94	10 / 10	0.07	13.5	13.4	200 – 100
AOC-2-TP-01	92	10 / 10	0.07	13.5	14.6	200 – 100
AOC-2-TP-01	90	10 / 10	0.07	13.5	14.6	200 – 100
AOC-2-TP-01	88	10 / 10	0.07	13.5	14.6	150 – 100
AOC-2-TP-01	86	10 / 10	0.07	13.5	11.2	200 – 100

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE:** 10/29/18 **DAY:** Monday	**Report #:** 011	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION:** AOC-2		
CONTRACTOR: Cascade		**WEATHER:** Cloudy w/ Showers		
REPORT PREPARED BY: Rick Read		**TEMP.:** 56°		
PROJECT MANAGER: Jil Frain		**WIND:** SW 2 MPH		
TIME ON-SITE: 7:00	**TIME LEFT SITE:** 17:50	**HUMIDITY:**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Rick Read (EA), Kyle King (Cascade), Caleb Trusty (Cascade), Cody Spiker (Cascade)

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7730DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom, mixing truck (idle)

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

n/a

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

n/a

ACTIVITIES COMPLETED TO DATE:

Drilled, completed injections and grouted at AOC-2-TP-04, AOC-2-TP-03, AOC-2-TP-05, AOC-2-TP-10, AOC-2-TP-09, AOC-2-TP-08, and AOC-2-TP-12. Prepared 2100 gallons of anaerobic water to date. Vacuumed out MW-18E. Injected 90 gallons of overflow mixture from well MW-18E into AOC-2-TP-08. Injected 70 gallons of overflow mixture from MW-18E into AOC-2-TP-12.

ACTIVITIES WORKED TODAY:

Grouted AOC-2-TP-01 and AOC-2-TP-11. Drilled and injected at AOC-2-TP-02.

ITEMS NEEDING ATTENTION:

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/29/2018	RPT #: 011	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

During the last 3 intervals product was noticed surfacing from around the edges of the vault at MW-18E. Approximately, 25 gallons of injection product surfaced.

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-02	120	10/10	0.07	13.5	4.7	200-100
AOC-2-TP-02	118	10/10	0.07	13.5	7.8	200-100
AOC-2-TP-02	116	10/10	0.07	13.5	7.8	200-100
AOC-2-TP-02	114	10/10	0.07	13.5	3.9	200-100
AOC-2-TP-02	112	10/10	0.07	13.5	7.8	175-100
AOC-2-TP-02	110	10/10	0.07	13.5	7.8	175-120
AOC-2-TP-02	108	10/10	0.07	13.5	5.9	150-100
AOC-2-TP-02	106	10/10	0.07	13.5	5.9	150-100
AOC-2-TP-02	104	10/10	0.07	13.5	7.8	200-100
AOC-2-TP-02	102	10/10	0.07	13.5	5.9	100-150
AOC-2-TP-02	100	10/10	0.07	13.5	5.9	150-100
AOC-2-TP-02	98	10/10	0.07	13.5	7.8	150-100
AOC-2-TP-02	96	10/10	0.07	13.5	5.9	150-100
AOC-2-TP-02	94	10/10	0.07	13.5	5.9	125-100
AOC-2-TP-02	92	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-02	90	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-02	88	10/10	0.07	13.5	7.8	200-100
AOC-2-TP-02	86	10/10	0.07	13.5	5.9	200-100

DAILY CONSTRUCTION REPORT

Boomsnub/Airco Superfund Site
In-situ Treatment Injections
Hazel Dell, Washington

PROJECT NAME: Boomsnub In-situ Treatment	**CLIENT:** Linde	**DATE:** 10/30/18 **DAY:** Tuesday	**Report #:** 012	**PAGE** 1 **OF** 2
EA PROJECT No: 1524069		**LOCATION:** AOC-2		
CONTRACTOR: Cascade		**WEATHER:** Foggy		
REPORT PREPARED BY: Rick Read		**TEMP.:** 47°		
PROJECT MANAGER: Jil Frain		**WIND:** 0 MPH		
TIME ON-SITE: 7:00	**TIME LEFT SITE:** 17:30	**HUMIDITY:**		

PERSONNEL ONSITE (include subcontractors; verify proper PPE & credentials):

Rick Read (EA), Kyle King (Cascade), Caleb Trusty (Cascade), Cody Spiker (Cascade)

EQUIPMENT AT SITE (identify in use or idled):

Geoprobe 7730DT drill rig, (2) 250-gal poly totes (idle), ChemGrout mixer, forklift, generator, EHC+ product, microbes, 1200-gal poly tank, construction fencing, portable bathroom, mixing truck (idle)

MATERIALS OR EQUIPMENT DELIVERED/PREPARED:

n/a

SAFETY OR QUALITY PROBLEMS NOTED/CORRECTIVE ACTION TAKEN:

n/a

ACTIVITIES COMPLETED TO DATE:

Drilled, completed injections and grouted at AOC-2-TP-04, AOC-2-TP-03, AOC-2-TP-05, AOC-2-TP-10, AOC-2-TP-09, AOC-2-TP-08, AOC-2-TP-12, AOC-2-TP-01 and AOC-2-TP-11. Prepared 2100 gallons of anaerobic water to date. Vacuumed out MW-18E. Injected 90 gallons of overflow mixture from well MW-18E into AOC-2-TP-08. Injected 70 gallons of overflow mixture from MW-18E into AOC-2-TP-12.

ACTIVITIES WORKED TODAY:

Grouted AOC-2-TP-02. Drilled and injected at AOC-2-TP-06. Drilled and began injections at AOC-2-TP-07.

ITEMS NEEDING ATTENTION:

OBSERVATIONS/GENERAL COMMENTS/PROJECT STATUS:

EA PROJECT NO: 1524069	CLIENT: Linde	DATE: 10/30/18	RPT #: 012	PAGE 2 OF 2
PROJECT: Boomsnub In-situ Treatment				

DAILY PHOTOS:

Download to project folder.

INJECTION DATA SUMMARY TABLE

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-06	120	10/10	0.07	13.5	5.9	200-150
AOC-2-TP-06	118	10/10	0.07	13.5	4.7	200-150
AOC-2-TP-06	116	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-06	114	10/10	0.07	13.5	4.7	200-100
AOC-2-TP-06	112	10/10	0.07	13.5	4.7	200-100
AOC-2-TP-06	110	10/10	0.07	13.5	7.8	200-100
AOC-2-TP-06	108	10/10	0.07	13.5	5.9	200-150
AOC-2-TP-06	106	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-06	104	10/10	0.07	13.5	5.9	175-100
AOC-2-TP-06	102	10/10	0.07	13.5	5.9	175-100
AOC-2-TP-06	100	10/10	0.07	13.5	5.9	200-150
AOC-2-TP-06	98	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-06	96	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-06	94	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-06	92	10/10	0.07	13.5	4.7	150-100
AOC-2-TP-06	90	10/10	0.07	13.5	5.9	175-125
AOC-2-TP-06	88	10/10	0.07	13.5	4.7	175-100
AOC-2-TP-06	86	10/10	0.07	13.5	4.7	175-100

Injection Point ID	Depth (ft bgs)	Quantity			Injection Rate (gpm)	Injection Pressure (psi)
		Anaerobic Water (gal)	Microbes (L)	Slurry (gal)		
AOC-2-TP-07	120	10/10	0.07	13.5	5.9	225-170
AOC-2-TP-07	118	10/10	0.07	13.5	5.9	250-150
AOC-2-TP-07	116	10/10	0.07	13.5	4.7	200-125
AOC-2-TP-07	114	10/10	0.07	13.5	5.9	200-100
AOC-2-TP-07	112	10/10	0.07	13.5	5.9	170-100
AOC-2-TP-07	110	10/10	0.07	13.5	5.9	170-100
AOC-2-TP-07	108	10/10	0.07	13.5	5.9	150-100
AOC-2-TP-07	106	10/10	0.07	13.5	5.9	150-100
AOC-2-TP-07	104	10/10	0.07	13.5	5.9	150-100
AOC-2-TP-07	102	10/10	0.07	13.5	5.9	180-100
AOC-2-TP-07	100	10/10	0.07	13.5	4.7	200-100
AOC-2-TP-07	98	10/10	0.07	13.5	4.7	200-100
AOC-2-TP-07	96	10/10	0.07	13.5	3.9	170-100
AOC-2-TP-07	94	10/10	0.07	13.5	4.7	200-125