Soil Vapor Extraction Pilot Test Report May 2012

Airport Kwik Stop Site
Ione, Washington

for
Washington State Department of Ecology

June 11, 2012

GeoEngineers
Earth Science + Technology

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File No. 0504-058-02

June 11, 2012

Prepared for:

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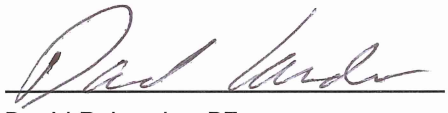

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

This report presents results of soil vapor extraction (SVE) pilot tests performed in May 2012 and provides a conceptual interim remediation plan at the Airport Kwik Stop Site in Ione, Washington (Vicinity Map, Figure 1). Pilot tests were performed in the area of known vadose-zone contamination at the Airport Kwik Stop, generally east of the former fuel dispensers and underground storage tanks (USTs). Test results were utilized to ascertain the effectiveness of SVE as an interim remediation approach to address source contamination, and will be used to design an interim SVE remediation system.

Pilot tests were also performed to assess air sparge techniques as an effective remedial approach to address gasoline-contaminated groundwater at the Airport Kwik Stop. The air sparge tests were not effective enough to utilize in an interim remediation approach; therefore, results are not discussed in this document but will be addressed in the forthcoming Remedial Investigation report.

1.1. Site Background

The Airport Kwik Stop previously sold regular and premium gasoline, which was contained in three underground storage tanks (USTs). Records indicate that two tanks were approximately 2,000 gallons, and a third had a capacity of less than 500 gallons. The small UST reportedly last stored gasoline in 1984, and was reportedly emptied. The two larger USTs were reportedly closed in 1989. The Airport Kwik Stop continued to dispense gasoline using above ground storage tanks (ASTs). The ASTs are located behind (west) of the Airport Kwik Stop. In May 2008, a flex pipe beneath the premium fuel dispenser was observed to be spraying gasoline inside the dispenser. The flex pipe was repaired and subsequently, after passing a tightness test, returned to service. The Airport Kwik Stop has not sold petroleum since fall 2008.

Recent assessment activities at the site have documented the presence of petroleum hydrocarbon contamination (gasoline) in soil and groundwater at the site as well as crossgradient and downgradient of the site. The entire site is shown on the Site Plan, Figure 2. Gasoline-range petroleum hydrocarbon (GRPH) contamination in shallow soil extends from less than 2 feet below ground surface (bgs) near the former premium fuel dispenser, to groundwater (about 34 to 38 feet bgs). Concentrations of GRPH in soil samples collected from explorations at the Airport Kwik Stop have ranged from non-detect to 17,200 milligrams per kilogram (mg/kg), with the highest concentrations from samples located nearest the fuel dispensers. Although the USTs were closed, and the ASTs no longer contain gasoline, gasoline contamination in soil continues to leach downward to groundwater, where it is transported laterally downgradient with groundwater flow from the Airport Kwik Stop in both liquid-phase form (product) and dissolved in groundwater. The gasoline-contaminated groundwater plume has migrated about 1,400 feet east-southeast from the Airport Kwik Stop and contamination has been detected in domestic drinking water wells. The approximate extent of soil contamination at the Airport Kwik Stop, and the depth to the top of soil contamination is shown in Airport Kwik Stop Vadose Zone Contamination, Figure 3. Groundwater Elevations, Flow Direction and Approximate Extent of Groundwater Plume, May 2012, Figure 4, illustrates the groundwater flow direction, groundwater elevations and approximate extent of the petroleum contamination observed in May 2012.

1.2. Regional Shallow Geology and Hydrogeology

The Town of Ione is situated within the Pend Oreille River Valley in Pend Oreille County, Washington. Topography slopes gently downward to the north along the main axis of the river valley, and the valley is bounded by upland areas to the east and west.

Review of water well reports from near the project area indicates that subsurface conditions consist of an upper zone of silt, sand and gravel, which extends to depths in the range of about 40 to 60 feet. The upper silt, sand and gravel unit appears to be underlain by clay of significant thickness. The water well report for the domestic water well at the Cabin Grill (located about 300 feet southeast of the Airport Kwik Stop) indicates that sand and gravel extends to a depth of about 50 feet below the site. Reports for several water wells in the area indicate that the clay layer extends to depths of at least several hundred feet.

Results of explorations at the Airport Kwik Stop completed during site characterization and RI/FS activities in 2010 through 2012 generally confirm the published geologic conditions. Shallow soil beneath the site generally consists of silty fine sand to depths of about 30 feet bgs, with increasing coarse material (sand and gravel) with depth. About 30 feet bgs, the soil conditions typically are fine to coarse sand with gravel and trace silt. A thick clay layer is located about 40 to 42 feet below grade; as mentioned above, the clay layer reportedly is several hundred feet thick. Groundwater typically was encountered about 35 feet bgs at the Airport Kwik Stop.

During groundwater monitoring events conducted at the Site, groundwater was encountered at depths ranging from 34.10 to 38.01 feet bgs in well MW-8, which is located at the Airport Kwik Stop. Based on the soil conditions encountered at the locations of the borings, the shallow groundwater table underlying the site appears to be unconfined and situated above the low-permeability clay unit. Interpreted groundwater flow direction during previous groundwater monitoring events generally was east-southeast; away from upland recharge areas to the west and towards the Pend Oreille River to the east. However, the local distribution in groundwater elevation, flow direction and gradient observed at the site was relatively complex. Within the west portion of the site (at the Airport Kwik Stop), hydraulic gradient was relatively steep, at about 1.6×10^{-2} feet per foot (about 85 feet per mile) and groundwater flowed east. Within the east portion of the site (closer to the Pend Oreille River), hydraulic gradient flattened significantly, averaging about 2.4×10^{-3} feet per foot (about 12.7 feet per mile) and groundwater flowed east-southeast. Figure 4 shows groundwater elevations measured at site monitoring wells and interpreted groundwater elevation contours and flow directions during the most recent monitoring activities in May 2012. Variation in hydraulic gradient could be caused by soil permeability variation across the site (an increase in permeability to the east), the geometry of perching layers, and/or Pend Oreille River stage.

The thickness of the saturated zone of the shallow aquifer beneath the Airport Kwik Stop (and most portions of the site) is minimal – about 5 to 8 feet. However, this aquifer appears to be productive enough for domestic well usage, and several homes in the east portion of the site (along the river) and the nearby Cabin Grill restaurant, draw water from this aquifer for domestic use.

2.0 SOIL VAPOR EXTRACTION TESTS

2.1. General

Before commencing with SVE pilot testing, three groundwater monitoring wells (MP-1, MP-2 and MW-8), one air sparge pilot test well (AS-1) and two pilot SVE test wells (SVE-1 and SVE-2) were installed at the site. The SVE pilot test wells are screened within the vadose (unsaturated) zone above the water table. During pilot testing, the test wells were connected to a blower, which applied a vacuum to the wells. The applied vacuum pulled air from the surrounding soil, into the well screens, and then through piping to an exhaust stack. Air flow through the soil enhances volatilization of petroleum products located within the vadose zone. The volatilized petroleum products are pulled into the SVE wells, thereby removing them from the ground.

Three SVE tests were performed by drawing a vacuum from wells SVE-1 and SVE-2, first individually, then collectively, for a period ranging from 1¾ to 3 hours per test. Tests were conducted using a Rotron EN 404 regenerative blower to apply a vacuum to piping connected to the wellhead(s) of SVE-1 and/or SVE-2. Vacuums were measured at adjacent monitoring wells, specifically wells MP-1, MP-2, and MW-8 (and the other SVE well during the individual tests). The locations of the wells at the Airport Kwik Stop site are shown in Figure 2 and Figure 3.

Test equipment included a trailer-mounted remediation system consisting of the regenerative blower, a moisture knockout tank, and an exhaust stack, and both flex and rigid pipe connecting the remediation system to the wellhead(s). The rigid pipe (5-foot-long, 2-inch diameter) was placed at the wellhead and sample ports were located at the end of the pipe furthest from the wellhead (the straight, rigid pipe can reduce the air flow turbulence and result in more reliable air flow readings); about 50 feet of 2-inch-diameter flex pipe connected the rigid pipe to the moisture knockout tank at the remediation system. Sample ports also were placed at the exhaust stack. Each test was performed in a stepped approach, beginning each test with low applied vacuum and ample dilution air, and increasing the vacuum by closing the dilution air valve in steps. The end of each test was performed with the dilution air valve completely closed (maximum applied vacuum). The moisture knockout tank was located in line between the wellhead and the blower to reduce the potential for moisture damage to the blower.

During each test, the following parameters were measured in the sample ports located on the rigid pipe and exhaust stack: air velocity, vacuum, volatile organic compounds (VOCs), oxygen levels, and carbon dioxide levels. Observed vacuum was measured at regular intervals during the tests using magnehelic gauges placed at the wellheads of observation wells; applied vacuum at the blower was increased after observed vacuum at observation wells stabilized. Depth to groundwater was measured in air sparge well AS-1 to monitor if applied vacuum affected groundwater elevations. At the conclusion of the individual tests at SVE-1 and SVE-2, a vapor sample was collected into a Summa canister from the sample port located at the exhaust stack.

Well screen information is provided below:

- Well SVE-1 is a 4-inch diameter well screened from about 10 to 20 feet bgs
- Well SVE-2 is a 4-inch diameter well screened from about 25 to 35 feet bgs
- Wells MP-1 and MP-2 are 2-inch diameter wells screened from about 10 to 40 feet bgs

- Well AS-1 is a 4-inch diameter well screened from about 40 to 42 feet bgs (submerged screen)
- Well MW-8 is a 2-inch diameter well screened from about 28½ to 43½ feet bgs

2.2. SVE Test Results Using SVE-1

The test conducted at well SVE-1 began at a measured vacuum of 10 inches of water (iow) at the moisture knockout tank and 6.0 iow at the wellhead; the dilution valve was about 50 percent open. Air velocity through the 2-inch diameter exhaust stack was measured between about 4,670 feet per minute (fpm) to 5,070 fpm; this converts to about 102 to 109 cubic feet per minute (cfm), which matches the manufacturer's blower rating curves for the applied vacuum. After about one hour into the test, the dilution valve was fully closed, which resulted in a measured vacuum of 16 iow at the moisture knockout tank and about 8.3 iow at the wellhead. The test at SVE-1 was operated at this vacuum for about 75 minutes, and the entire test was completed after about 2¼ hours. Air flows decreased slightly during the second half of the test at SVE-2 and ranged from about 87 cfm to 103 cfm with the dilution valve fully closed. Air flows generally remained constant throughout the test at SVE-1. Field data is provided in Figure 5 and a summary of measurements is listed below:

- Oxygen levels at the wellhead ranged from about 2.6 percent to 5.6 percent during the test. Oxygen levels at the exhaust stack were measured at 7.1 percent during the first hour of the test; then decreased to about 1.2 percent to 1.4 percent after the dilution valve was closed.
- Carbon dioxide levels were consistently measured greater than 5 percent at both the wellhead and exhaust stack during the test.
- Temperatures ranged from about 58.0 to 65.5 degrees Fahrenheit at the wellhead and from about 88.5 to 96.5 degrees Fahrenheit at the exhaust stack; temperatures gradually increased in the exhaust stack during the test.
- VOCs, as measured using a photoionization detector (PID) consistently exceeded the maximum range of the PID within 1 to 2 seconds. The PID was removed from the air flow after the pre-set alarm sounded because extended readings could have damaged the equipment. Results shown in Table 1 represent the last reading observed before the alarm sounded.
- Applied vacuums at four monitoring wells were measured during the test; wells ranged in linear distance from about 12½ to 39½ feet from SVE-1. Actual distances, as measured from the closest point between screened intervals of SVE-1 and observation wells, ranged from about 22½ to 39½ feet. Observed vacuum at observation wells at the conclusion of each stepped test ranged from about 4.7 percent to 7.6 percent of the applied vacuum at the wellhead.
- The depth to groundwater, as measured in well AS-1, remained steady at 34.75 feet below the top of well casing throughout the test.
- Analytical results of the vapor sample collected at the conclusion of the SVE-1 test indicate concentrations of total petroleum hydrocarbons were 16,500 parts per million by volume (ppmv) and benzene concentrations were 870 ppmv. Results are shown in Table 1.

2.3. SVE Test Results Using SVE-2

The test conducted at well SVE-2 began at a measured vacuum of 5 iow at the moisture knockout tank and 1.8 iow at the wellhead; the dilution valve was about 50 percent open. Air velocity

through the 2-inch-diameter exhaust stack was measured between about 4,700 fpm to 5,800 fpm; this converts to about 102 to 126 cfm, which generally matches the manufacturer's blower rating curves for the applied vacuum (the highest reading exceeds the rating curves and is assumed to be an anomaly). After about one hour into the test, the dilution valve was about ¾ closed, which resulted in a measured vacuum of 10 iow at the moisture knockout tank and about 3.4 iow at the wellhead. After about another hour, the dilution valve was fully closed, which resulted in a measured vacuum of 12 iow at the moisture knockout tank and about 4.1 iow at the wellhead. The test at SVE-2 was completed after about 2¾ hours. Air flows decreased slightly during the test at SVE-2 and ranged from about 89 cfm to 102 cfm with the dilution valve fully closed. Field data is provided in Figure 6 and a summary of measurements is listed below:

- Oxygen levels at the wellhead ranged from about 2.8 percent to 4.5 percent during the test. Oxygen levels at the exhaust stack were measured at about 11 percent during the first hour of the test; then decreased to about 1.3 percent after the dilution valve was closed.
- Carbon dioxide levels were consistently measured greater than 5 percent at both the wellhead and exhaust stack during the test.
- Temperatures ranged from about 59.7 to 66.2 degrees Fahrenheit at the wellhead and from about 88.8 to 94.4 degrees Fahrenheit at the exhaust stack; temperatures gradually increased in the exhaust stack during the test.
- VOCs, as measured using a PID consistently exceeded the maximum range of the PID within 1 to 2 seconds. The PID was removed from the air flow after the pre-set alarm sounded because extended readings could have damaged the equipment. Results shown in Figure 6 represent the last reading observed before the alarm sounded.
- Applied vacuums at four monitoring wells were measured during the test; wells ranged in distance from about 15 to 46½ feet from SVE-2. Actual distances, as measured from the closest point between screened intervals of SVE-2 and observation wells, also ranged from about 15 to 46½ feet. Observed vacuum at observation wells ranged from about 10.0 percent to 23.3 percent of the applied vacuum at the wellhead.
- The depth to groundwater, as measured in well AS-1, remained steady at 34.75 feet below the top of well casing throughout the test.
- Analytical results of the vapor sample collected at the conclusion of the SVE-2 test indicate concentrations of total petroleum hydrocarbons were 14,700 ppmv and benzene concentrations were 677 ppmv. Results are shown in Table 1.

2.4. Combined SVE Test Results Using SVE-1 and SVE-2

A combined test was conducted by drawing a vacuum from both SVE-1 and SVE-2 simultaneously. The test was started with the dilution valve at the knockout tank fully closed and valves at both wellheads fully open. This portion of the test operated for about one hour, but resulted in uneven vacuum applied at the wellheads. The second portion of the test operated for about 40 minutes, but the valves at the wellheads were adjusted to result in roughly equal applied vacuum at both wellheads.

The combined test began at a measured vacuum of 8.5 iow at the moisture knockout tank, 3.5 iow at SVE-1, and 2.3 iow at SVE-2. Air velocity through the 2-inch diameter exhaust stack was

measured between about 4,230 fpm to 4,490 fpm; this converts to about 92 to 98 cfm, which matches the manufacturer's blower rating curves for the applied vacuum. After one hour into the test, the vacuums were balanced at each wellhead, which resulted in a measured vacuum of 10 iow at the moisture knockout tank and about 2.8 iow at each wellhead. Air flows remained steady after balancing the vacuums. The combined SVE-1 and SVE-2 test was completed after about 1¾ hours. Field data is provided in Figure 7 and a summary of measurements is listed below:

- Oxygen and carbon dioxide levels were not measured during the combined test.
- Temperatures ranged from about 61.3 to 65.8 degrees Fahrenheit at the SVE-1 wellhead, from about 59.5 to 60.9 degrees Fahrenheit at the SVE-2 wellhead, and from about 89.0 to 91.5 degrees Fahrenheit at the exhaust stack; temperatures generally remained steady during the test.
- VOCs as measured using a PID consistently exceeded the maximum range of the PID within 1 to 2 seconds. The PID was removed from the air flow after the pre-set alarm sounded because extended readings could have damaged the equipment. After a few minutes into the test, the PID was less frequently used because of concerns regarding damaged equipment; therefore, results were not listed in Figure 7.
- Applied vacuums at three monitoring wells were measured during the test; wells ranged in distance from about 12½ to 20½ feet from either SVE-1 or SVE-2 (whichever was closer); observed vacuum at observation wells at the conclusion of the test (under balanced vacuum) ranged from about 17.1 percent to 24.3 percent of the applied vacuum at the wellheads.
- The depth to groundwater, as measured in well AS-1, remained steady at 34.75 feet below the top of well casing throughout the test.
- No vapor sample was collected during the combined test.

2.5. SVE Test Analysis

Results of the individual tests conducted at both SVE-1 and SVE-2, and the combined SVE-1/SVE-2 test, indicate soil vapor extraction is a viable remedial approach to remove petroleum hydrocarbons from vadose-zone soil. Vacuum was observed in all monitoring points utilized during the test, and frequently was 5 percent or greater than the applied vacuum at the wellhead. Results of field measurements of VOCs (which consistently exceeded the range of the instrument) and analytical results of vapor samples collected during the tests indicated petroleum hydrocarbons could be readily removed from the subsurface soil. Petroleum hydrocarbon concentrations (as gasoline) were greater than 10,000 parts per million by volume (greater than 1 percent in air). Based on removal rates of 100 cfm and the TPH concentrations in vapor samples collected during the pilot tests, approximately 600 pounds of TPH (about 90 gallons) could be removed daily using an SVE system.

The effective radius of influence was calculated by plotting the ratio of measured to applied vacuum at monitoring points and the distance from the monitoring point to the SVE wellhead on a semi-log graph. The distance from the monitoring point to the extraction well was placed on the logarithmic scale and the average ratio of monitored vacuum to applied vacuum was placed on the arithmetic scale for each applied vacuum. A best-line fit was placed on each graph. The distance where the ratio was 1 percent was considered to be within the zone of influence and the distance

where a ratio of 5 percent was considered to be an acceptable distance for remedial design purposes. The distance where the ratio was greater than 10 percent was considered to be strongly influenced. Considering the SVE and monitoring wells are screened at varying depths, the effective distance between two points was measured from the top of screened interval in the SVE well to the closest point within the screened interval in the monitoring wells.

Based on the SVE test data, and utilizing the measured and applied vacuum at the conclusion of each stepped test, the approximate radius of influence was about 30 feet for the test conducted using SVE-1 (shallow), and more than 100 feet for the test conducted using SVE-2. The larger radius of influence for the test conducted at SVE-2 likely is because of the coarser soil conditions encountered at depth and relative ease of air flow through coarser soil compared to finer soil. Considering none of the wells was located further than 46½ feet from SVE-2, a more conservative radius of influence for the test conducted at SVE-2 is 50 feet.

3.0 CONCEPTUAL SVE DESIGN

As mentioned above, the pilot tests indicate SVE can be an effective remedial technology to address vadose-zone soil beneath the Airport Kwik Stop. The radius of influence became larger with depth, likely because more coarse material was observed in soil borings. One observation noted during the pilot tests was that the wells screened at similar depths as the extraction well showed quicker response and higher measured vacuum as a relation to distance; therefore, preferential air flow appears to be horizontal as compared to vertical. Therefore, wells should be placed to maximize horizontal flow at varying depths. Another observation noted during assessment activities is the western extent of contamination is not well defined because of the presence of the building; therefore, a more conservative design approach to capture potential contamination beneath the building will be to place extraction wells near the building. Oxygen levels were relatively low during the tests, and the presence of oxygen can accelerate biodegradation at the site.

A typical simplified SVE system is shown in Typical Soil Vapor Extraction System, Figure 8. A regenerative blower applies a vacuum to several wells, which are screened at various depths in the contaminated vadose-zone soil. Valves at a manifold located between the blower and the wells control the vacuum and air flow to each well. The extracted contaminated soil vapors are treated before discharge to the atmosphere. The system also can be configured to force ambient air into the soil, thus providing oxygen to stimulate biodegradation of petroleum products.

We propose an interim remedial design that consists of the following elements:

- Utilizing the existing SVE wells: SVE-1 (screened from about 10 to 20 feet bgs) and SVE-2 (screened from about 25 to 35 feet bgs).
- Installing one new well SVE-3 with a shallow screened interval between 5 to 15 feet, near the center of the southwest edge of the (see Proposed SVE Extraction Shallow Wells, Figure 9).
- Installing two new wells with middle screened intervals (one screened between 15 and 25 feet bgs and one screened between 20 and 30 feet bgs) placed near the east and west limits of the

vadose-zone contaminated soil (shown as SVE-4 and SVE-5 in Proposed SVE Extraction Middle Wells, Figure 10).

- Installing one new well with a deep screened interval (screened between 25 and 35 feet bgs) placed near the northwest corner of the canopy (see Proposed SVE Extraction Deep Wells, Figure 11).
- Utilizing the existing monitoring wells, MP-1 and MP-2, as either SVE wells or bioventing wells.
- Installing a temporary remedial system on the south side of the Airport Kwik Stop. The remedial system likely will include two regenerative blowers capable of collectively generating flows between 300 and 500 cubic feet per minute. The blowers will be arranged to have the capacity to switch from soil vapor extraction (vacuum) mode to bioventing (pressure) mode. The remedial equipment will include a moisture knockout tank(s), an electrical panel, valves and gauges, and connections to vapor discharge apparatus, as needed.
- Utilize vapor treatment equipment until such time that petroleum hydrocarbon concentrations in vapor and daily flow rates result in total petroleum discharge amounts that are less than allowable discharge limits. We anticipate that, based on the high petroleum concentrations observed during the pilot test, that a catalytic oxidizer or combustion unit might be the short-term option until carbon scrub units can be utilized.

TABLES

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Table 1

Vapor Sample Analytical Results

Airport Kwik Stop Site
Ione, Washington

		Sample ID	SVE-1-050812	SVE-2-050812
		Date Sampled	5/8/2012	5/8/2012
TO-15 (µg/m^3)	Benzene		5,870,000	5,150,000
	Cyclohexane		13,800,000	12,700,000
	Ethanol		82,000	<11,600
	Ethylbenzene		1,400,000	1,340,000
	4-Ethyltoluene		117,000	187,000
	n-Heptane		3,720,000	3,130,000
	n-Hexane		5,610,000	4,990,000
	Toluene		9,360,000	8,840,000
	1,2,4-Trimethylbenzene		199,000	356,000
	1,3,5-Trimethylbenzene		80,800	149,000
	m&p-Xylene		4,390,000	4,510,000
	o-Xylene		1,350,000	1,490,000
TO-3 Air (ppmv)	Benzene		870	677
	BTEX (Total)		3,960	3,470
	Ethylbenzene		107	102
	n-Hexane		730	641
	Methyl-tert-butyl ether		274	243
	THC as Gas		16,500	14,700
	Toluene		2,510	2,180
	1,2,4-Trimethylbenzene		<14.9	22.9
	1,3,5-Trimethylbenzene		<14.9	<14.9
	Xylene (Total)		473	516
	m&p-Xylene		370	396
	o-Xylene		103	121

https://projects.geoengineers.com/sites/0050405802/Final/Ione SVE Pilot Test Report/[Table 1 Ione Vapor Chemistry.xlsx]Chemistry

FIGURES

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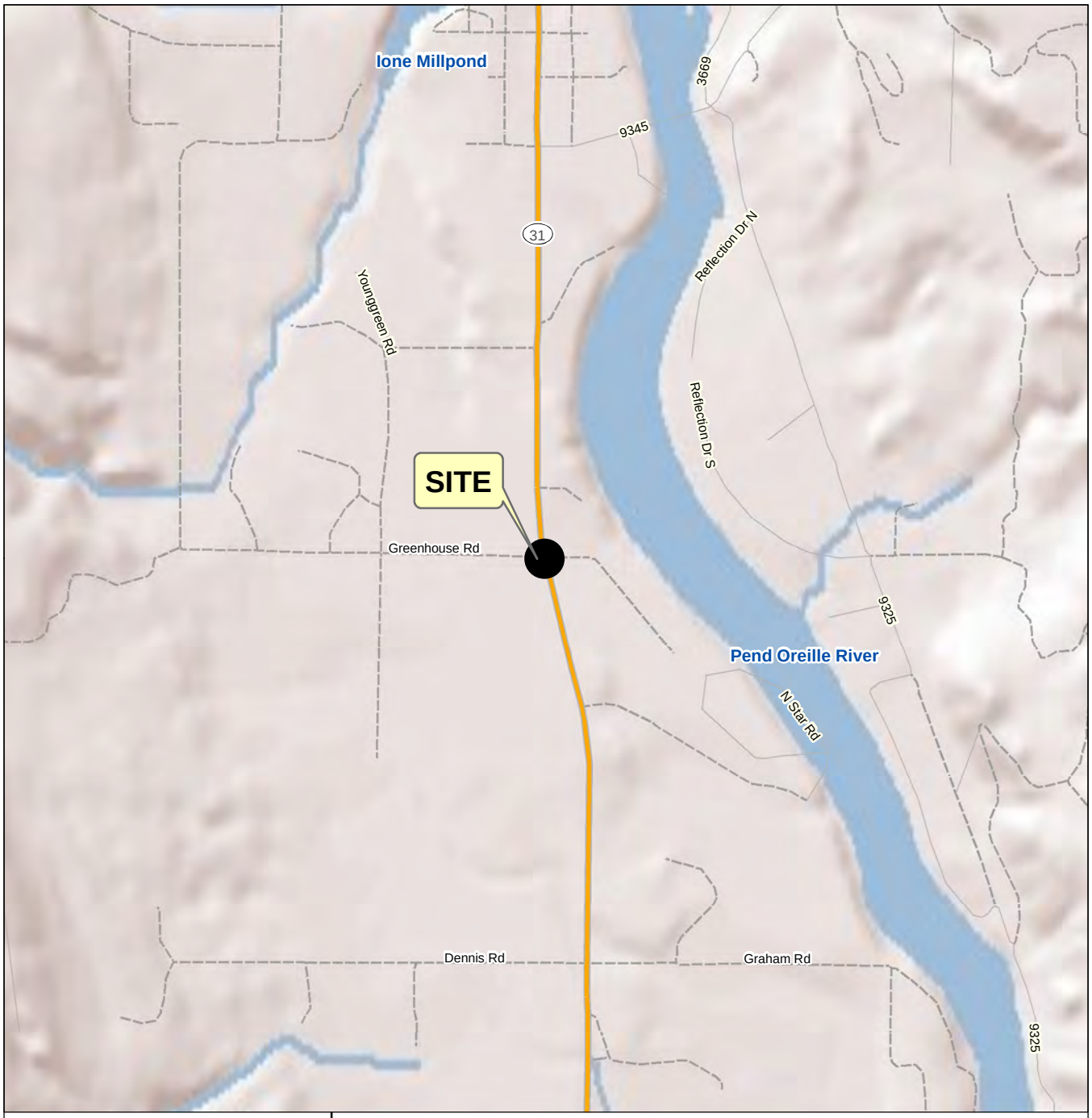

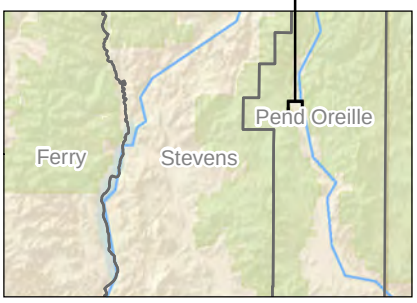

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
Data Sources: ESRI Data & Maps, Street Maps 2008.
Projection: NAD 1983, UTM Zone 11 North.

Vicinity Map

Airport Kwik Stop
Ione, Washington

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Figure 1

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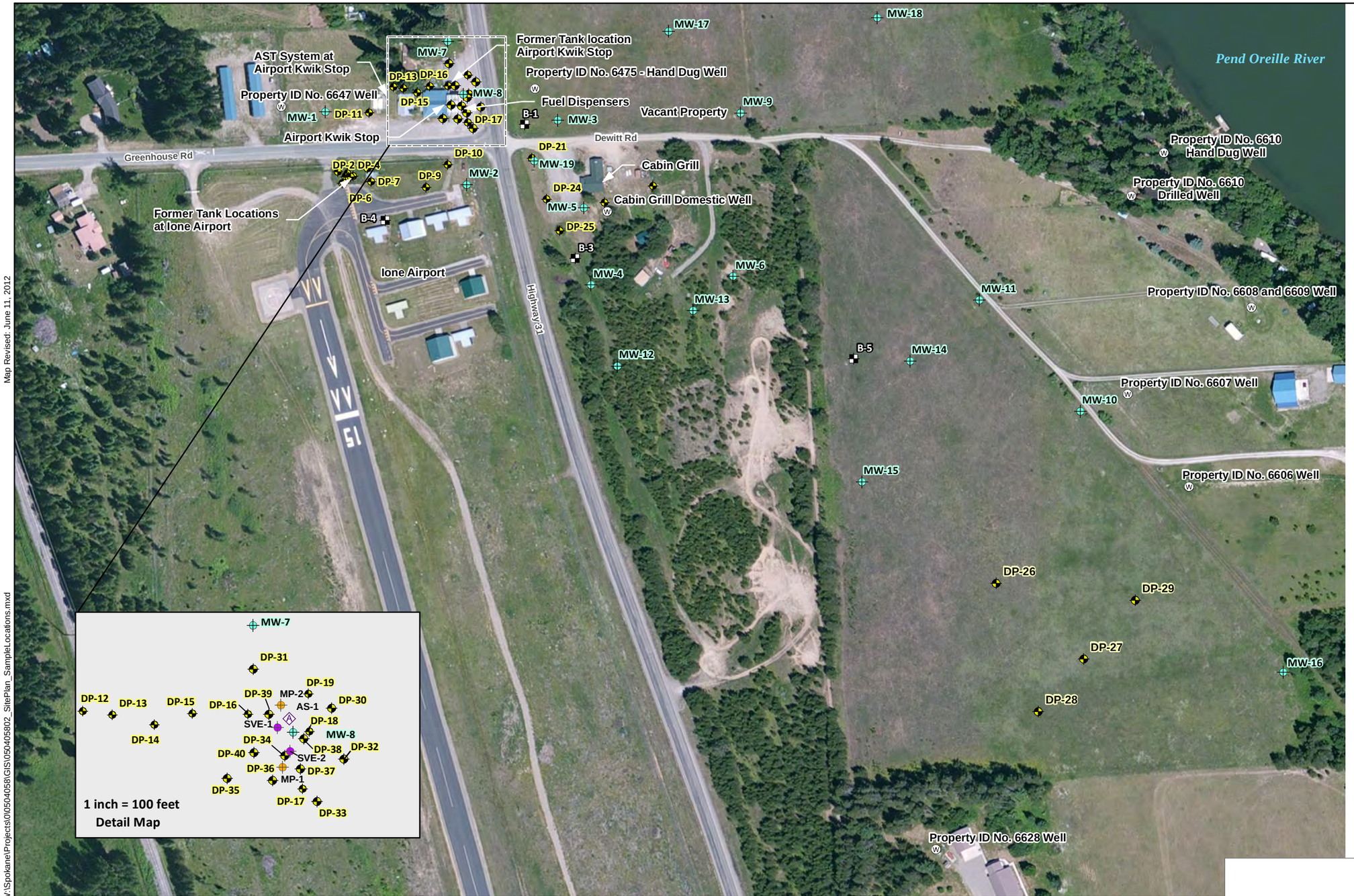

Legend

- DP-1 — Approximate Location of Direct-Push Boring
- B-1 — Approximate Location of Exploration
- MW-1 — Approximate Location of Monitoring Well
- (W) — Approximate Location of Existing Water Well
- AS-1 — Approximate Location of Air Sparge Pilot Well
- MP-1 — Approximate Location of 2" Monitoring Point
- SVE-1 — Approximate Location of 4" SVE Extraction Well

Reference: Bing Maps aerial from ESRI, Online Data Resource Center.
ESRI Data & Maps, Street Maps 2008

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Site Plan

Airport Kwik Stop
Ione, Washington

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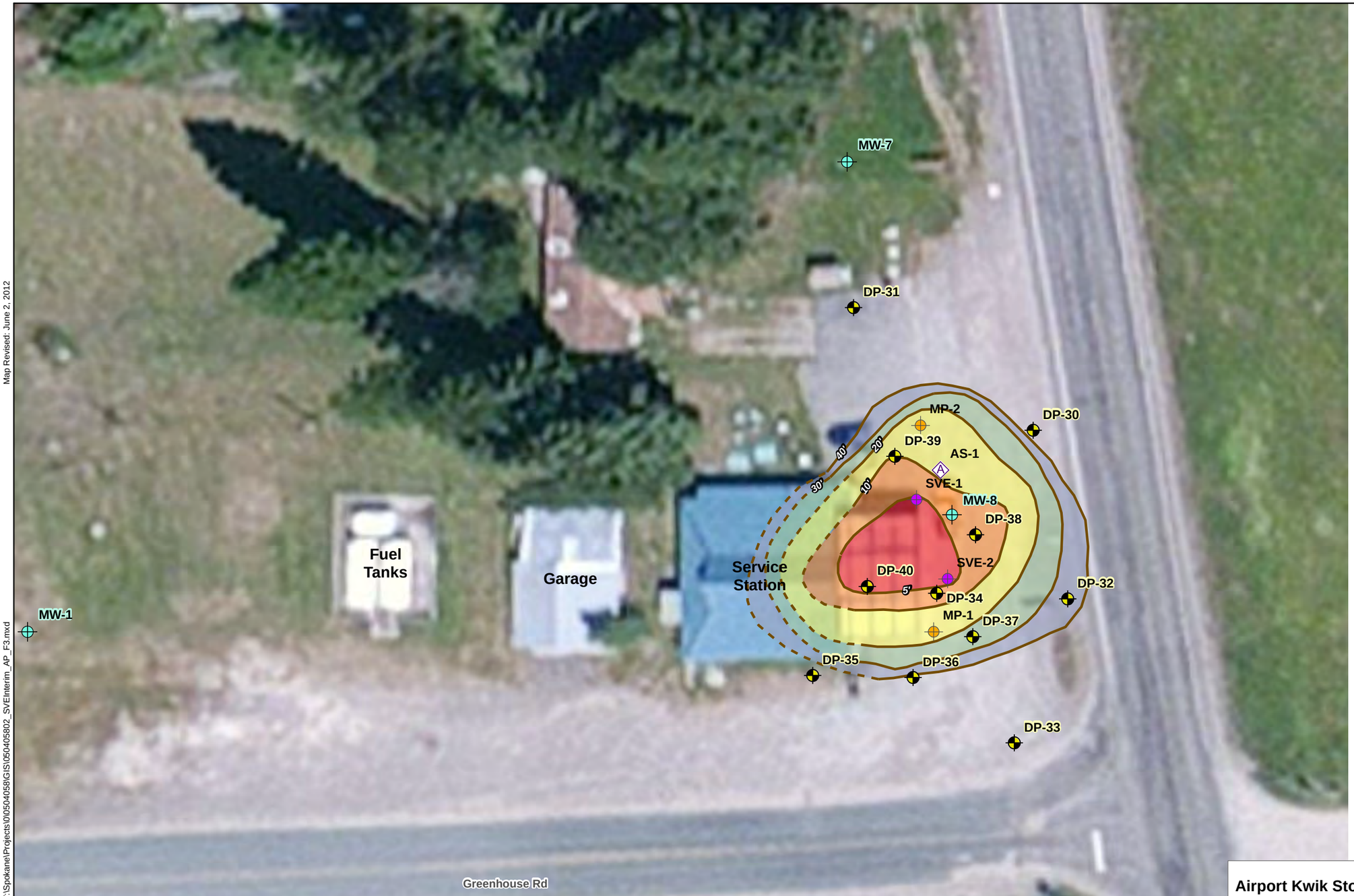
Figure 2

Map Revised: June 11, 2012

Path: W:\Spokane\Projects\0050405\8\GIS\0504058\GIS\0504058_SitePlan_SampleLocations.mxd

OfficeLocation: SPO



Legend

- DP-1 — Approximate Location of Direct-Push Boring
- MW-1 — Approximate Location of Monitoring Well
- SVE-1 — Approximate Location of 4" SVE Extraction Well
- MP-1 — Approximate Location of 2" Monitoring Point
- AS-1 — Approximate Location of Air Sparge Pilot Well
- 20' — Contamination Contours (10 ft depth bgs)
- Extrapolated Contamination Contours

Depth to Top of Contamination

- 0 - 5' bgs
- 5 - 10' bgs
- 10' - 20' bgs
- 20' - 30' bgs
- 30' - 40' bgs

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Feet

Map Revised: June 2, 2012

Path: W:\Spokane\Projects\0\050405802\GIS\050405802_SVEInterim_AP_F3.mxd

OfficeLocation: SPO

Reference: Bing Maps aerial from ESRI, Online Data Resource Center.
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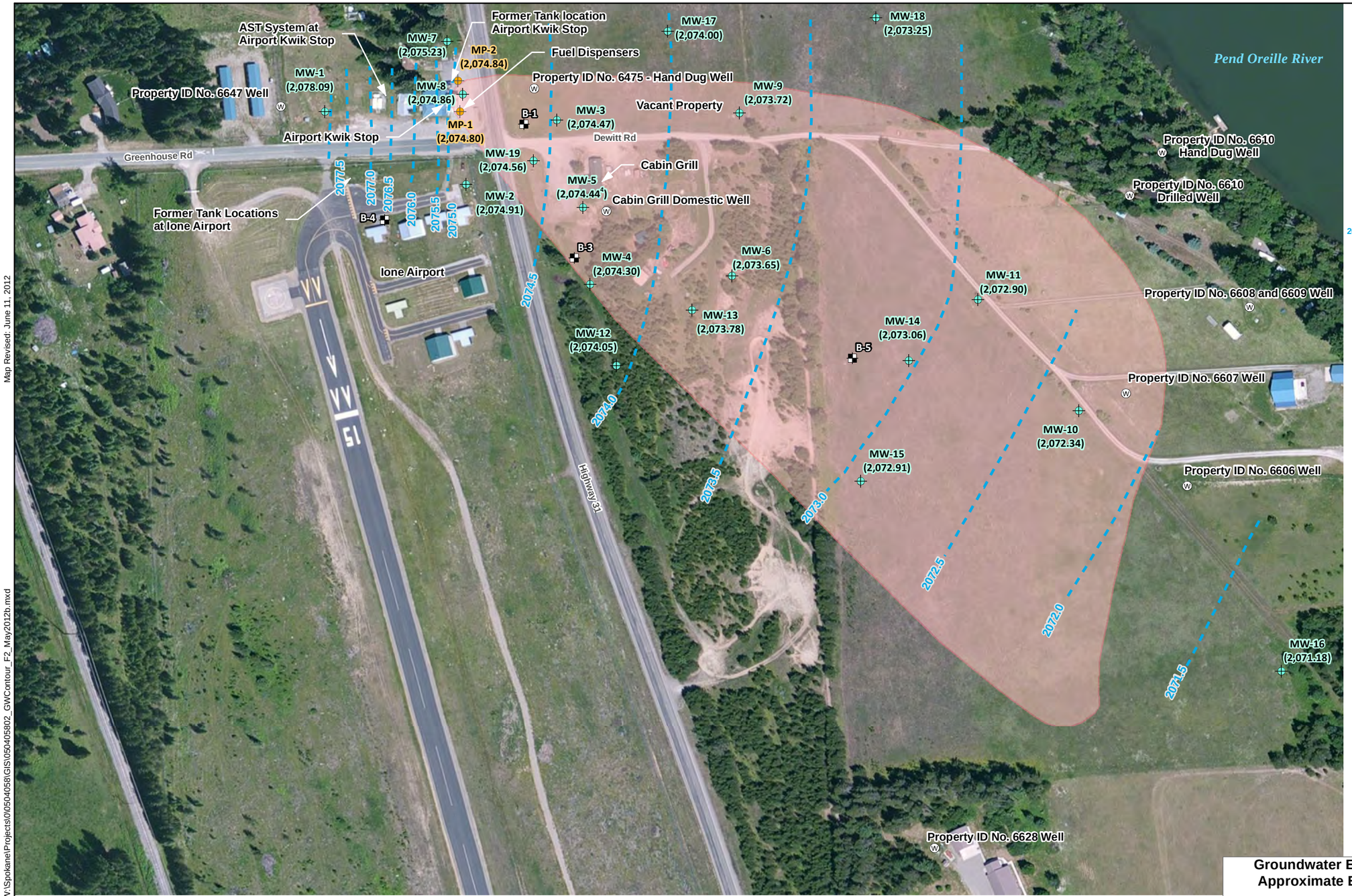
Airport Kwik Stop Vadose Zone Contamination

Airport Kwik Stop
Ione, Washington

GeoEngineers

Figure 3



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- W — Approximate Location of Existing Water Well
- MP-1 — Approximate Location of 2" Monitoring Point
- 2071.5 — Approximate Groundwater Elevation Contour (0.5-Foot Interval)
- Approximate Extent of Plume of Petroleum Contaminated Groundwater

N W E S

200 0 200
Feet

Reference: Bing Maps aerial from ESRI, Online Data Resource Center.
ESRI Data & Maps, Street Maps 2008

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Elevations are referenced in NAVD 88.
4. The equivalent (true) groundwater elevation at MW-4 and MW-5 as showing calculated to account for the presence of the free product using the following equation: GW = SG X T + IE; where GW = equivalent groundwater elevation SG = specific gravity of free product (0.75) for gasoline; T = thickness of product measured in well using oil/water interface probe; IE =elevation of water/product interface measured in the well.

Groundwater Elevations, Flow Direction and Approximate Extent of Groundwater Plume May 2012

Airport Kwik Stop
Ione, Washington

GeoEngineers

Figure 4

Map Revised: June 11, 2012

Path: W:\Spokane\Projects\0\0504058\GIS\0504058_GWContour_F2_May2012b.mxd

OfficeLocation: SPO

SVE-1 Test
Extraction Well: SVE -1

Time	Vacuum at wellhead (Inches of water)	VOCs (ppm)	Air Velocity (FPM)	Air Flow Rate (cf/m)	O2%	CO2%	Temperature (F)	Notes
945	5.6	2,400	4,333	94	2.9	>5	58.0	start low vacuum test
953	5.8	1,000	5,344	117	3.2	>5	65.5	
958	6.0	1,200	4,526	99	3.1	>5	58.4	
1005	6.0	1,600	7,545	165	5.2	>5	59.2	
1016	6.0	1,760	6,138	134	5.2	>5	59.8	
1026	6.0	1,130	6,608	144	5.1	>5	59.7	
1039	6.0	2,200	6,980	152	5.6	>5	60.7	
1046	8.2	1,600	9,600	209	2.7	>5	60.0	start high vacuum test
1056	8.4	2,300	11,000	240	2.8	>5	62.7	
1103	8.5	2,600	9,926	216	2.6	>5	60.9	
1116	8.4	2,500	9,500	207	2.8	>5	61.6	
1126	8.3	1,700	10,571	231	2.9	>5	62.5	
1150	8.3	–	8,724	190	–	–	59.8	

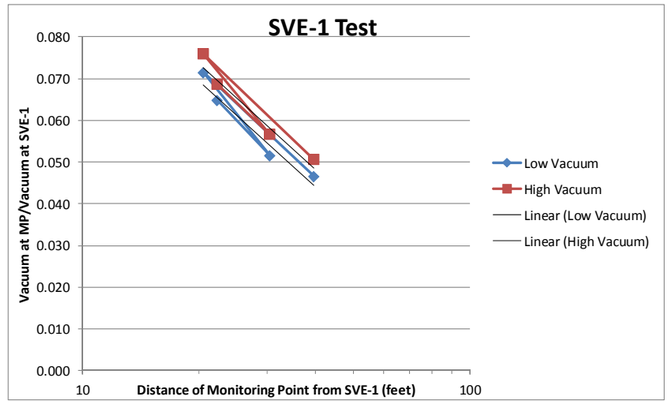
Summary

Low Vacuum

	Distance	MP/Extraction
MP-1	39.5	0.047
MP-2	20.5	0.072
SVE-2	30.5	0.052
MW-8	22.3	0.065

High Vacuum

	Distance	MP/Extraction
MP-1	39.5	0.051
MP-2	20.5	0.076
SVE-2	30.5	0.057
MW-8	22.3	0.069



Time	Vacuum at blower (inches of water)	VOCs (ppm)	Air Velocity (FPM)	Air Flow Rate (cf/m)	O2%	CO2%	Temperature (F)	Notes
945	10	1,700	4,960	108	7.1	>5	88.5	start low vacuum test
953	10	2,900	4,838	105	7.1	>5	88.6	
958	10	3,000	4,944	108	7.1	>5	89.7	
1005	10	1,700	5,070	111	7.1	>5	89.2	
1016	10	3,200	5,004	109	7.1	>5	89.0	
1026	10	3,400	4,670	102	7.1	>5	88.8	
1039	10	3,300	4,797	105	7.1	>5	90.1	
1046	16	3,000	4,000	87	1.2	>5	92.1	start high vacuum test
1056	15	2,900	4,184	91	1.3	>5	94.2	
1103	15	2,800	4,737	103	1.3	>5	93.8	
1116	15	2,600	4,165	91	1.3	>5	95.7	
1126	15	2,400	4,175	91	1.4	>5	96.5	
1150	15	–	4,528	99	–	>5	91.7	

	Monitoring Points							
	MP-1		MP-2		SVE-2		MW-8	
	distance to SVE-1:	39.5 feet	distance to SVE-1:	20.5 feet	distance to SVE-1:	26.5 feet	distance to SVE-1:	12.5 feet
	distance from screen to SVE-1 screen:	39.5 feet	distance from screen to SVE-1 screen:	20.5 feet	distance from screen to SVE-1 screen:	30.5 feet	distance from screen to SVE-1 screen:	22.3 feet
Time	Vacuum (Inches of water)	MP/Extraction	Vacuum (Inches of water)	MP/Extraction	Vacuum (Inches of water)	MP/Extraction	Vacuum (Inches of water)	MP/Extraction
945	0.16		0.40		0.22		0.22	
955	0.22		0.42		0.28		0.35	
1010	0.28		0.43		0.32		0.40	
1020	0.24		0.40		0.28		0.36	
1030	0.24		0.41		0.29		0.37	
1040	0.28	0.047	0.43	0.072	0.31	0.052	0.39	0.065
1045	0.38		0.57		0.43		0.53	
1100	0.45		0.68		0.51		0.62	
1115	0.43		0.66		0.50		0.60	
1130	0.37		0.57		0.44		0.53	
1145	0.40		0.62		0.46		0.58	
1200	0.42	0.051	0.63	0.076	0.47	0.057	0.57	0.069

File No. 0504-058-02

SVE- 1 Test Data

Airport Kwik Stop Site
Ione, Washington

GeoEngineers

Figure 5

SVE-2 Test
Extraction Well: SVE -2

Time	Vacuum at wellhead (Inches of water)	VOCs (ppm)	Air Velocity (FPM)	Air Flow Rate (cf/m)	O2%	CO2%	Temperature (F)	Notes
1255	1.6	1,700	3,892	85	4.0	>5	60.1	start low vacuum test
1301	1.8	1,700	4,084	89	3.5	>5	61.1	
1309	1.8	–	4,178	91	–	–	62.5	
1313	1.8	1,800	4,550	99	3.5	>5	62.7	
1328	1.8	–	4,120	90	–	–	61.8	
1340	1.8	2,400	4,400	96	4.1	>5	66.2	
1355	3.3	1,900	6,758	147	4.1	>5	61.5	
1401	3.4	–	6,472	141	–	–	60.4	start medium vacuum test
1409	3.4	1,500	6,145	134	4.0	>5	60.0	
1419	3.4	–	6,801	148	–	–	60.9	
1430	3.4	1,900	6,624	144	4.3	>5	60.4	
1444	3.4	–	6,400	140	–	–	59.8	
1447	4.0	1,800	7,098	155	4.5	>5	59.8	start high vacuum test
1456	4.0	1,900	7,355	160	4.2	>5	60.2	
1509	4.0	–	7,324	160	–	–	59.8	
1522	4.1	2,400	7,305	159	2.8	>5	59.7	
1532	4.1	2,700	7,378	161	3.1	>5	59.8	

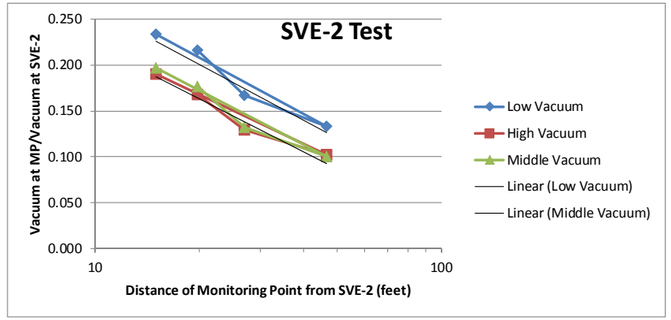
Time	Vacuum at blower (inches of water)	VOCs (ppm)	Air Velocity (FPM)	Air Flow Rate (cf/m)	O2%	CO2%	Temperature (F)	Notes
1255	5	3,306	4,979	109	11.1	>5	89.7	start low vacuum test
1301	5	3,400	4,712	103	10.9	>5	88.8	
1309	5	–	5,787	126	–	–	92.4	
1313	5	3,300	5,184	113	10.9	>5	94.2	
1328	5	–	4,714	103	–	–	93.5	
1340	5	2,400	5,215	114	10.8	>5	92.9	
1355	10	2,600	4,900	107	4.1	>5	93.9	start medium vacuum test
1401	10	–	4,489	98	–	–	94.0	
1409	10	3,100	4,917	107	4.1	>5	94.0	
1419	10	–	4,454	97	–	–	94.0	
1430	10	3,900	4,431	97	5.7	>5	93.7	
1447	12	3,200	4,080	89	1.3	>5	93.7	start high vacuum test
1456	12	3,000	4,279	93	1.3	>5	94.2	
1509	12	–	4,656	102	–	–	93.9	
1522	12	3,400	4,300	94	3.4	>5	94.2	
1532	12	3,400	4,376	95	1.2	>5	92.4	

Summary

	Distance	MP/Extraction
MP-1	15	0.233
MP-2	46.5	0.133
SVE-1	27	0.167
MW-8	19.8	0.217

	Distance	MP/Extraction
MP-1	15	0.197
MP-2	46.5	0.100
SVE-1	27	0.132
MW-8	19.8	0.176

	Distance	MP/Extraction
MP-1	15	0.190
MP-2	46.5	0.102
SVE-1	27	0.129
MW-8	19.8	0.168



	Monitoring Points							
	MP-1		MP-2		SVE-1		MW-8	
	distance to SVE-2: 15 feet		distance to SVE-2: 46.5 feet		distance to SVE-2: 26.5 feet		distance to SVE-2: 19.5 feet	
	distance to screen from SVE-2 screen: 15 Feet		distance to screen from SVE-2 screen: 46.5 feet		distance to screen from SVE-2 screen: 27.0 feet		distance to screen from SVE-2 screen: 19.8 feet	
Time	Vacuum (Inches of water)	MP/Extraction	Vacuum (Inches of water)	MP/Extraction	Vacuum (Inches of water)	MP/Extraction	Vacuum (Inches of water)	MP/Extraction
1255.00	0.30		0.18		0.22		0.28	
1305.00	0.40		0.21		0.27		0.37	
1315.00	0.38		0.17		0.24		0.32	
1330.00	0.38		0.21		0.26		0.35	
1340.00	0.42		0.23		0.31		0.39	
1350.00	0.42	0.233	0.24	0.133	0.30	0.167	0.39	0.217
1355.00	0.60		0.33		0.42		0.56	
1410.00	0.62		0.33		0.43		0.56	
1420.00	0.67		0.35		0.46		0.60	
1430.00	0.61		0.33		0.43		0.58	
1445.00	0.67	0.197	0.34	0.100	0.45	0.132	0.60	0.176
1450.00	0.71		0.38		0.48		0.65	
1500.00	0.72		0.39		0.51		0.68	
1510.00	0.77		0.40		0.53		0.70	
1525.00	0.72		0.43		0.56		0.70	
1535.00	0.78	0.190	0.42	0.102	0.53	0.129	0.69	0.168

File No. 0504-058-02

SVE-2 Test Data

Airport Kwik Stop Site
Ione, Washington

GeoEngineers

Figure 6

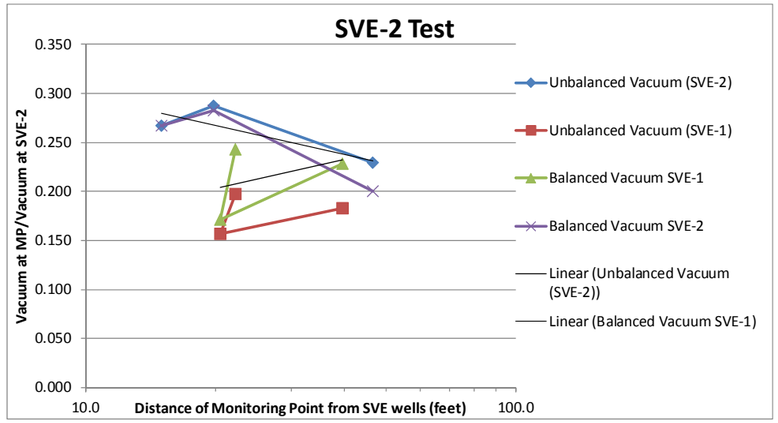
SVE-1 and SVE-2 Test
Extraction Well: SVE-1 & SVE -2

Time	Vacuum at wellhead (SVE-1) (Inches of water)	VOCs (ppm)	Air Velocity (FPM)	Air Flow Rate (cf/m)	O2%	CO2%	Temperature (F)
1554	3.5	–	4070	89	–	–	64.0
1558	3.5	–	4350	95	–	–	64.3
1610	3.5	–	4473	98	–	–	64.7
1623	3.5	–	3700	81	–	–	64.5
1632	3.5	–	4995	109	–	–	65.4
1645	3.5	–	3700	81	–	–	61.3
1648	2.8	–	3000	65	–	–	65.8
1700	2.8	–	3084	67	–	–	64.8
1710	2.8	–	3271	71	–	–	64.7

Time	Vacuum at wellhead (SVE-2) (Inches of water)	VOCs (ppm)	Air Velocity (FPM)	Air Flow Rate (cf/m)	O2%	CO2%	Temperature (F)
1550	2.3	–	4,700	102	–	–	60.6
1558	2.4	–	4,721	103	–	–	60.9
1607	2.4	–	4,774	104	–	–	60.9
1620	2.4	–	4,668	102	–	–	60.9
1634	2.4	–	4,463	97	–	–	60.6
1642	2.4	–	4,496	98	–	–	60.0
1650	2.8	–	4,871	106	–	–	60.4
1658	2.8	–	5,100	111	–	–	59.5
1708	2.8	–	5,618	123	–	–	60.4

Time	Vacuum at blower (inches of water)	VOCs (ppm)	Air Velocity (FPM)	Air Flow Rate (cf/m)	O2%	Temperature CO2%	Temperature (F)
1556	8.5	–	4,228	92	–	–	91.2
1603	8.5	–	4,372	95	–	–	91.5
1612	8.5	–	4,255	93	–	–	90.6
1626	8.5	–	4,487	98	–	–	90.3
1637	8.5	–	4,319	94	–	–	89.2
1645	–	–	–	–	–	–	–
1648	10.0	–	–	–	–	–	–
1702	10.0	–	4,356	95	–	–	88.8
1712	10.0	–	4,166	91	–	–	89.0

	Monitoring Points								
	MP-1			MP-2			MW-8		
	distance to SVE-1:	39.5 feet		distance to SVE-1:	20.5 feet		distance to SVE-1:	12.5 feet	
	distance to SVE-2:	15 feet		distance to SVE-2:	46.5 feet		distance to SVE-2:	19.5 feet	
	distance from screen to SVE-1 screen:	39.5 feet		distance from screen to SVE-1 screen:	20.5 feet		distance from screen to SVE-1 screen:	22.3 feet	
	distance from screen to SVE-2 screen:	15 feet		distance from screen to SVE-2 screen:	46.5 feet		distance from screen to SVE-2 screen:	19.8 feet	
Time	Vacuum (Inches of water)	MP/Extraction (SVE-1)	MP/Extraction (SVE-2)	Vacuum (Inches of water)	MP/Extraction (SVE-1)	MP/Extraction (SVE-2)	Vacuum (Inches of water)	MP/Extraction (SVE-1)	MP/Extraction (SVE-2)
1550	0.62			0.50			0.65		
1600	0.63			0.51			0.69		
1610	0.65			0.55			0.71		
1620	0.70			0.56			0.71		
1630	0.67			0.59			0.73		
1640	0.64	0.183	0.267	0.55	0.157	0.229	0.69	0.197	0.288
1650	0.67			0.52			0.71		
1700	0.65			0.50			0.68		
1710	0.63			0.48			0.66		
1720	0.64	0.229	0.267	0.48	0.171	0.200	0.68	0.243	0.283



Summary

Unbalanced Vacuums (AVE-1 and SVE-2 at different vacuums)

	Distance - SVE-2	MP/Extraction		Distance - SVE-1	MP/Extraction
MP-1	15.0	0.267	MW-8	22.3	0.197
MW-8	19.8	0.288	MP-2	20.5	0.157
MP-2	46.5	0.229	MP-1	39.5	0.183

Balanced Vacuums (Equal vacuum applied to SVE-1 and SVE-2)

	Distance - SVE-1	MP/Extraction		Distance - SVE-2	MP/Extraction
MW-8	**22.3**	**0.243**	MP-1	**15.0**	**0.267**
MP-2	**20.5**	**0.171**	MW-8	19.8	0.283
MP-1	39.5	0.229	MP-2	46.5	0.200

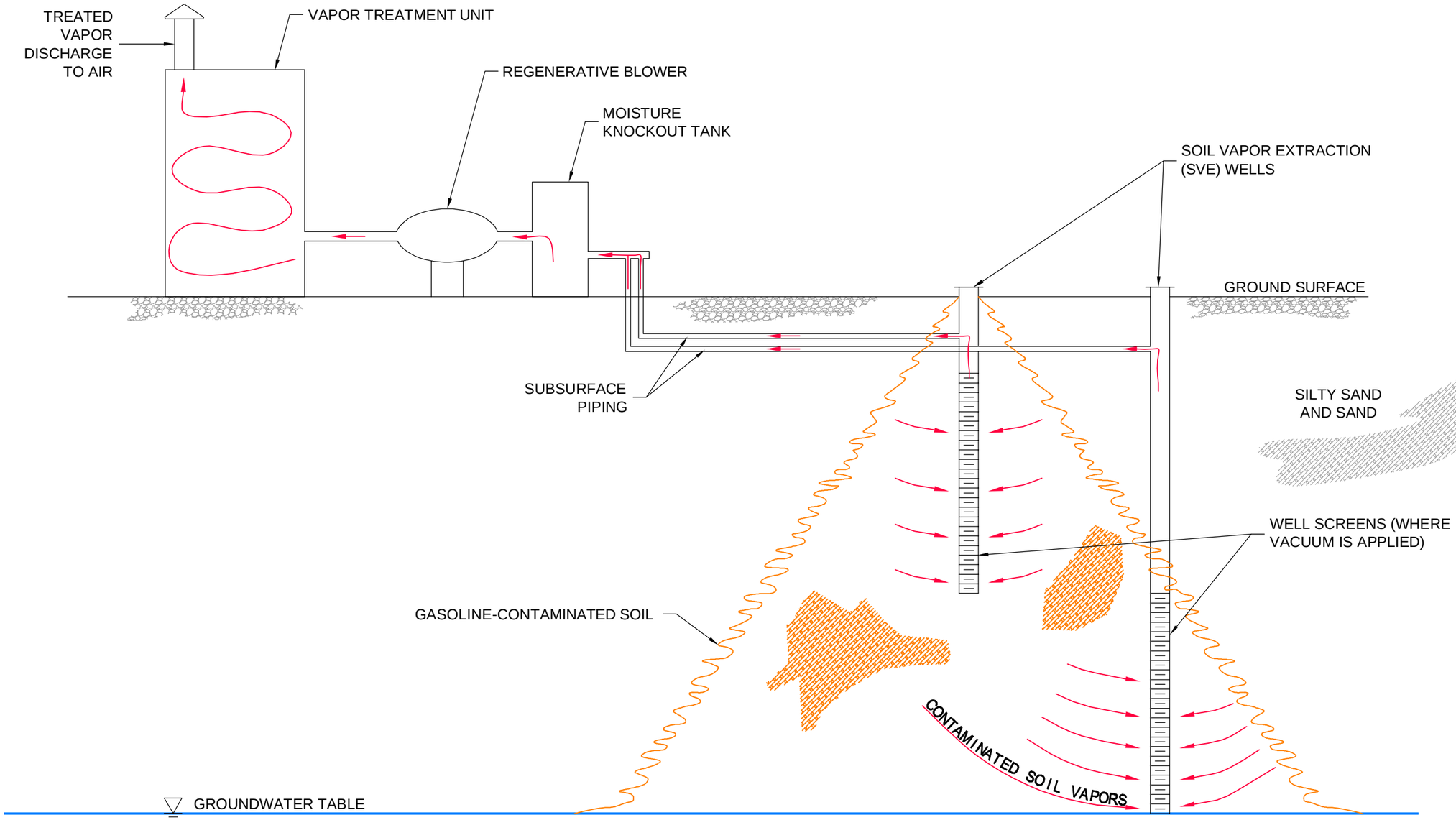
SVE-1 and SVE-2 Combined Test Data

Airport Kwik Stop Site
Ione, Washington

GeoEngineers

Figure 7

File No. 0504-058-02



NOT TO SCALE

Notes

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

Reference: GeoEngineers employee sketch.

Typical Soil Vapor Extraction System

Airport Kwik Stop
Ione, Washington

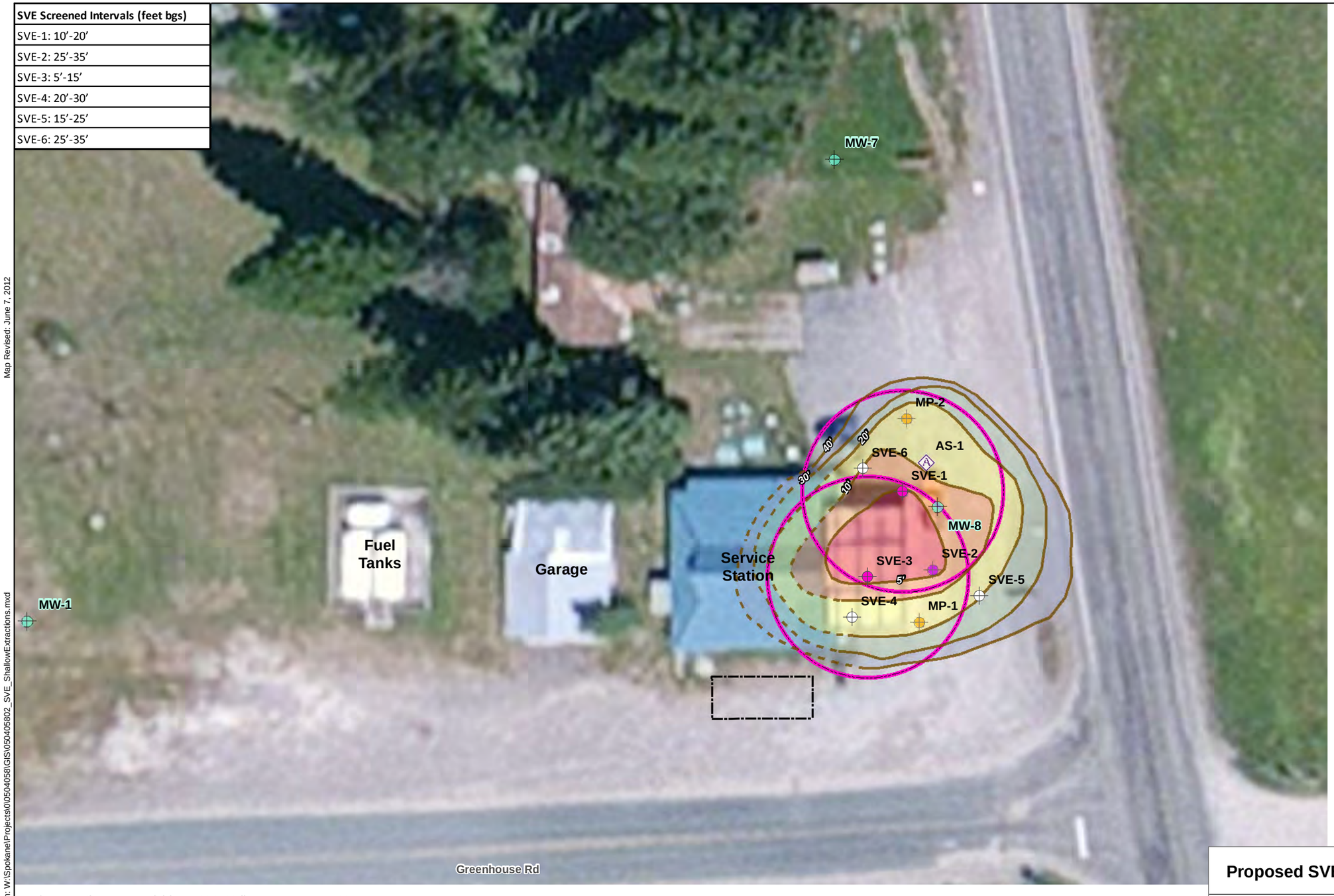
GeoEngineers

Figure 8

BDW : MGF

\\SPO\projects\0\05040058\02\CAD\05040058-02 SOIL VAPOR EXTRACTION.dwg\TAB:Layout1 modified on Jun 08, 2012 - 10:52am

SVE Screened Intervals (feet bgs)
SVE-1: 10’-20’
SVE-2: 25’-35’
SVE-3: 5’-15’
SVE-4: 20’-30’
SVE-5: 15’-25’
SVE-6: 25’-35’



Legend

- MW-1 — Approximate Location of Monitoring Well
- SVE-1 — Approximate Location of 4" SVE Extraction Well
- MP-1 — Approximate Location of 2" Monitoring Point
- AS-1 — Approximate Location of Air Sparge Pilot Well
- SVE-3 — Approximate Location of Proposed Shallow SVE Extraction Well
- SVE-5 — Approximate Location of Other Proposed SVE Extraction Well
- Approximate Radius of Influence: 5'-15' bgs
- Approximate Location of Proposed Temporary Remedial Treatment System
- 20' — Contamination Contours (10 ft depth bgs)
- Extrapolated Contamination Contours

Depth to Top of Contamination

- 0 - 5' bgs
- 5 - 10' bgs
- 10' - 20' bgs
- 20' - 30' bgs
- 30' - 40' bgs

N W E S

30 0 30
Feet

Map Revised: June 7, 2012

Path: W:\Spokane\Projects\0\050405802\GIS\050405802_SVE_ShallowExtractions.mxd

OfficeLocation: SPO

Reference: Bing Maps aerial from ESRI, Online Data Resource Center.
ESRI Data & Maps, Street Maps 2008

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Proposed SVE Extraction Shallow Wells

Airport Kwik Stop
Ione, Washington

GeoEngineers

Figure 9

SVE Screened Intervals (feet bgs)
SVE-1: 10'-20'
SVE-2: 25'-35'
SVE-3: 5'-15'
SVE-4: 20'-30'
SVE-5: 15'-25'
SVE-6: 25'-35'

Legend

MW-1 — Approximate Location of Monitoring Well

SVE-1 — Approximate Location of 4" SVE Extraction Well

MP-1 — Approximate Location of 2" Monitoring Point

AS-1 — Approximate Location of Air Sparge Pilot Well

SVE-5 — Approximate Location of Proposed and Existing Middle SVE Extraction Well

SVE-3 — Approximate Location of Other Proposed SVE Extraction Well

Approximate Radius of Influence

Approximate Location of Proposed Temporary Remedial Treatment System

20' — Contamination Contours (10 ft depth bgs)

Extrapolated Contamination Contours

Depth to Top of Contamination

- 0 - 5' bgs
- 5 - 10' bgs
- 10' - 20' bgs
- 20' - 30' bgs
- 30' - 40' bgs

N W E S

30 0 30
Feet

Map Revised: June 11, 2012

Path: W:\Spokane\Projects\0\050405802\GIS\050405802_SVE_DeepExtractions.mxd

OfficeLocation: SPO

Reference: Bing Maps aerial from ESRI, Online Data Resource Center.
ESRI Data & Maps, Street Maps 2008

Notes:
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Proposed SVE Extraction Middle Wells

Airport Kwik Stop
Ione, Washington

GeoEngineers

Figure 10

SVE Screened Intervals (feet bgs)
SVE-1: 10’-20’
SVE-2: 25’-35’
SVE-3: 5’-15’
SVE-4: 20’-30’
SVE-5: 15’-25’
SVE-6: 25’-35’

Legend

MW-1 — Approximate Location of Monitoring Well

SVE-1 — Approximate Location of 4" SVE Extraction Well

MP-1 — Approximate Location of 2" Monitoring Point

AS-1 — Approximate Location of Air Sparge Pilot Well

SVE-2 — Approximate Location of Proposed and Existing Deep SVE Extraction Well

SVE-5 — Approximate Location of Other Proposed SVE Extraction Well

Approximate Radius of Influence

Approximate Location of Proposed Temporary Remedial Treatment System

20' — Contamination Contours (10 ft depth bgs)

Extrapolated Contamination Contours

Depth to Top of Contamination

- 0 - 5' bgs
- 5 - 10' bgs
- 10' - 20' bgs
- 20' - 30' bgs
- 30' - 40' bgs

N W E S

30 0 30
Feet

Reference: Bing Maps aerial from ESRI, Online Data Resource Center.
ESRI Data & Maps, Street Maps 2008

Notes:
1. The locations of all features shown are approximate.
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Proposed SVE Extraction Deep Wells

Airport Kwik Stop
Ione, Washington

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Figure 11

Map Revised: June 11, 2012
Path: W:\Spokane\Projects\0\00504058\GIS\05040580 2_SVE_DeepExtractions.mxd
OfficeLocation: SPO

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