

GROUNDWATER CLASSIFICATION AND PROPOSED CLEANUP STANDARDS

HERS Industrial Park Site

4403 Russell Road, Mukilteo, Washington

FS No. 127256, VCP Site ID No. NW1554

Prepared for: Russell Road Industrial Park, LLC

Project No. 140252 • January 29, 2018 Ecology Draft



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Acronyms

asl	above sea level
Aspect	Aspect Consulting, LLC
bgs	below ground surface
cm/sec	centimeters per second
CUL	cleanup level
DCE	dichloroethylene
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
ft/day	feet per day
gpm	gallons per minute
ISCO	<i>in situ</i> chemical oxidation
MCL	maximum contaminant level
mg/kg	milligrams/kilograms
µg/L	micrograms per liter
MTCA	Model Toxics Control Act
NAPL	nonaqueous phase liquid
PCE	tetrachloroethylene
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
Riley	The Riley Group
psi	pounds per square inch
Site	HERS Industrial Park site
TCE	trichloroethylene
TCEQ	Texas Commission on Environmental Quality
TPH	total petroleum hydrocarbons
TPN	Tax Parcel Number
Qtb	transitional beds confining bed

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Qva	advance outwash
Qe	Esperance sand
Qvt	Vashon till
Qw	Whidbey formation
TCEQ	Texas Commission on Environmental Quality
UCL	upper confidence limit
USGS	U.S. Geological Survey
UST	underground storage tank
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
WAC	Washington Administrative Code

Executive Summary

The HERS Industrial Park site (Site), located at 4403 Russell Road in Mukilteo, Washington, is enrolled in the Washington State Department of Ecology (Ecology) Voluntary Cleanup Program (VCP) and assigned VCP No. NW1554. Figure 1 shows the Site location and vicinity. The Site is being cleaned up in accordance with the Model Toxics Control Act (MTCA) and its implementing regulations in Section 173-340 of the Washington Administrative Code (WAC).

Aspect Consulting, LLC (Aspect) submitted the Site Remedial Investigation and Feasibility Study (RI/FS) report (Aspect, 2015) to Ecology on November 5, 2015. Aspect subsequently met with Ecology on May 24, 2016, to discuss the RI/FS report and the viability and implications of demonstrating a nonpotable groundwater classification in accordance with WAC 173-340-720(2). Ecology provided review comments for the RI/FS in an opinion letter on November 8, 2016 (Ecology, 2016a). Appendix A lists the review comments and responses.

This report demonstrates that groundwater within the shallow, weathered Vashon till is nonpotable based on sustainable yield, and that contamination in the weathered Vashon till would not be transported to potable groundwater at concentrations above applicable criteria:

- The Site is underlain by 177 feet of Vashon glacial till. The top 15 feet of the glacial till is weathered and contains nonpotable groundwater, and additional groundwater is intermittently present in the underlying, nonweathered till.
- Vashon till is underlain by the Vashon advance outwash. Advance outwash groundwater is a potential future source of drinking water; however, the advance outwash outcrops along Possession Sound west and northwest of the Site, and there are no downgradient wells that penetrate into the advance outwash.
- The measured and calculated 6-inch equivalent well yield is approximately 0.2 gallons per minute (gpm) in the weathered Vashon till, which is below the minimum 0.5-gpm sustainable well yield defined for potable groundwater. Additional lines of evidence for low yield include aquifer responses to stormwater infiltration and low injectivity observations from past injection activities.
- Groundwater is hydraulically isolated in the weathered till, the nonweathered till, and the advance outwash. The groundwater head difference is more than 50 feet between the weathered and nonweathered Vashon till, and more than 150 feet between the weathered till and advance outwash.

The report proposes cleanup standards for the Site:

- Method A groundwater cleanup levels (CULs) are proposed for the advance outwash.

- Method A soil CULs are proposed throughout the Site.
- Groundwater CULs are proposed for weathered till in accordance with MTCA that are protective of the direct contact exposure pathway and nonaqueous phase liquid (NAPL) prohibition. The surface water exposure pathway is not viable at the Site and arsenic groundwater CULs are subject to natural background conditions.
- Method B air CULs are proposed for indoor air at the Site, pending future assessment of the soil vapor intrusion exposure pathway.

This report proposes chlorinated volatile organic compounds (VOCs) as chemicals of concern. Total petroleum hydrocarbons (TPH) are proposed for elimination as a chemical of concern because TPH has not been encountered above soil detection limits¹ and TPH concentrations do not exceed proposed groundwater CULs. Arsenic is proposed for elimination as a chemical of concern because there are no sources of arsenic or altered groundwater conditions that potentially impact natural arsenic concentrations, and the concentrations are representative of natural background concentrations.

The proposed Site boundary is limited to the three properties that are impacted by chlorinated VOCs, including:

- 4403 Russell Road, Snohomish County Tax Parcel No. (TPN) 00441400004600, 1.64 acres, owned by Russell Road Industrial Park, LLC.
- 4351 Chennault Beach Road, Snohomish County TPN 00441400004700, 1.59 acres, owned by Russell Road Industrial Park, LLC.
- 4424 Chennault Beach Road, Snohomish County TPN 00548700001700 (2.36 acres) and TPN 00548700001701 (0.5 acres), owned by International Church of Foursquare Gospel.

We are requesting Ecology's opinion on the proposed cleanup standards in this report. With Ecology's concurrence, we recommend evaluating the soil vapor intrusion exposure pathway, and preparing a focused feasibility study to evaluate applicable cleanup alternatives and recommend a preferred cleanup alternative that is protective of applicable exposure pathways, as outlined in this report.

¹ TPH was detected in only one sample from the Phase II environmental site assessment in 2005 and was not detected in the remedial investigation soil samples in 2015. Diesel- and oil-range TPH were detected well-below Method A soil cleanup levels beneath a former heating-oil underground storage tank (UST) located about 500 feet from the chlorinated VOC source area. In an October 18, 2012, opinion, Ecology stated "petroleum-contaminated soil associated with the UST was excavated with confirmational sampling indicating soil where the former tank was located is compliant with MTCA."

1 Geological and Hydrogeological Setting

The surficial geology of the Puget Sound basin results from long periods of erosion and nonglacial sedimentation in depositional environments like those present today, punctuated by multiple glacial advances into the Puget Sound lowland. The most recent glaciation, the Vashon Stade of the Fraser glaciation, ended about 13,000 years ago, and the resulting landform consists of glacially sculpted uplands composed of north to south elongated glacial drumlins and flutes, and waterways of Puget Sound. Postglacial erosion has locally incised the uplands and created steep-sided ravines and steep bluffs near coastal areas and river valleys. Alluvial soils have been deposited in river and stream valleys since the end of the Vashon glaciation.

The Site is located on the Intercity Plateau, which is bound by Possession Sound on the north and west and the Snohomish River basin on the east, and extends to the southern boundary of Snohomish County (U.S. Geological Survey (USGS), 1997). The Intercity Plateau extent is shown in Appendix B. Vashon glacial till (Qvt) is the predominant surface unit on the Intercity Plateau, and is underlain by the Vashon advance outwash (Qva), nonglacial transitional beds (Qtb), and undifferentiated sediments (Qu), which outcrop in places along the Possession Sound and the Snohomish River basin. Smith (1976) mapped the advance outwash (Qva) as Esperance sand (Qe) and mapped the undifferentiated sediments (Qu) as the Whidbey formation (Qw) locally, and did not distinguish the transitional beds (Qtb) from the Whidbey formation (Qw). The transitional beds and undifferentiated sediments were not distinguished in this report due to the limited data.

1.1 Regional Geological and Hydrogeological Description

The USGS (1997) prepared a surface geological map for western Snohomish County study area, and constructed cross-sections A–A' to G–G'. The USGS cross sections are shown in Appendix B. Cross-section D–D' is a west-east cross section, located about 1.5 miles north of the Site, that extends approximately 28 miles from Possession Sound on the west towards Gold Bar, Washington, on the east. Cross-section D–D' extends through Sections 13 to 17, Township 28 North, Range 4 East, Willamette Meridian. Cross-section D–D' shows that Vashon till is approximately 100 feet thick on the east side of Paine Field in Section 14, and the underlying advance outwash outcrops in Section 17 near Possession Sound. However, the Vashon till ranges in thickness up to 200 feet due north of the Site. This thick Vashon till forms a hydraulic barrier to the underlying advance outwash formation.

Smith (1976) prepared a 1:24,000 scale geological map with topographic contours for the Mukilteo and Everett quadrangles. Figure 2 shows the 1:24,000 scale geological map near the Site. The surficial geological unit in the Site vicinity is Vashon till, which is underlain by advance outwash sand. Smith (1976) maps the Esperance sand, advance outwash, and Whidbey formation outcropping along Possession Sound west and

northwest of the Site. The advance outwash predominately consists of Esperance sand locally, and advance outwash and Esperance sand are not distinguished in this report.

The Site is located on Vashon till soil at an approximate elevation of 540 feet above sea level (asl²), about 1.6 miles east of Possession Sound. Vashon till is underlain by advance outwash, which generally outcrops between 350 and 400 feet asl, approximately 1 mile west and northwest of the Site. The Site topography is relatively flat, and overlies a topographic divide, such that stormwater on the northern portion of the Site flows northwest towards Big Gulch Creek and stormwater on the southern portion of the Site flows southwest toward Picnic Point Creek.

Regional geological cross sections were constructed using the surface geology map and Site and regional boring logs. Figures 2 and 3 show the regional geological cross-section projections and well locations, and Figures 4 and 5 show cross-sections A–A' and B–B', respectively. Note that USGS (1997) cross-section D–D' extends through Sections 14 to 17 on the north side of Big Gulch Creek north of regional cross-section B–B' (Figure 5). The contaminated area of the Site is located approximately 1,000 feet north of the intersection of Sections 21, 22, 27, and 28 in Township 28 North, Range 4 East, Willamette Meridian. Well logs were retrieved from the Washington State Well Report Viewer (Ecology, 2017) and from two nearby sites. No water wells were identified in the four nominal 1-square-mile sections near the Site. The utilized regional borings logs include geotechnical borings, monitoring wells, and 26 heat-exchange wells.³ The Site well construction and boring logs are provided in Appendix C and the regional well construction and boring logs used in the cross sections are provided in Appendix D.

Cross-section A–A' (Figure 4) is parallel to and approximately 1 mile south of USGS cross-section D–D' (Appendix B), and cross-section A–A' is constructed from more wells to refine the profile. These profiles share several general characteristics, where the top of the advance outwash dips west from Paine Field toward Possession Sound, and the Vashon till is thickest between Paine Field and the top of the escarpment above Possession Sound. The thickness of the Vashon till is more than 153 feet in BMH-331 and the thickness ranges from 166 feet for the GEOLoop wells to 177 feet in MW-2D at the Site. Cross-section A–A' maps the advance outwash as a relatively thin formation⁴, about 40 feet at the Site, because the pre-Vashon, Whidbey formation was detected in borings for LAI-MW-3, LAI-MW-6, and the GEOLoop wells, and at the outcrops along Possession Sound and Big Gulch.

Cross-section B–B' (Figure 5) is constructed from Big Gulch Creek on the northwest and extends 12,000 feet southeast and parallel to Mukilteo Speedway (State Route 525) to capture borings logs near a Harbour Pointe site. Cross-section B–B' shows the

² Site elevation is based on the topographic contours shown in the 1:24,000 scale geological map (Smith, 1976), which are expressed in the National Geodetic Vertical Datum of 1929. The top-of-casing elevation of MW-1 was set to 540 feet asl, and all Site wells and groundwater elevations are referenced to this datum.

³ The City of Mukilteo has 26 heat-exchange wells in the NW ¼ of NW ¼ of S27, T28N, R04E, WM. The wells are constructed to 300 feet bgs and the geologic descriptions recorded on the boring logs are identical.

⁴ According to recent work performed for the City of Mukilteo, the advance outwash is locally thinner than previously mapped (Altaterra and Aspect, 2014).

topographic divide near the Site. The relatively flat surface at the top of the cross section is bound by Harbour Pointe Boulevard on the north and south; Harbour Pointe Boulevard is a semicircular street that encircles an extension of the plateau. The advance outwash is intersected by Site well MW-2D and the GEOLoop wells and outcrops in Big Gulch canyon. Cross-section B–B' does not indicate that the advance outwash dips towards Big Gulch Canyon.

The USGS (1997) study identified the Vashon advance outwash as the regional aquifer, and states that the general pattern of groundwater flow in the Intercity Plateau is radially outward towards the edges, with some interruptions caused by groundwater discharge to creeks. Near the Site, the USGS (1997) mapped potentiometric gradient is directed outward, ranging from a southwest direction south of the Site to a northwest direction north of the Site. Cross-sections A–A' and B–B' (Figures 4 and 5) show that the advance outwash dips west, towards Possession Sound. The inferred groundwater gradient in the advance outwash beneath the Site is down dip to the west, where groundwater discharges at the outcrop along Possession Sound, approximately 1 mile west from MW-2D (see Figures 2 and 4).

1.2 Site Geological and Hydrogeological Description

Table 1 summarizes the well specifications for the Site, as requested by Washington State Department of Ecology (Ecology; 2016a) in the November 8, 2016, opinion letter.

- Twenty-two (22) shallow wells (MW-1 to MW-22) were installed to an approximate 15-foot depth and screened in the weathered till, with well screens from 5 to 15 feet below ground surface (bgs).
- A 100-foot-deep soil boring was sampled to evaluate the depth of contamination, as requested by Ecology (2012). Well MW-16D was installed in the soil boring and screened from 80 to 100 feet bgs within the Vashon till.
- The MW-2D boring was advanced through clean till to determine the depth of the Vashon till, which was encountered from the surface to a 177 feet bgs. MW-2D was installed in the boring and screened from 176 to 196 feet bgs in the advance outwash formation.

Vashon till extends from the surface to 177 feet bgs at the Site, which is consistent with USGS (1997) cross-section D–D' due north of the Site. The till becomes very hard at 15 feet bgs; the top 15 feet of till is characterized as weathered till and the underlying hard till is characterized as nonweathered till. The weathered Vashon till was generally moist to wet from 5 to 15 feet bgs during drilling. Wet nonweathered till was also encountered about 65 feet bgs in MW-16D. In MW-2D, the nonweathered till became more sandy and moist from 85 to 100 feet bgs and became more sandy and wet from 115 to 165 feet bgs.

Groundwater is present in the weathered till, intermittently in nonweathered till, and in the underlying advance outwash. As described further in Section 2, groundwater flow in the weathered till is impacted by local recharge and topography, and the shallow

groundwater is hydraulically isolated from groundwater in the nonweathered till and in the advance outwash.

The groundwater gradient in the advance outwash is expected to be directed downdip, toward Possession Sound to the west. The Site water levels indicate groundwater in the advanced outwash is slightly confined (i.e., static groundwater level in MW-2D is about 14 feet above the top of the advance outwash), and that groundwater in the advance outwash is hydraulically isolated from groundwater in the weathered and nonweathered till.

2 Nonpotable Groundwater Demonstration

In accordance with Washington Administrative Code (WAC) 173-340-720(2)(b) and (c), groundwater can be designated as nonpotable when the sustainable yield is less than 0.5 gpm for a well built in accordance with normal construction practices for drinking water (i.e., a 6-inch well) and when Ecology determines that hazardous substances in contaminated groundwater would be unlikely to be transported to groundwater that is a current or potential source of drinking water at concentrations above applicable water quality criteria.

Vashon till is composed of a glacially overconsolidated mixture of silts, sands, and gravel, and generally has a low hydraulic conductivity. The weathered Vashon till at the surface is the least-dense portion of the formation and would be anticipated to have highest permeability. The low permeability of the weathered Vashon till can be observed by groundwater mounding around storm drains and by the low injectivity and short-circuiting observed during *in situ* chemical oxidation (ISCO) injections. The 6-inch equivalent well yield is less than 0.5 gpm based on aquifer testing. Additionally, the weathered Vashon till has insufficient groundwater recharge to allow the sustainable withdrawal of groundwater.

Contaminated groundwater in the weathered Vashon till would not be anticipated to impact the potential future use of drinking water in the underlying advance outwash formation. Approximately 160 feet of nonweathered Vashon till separate the weathered Vashon till from the advance outwash, and groundwater is not hydraulically connected between the two formations.

2.1 Shallow Groundwater Observations

Groundwater is encountered in the weathered till from about 2 to 15 feet bgs at the Site. The groundwater gradient within the weathered till is affected by stormwater infiltration and the topographic divide at the Site. The Site is covered by impervious surfaces, and stormwater is captured by catch basins and discharged through perforated lateral storm drains beneath the parking lot. Groundwater is primarily recharged from stormwater infiltration from the perforated lateral storm drains. Groundwater also appears to discharge through a storm drain beneath the downgradient building to the north (i.e., the Foursquare Church building at 4424 Chennault Beach Road). This storm drain captures stormwater from a catch basin at the bottom of the depressed truck ramp; the catch basin elevation is approximately 4 feet below the finished floor of the Foursquare Church building, which is constructed near grade level.

Figures 6 to 8 show groundwater gradients in January, April, and August 2015, respectively, and show seasonal impacts of storm water infiltration to the weathered till. The groundwater elevations vary the most in wells nearest to the perforated storm drains. For example, the groundwater elevation was 3.93 feet higher in MW-6 on January 23, 2015, than on August 10, 2015; whereas, the groundwater elevation was essentially unchanged in MW-5, which is least impacted by the storm drains. As shown on Figure 6, the high groundwater gradients are directed outward from the perforated storm drains on

the east and west sides of the 4403 Russell Road building. The high gradients in the weathered till are due its low permeability, which inhibits the dissipation of the stormwater. The perforated storm drains have less impact in April 2015 and no impact in August 2015. Groundwater elevations equilibrated in August 2015 in the absence of precipitation.

Groundwater gradients in the weathered till are impacted by the topographic divide. Storm drains on the east and west sides of the 4403 Russell Road building discharge south, towards Russell Road and along Cyrus Way toward Picnic Point Creek. Stormwater drains north and west of this building discharge northwest along Chennault Beach Road toward Big Gulch Creek. The groundwater divide appears near the east-wide centerline of the 4403 Russell Road building. Groundwater gradients near the chlorinated VOC exceedance area are generally to the northwest, with seasonal impacts due to groundwater recharge from the storm drains and potential groundwater discharge into a storm drain beneath the Foursquare Church building.

2.2 Limited Injectivity Observations

The Riley Group (Riley) constructed injection wells within the weathered Vashon till and injected modified Fenton's reagents into select injection wells on March 15, 2006, April 14, 2006, and October 4, 2006. Table 1 identifies the injection wells and summarizes the well specifications. The ISCO injection events were only documented in Daily Field Logs, and Table 2 summarizes the injection notes. ISCO was performed by injecting an acidic ferrous sulfate solution and then an 18 percent hydrogen peroxide solution.

In general, Riley used high injection pressures to overcome the low permeability of the weathered Vashon till, and the formation was not capable of receiving a sufficient volume of reagent to treat groundwater more than 2 feet from the injection well. Additionally, the high injection pressures damaged the well seals, resulting in the surfacing of reagent during injection. Greater leaking was observed in subsequent injection events, indicating that previous injection activities compromised the well seals.

ISCO was performed most aggressively in MW-7. Riley performed two rising head slug tests in MW-7 on October 12, 2005, and calculated a hydraulic conductivity of 0.45 feet per day (ft/day). On March 15, 2006, 240 gallons of hydrogen peroxide solution were injected MW-7 during a 1-hour interval; i.e., 4 gallons per minute (gpm), with an injection pressure of 20 pounds per square inch (psi). The expected injection radius is 1.7 feet based on the estimated groundwater travel distance. The injection duration was not recorded for the other injection events. Although injection notes were limited on March 15, 2006, Riley reduced subsequent injections volumes that day to 50 or 110 gallons of hydrogen peroxide solution for MW-9, MW-10, and MW-11.

The problems with the high injection rates were observed in the notes for subsequent injection dates. On April 14, 2006, the injection volume in MW-7 was reduced to 110 gallons of hydrogen peroxide solution, and leaking was observed at the wellhead. On October 4, 2006, 190 gallons of hydrogen peroxide solution was injected in MW-7 and significant leaking was observed at the wellhead. As shown in Table 2, increased leakage was noted in the second injection event for four of five injection wells.

The low permeability and low yield of the weathered Vashon till prevent the short-term ISCO reagents from interacting with contamination beyond the injection wells. The injection pressures (18–20 psi) significantly exceed the expected fracture pressures across the well screen (4–11 psi). Because of the near-well treatment, hydraulic fracturing, and damaged well seals, the injection wells are inappropriate monitoring wells.

2.3 Estimated Well Yield from Slug Tests

The well yield can be estimated from the hydraulic conductivity, saturated thickness, and confining conditions for each evaluation location in the aquifer using the Cooper and Jacobs (1946) approximation to the Theis (1935) solution for radial flow to a pumping well. This methodology is described in Attachment B of the Texas Commission on Environmental Quality (TCEQ) groundwater classification guidance (TCEQ, 2010).

Riley (2005) performed two rising head slug tests in MW-7 on October 12, 2005, and the results are provided in Appendix E. The calculated hydraulic conductivities were $1.68\text{E-}4$ and $1.48\text{E-}4$ centimeters per sec (cm/sec), with a geometric mean hydraulic conductivity of $1.58\text{E-}4$ cm/sec (0.45 ft/day).

Table 3 summarizes the well-yield calculation for MW-7. The 4-inch equivalent well yield for an unconfined aquifer was calculated using Method 1, Equation B.3d in the TCEQ groundwater classification guidance (TCEQ, 2010), and then converted to a 6-inch equivalent well yield using Table C-1 correction factors. The 6-inch equivalent well yield of MW-7 is 0.15 gpm for a 10-foot saturated interval in the weathered till. The 6-inch equivalent well yield is well below the minimum 0.5 gpm sustainable well yield for potable groundwater (WAC 173-340-720(2)(b)).

2.4 Estimated Well Yield from Step Drawdown Pump Test

Aspect performed a step drawdown pump test in MW-22 on August 16, 2017, to evaluate the well yield in a 2-inch-diameter well in the weathered Vashon till. Groundwater was pumped from the well using a Geotech-brand geosub submersible pump and controller, and groundwater was pumped to a 275-gallon tote. The flow rate was monitored throughout the test with a 1-inch-diameter instantaneous flowmeter equipped with a gate valve to fine tune the flow. Groundwater levels were monitored with a vented PT2X pressure transducer with data logger and with manual depth-to-water measurements using an electric tape.

Figure 9 shows the results of the step drawdown pump test. The initial depth to groundwater was 4.9 feet bgs in the 14.75-foot-deep well. Monitoring well MW-22 is constructed to the base of the weathered till, and static groundwater level was 9.85 feet above the bottom of the well and weathered till. The well was initially pumped at a constant pumping rate of approximately 0.18 gpm, and the groundwater level decreased by 3.58 feet after 120 minutes of pumping. The 0.18-gpm pumping rate appears sustainable, which is consistent with the 0.15-gpm, 6-inch equivalent well yield calculated from the MW-7 slug test results. Using conversion factors in Table C-1 of the groundwater classification guidance (TCEQ, 2010), a 0.18-gpm well yield in 2-inch well is equivalent to a 0.21-gpm well yield in a 6-inch well.

The pumping rate was increased to approximately 0.3 gpm to evaluate the sustainable well yield. The groundwater level dropped by 3.49 feet in 13 minutes to below the pressure transducer at an elevation of 2.78 above the base of the well. This indicates that sustainable well yield is less than 0.3 gpm for a 2-inch well, or 0.35 gpm for a 6-inch well. The pump was then shutdown for 9 minutes while it was lowered to the bottom of the well, and the groundwater level increased to 4.37 feet above the base of the well. The pump was restarted at a 0.5-gpm pumping rate to evaluate the response to the minimum pumping rate for potable groundwater. Within 8 minutes the groundwater level dropped below the top of the pump and within a foot above the base of the well and weathered till.

The step drawdown pumping test confirms that the 6-inch equivalent well yield in the weathered Vashon till is approximately 0.2 gpm, and that the formation is not capable of providing a 0.5-gpm sustainable well yield. The 6-inch equivalent well yield is well below the minimum 0.5-gpm sustainable well yield for potable groundwater (WAC 173-340-720(2)(b)).

2.5 Hydraulic Connectivity to Potable Groundwater

The Site is within the Mukilteo Water and Wastewater District⁵ and areas south of the Site are within the Alderwood Water District (Washington State Department of Health, DOH, 2017). There are no water wells located near the Site. The City of Mukilteo has 26 geothermal heat exchange wells southeast of the Site, which are completed to 300 feet bgs and penetrate through the advance outwash and into the Whidbey formation. The heat exchange wells are not screened and do not withdraw groundwater. Except for MW-2D, no other wells extend to the advance outwash in Sections 21, 22, 27, and 28 in Township 28 North, Range 4 East, Willamette Meridian. The closest Group A⁶ wellhead protection area is about 3.5 miles south of the Site for a well in the City of Lynnwood, and the closest Group B wellhead protection area is about 2.3 miles northeast of the Site on the opposing side of Paine Field (DOH, 2017). The advance outwash formation is presumed to be a potential future source of drinking water near the Site.

Groundwater in the Vashon till is not hydraulically connected to groundwater in the advance outwash. This hydraulic isolation is demonstrated by differences in groundwater levels in the weathered Vashon till, nonweathered Vashon till, and underlying advance outwash:

- The groundwater surface ranged from 533.5 to 539.7 feet asl in the shallow wells within the weathered Vashon till during sampling in January, April, and August 2015.

⁵ The boundary between the Mukilteo Waste and Wastewater District and the Alderwood Water District extends in an east-west direction between Sections 20 to 24 and Sections 25 to 29 of Township 28 North, Range 4 East, Willamette Meridian.

⁶ Group A public water systems have 15 or more service connections or serve 25 or more people 60 or more days per year. Group B public water systems serve fewer than 15 connections and fewer than 25 people per day.

- The groundwater surface elevation was about 484 feet asl in the nonweathered Vashon till encountered in MW-16D, which is more the 50 feet below the groundwater elevation in the weathered Vashon till.
- The groundwater elevation was about 379 feet asl in MW-2D in the advance outwash. Thus, the groundwater level in the advance outwash is more than 150 feet below the weathered Vashon till. The advance outwash is a confined aquifer, since the top of the aquifer is about 365 feet asl, which is about 14 feet below the groundwater level in MW-2D.

A hydrogeological cross section was generated using Site monitoring wells. Figures 10 and 11 show the projection and profile of hydrogeological cross-section C–C' through the Site. The weathered Vashon till contains groundwater that is perched onto the hard, nonweathered Vashon till encountered at 15 feet bgs, and these groundwater levels are influenced by stormwater discharge through perforated lateral storm drains. Although portions of the nonweathered Vashon till are wet, this groundwater is hydraulically isolated from the weathered Vashon till at the surface and from the underlying advance outwash. There are no wells near the Site that could potentially be pumped to influence groundwater levels in the advance outwash. The advance outwash is under slightly confining conditions, and the groundwater in the advance outwash is not connected to groundwater within the Vashon till.

The groundwater flow direction in the advance outwash is presumed to be directed downdip, toward Possession Sound. As described in Section 1.2 and shown in cross-sections A–A', B–B', and C–C', the advance outwash dips west toward Possession Sound, but not northwest toward Big Gulch Creek. The Remedial Investigation/Feasibility Study (RI/FS) identified the current and former catch basins on the east side of the 4403 Russell Road building near MW-7 and MW-16 as the source of chlorinated VOC contamination. MW-2D is constructed in the advance outwash about 100 feet west and downgradient from the chlorinated VOC source area. MW-2D was sampled once in August 2015 and no chlorinated VOCs were detected. MW-2D has been, and can be, used as a sentinel well to confirm that contamination does not migrate to the advance outwash. Long-term groundwater monitoring of the advance outwash is not recommended because the formation is hydraulically isolated.

3 Proposed Cleanup Standards and Site Boundary

This section identifies the viable exposure pathways at the Site, proposes cleanup levels and chemicals of concern, and proposes a refined Site boundary.

3.1 Potential Exposure Pathways

The viable exposure pathways at the Site include:

- Groundwater ingestion pathway for the potential future use of advance outwash groundwater as drinking water.
- Soil and groundwater direct-contact exposure pathways for the weathered Vashon till soil to a depth of 15 feet bgs.
- Soil-to-groundwater leaching exposure pathway for Vashon till soil from the surface to the advance outwash to protect the potential future use of advance outwash groundwater as drinking water.
- Vapor-intrusion exposure pathway from soil gas to indoor air.

The following exposure pathways are not viable at the Site:

- The groundwater-ingestion exposure pathway in the Vashon till is not viable. This report demonstrates through multiple lines of evidence that the sustainable well yield in the weathered Vashon till is less than 0.5 gpm. The hydraulic conductivity and well yield in the underlying nonweathered Vashon till from approximately 15 to 177 feet bgs would be lower than the less-dense weathered Vashon till at the surface. Additionally, contamination in the weathered Vashon till is hydraulically separated from groundwater within the nonweathered Vashon till and from groundwater within the advance outwash. There is approximately 160 feet of nonweathered Vashon till separating contaminated groundwater from the potential future source of drinking water in the advance outwash, and the head differential between the shallow and deep groundwater is more than 150 feet.
- The terrestrial ecological exposure pathway has been excluded because there is less than 1.5 acres of contiguous undeveloped land on or within 500 feet of any area of the Site. Aspect submitted the Terrestrial Ecological Evaluation Form to Ecology on March 29, 2016.

3.2 Proposed Cleanup Levels

This section identifies the proposed cleanup levels (CULs) for the viable exposure pathways at the Site.

3.2.1 Potable Groundwater in Advance Outwash

Method A groundwater CULs are proposed for the advance outwash formation. As allowed in WAC 173-340-704(1)(b), State maximum contaminant levels (MCLs) are proposed for the dichloroethylene (DCE) isomers because Method A groundwater CULs

are not defined and State MCLs are applicable. Method A groundwater CULs and MCLs are protective of the groundwater ingestion exposure pathway.

The groundwater CUL for arsenic shall not be set lower than the natural background concentration, in accordance with WAC 173-340-720(7)(c). Ecology (2016b) evaluated the groundwater arsenic concentrations on a basin- and state-wide-basis, and defined the natural background concentrations as the 90 percent upper confidence limit (UCL) of the evaluated data sets, in accordance with WAC 173-340-709(3)(c). The natural background concentration of arsenic is 11.8 micrograms per liter ($\mu\text{g/L}$) in the Snohomish basin and 8.0 $\mu\text{g/L}$ in the Puget Sound basin. The USGS (1997) reports a dissolved arsenic concentration of 6 $\mu\text{g/L}$ in well 27N/04E-02N01, which is completed in the advance outwash approximately 3 miles southeast of the Site, and is the closest study well to the Site with arsenic results. The proposed groundwater CUL for arsenic is 11.8 $\mu\text{g/L}$. Monitoring well MW-2D was sampled for dissolved and total arsenic on August 10, 2015, and the concentration of dissolved arsenic was 3.33 $\mu\text{g/L}$ and the concentration of total arsenic was 11.4 $\mu\text{g/L}$.

3.2.2 Soil throughout the Site

Method A soil CULs are proposed for the Vashon till from the surface to the top of the advance outwash. Method A soil CULs are protective of the direct-contact and groundwater-ingestion exposure pathways. Method A soil CULs exist for tetrachloroethylene (PCE), trichloroethylene (TCE), total petroleum hydrocarbons (TPH), and arsenic, but are not defined for the DCE isomers and vinyl chloride. PCE and TCE were detected near or above the Method A soil CULs in soil samples from the borings for MW-16, MW-16D, and MW-21. Additionally, the presence of PCE and TCE in soil can be inferred by historical groundwater samples from MW-1, MW-7, MW-10, MW-11, MW-12, MW-13, MW-14, MW-15, MW-20, and SP10. The highest residual concentrations of DCE isomers and vinyl chloride were detected in MW-16; however, the concentrations of cis-1,2-DCE slightly exceeded the detection limit, and trans-1,2-DCE, 1,1-DCE, and vinyl chloride were not detected. Although PCE and TCE are the indicator chemicals of concern, soil CULs can be calculated for the DCE isomers and vinyl chloride from Equation 747-1 in WAC 173-340-747(4)(b) using Method A groundwater CULs and State MCLs, and conservative, default parameters.

3.2.3 Nonpotable Groundwater in Vashon Till

Groundwater CULs can be established for nonpotable groundwater in accordance with WAC 173-340-720(6). Table 4 summarizes the calculated groundwater CULs for the Vashon till.

The groundwater CULs should be protective of persons engaged in site development or utility construction and maintenance activities, using a hazard quotient of 1 or an excess cancer risk of $1\text{E-}6$ for individual substances. The proposed groundwater CULs for the Vashon till groundwater are calculated from Method B soil CUL table values and the soil-leachate partitioning factor used in Equation 747-1 in WAC 173-340-747(4)(b). The Method B noncarcinogenic table values are calculated from Equation 740-1 in WAC 173-340-740(3)(b)(iii)(B)(I) using a hazard quotient of 1 and the Method B carcinogenic table values are calculated from Equation 740-2 in WAC 173-340-740(3)(b)(iii)(B)(II) using

an excess cancer risk of 1E-6. The proposed groundwater CULs for direct contact are calculated by assuming that the dissolved contamination in groundwater is in equilibrium with the sorbed contamination on soil. Thus, the proposed groundwater CULs for the Vashon till are calculated from:

$$C_w(\mu g/L) = C_s(mg/kg) \times \left(\frac{\rho_b}{\rho_b f_{oc} K_{oc} + \theta_w + \theta_a H_{cc}} \right) \times UCF$$

where C_w is the proposed groundwater CUL for direct-contact exposure, C_s is the most stringent Method B soil CUL, ρ_b is the default bulk density (1.5 kilograms/liter), f_{oc} is the default fraction of soil organic carbon (0.001 grams/gram), K_{oc} is the chemical-specific soil organic carbon-water partitioning coefficient, θ_w is the default water-filled soil porosity (0.3), θ_a is the default air-filled soil porosity (0.13), H_{cc} is the chemical-specific dimensionless Henry's law constant, and UCF is the unit conversion factor of 1,000. The partitioning ratio is calculated from default parameters used in Equation 747-1 and 747-2 in WAC 173-340-740(3)(b)(iii)(B), and from chemical parameters defined in the Ecology's Cleanup Levels and Risk Calculation (CLARC) tables.

The calculated groundwater CUL for arsenic based on the carcinogenic Method B soil CUL is 2.30 µg/L and the groundwater CUL for arsenic based on the noncarcinogenic Method B soil CUL is 82.7 µg/L. These CULs are calculated using default partitioning parameters for arsenic. The calculated partitioning ratio of 0.0034 grams of soil per milliliter reconciles with the empirically calculated partitioning ratio of 0.0036 grams per milliliter for dissolved arsenic and 0.0032 grams per milliliter for total arsenic.

As described in Section 3.2.1, the groundwater CUL for arsenic shall not be set lower than the natural background concentration, and the natural background concentration for the Snohomish basin is 11.8 µg/L (Ecology, 2016b).

Nonpotable groundwater shall comply with limitations on free product and the concentrations shall not result in a nonaqueous phase liquid (NAPL) being present in or on the groundwater. Physical observations of the groundwater, such as a lack of film, sheen, discoloration, sludge, or emulsion may be used to show compliance (WAC 173-340-720(7)(d)). These adverse physical properties have not been observed and would not be anticipated. As a rule of thumb, NAPL may be present when the concentration of a contaminant exceeds 1 percent of its solubility limit (EPA, 2009). The solubility limit of PCE is approximately 200,000 µg/liter; thus, the groundwater cleanup level of PCE shall not exceed 2,000 µg/L. Similarly, the groundwater CUL of TCE should not exceed 11,000 µg/L, the groundwater CUL of cis-1,2-DCE should not exceed 35,000 µg/L, and the groundwater CUL of vinyl chloride should not exceed 27,600 µg/L.

The reconnaissance groundwater sample collected from soil boring SP10 on June 14, 2005 is the only groundwater sample that indicates the potential presence of NAPL, and this sample likely contained suspended solids that biased the analytical result high. Although TCE was detected at a concentration of 42,000 µg/L in this reconnaissance groundwater sample, TCE was detected at a concentration of 7,000 µg/L in adjacent well MW-7 in October 7, 2005, which is below the 11,000 µg/L groundwater CUL. The maximum concentration of TCE was 200 µg/L in 2015, and there are no indications of NAPL being present in groundwater.

The groundwater CULs should be protective of surface water when applicable. As discussed in Section 2.5, the groundwater gradient is impacted by stormwater capture and discharge through perforated storm drains and potentially by groundwater discharge to a storm drain beneath the 4424 Chennault Beach Road building. This storm drain discharges to a vegetated storm drain on the south side of Chennault Beach Road. The closest surface water body is Big Gulch Creek, which is more than 4,000 feet north from the storm drain, and perpendicular to the flow direction along Chennault Beach Road. As discussed with Ecology on May 24, 2016, surface water CULs would not be applicable for groundwater.

3.2.4 Indoor and Ambient Air

Air CULs shall be established for VOCs when a nonpotable groundwater CUL is established, in accordance with WAC 173-340-750(1)(a)(i). Standard or modified Method B air CULs may be applied for indoor and ambient air. Method B air CULs are proposed for the indoor air at the Site, pending future assessment of the soil vapor intrusion exposure pathway.

3.2.5 Proposed Cleanup Levels

Table 5 summarizes the proposed CULs for the chemicals of potential concern at the Site.

3.3 Proposed Chemicals of Concern

The chemicals of potential concern include PCE, TCE, and related degradation products; diesel- and oil-range TPH; and arsenic. The proposed chemicals of concern for the Site are:

- PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and vinyl chloride. These chlorinated VOCs are proposed as chemicals of concern when applicable.

The following chemicals of potential concern are proposed for elimination:

- Diesel-range and oil-range TPH. Diesel-range and oil-range TPH were encountered in the weathered Vashon till groundwater at concentrations above the Method A groundwater screening levels. These chemicals originate from stormwater drainage from the asphalt parking lot, which is captured by catch basins and infiltrates to groundwater through perforated lateral storm drains in accordance with low-impact development practices. The detected TPH concentrations were minor (less than twice the screening level), and the concentrations generally varied above and below the screening level and detection limits.
- Arsenic. The arsenic concentrations are not associated with historical business practices and have not been influenced by altered groundwater conditions. The soil arsenic concentrations are below the Method A soil CUL based on groundwater protection, and the groundwater concentrations of arsenic are consistent with background conditions, as described below.

Ecology (2016b) evaluated the groundwater arsenic concentrations on a basin- and state-wide basis, and defined the natural background concentrations as the 90 UCL of the

evaluated data sets, in accordance with WAC 173-340-709. The 22 Site wells were sampled for total arsenic in January or April 2015, and in August 2015; wells MW-2D and MW-20 to MW-22 were only sampled once in August 2015. The August 2015 groundwater samples were also submitted for the dissolved arsenic.

Table 6 summarizes the arsenic sample results from the Site. Arsenic was detected above the 11.8 µg/L natural background concentration in 6 of 22 wells. The concentration of total arsenic increased from below to above background in three wells and decreased from above to below background in one well. The concentration of dissolved arsenic also exceeded background in these six wells. The total and dissolved arsenic concentrations were essentially the same in August 2015. The wells with arsenic exceedances are not associated with the chlorinated VOC exceedance area, and are not associated with any sources of contamination.

Table 7 compares summary statistics for the dissolved and total arsenic data sets for the Site and the Snohomish Basin background data set (Ecology, 2016b). The summary statistics were calculated using ProUCL 5.0 software (Environmental Protection Agency, 2013), and one-half of the method detection limit was assigned when arsenic was not detected, in accordance with WAC 173-340-709(5)(a). The Snohomish Basin data set covers a much larger area with varied geology, and is also biased by higher historical detection limits and by the averaging of concentrations within individual wells. The detection limits decreased beginning in 2000, when the arsenic MCL was reduced from 50 to 10 µg/L. Consequently, the Site data sets have lower minimum detection limits and a lower percentage of nondetects. Nevertheless, the side-by-side comparison of the Site and regional data sets show that the mean, maximum, and 90 percent UCL are lower for the Site data sets than for the regional data set. The regional data set has a lower variance because of the larger number of samples in the data set, a significantly higher kurtosis because of the outliers potentially due to varied geology, and a larger skewness potentially because of varied soil type and higher detection limits. This comparison shows that the arsenic concentrations at the Site are representative of background concentrations. In the absence of contamination, the concentrations of arsenic would be expected to exceed natural background in 10 percent of the samples because the natural background is defined as the 90 percent UCL of logarithmically-distributed data sets.

The proposed chemicals of concern at the Site are compared with the proposed CULs. Table 8 compares the soil concentrations with the Method A CULs, Table 9 compares the weathered Vashon till groundwater with the proposed CULs for nonpotable groundwater, and Table 10 compares the advance outwash groundwater with the proposed CULs of potable groundwater.

3.4 Proposed Site Boundary

The RI/FS (Aspect, 2015) identified the impacted parcels in Table ES-1 and Ecology recommended a reduced Site boundary in the opinion letter (Ecology, 2016a).

The proposed Site boundary is restricted to three properties:

- 4403 Russell Road, Snohomish County TPN 00441400004600, 1.64 acres, owned by Russell Road Industrial Park, LLC.

- 4351 Chennault Beach Road, Snohomish County TPN 00441400004700, 1.59 acres, owned by Russell Road Industrial Park, LLC.
- 4424 Chennault Beach Road, Snohomish County TPN 00548700001700 (2.36 acres) and TPN 00548700001701 (0.5 acres), owned by International Church of Foursquare Gospel.

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Limitations

Work for this project was performed for the Russell Road Industrial Park, LLC (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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TABLES

Table 1. Summarized Well Specifications

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Well	Installation Date	TOC Elevation (Flush Mount Wells)	Total Depth (ft bgs)	Well Description	Screen Slot Size	Screen Interval (ft bgs)	Purpose	Lithology	Condition	Depth to Water Range (ft bgs)	Groundwater Elevation (January 2015) (ft asl)	Groundwater Elevation (April 2015) (ft asl)	Groundwater Elevation (August 2015) (ft asl)
MW-1	9/11/05	540.00	15	1-inch PVC	0.020-inch	5-15	Injection	Vashon till, weathered	Good	2.71 to 4.97	537.29	537.21	535.03
MW-2	9/11/05	542.06	15	1-inch PVC	0.020-inch	5-15	Monitor	Vashon till, weathered	Good	5.68 to 8.57	533.49	536.38	534.97
MW-3	9/11/05	542.23	15	1-inch PVC	0.020-inch	5-15	Monitor	Vashon till, weathered	Good	4.94 to 6.42	537.29	536.49	535.81
MW-4	9/11/05	542.18	15	1-inch PVC	0.020-inch	5-15	Monitor	Vashon till, weathered	Good	3.88 to 6.93	538.30	535.31	535.25
MW-5	9/11/05	541.39	15	1-inch PVC	0.020-inch	5-15	Monitor	Vashon till, weathered	Good	5.81 to 5.84	535.58	535.55	535.56
MW-6	10/4/05	540.24	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Monitor	Vashon till, weathered	Good	0.57 to 4.5	539.67	538.13	535.74
MW-7	10/4/05	540.32	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Damaged Seal	2.91 to 7.71	532.61	537.41	535.40
MW-8	10/4/05	540.19	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Monitor	Vashon till, weathered	Good	2.64 to 5.52	537.55	536.86	534.67
MW-9	Mar-06	540.58	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Damaged Seal	2.67 to 4.96	537.91	537.59	535.62
MW-10	Mar-06	540.97	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Good	4.02 to 6.10	536.95	536.87	534.87
MW-11	Mar-06	541.93	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Good	5.22 to 6.93	536.71	536.69	535.00
MW-12	Mar-06	541.00	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Damaged Seal	3.79 to 5.83	537.21	536.94	535.17
MW-13	Mar-06	540.28	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Silted	4.20	536.08	NM	NM
MW-14	Mar-06	ND	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Abandoned	NA	NA	NA	NA
MW-15	Mar-06	540.13	15	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Injection	Vashon till, weathered	Good	2.86 to 5.02	537.27	537.07	535.11
MW-16	1/21/15	541.83	16	1-inch Sch. 40 PVC	0.010-inch	5-15	Monitor	Vashon till, weathered	Good	4.72 to 6.62	537.11	536.94	535.21
MW-17	1/21/15	539.75	15	1-inch Sch. 40 PVC	0.010-inch	5-15	Monitor	Vashon till, weathered	Good	2.47 to 4.93	537.28	537.22	534.82
MW-18	1/21/15	542.25	15.9	1-inch Sch. 40 PVC	0.010-inch	5-15	Monitor	Vashon till, weathered	Good	4.58 to 6.27	537.07	537.67	535.98
MW-19	1/21/15	539.43	16	1-inch Sch. 40 PVC	0.010-inch	5-15	Monitor	Vashon till, weathered	Good	2.94 to 4.40	536.49	536.40	535.03
MW-20	4/10/15	540.06	15.75	1-inch Sch. 40 PVC	0.010-inch	5-15	Monitor	Vashon till, weathered	Good	3.29 to 5.09	NA	536.77	534.97
MW-21	8/10/15	541.00	15.5	2-inch Sch. 40 PVC	0.010-inch	5-15	Monitor	Vashon till, weathered	Good	6.21	NA	NA	534.79
MW-22	8/10/15	540.09	16	2-inch Sch. 40 PVC	0.010-inch	5-15	Monitor	Vashon till, weathered	Good	5.22	NA	NA	534.87
MW-16D	4/10/15	541.87	100.3	2-inch Sch. 40 PVC	0.010-inch	80-100	Monitor	Vashon till (0-15 feet bgs) and non-weathered Vashon till (15 to 100 feet bgs). Becomes very dense at 10 ft bgs and becomes wet at 65 ft bgs.	Good	57.65 to 58.55	NA	484.22	483.32
MW-2D	7/31/15	542.13	200.5	2-inch Sch. 40 PVC	0.020-inch	176-196	Monitor	Weathered Vashon till (0 to 15 ft bgs), non-weathered Vashon till (15 to 177 ft bgs), and advance outwash (177 to 200 ft bgs). Becomes very dense at 10 ft bgs. Vashon till is more sandy and moist between 85 and 100 ft bgs, and is more sandy and wet between 115 and 165 ft bgs.	Good	162.75	NA	NA	379.38

Notes
NA - not applicable, ND - not determined, NM - not measured
PVC - polyvinyl chloride, SS - stainless steel, TOC - top of casing
asl - above sea level, bgs - below ground surface, ft - feet

Table 2. *In Situ* Chemical Oxidation Injection Notes
Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Well	Installation Date	Well Description	Screen Slot Size	Screen Interval (ft bgs)	Lithology	ISCO Injection Notes (3/15/2006)	ISCO Injection Notes (4/14/2006)	ISCO Injection Notes (10/4/2006)
MW-1	9/11/05	1-inch PVC	0.020-inch	5-15	Vashon till, weathered			50 gal HAc/FeSO ₄ , 180 gal H ₂ O ₂
MW-7	10/4/05	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered	40 gal HCl/FeSO ₄ , 240 gal H ₂ O ₂ (240 gallons/hour of H ₂ O ₂ injected)	30 gal HCl/FeSO ₄ , 110 gal H ₂ O ₂ (leaking observed at wellhead, 20 psi injection pressure)	50 gal HAc/FeSO ₄ , 190 gal H ₂ O ₂ (significant leaking observed at wellhead)
MW-9	Mar-06	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered	40 gal HCl/FeSO ₄ , 50 gal H ₂ O ₂	30 gal HCl/FeSO ₄ , 110 gal H ₂ O ₂ (leaking observed at wellhead)	
MW-10	Mar-06	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered	30 gal HCl/FeSO ₄ , 110 gal H ₂ O ₂		
MW-11	Mar-06	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered	30 gal HCl/FeSO ₄ , 110 gal H ₂ O ₂		
MW-12	Mar-06	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered		30 gal HCl/FeSO ₄ , 120 gal H ₂ O ₂ (leaking observed at wellhead, 18 psi injection pressure)	50 gal HAc/FeSO ₄ , 180 gal H ₂ O ₂ (leaking observed at wellhead)
MW-13	Mar-06	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered		30 gal HCl/FeSO ₄ , 120 gal H ₂ O ₂ (no leaks at wellhead, but gas bubbled through asphalt pavement cracks. 20 psi injection pressure)	50 gal HAc/FeSO ₄ , 180 gal H ₂ O ₂ (leaking observed at wellhead)
MW-14	Mar-06	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered		30 gal HCl/FeSO ₄ , 120 gal H ₂ O ₂ (no leaks at wellhead, but gas bubbled through asphalt pavement cracks)	
MW-15	Mar-06	2-inch Sch. 5, 304 SS	0.020-inch	5-15	Vashon till, weathered		30 gal HCl/FeSO ₄ , 110 gal H ₂ O ₂ (18 psi injection pressure)	50 gal HAc/FeSO ₄ , 180 gal H ₂ O ₂ (14 psi injection pressure)

Notes
FeSO₄ - ferrous sulfate, HAc - acetic acid, HCl - hydrochloric acid, H₂O₂ - hydrogen peroxide, 18%, ISCO - *in situ* chemical oxidation
PVC - polyvinyl chloride, SS - stainless steel
bgs - below ground surface, ft - feet

Table 3. Calculated Well Yield of Weathered Vashon Till from Slug Tests

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Well yield calculation for MW-7 using rising head slug tests performed by The Riley Group (2005)

K (cm/sec) = 1.68E-04 Slug test #1, October 12, 2005, (Riley, 2005, see Appendix D)

K (cm/sec) = 1.48E-04 Slug test #2, October 12, 2005, (Riley, 2005, see Appendix D)

K (cm/sec) = 1.58E-04 Geometric mean

b (ft) = 10 Saturated thickness

Q (gpd) = 208 Well yield, 4-inch equivalent, unsaturated

Q (gpm) = 0.144 Well yield, 4-inch equivalent, unsaturated

Q (gpd) = 221 Well yield, 6-inch equivalent, unsaturated

Q (gpm) = 0.153 Well yield, 6-inch equivalent, unsaturated

Reference: Groundwater Classification, Texas Commission on Environmental Quality,
Regulatory Guidance for Texas Risk Reduction Program, RG-366/TRRP-8, Revised March 2010

Well yield calculation formulas:

3d) 4-inch diameter well screen:

$$Q = \frac{(57,923)(K)(b^2)}{7.2 + \log[(K)(b)]} \quad (\text{B.3d})$$

where:

b = saturated thickness of water-bearing unit (ft)

h_c = confining head above top of water-bearing unit (ft)

K = hydraulic conductivity of water-bearing unit (cm/s)

Q = well yield (gpd)

e = well efficiency (assumed to be 100%)

Table C- 1. Method 2 Correction Factors for Estimation of Equivalent Yield Based on Alternate Test Well Diameter

Nominal Screen Diameter of Test Well	Correction Factor for Equivalent Yield From:			
	4-inch Diameter Well		12-inch Diameter Well	
	Confined Unit	Unconfined Unit	Confined Unit	Unconfined Unit
2-inch	1.08	1.10	1.24	1.30
4-inch	1.00	1.00	1.14	1.18
6-inch	0.95	0.94	1.09	1.12
8-inch	0.92	0.90	1.05	1.07
10-inch	0.89	0.87	1.02	1.03
12-inch	0.87	0.85	1.00	1.00
16-inch	0.84	0.80	0.96	0.95
24-inch	0.79	0.75	0.91	0.88
Multiply well yield measured in test well by the specified correction factor to obtain the equivalent yield of a well with either a 4-inch diameter screen or a 12-inch diameter screen.				

Table 4. Proposed Groundwater Cleanup Levels for Vashon Till Groundwater

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Chemical Name	Direct Contact Exposure Pathway								NAPL Prohibition		Background	Cleanup Level
	Method B Soil CUL (Table Value, Noncancer) (mg/kg)	Method B Soil CUL (Table Value, Cancer) (mg/kg)	Method B Soil CUL (Most Stringent) (mg/kg)	Soil Organic Carbon-Water Partitioning Coefficient (K _{oc} , L/kg) (ml-H ₂ O/g-carbon)	Soil-Water Partitioning Coefficient (K _d , L/kg) (ml-H ₂ O/g-carbon)	Henry's Law Coefficient (H _{cc} , dimensionless)	Partitioning Ratio (g-soil/ml-H ₂ O)	Groundwater CUL (Direct Contact) (µg/L)	Solubility Limit (mg/L)	Groundwater CUL (NAPL prohibition) (µg/L)	Natural Background Concentration in Snohomish Basin (µg/L)	Groundwater CUL (nonpotable) (µg/L)
Tetrachloroethylene (PCE)	480	476.19	476.19	265	0.265	0.754	1.8856	898,000	200	2,000	NA	2,000
Trichloroethylene (TCE)	40	12	12	94	0.094	0.422	3.0250	36,300	1,100	11,000	NA	11,000
Dichloroethylene;1,2-,cis	160	NA	160	35.5	0.0355	0.167	4.0004	640,000	3,500	35,000	NA	35,000
Dichloroethylene;1,2-,trans	1,600	NA	1,600	38	0.038	0.385	3.6851	5,900,000	6,300	63,000	NA	63,000
Dichloroethylene;1,1-	4,000	NA	4,000	65	0.065	1.07	2.7954	11,200,000	2,250	22,500	NA	22,500
Vinyl chloride	240	0.67	0.67	18.6	0.0186	1.11	3.1766	2,130	2,760	27,600	NA	2,130
Arsenic	24	0.667	0.667	NA	290	0	0.0034	2.298	NA	NA	11.8	11.8
TPH, Diesel Range	NA	NA	-	-	-	-	-	NA	-	-	NA	NA
TPH, Oil Range	NA	NA	-	-	-	-	-	NA	-	-	NA	NA
Additional Calculations for Arsenic												
Arsenic (carcinogenic)	24	0.667	0.667	NA	290	0	0.0034	2.298	NA	NA	11.8	11.8
Arsenic (non-carcinogenic)	24	NA	24	NA	290	0	0.0034	82.702	NA	NA	11.8	83
Arsenic (empirical, dissolved)	24	0.667	0.667	NA	290	0	0.0036	2.386	NA	NA	11.8	2.386
Arsenic (empirical, total)	24	0.667	0.667	NA	290	0	0.0032	2.128	NA	NA	11.8	2.128

Notes

Partitioning ratio nonchemical-specific parameters in Equation 747-1 of WAC 173-340-340-747

Unit conversion factor (UCF)	0.001
Dilution dactor	1
Fraction organic carbon (foc)	0.001 g-carbon/g-soil
Water-filled porosity (Theta_w)	0.3 ml-H ₂ O/ml-soil
Air-filled porosity (Theta_a)	0.13 ml-air/ml-soil
Soil bulk density (Rho_b)	1.5 g-soil/ml-soil

Table 5. Proposed Cleanup Levels for the Site

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Chemical Name	Method A Soil Cleanup Levels for Site (mg/kg)	Potable Groundwater Cleanup Levels for Advance Outwash (µg/L)	Non-Potable Groundwater Cleanup Levels for Vashon Till (µg/L)	Indoor and Ambient Method B Air Cleanup Levels (µg/m ³)
Tetrachloroethylene (PCE)	0.05	5	2,000	9.62
Trichloroethylene (TCE)	0.03	5	11,000	0.37
Dichloroethylene;1,2-,cis	0.35	70	35,000	NA
Dichloroethylene;1,2-,trans	0.54	100	63,000	NA
Dichloroethylene;1,1-	0.050	7	22,500	91.4
Vinyl chloride	0.0013	0	2,130	0.28
Arsenic	20	12	11.8	5.81E-04
TPH, Diesel Range	2,000	500	NA	NA
TPH, Oil Range	2,000	500	NA	NA

Notes

Method A soil cleanups levels are calculated for DCE isomers and vinyl chloride using Equation 747-1 of WAC 173-340-747.

Table 6. Comparison of Site Arsenic Concentrations with Natural Background

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Sample	Date	Dissolved Arsenic (µg/L)	Total Arsenic (µg/L)	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (millivolts)	pH
Method A Cleanup Level		5	5	-	-	-
Maximum Contaminant Level		10	10	-	-	-
Natural Background		11.8	11.8	-	-	-
MW-1	1/22/2015	-	23.1	0.2	-44	6.7
	8/10/2015	20.4	22.4	0.3	28	6.6
MW-2	1/23/2015	-	<1	2.2	87	6.3
	8/11/2015	<1	11.4	1.9	35	6.1
MW-2D	8/10/2015	3.33	11.4	0.7	110	8.4
MW-3	1/22/2015	-	10.6	0.7	-5	6.6
	8/11/2015	17.9	13.6	0.6	47	6.2
MW-4	1/22/2015	-	34.7	1.3	-29	6.5
	8/11/2015	13.3	7.59	-	-	-
MW-5	1/22/2015	-	5.56	0.2	6	6.7
	8/11/2015	<1	2.70	0.5	16	6.5
MW-6	1/23/2015	-	<1	0.6	69	5.8
	8/11/2015	<1	<1	0.9	32	5.6
MW-7	1/28/2015	-	<1	4.1	30	6.1
	8/11/2015	2.58	2.52	0.6	77	5.4
MW-8	1/22/2015	-	<1	0.5	65	6.4
	8/11/2015	<1	<1	0.4	158	6.2
MW-9	1/23/2015	-	2.73	0.2	-32	6.4
	8/11/2015	5.25	5.17	0.3	146	6.1
MW-10	1/22/2015	-	1.11	0.9	94	5.6
	8/10/2015	3.99	4.28	0.3	50	6.2
MW-11	1/28/2015	-	<1	1.1	53	6.2
	8/10/2015	1.44	1.44	0.3	63	6.1
MW-12	1/23/2015	-	<1	0.5	110	6.4
	8/11/2015	1.75	1.78	0.3	152	6.2
MW-15	1/22/2015	-	22.3	0.2	-37	6.3
	8/10/2015	28.1	29.4	0.2	-12	6.1
MW-16	1/23/2015	-	1.02	5.7	107	6.4
	8/11/2015	<1	8.82	0.2	156	6.2
MW-16D	4/27/2015	-	1.22	0.5	118	8.1
	8/11/2015	2.71	3.36	1.0	113	10.9
MW-17	1/23/2015	-	9.82	1.8	34	6.6
	8/10/2015	39.4	38.5	0.4	-8	6.4
MW-18	1/23/2015	-	<1	2.7	56	6.2
	8/11/2015	2.05	3.68	0.2	115	6.1
MW-19	1/23/2015	-	3.75	6.4	51	6.7
	1/23/2015	-	3.93	6.4	51	6.7
	8/11/2015	15.0	15.5	0.4	40	6.3
MW-20	4/27/2015	-	4.99	0.8	120	6.8
	8/10/2015	1.24	1.25	0.6	34	6.5
MW-21	8/10/2015	<1	<1	0.6	37	6.4
MW-22	8/10/2015	<1	<1	2.7	65	6.7

Notes

- Highlighted, bold font indicates that value exceeds MTCA Method A groundwater CUL or MCL
- Gray shaded text is below detection limit and detection does not exceed Method A groundwater CUL or MCL
- "-" indicates that sample not collected or value not given
- TPH was analyzed after silica gel cleanup for June 14, 2005 groundwater samples.

Table 7. Statistical Summaries of Site and Regional Arsenic Data Sets

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Statistical Metric	Dissolved Arsenic Concentrations at Site	Total Arsenic Concentrations at Site	Arsenic Concentrations in Snohomish Basin	Notes
Area	5	5	1,910	
Number of Samples	22	42	207	
Number of Detects	15	31	129	
Numboer of Non-Detects	7	11	78	
Percent Non-Detect	31.8%	26.2%	37.7%	Historical background sample data set includes higher detection limits when MCL was 50 ug/L arsenic.
Min	0.5	0.5	1.2	Minimum is half of the detection limit
Max	39.4	38.5	76	
Mean	7.4	7.5	7.6	Site mean is lower than the background mean.
Median	2.3	3.5	5.5	
Mode	0.5	0.5	4	The mode values are half the detection limit.
Standard Deviation	10.6	9.8	7.9	Decreases with increased number of samples.
Variance	112.8	96.0	62.4	Decreases with increased number of samples.
Coefficient of Variance	1.443	1.306	104	Decreases with increased number of samples.
Skewness	1.857	1.791	5.3	
Kurtosis	3.022	2.592	42.4	Regional data has more outliers due to the varied geology.
Distribution	Gamma	Gamma	Lognormal	
Parametric Upper 90% UCL	10.36	9.469	11.8	Site 90% UCL is lower than background.
Non-Parametric Upper 90% UCL	11.54	9.892	13.6	Site 90% UCL is lower than background.
Natural Background	NA	NA	11.8	

Number Samples above Site 90% UCL	6	11
Percent Samples above Site 90% UCL	27.3%	26.2%
Number Samples above Snohomish Basin 90% UCL	6	8
Percent Samples above Snohomish Basin 90% UCL	27.3%	19.0%

Notes

MCL - maximum contaminant level

UCL - upper confidence limit

Natural Background Groundwater Arsenic Concentrations in Washington State, Ecology Publication No. 14-09-004, March 2016.

Aspect Consulting

December 2017

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Table 7

Groundwater Classification and Proposed Cleanup Standards

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Table 8. Comparison of Soil Concentrations with Method A Soil Cleanup Levels

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Sample	Depth (feet below ground surface)	Date	PID (ppm)	Tetrachloro ethylene (mg/kg)	Trichloro ethylene (mg/kg)	cis-1-2- Dichloro ethylene (mg/kg)	trans-1-2- Dichloro ethylene (mg/kg)	1,1- Dichloro ethylene (mg/kg)	Vinyl Chloride (mg/kg)	TPH-Diesel (mg/kg)	TPH-Oil (mg/kg)	Arsenic (mg/kg)
Method A Cleanup Level				0.05	0.03	-	-	-	-	2,000	2,000	20
Method B Cleanup Level (Calculated)						0.35	0.54	0.05	0.0013			
AB-1	2.5	7/30/2015	6.1	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	-	-	-
AB-3	11	7/30/2015	0.6	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	-	-	-
SP1	7-8	6/14/2005	0.1	-	-	-	-	-	-	-	-	-
SP2	7-8	6/14/2005	0	-	-	-	-	-	-	-	-	-
	10-11		0	-	-	-	-	-	-	-	-	-
SP3	4-5	6/14/2005	0	-	-	-	-	-	-	-	-	-
	5-6		0	-	-	-	-	-	-	-	-	-
	7-8		0	-	-	-	-	-	-	-	-	-
	11-12		0	-	-	-	-	-	-	-	-	-
SP4	7-7.5	6/14/2005	0	-	-	-	-	-	-	-	-	-
	8-9		0	-	-	-	-	-	-	-	-	-
SP5	6-7	6/14/2005	0	-	-	-	-	-	-	-	-	-
	9-10		0	-	-	-	-	-	-	-	-	-
SP6	5-6	6/14/2005	0	-	-	-	-	-	-	-	-	-
	9-10		0	-	-	-	-	-	-	-	-	-
SP7	9-10	6/14/2005	0	-	-	-	-	-	-	-	-	-
SP8	6.5-7	6/14/2005	0.1	-	-	-	-	-	-	-	-	-
	7.5-8		1.8	-	-	-	-	-	-	33	520	-
	11-12		0.7	-	-	-	-	-	-	-	-	-
SP9	6-6.5	6/14/2005	0	-	-	-	-	-	-	-	-	-
	8.5-9		0	-	-	-	-	-	-	-	-	-
SP10	7-8	6/14/2005	34	-	-	-	-	-	-	-	-	-
	8-9		57.2	-	-	-	-	-	-	-	-	-
	10-11		532	-	-	-	-	-	-	<25	<50	7.9
MW-2D	55	7/27/2015	0.4	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	-	-	-
	190	7/30/2015	0	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	-	-	-
MW-16	1-1.5	1/21/2015	0.1	-	-	-	-	-	-	-	-	-
	3-3.5		0.4	-	-	-	-	-	-	-	-	-
	5.5-6		1.2	-	-	-	-	-	-	-	-	-
	8-8.5		2.4	-	-	-	-	-	-	-	-	-
	10.5-11		12.5	-	-	-	-	-	-	-	-	-
	13-13.5		21.3	-	-	-	-	-	-	-	-	-
	15.5-16		61.5	0.066	4.9	0.066	<0.05	<0.05	<0.05	<50	<250	2.06
MW-16D	15	4/9/2015	5.0	0.13	1.9	<0.05	<0.05	<0.05	<0.05	-	-	-
	25		0.0	<0.025	0.042	<0.05	<0.05	<0.05	<0.05	-	-	-
	45		15.4	0.037	1.3	<0.05	<0.05	<0.05	<0.05	-	-	-
	65		0.0	<0.025	0.067	<0.05	<0.05	<0.05	<0.05	-	-	-
	90		0.0	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	-	-	-
MW-17	10-11.5	1/21/2015	0	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	<50	<250	2.28
MW-18	10.5-11	1/21/2015	1.8	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	<50	<250	2.85
MW-19	15-15.5	1/21/2015	0.2	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	<50	<250	2.61
MW-20	10	4/9/2015	0	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	-	-	2.13
MW-21	9-10	7/24/2015	1.3	0.048	0.056	<0.05	<0.05	<0.05	<0.05	<50	<250	2.25
MW-22	10-11	7/24/2015	0	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05	<50	<250	2.04

Notes

- Highlighted, bold font indicates that value exceeds MTCA Method A soil Cleanup Level (CUL)
- Gray shaded text is below detection limit and detection does not exceed Method A soil CUL
- "-" indicates that sample not collected or value not given
- TPH was analyzed after silica gel cleanup for soil sample from SP8 on June 14, 2005.

Table 9. Comparison of Vashon Till Groundwater Concentrations with Proposed Cleanup Levels for Nonpotable Groundwater

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Sample	Date	Tetrachloro ethylene (µg/L)	Trichloro ethylene (µg/L)	cis-1-2-Dichloro ethylene (µg/L)	trans-1-2-Dichloro ethylene (µg/L)	1-1-Dichloro ethylene (µg/L)	Vinyl Chloride (µg/L)	TPH-Diesel (µg/L)	TPH-Oil (µg/L)	Dissolved Arsenic (µg/L)	Total Arsenic (µg/L)
Proposed Cleanup Levels		2,000	11,000	35,000	63,000	22,500	2,130	-	-	11.8	11.8
SP1	6/14/2005	5	<2	<2	<2	<2	<2	-	-	-	-
SP2	6/14/2005	<2	7	6	<2	<2	<2	-	-	-	-
SP3	6/14/2005	2	2	53	<2	<2	12	-	-	-	-
SP4	6/14/2005	<2	<2	<2	<2	<2	<2	-	-	-	-
SP5	6/14/2005	<2	<2	<2	<2	<2	<2	-	-	-	-
SP6	6/14/2005	<2	<2	<2	<2	<2	<2	-	-	-	-
SP7	6/14/2005	<2	<2	<2	<2	<2	<2	-	-	-	-
SP8	6/14/2005	<2	<2	<2	<2	<2	<2	-	-	-	-
SP9	6/14/2005	<2	<2	<2	<2	<2	<2	-	-	-	-
SP10	6/14/2005	300	42,000	290	6	76	21	-	-	-	-
MW-1	9/13/2005	<0.2	1.3	0.25	<0.2	<0.2	<0.2	-	-	-	-
	May-06	<2	<2	2	<2	<2	0.4	-	-	-	-
	10/4/2006	Injected 50 gallons of acetic acid & FeSO ₄ solution and then 180 gallons of 18% H ₂ O ₂ solution									
	1/10/2007	<0.2	3	2.5	<0.2	0.56	0.59	-	-	-	-
	4/30/2008	<0.2	6.4	3.3	<0.2	0.39	0.76	-	-	-	-
	Mar-09	<0.2	27	3.3	<0.2	0.62	0.51	-	-	-	-
	9/16/2009	<2	1.1	0.98	<0.2	0.62	<0.2	-	-	-	-
	1/13/2012	15	1,100	15	<10	<10	<10	-	-	-	-
	1/22/2015	2.3	96	5.2	<1	1.2	4.1	390 x	270x	-	23.1
MW-2	8/10/2015	5.3	200	6.9	<1	1.8	4.0	330 x	<250	20.4	22.4
	9/13/2005	<0.2	4.1	0.91	<0.2	<0.2	<0.2	-	-	-	-
	May-06	<2	11	5	<2	<2	<0.2	-	-	-	-
	1/10/2007	<0.2	6.8	0.75	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	3	0.35	<0.2	<0.2	<0.2	-	-	-	-
	1/13/2012	<0.2	3.5	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/23/2015	<1	<1	<1	<1	<1	<0.2	<60	<300	-	<1
	8/11/2015	<1	4.7	<1	<1	<1	<0.2	<50	<250	<1	11.4
MW-3	9/13/2005	<0.2	<0.2	0.96	<0.2	<0.2	<0.2	-	-	-	-
	1/10/2007	<0.2	<0.2	2.9	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	<0.2	1.4	<0.2	<0.2	<0.2	-	-	-	-
	1/22/2015	<1	<1	1.5	<1	<1	<0.2	600 x	350 x	-	10.6
	8/11/2015	<1	<1	1.5	<1	<1	<0.2	700 x	420 x	17.9	13.6
MW-4	9/13/2005	<0.2	<0.2	0.96	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	<0.2	1.4	<0.2	<0.2	<0.2	-	-	-	-
	1/22/2015	<1	<1	<1	<1	<1	<0.2	150 x	<250	-	34.7
	8/11/2015	<1	<1	<1	<1	<1	<0.2	<50	<250	13.3	7.59
MW-5	9/13/2005	<0.2	<0.2	0.43	<0.2	<0.2	<0.2	-	-	-	-
	1/10/2007	<0.2	<0.2	0.61	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/22/2015	<1	<1	<1	<1	<1	<0.2	59 x	<250	-	5.56
	8/11/2015	<1	<1	<1	<1	<1	<0.2	58 x	<250	<1	2.70
MW-6	10/7/2005	3.9	0.26	0.33	<0.2	<0.2	<0.2	-	-	-	-
	May-06	<2	<2	<2	<2	<2	<0.2	-	-	-	-
	1/9/2007	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/13/2012	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/23/2015	<1	<1	<1	<1	<1	<0.2	84 x	<250	-	<1
	8/11/2015	<1	<1	<1	<1	<1	<0.2	590 x	330 x	<1	<1
MW-7	10/7/2005	460	7,000	140	<50	<50	<50	-	-	-	-
	3/15/2006	Injected 40 gallons of HCl & FeSO ₄ solution and then 240 gallons of 18% H ₂ O ₂ solution									
	4/14/2006	Injected 30 gallons of HCl & FeSO ₄ solution and then 110 gallons of 18% H ₂ O ₂ solution									
	May-06	10	21	<2	<2	<2	0.7	-	-	-	-
	10/4/2006	Injected 50 gallons of acetic acid & FeSO ₄ solution and then 190 gallons of 18% H ₂ O ₂ solution									
	1/10/2007	<0.2	0.22	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	Mar-09	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	9/16/2009	0.33	1	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/13/2012	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/28/2015	<1	<1	<1	<1	<1	<0.2	130 x	340 x	-	<1
	8/11/2015	<1	<1	<1	<1	<1	<0.2	220 x	<250	2.58	2.52

Table 9

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Table 9. Comparison of Vashon Till Groundwater Concentrations with Proposed Cleanup Levels for Nonpotable Groundwater

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Sample	Date	Tetrachloro ethylene (µg/L)	Trichloro ethylene (µg/L)	cis-1-2-Dichloro ethylene (µg/L)	trans-1-2-Dichloro ethylene (µg/L)	1-1-Dichloro ethylene (µg/L)	Vinyl Chloride (µg/L)	TPH-Diesel (µg/L)	TPH-Oil (µg/L)	Dissolved Arsenic (µg/L)	Total Arsenic (µg/L)
Proposed Cleanup Levels		2,000	11,000	35,000	63,000	22,500	2,130	-	-	11.8	11.8
MW-8	10/7/2005	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	May-06	<2	<2	<2	<2	<2	<2	-	-	-	-
	1/9/2007	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	Mar-09	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	9/16/2009	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/13/2012	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/22/2015	<1	<1	<1	<1	<1	<0.2	<50	<250	-	<1
	8/11/2015	<1	<1	<1	<1	<1	<0.2	73 x	<250	<1	<1
MW-9	3/15/2006	Injected 40 gallons of HCl & FeSO ₄ solution and then 50 gallons of 18% H ₂ O ₂ solution									
	4/14/2006	Injected 20 gallons of HCl & FeSO ₄ solution and then 110 gallons of 18% H ₂ O ₂ solution									
	4/30/2008	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	Mar-09	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	9/16/2009	0.43	0.27	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/13/2012	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/23/2015	<1	<1	<1	<1	<1	<0.2	110 x	<250	-	2.73
	8/11/2015	<1	<1	<1	<1	<1	<0.2	830 x	950 x	5.25	5.17
MW-10	3/15/2006	Injected 30 gallons of HCl & FeSO ₄ solution and then 110 gallons of 18% H ₂ O ₂ solution									
	May-06	23	<2	<2	<2	<2	<0.2	-	-	-	-
	1/10/2007	11	0.54	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	22	0.6	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	Mar-09	18	0.53	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	9/16/2009	4	<0.2	<0.2	<0.2	6.3	4.1	-	-	-	-
	1/13/2012	3.9	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/22/2015	7.5	<1	<1	<1	<1	<0.2	<50	<250	-	1.11
	8/10/2015	3.2	<1	<1	<1	<1	<0.2	140 x	<250	3.99	4.28
MW-11	3/15/2006	Injected 30 gallons of HCl & FeSO ₄ solution and then 110 gallons of 18% H ₂ O ₂ solution									
	May-06	58	270	42	<2	5	1.4	-	-	-	-
	1/9/2007	150	700	140	<4	12	<4	-	-	-	-
	4/30/2008	14	130	11	<0.2	3.3	<0.2	-	-	-	-
	Mar-09	8.4	88	5.2	<0.2	1.7	<0.2	-	-	-	-
	9/16/2009	220	580	180	<0.2	1.7	<0.2	-	-	-	-
	1/13/2012	27	130	9.5	<1	2.2	<1	-	-	-	-
	1/28/2015	12	54	7.4	<1	<1	<0.2	<50	<250	-	<1
	8/10/2015	69	190	66	<1	2.2	1.3	120 x	<250	1.44	1.44
MW-12	4/14/2006	Injected 30 gallons of HCl & FeSO ₄ solution and then 120 gallons of 18% H ₂ O ₂ solution									
	Jun-06	180	1,700	290	4	8	23	-	-	-	-
	10/4/2006	Injected 50 gallons of acetic acid & FeSO ₄ solution and then 180 gallons of 18% H ₂ O ₂ solution									
	1/9/2007	140	480	240	2.7	2.1	8.9	-	-	-	-
	4/30/2008	99	320	220	3.5	3.3	17	-	-	-	-
	Mar-09	85	230	130	2.6	2.2	8.2	-	-	-	-
	9/16/2009	95	230	160	2.8	2.2	9.1	-	-	-	-
	1/13/2012	54	99	60	1.3	1.1	6.3	-	-	-	-
	1/23/2015	14	20	11	<1	<1	0.3	56 x	<250	-	<1
	8/11/2015	28	59	40	<1	<1	2.8	110 x	<250	1.75	1.78
MW-13	4/14/2006	Injected 30 gallons of HCl & FeSO ₄ solution and then 120 gallons of 18% H ₂ O ₂ solution									
	Jun-06	9	270	12	<2	<2	1.4	-	-	-	-
	10/4/2006	Injected 50 gallons of acetic acid & FeSO ₄ solution and then 180 gallons of 18% H ₂ O ₂ solution									
	1/9/2007	11	44	9.1	0.3	1.3	1.9	-	-	-	-
	4/30/2008	4.2	25	9.6	0.28	0.94	2.9	-	-	-	-
	1/23/2015	Well was full of silty sand, not sampled									
MW-14	4/14/2006	Injected 30 gallons of HCl & FeSO ₄ solution and then 120 gallons of 18% H ₂ O ₂ solution									
	Jun-06	<2	17	<2	<2	<2	<0.2	-	-	-	-
	1/9/2007	<0.2	2.6	4.3	<0.2	<0.2	<0.2	-	-	-	-
	4/30/2008	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	Jan-12	Well was abandoned									

Table 9

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Table 9. Comparison of Vashon Till Groundwater Concentrations with Proposed Cleanup Levels for Nonpotable Groundwater

Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, Washington

Sample	Date	Tetrachloro ethylene (µg/L)	Trichloro ethylene (µg/L)	cis-1-2-Dichloro ethylene (µg/L)	trans-1-2-Dichloro ethylene (µg/L)	1-1-Dichloro ethylene (µg/L)	Vinyl Chloride (µg/L)	TPH-Diesel (µg/L)	TPH-Oil (µg/L)	Dissolved Arsenic (µg/L)	Total Arsenic (µg/L)
Proposed Cleanup Levels		2,000	11,000	35,000	63,000	22,500	2,130	-	-	11.8	11.8
MW-15	4/14/2006	Injected 30 gallons of HCl & FeSO ₄ solution and then 110 gallons of 18% H ₂ O ₂ solution									
	Jun-06	<2	26	3	<2	<2	0.9	-	-	-	-
	10/4/2006	Injected 50 gallons of acetic acid & FeSO ₄ solution and then 180 gallons of 18% H ₂ O ₂ solution									
	1/9/2007	28	1,000	<10	<10	<10	<10	-	-	-	-
	4/30/2008	0.26	4.8	<0.2	<0.2	<0.2	<0.2	-	-	-	-
	1/22/2015	<1	1.6	<1	<1	<1	0.69	370 x	370 x	-	22.3
MW-16	8/10/2015	<1	5.8	1.5	<1	<1	0.96	300 x	<250	28.1	29.4
	1/23/2015	100	410	270	2.8	1.5	5.8	330 x	<250	-	1.02
MW-16D	8/11/2015	110	120	290	3.5	1.1	6.5	220 x	<250	<1	8.82
	4/27/2015	<1	24	1	<1	<1	<0.2	750 x	540 x	-	1.22
MW-17	8/11/2015	<1	10	1.1	<1	<1	<0.2	460 x	<250	2.71	3.36
	1/23/2015	<1	<1	<1	<1	<1	<0.2	300 x	<250	-	9.82
MW-18	8/10/2015	<1	<1	<1	<1	<1	<0.2	200 x	<250	39.4	38.5
	1/23/2015	1.2	<1	<1	<1	<1	<0.2	96 x	<250	-	<1
MW-19	8/11/2015	<1	<1	<1	<1	<1	<0.2	110 x	<250	2.05	3.68
	1/23/2015	<1	<1	<1	<1	<1	<0.2	590 x	420 x	-	3.75
	1/23/2015	<1	<1	<1	<1	<1	<0.2	660 x	500 x	-	3.93
MW-20	8/11/2015	<1	1.2	<1	<1	<1	<0.2	450 x	410 x	15.0	15.5
	4/27/2015	17	<1	<1	<1	<1	<0.2	<50	<250	-	4.99
MW-21	8/10/2015	25	<1	<1	<1	<1	<0.2	64 x	<250	1.24	1.25
	8/10/2015	85	280	55	<1	2.9	1.3	130 x	<250	<1	<1
MW-22	8/10/2015	<1	<1	<1	<1	<1	<0.2	300 x	<250	<1	<1

Notes

- Highlighted, bold font indicates that value exceeds proposed cleanup levels for nonpotable groundwater.
- Gray shaded text is below detection limit and detection does not exceed Method A groundwater CUL or MCL
- "-" indicates that sample not collected or value not given
- TPH was analyzed after silica gel cleanup for June 14, 2005 groundwater samples.

Table 9

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Table 10. Comparison of Advance Outwash Groundwater Concentrations with Proposed Cleanup Levels for Potable Groundwater

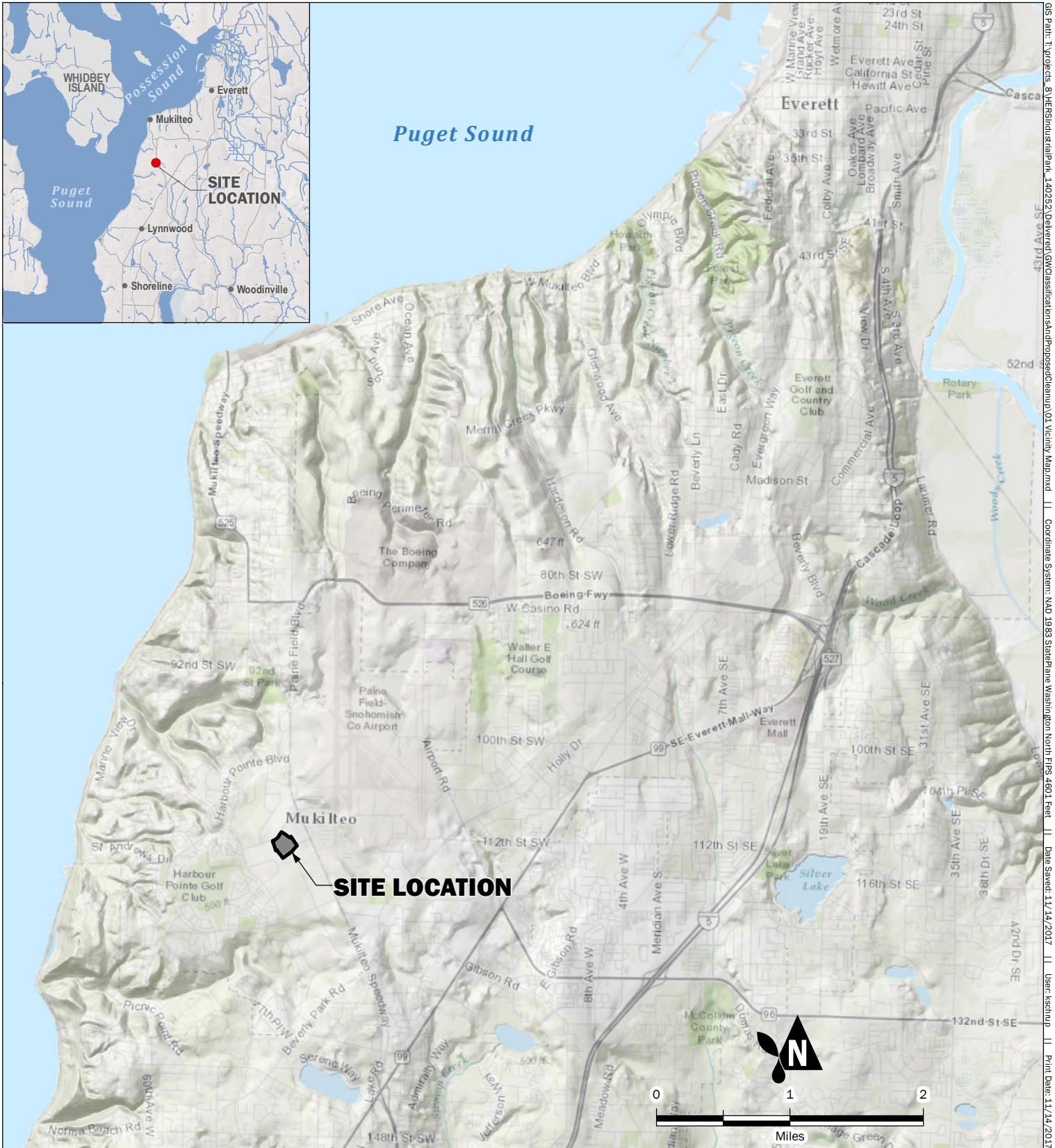
Project No. 140252, HERS Industrial Park (VCP No. NW1554), 4403 Russell Road, Mukilteo, WA

Sample	Date	Tetrachloro ethylene (µg/L)	Trichloro ethylene (µg/L)	cis-1-2-Dichloro ethylene (µg/L)	trans-1-2-Dichloro ethylene (µg/L)	1-1-Dichloro ethylene (µg/L)	Vinyl Chloride (µg/L)	TPH-Diesel (µg/L)	TPH-Oil (µg/L)	Dissolved Arsenic (µg/L)	Total Arsenic (µg/L)
Proposed Cleanup Levels		5	5	70	100	7	0.2	500	500	11.8	11.8
MW-2D	8/10/2015	<1	<1	<1	<1	<1	<0.2	<50	<250	3.33	11.4

Notes

- Highlighted, bold font indicates that value exceeds proposed cleanup levels for potable groundwater.
- Gray shaded text is below detection limit and detection does not exceed Method A groundwater CUL or MCL
- "-" indicates that sample not collected or value not given
- TPH was analyzed after silica gel cleanup for June 14, 2005 groundwater samples.

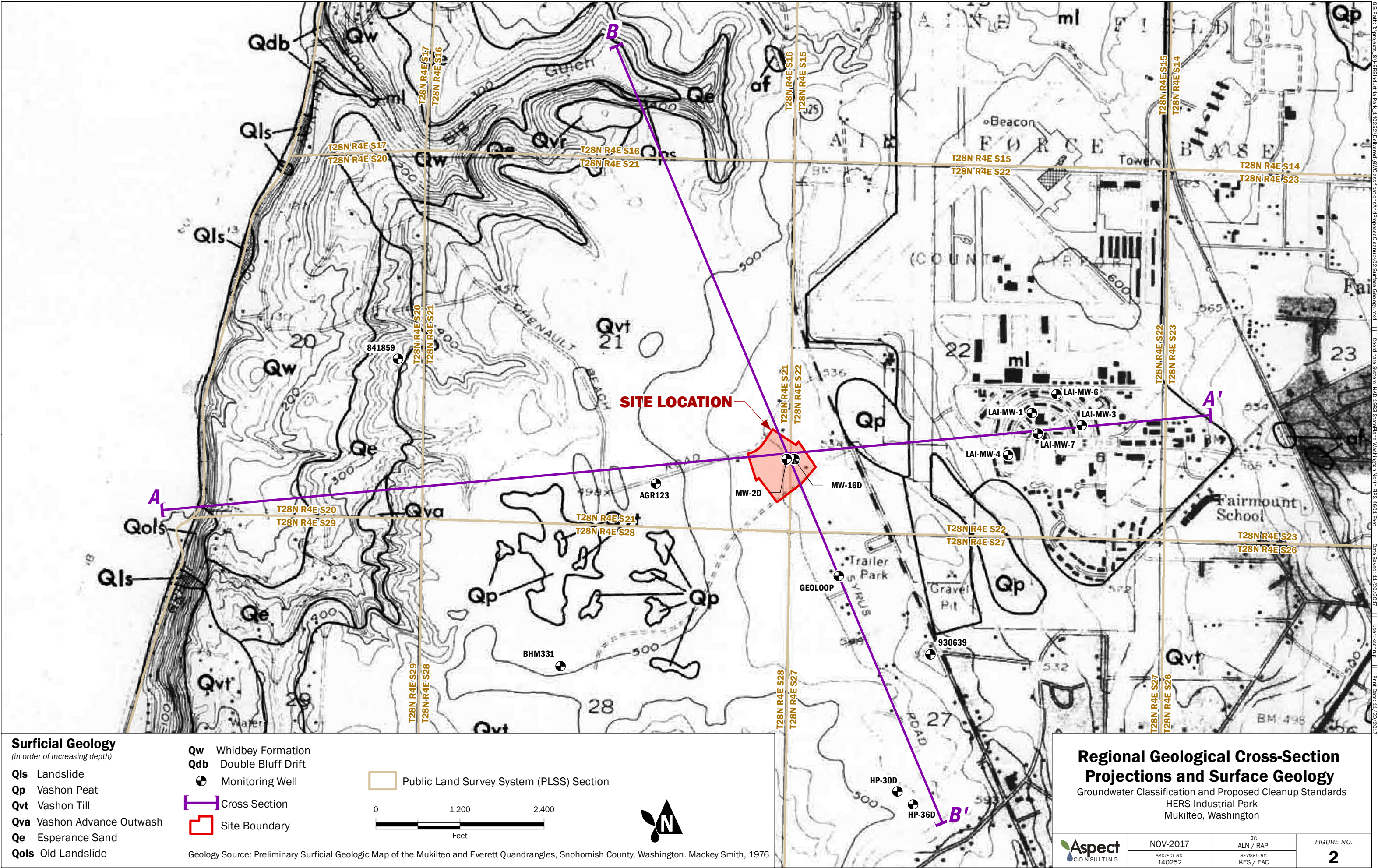
FIGURES

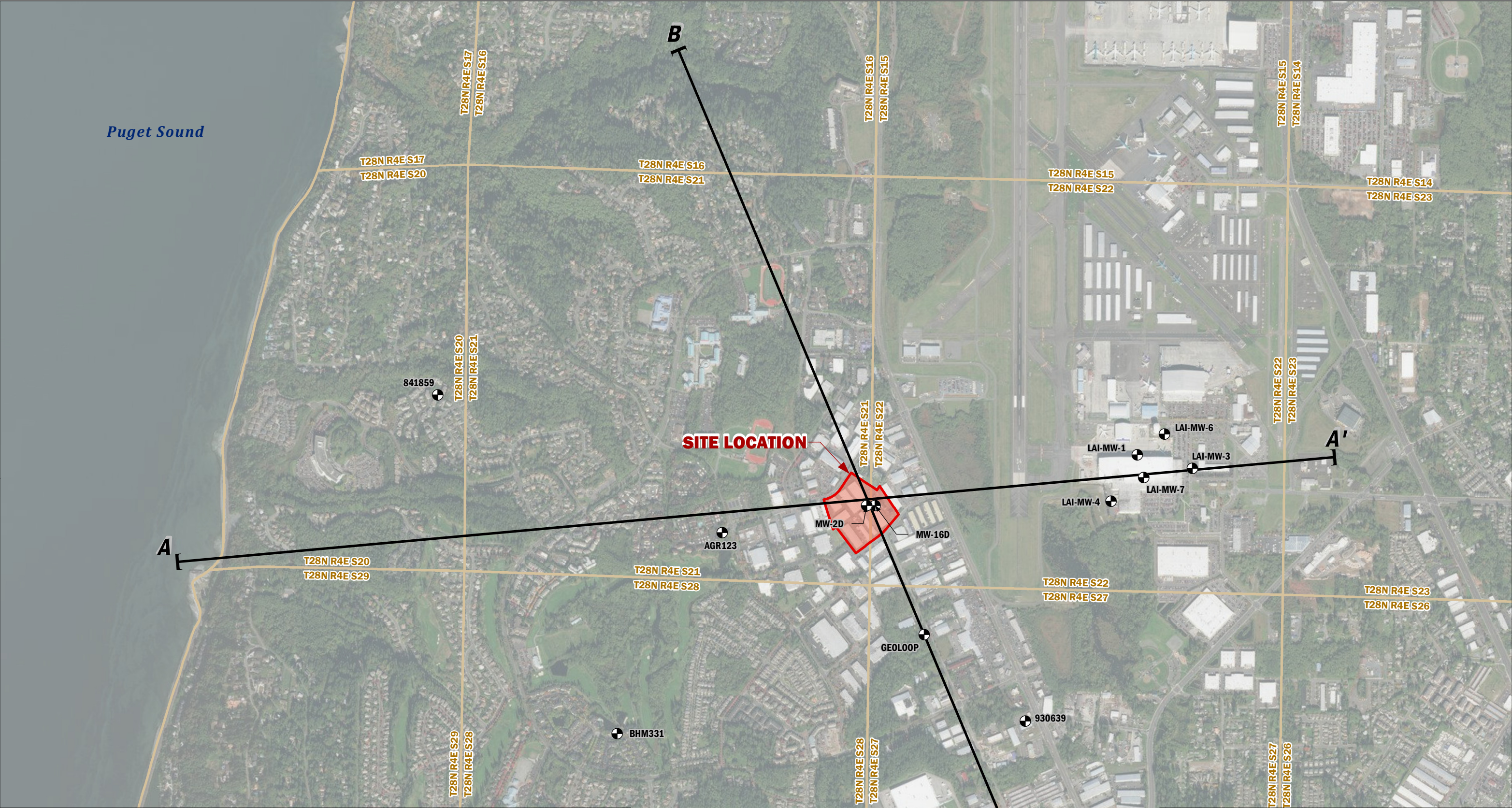


Vicinity Map

Groundwater Classification and Proposed Cleanup Standards
HERS Industrial Park
Mukilteo, Washington

	NOV-2017	BY: ALN / KES	FIGURE NO. 1
	PROJECT NO. 140252	REVISED BY: ---	





Monitoring Well

Cross Section

Site Boundary

Public Land Survey System (PLSS) Section

0

1,200

2,400

Feet

**Regional Geological Cross-Section
Projections and Well Locations**

Groundwater Classification and Proposed Cleanup Standards
HERS Industrial Park
Mukilteo, Washington

NOV-2017

PROJECT NO.
140252

BY:
ALN / KES

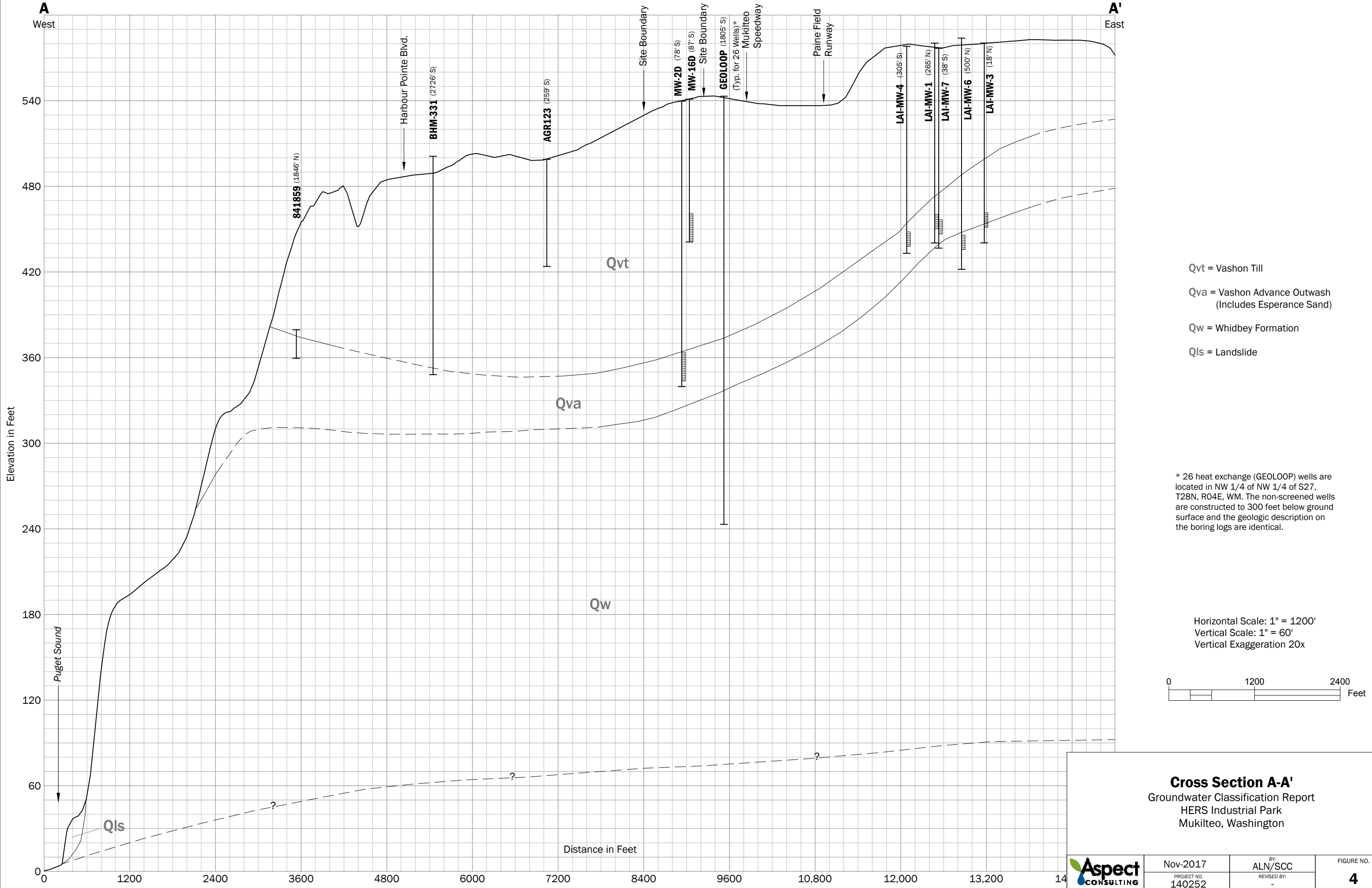
REVISED BY:
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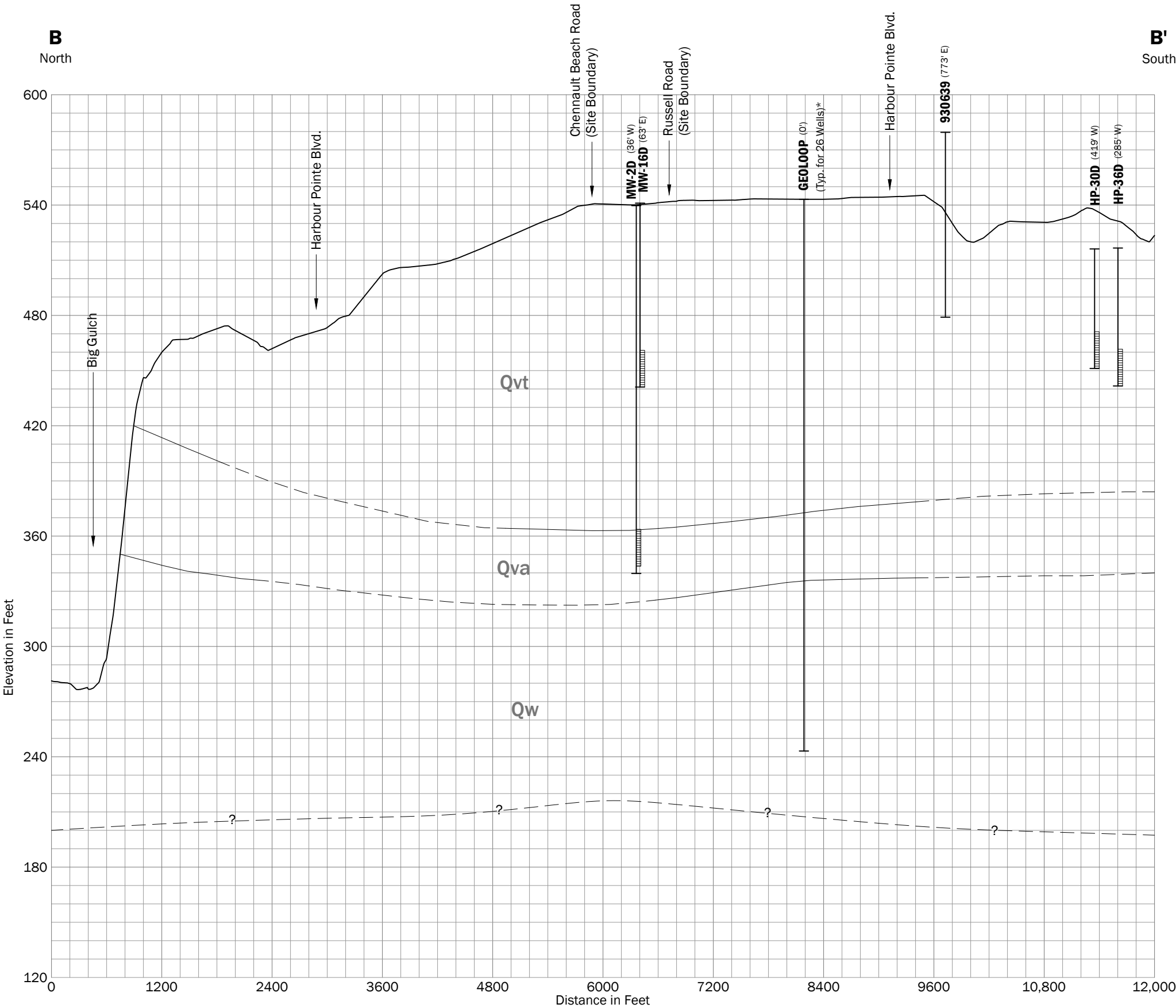
FIGURE NO.

3

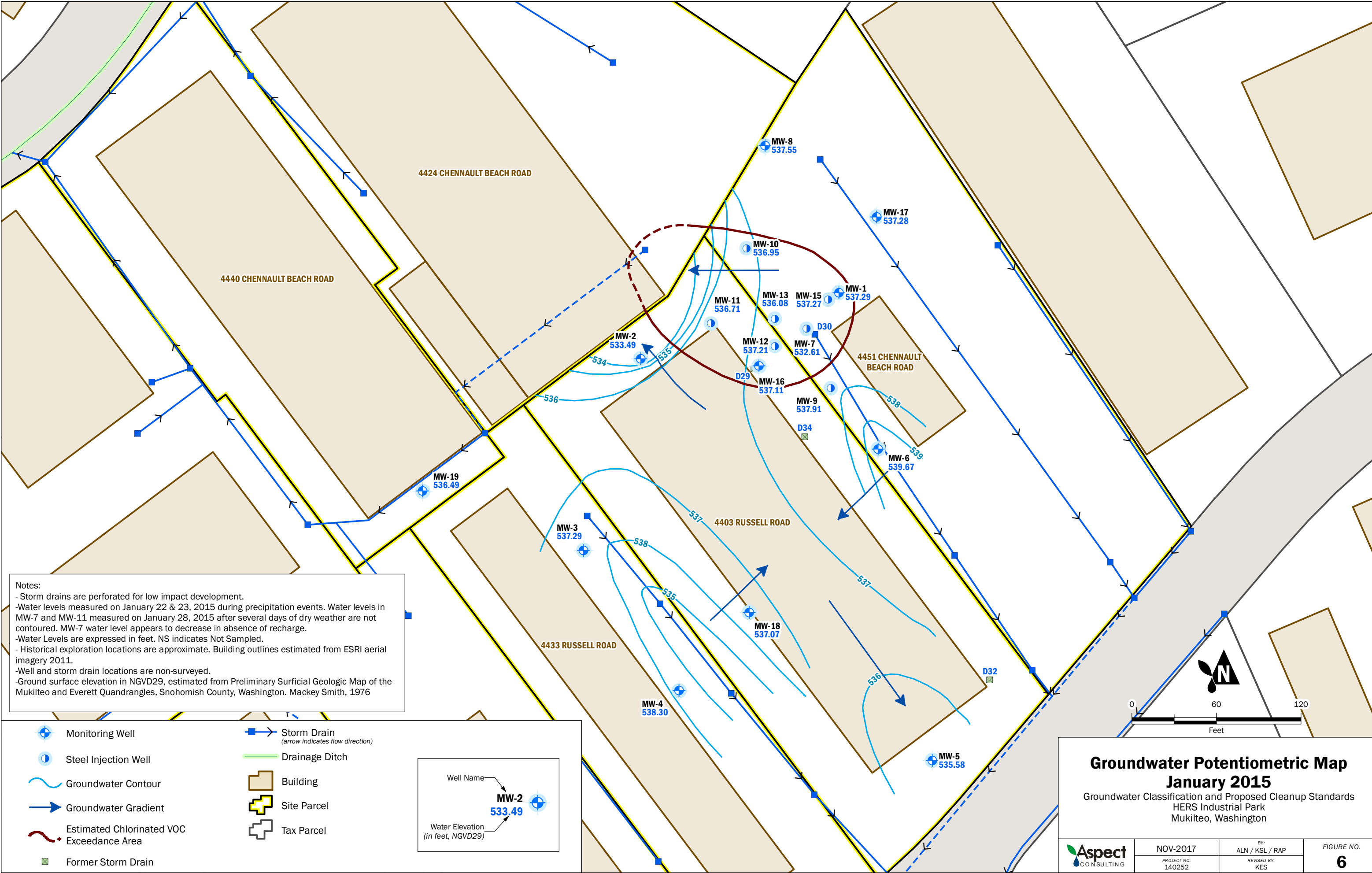
Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

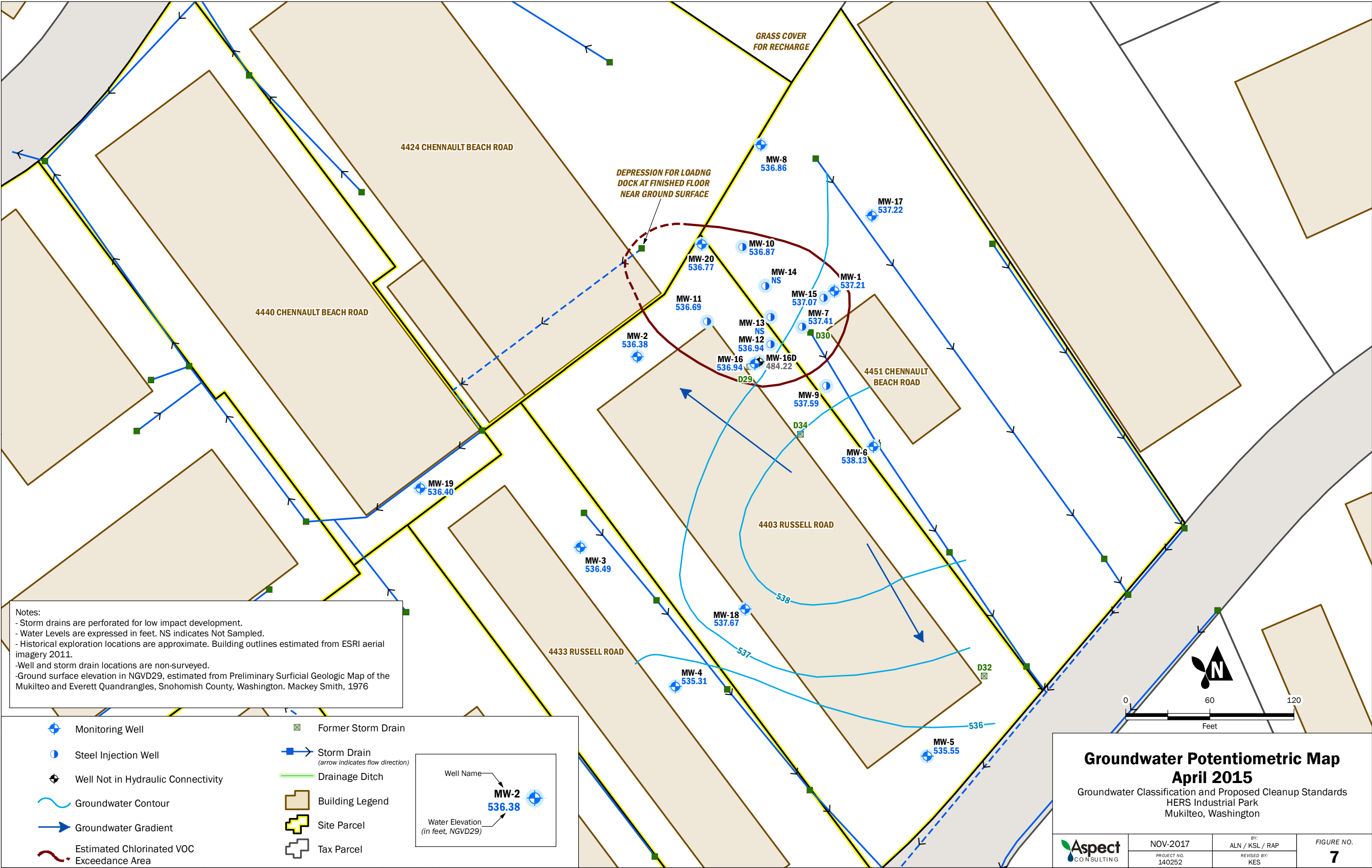
GIS Path: T:\Projects_8\HERSIndustrialPark_140252\Delivered\GIS\ClassificationsAndProposedCleanup\03 Geological Cross Section Projections and Wells.mxd | Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet | Date Saved: 11/15/2017 | User: ecumbykay | Print Date: 11/15/2017

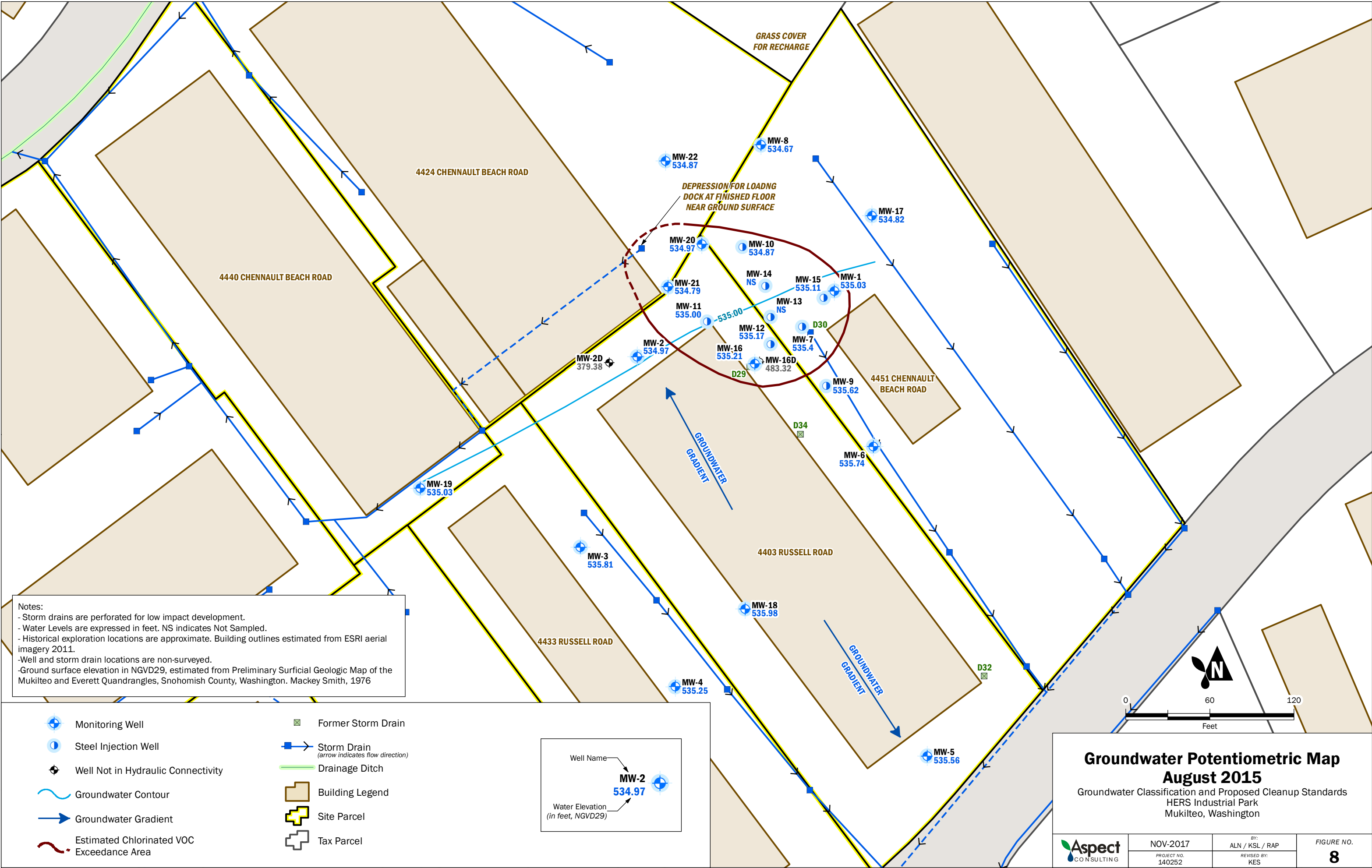


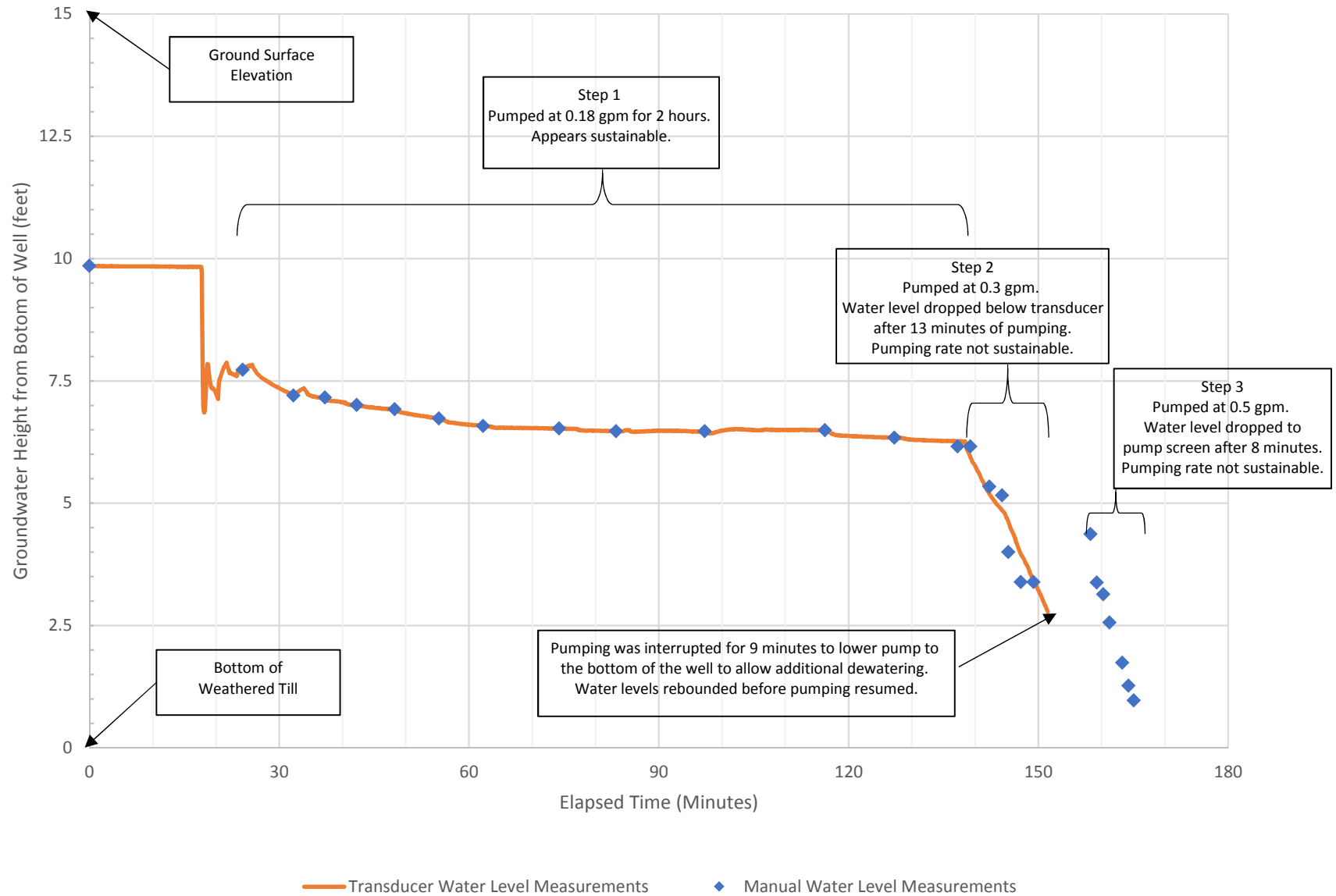


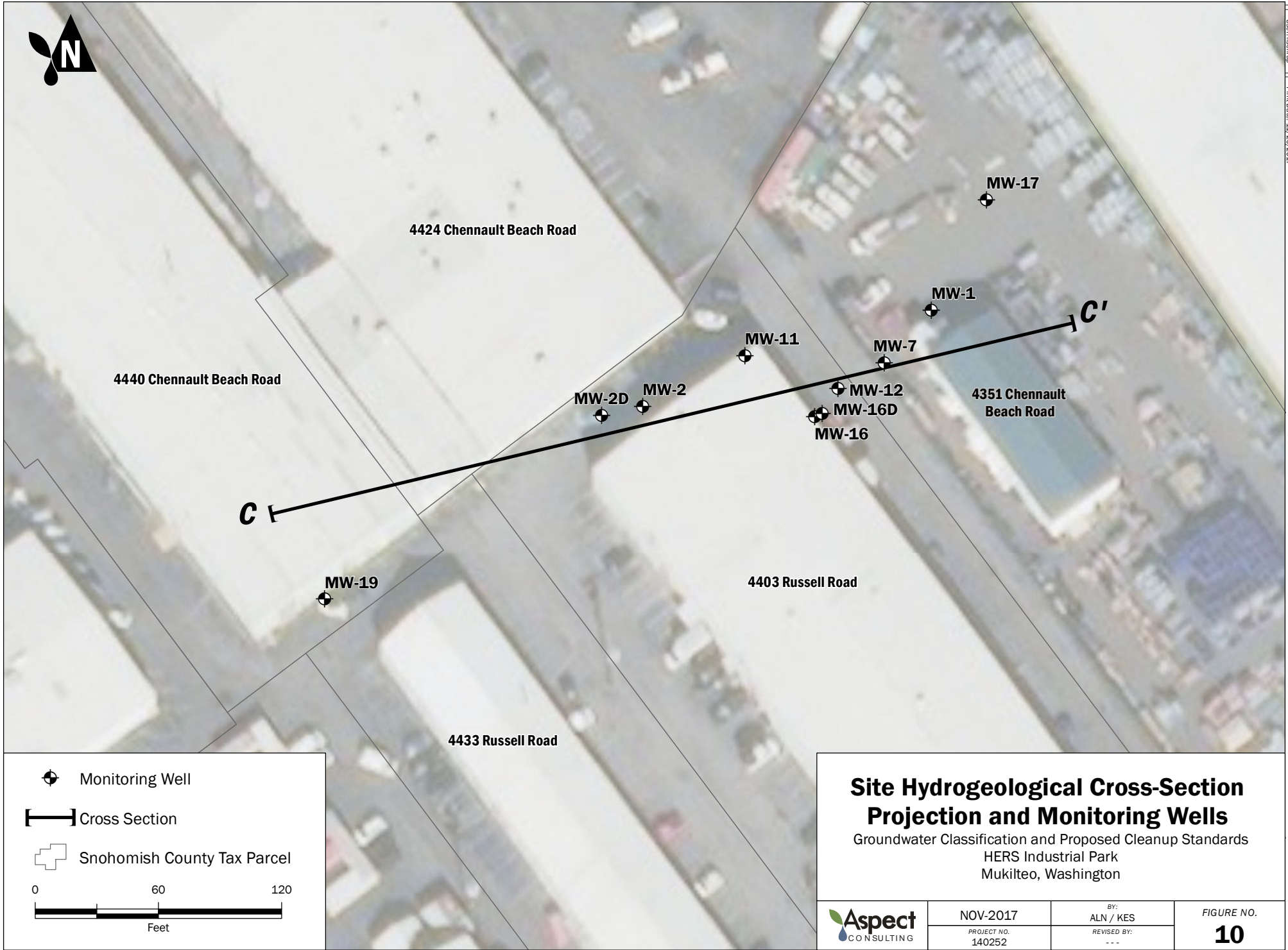
Cross Section B-B'
Groundwater Classification Report
HERS Industrial Park
Mukilteo, Washington









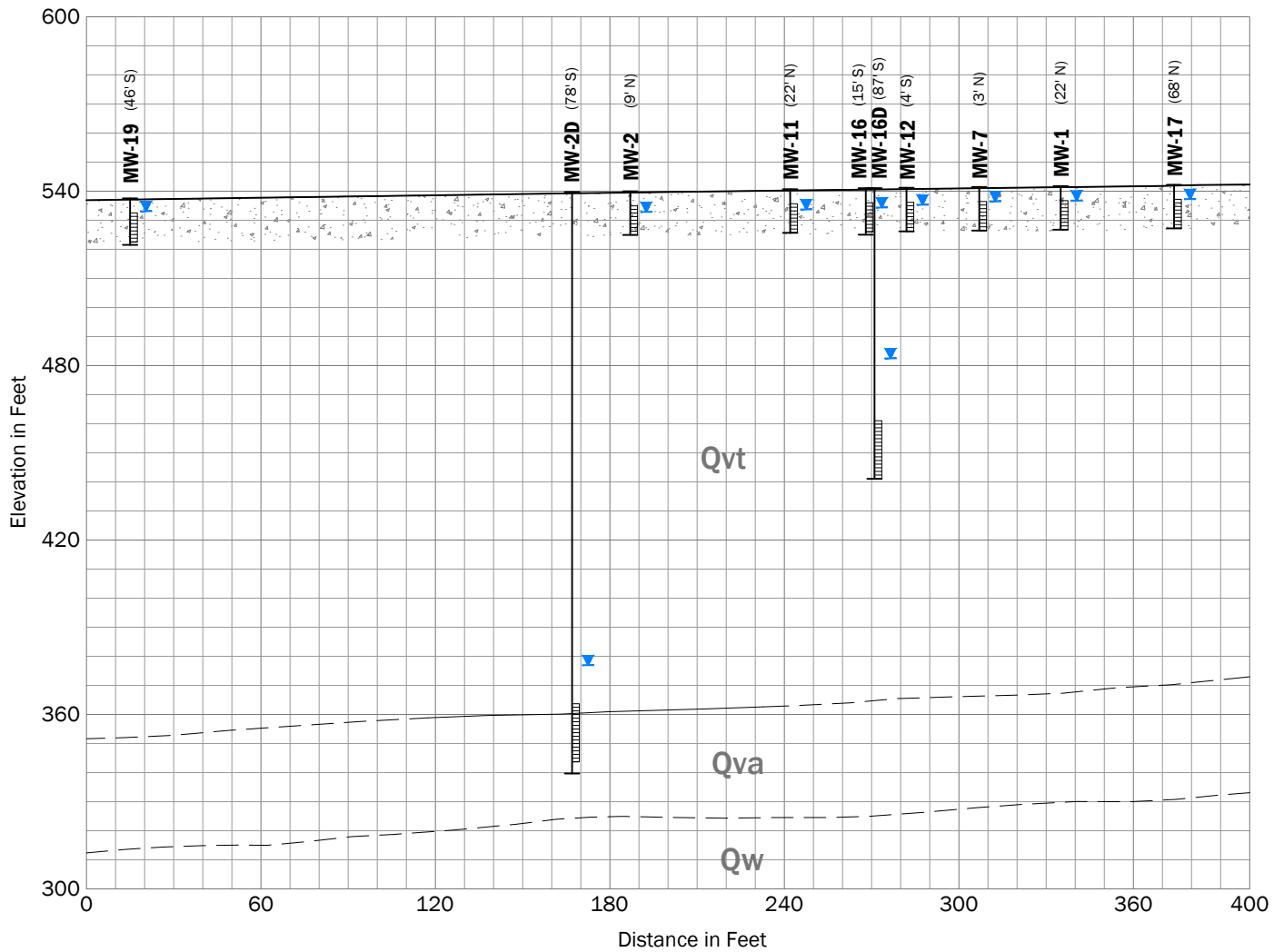


C

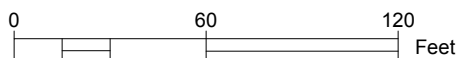
West

C'

East

**Cross Section C-C'**

Groundwater Classification Report
HERS Industrial Park
Mukilteo, Washington



Nov-2017
PROJECT NO.
140252

BY:
ALN/SCC
REVISED BY:
-

FIGURE NO.

11

APPENDIX A

Response to Ecology Review Comments

Table 1. Response to Comments from Ecology	
Ecology comments (November 8, 2016)	Response
1. The Site is currently the location of comingled plumes in groundwater consisting of PCE/TCE and related degradation products, TPH-D/TPH-O and arsenic, at concentrations exceeding Method A cleanup levels. An approximate current Site boundary is provided in the Site Diagrams where a dashed line represents an inferred boundary. Further characterization may aid in refining the Site boundary.	The proposed Site boundary is defined in Section 3.4 of the <i>Groundwater Classification and Proposed Cleanup Standards</i> report. The proposed Site boundary is limited to the three properties with chlorinated VOC contamination. The <i>Groundwater Classification and Proposed Cleanup Standards</i> report makes a case for removing TPH and arsenic as COCs.
2. According to the Remedial Investigation/Feasibility Study (RI/FS), injection well MW-13 was inaccessible due to the monument being silted in so no groundwater elevation data was collected. Ecology recommends that the monument/wellhead be excavated and the gasket repaired or replaced on the monument cover to prevent future siltation. MW-13 should be then reestablished as a monitoring point for groundwater levels and Site characterization groundwater sampling. In addition, injection well MW-14 should be located using a metal detector, uncovered and if necessary, the casing extended and monument reinstalled. The well would then need to be surveyed in order to restore it as a monitoring and potential injection point.	Disagree. The former remediation wells are inappropriate as monitoring wells, as discussed in Section 2.2 of the <i>Groundwater Classification and Proposed Cleanup Standards</i> report.
3. The RI/FS report should include a table of all monitoring and injection well specifications that includes at a minimum: the well installation date, top of casing elevation, ground elevation, casing/diameter, total depth, screened interval depths, measured range of depth to water, and a general description of lithologies encountered in the borehole.	The requested data is summarized in Table 1 of the <i>Groundwater Classification and Proposed Cleanup Standards</i> report.
4. The legends of Figures 8A through 8C indicate that the groundwater elevations are relative to the National Geodetic Datum of 1929. However, according to a note at the bottom of Table 4.5, groundwater elevation data were calculated using top of casing measuring point elevations that were not surveyed to a United States Geological Survey	Disagree. The referenced regulations and guidance do not require or mention using a Professional Land Surveyor. Monitoring well elevations were not surveyed by a PLS. Aspect surveyed the horizontal position of the monitoring wells using GPS technology and surveyed the relative tops-of-casing elevations

Table 1. Response to Comments from Ecology

Ecology comments (November 8, 2016)	Response
datum in accordance with WAC 173-340-840(4e). A comparison of the previously established wellhead elevations (Riley Group) and the current ones results in some significant discrepancies. See also Section 4.5 in Ecology's <i>Guidance for Remediation of Petroleum Contaminated Sites</i> dated September 2011. The wellhead elevations need to be established by a Washington-state licensed land surveyor.	using a rod and level with a vertical accuracy of 0.01 feet. The floating vertical datum was reconciled with the geologic and topographic map shown in Figure 3 of the RI/FS, which has elevation contours in the National Geodetic Vertical Datum (NGVD) of 1929. The top of casing of MW-1 was set to 540 feet NGVD of 1929 to reconcile with the elevation contour crossing the site shown in Figure 3. This was performed to reconcile water levels and geological formations. Aspect's and Riley's groundwater elevation contours are generally consistent; however, Riley's contours do not consider the recharge of groundwater through the perforated lateral storm drains or the seasonal discharge of groundwater into storm drains.
5. The groundwater elevation contour maps (Figures 8A through 8C) are inconsistent with regard to flow direction. The January and April 2015 maps use a 1-foot contour interval but the August 2015 map uses a 0.25-foot contour interval. It is preferable that the same contour interval be used so that different measuring events can be compared. The January 2015 groundwater contour map, which shows data collected during precipitation events over a two-day period, suggests shallow groundwater mounding in the shallow zone presumably due to recharge from the storm water catch basins. Because of this potential localized and temporary effect, Ecology recommends that Site groundwater elevation data be collected synoptically following an extended dry period. Also, Figure 8C should not have a 536-foot groundwater elevation contour line; there is insufficient data to support it.	The groundwater elevation contours and gradients are described in Section 2.1 of the <i>Groundwater Classification and Proposed Cleanup Standards</i> report, and the groundwater gradient maps were revised as suggested in Figures 6 to 8 of the report. Contour maps were generated for winter, spring, and summer to show effects of precipitation, storm water discharge through perforated lateral storm drains, and groundwater levels. The Site is predominantly covered by buildings and asphalt pavement, and storm water discharge through the perforated lateral storm drains is the primary means of groundwater recharge in the weathered Vashon till.
6. If there is recharge to the water table due to the storm drains as suggested by the January 2015 groundwater elevation contours, it indicates that the storm water drainage system leaks and helps to explain how contaminated fluids reportedly poured into the drains became a source of contamination in groundwater on the Site.	Agreed.

Table 1. Response to Comments from Ecology

Ecology comments (November 8, 2016)	Response
7. Previous groundwater elevation data indicated a flow direction to the northeast as does the August 2015 data. Given this possible trend, MW-2 and MW-2D are most likely not located downgradient of the plume, they are cross gradient. So the conclusion that the regional outwash (Esperance sand) aquifer is unaffected by the Site is inconclusive. However, Ecology does not recommend additional monitoring wells be installed in the Esperance sand at this time.	The <i>Groundwater Classification and Proposed Cleanup Standards</i> report describes the regional and Site geology and hydrogeology. The Vashon advance outwash primarily consists of Esperance sand near the Site, and the Esperance sand is not distinguished from the advance outwash in the report. The hydraulic connectivity between the shallow groundwater in the weathered till and the groundwater in the advance outwash is described in Sections 1.2 and 2.5 of the <i>Groundwater Classification and Proposed Cleanup Standards</i> report. Groundwater in the weathered till and advance outwash is not hydraulically connected, the groundwater head difference is more than 150 feet between the two intervals. Groundwater in the advance outwash near the Site would be expected to flow downdip towards Possession Sound in a westerly direction, which is consistent with the referenced 1997 USGS report and cross-sections A–A', B–B', and C–C' of the <i>Groundwater Classification and Proposed Cleanup Standards</i> report. MW-2D is located downdip and directly west of the chlorinated VOC area. Agree that additional wells are not warranted for the advance outwash.
8. In order to show the lateral distribution of chlorinated VOCs, Ecology recommends the preparation of contaminant plume maps on a base map that does not include the Gore sorber data.	Agreed. Gore sorber data interpolations can be removed from Figures 6A–6B and 7A–7D. Gore sorber data interpolations were retained on Figures 6A–6B and 7A–7D to shown correlation between soil and groundwater analytical results and screening level data. Monitoring well locations are shown on the Gore sorber maps in Figures 5A–5E, which provides rationale for the selection of well locations.
9. Geologic cross-sections are needed through the impacted areas to demonstrate that the horizontal and vertical extent of contamination has been delineated. The cross- sections should include the recently installed deep monitoring wells MW-2D and MW-16D and show the hydrostratigraphy as well as contaminant concentrations in soil and groundwater.	The <i>Groundwater Classification and Proposed Cleanup Standards</i> report includes two regional geological cross-sections, A–A' and B–B', and one hydro-stratigraphic cross-section, C–C', at the Site. Additionally, the report includes USGS regional cross-sections for western Snohomish County in an appendix of the report.

Table 1. Response to Comments from Ecology

Ecology comments (November 8, 2016)	Response
10. Appendix C of the RI/FS report contains monitoring well installation logs for MW- 2D and MW-16D. It appears that no measures were taken to prevent the potential downward vertical migration of pure-phase PCE along the outer edge of the annular and bentonite seals such as the installation of telescoping or conductor casing to prevent cross-contamination of deep water-bearing zones in the Advance outwash underlying the Vashon till. Any future monitoring wells installed in the intermediate or deep water-bearing zones on the Site need to have this additional construction feature specified and installed as a precaution.	Applicable regulations in WAC 173-160-241 were reviewed, and no additional deep wells are planned or anticipated. MW-16 and MW-16D are adjoining wells completed from 5 to 15 feet bgs and from 80 to 100 feet bgs within the same Vashon till geologic unit, which extends from the surface to 177 feet bgs at the Site. MW-16 and MW-16D contained the highest soil and groundwater concentrations for PCE and TCE at the base of the weathered till, but these concentrations were orders-of-magnitude below levels indicative of free product. Soil samples were collected from within a hollow-stem auger, without the potential for drag-down during sampling, and the filter packs and bentonite seals for the wells were constructed from the bottom up as the augers were withdrawn from the borings. On January 21, 2015, MW-16 was drilled to 16 feet bgs and encountered hard till at 15.5 feet bgs and the well was screened from 5 to 15 feet bgs. On April 9–10, 2015, soil boring MW-16D was advanced adjacent to MW-16 to evaluate the depth of contamination, as requested by Ecology in the October 18, 2012, opinion letter. Hard, nonweathered Vashon till was encountered at 15.5 feet bgs and contamination was encountered to 60 feet bgs using a PID. Soil samples from 15, 25, 45, and 65 feet bgs contained TCE above the Method A soil CUL, and the sample from 90 feet bgs did not contain TCE above the detection limit. MW-16D was originally intended as a soil boring, but a well was installed in the boring because a wet interval of nonweathered Vashon till was encountered. The boring was backfilled with bentonite grout from 12 to 77.5 feet bgs and with bentonite chips from 1.5 to 12 feet bgs to prevent the interconnection of groundwater, per WAC 173-160-181. The depth to water is about 58 feet bgs in MW-16D and about 5 to 7 feet bgs in MW-16, which confirms that MW-16D is sealed from the weathered till at the surface. On July 27–31, 2015, MW-2D was drilled in a clean, downgradient location to identify the thickness of Vashon till and to construct a sentinel well in the advance outwash to confirm that contamination does not extend to the formation from potential source areas. No contamination was detected from PID readings or from soil

Table 1. Response to Comments from Ecology	
Ecology comments (November 8, 2016)	Response
	samples. Advance outwash was encountered at 177 feet bgs and the well was screened from 176 to 196 feet bgs. MW-2D was backfilled with bentonite chips from 1 to 173 feet bgs to seal the well. The depth to water was 163 feet in MW-2D, confirming that the well was sealed from the weathered till near the surface.
11. Ecology requests that both isomers of 1,2-dichloroethene be included as chemicals of concern. Since both are degradation products of TCE, they can help document that the degradation process is occurring especially if different remediation methods are introduced.	The <i>Groundwater Classification and Proposed Cleanup Standards</i> report includes the dichloroethylene (DCE) isomers as proposed chemicals of concern in Section 3.3 of the report.
12. Please provide concentration versus time graphs for monitoring wells that had or have contaminants at concentrations above Method A cleanup levels. The graphs should indicate when injections were conducted and what the injections consisted of. Because the in-situ chemical oxidation injections conducted in 2006 were successful in reducing VOC concentrations in groundwater, the graphs are needed in order to support evaluation of the proposed remedial action alternatives. The graphs will also be useful for demonstrating the progress of the selected remedial action.	These graphs can be provided in a revised FFS.
13. Ecology does not recognize the use of silica gel cleanup for NWTPH analyses of groundwater (see Ecology publication No. 10-09-057 <i>Guidance for Remediation of Petroleum Contaminated Sites</i> dated June 2016; pages 91 and 92 for more detail).	Agreed. This was not a settled Ecology position at the time of RI/FS submittal in November 2015. Ecology published this position in the June 2016 revision of the guidance.
14. Except for the planned decommissioning of selected monitoring wells, Ecology agrees either Alternative 2 or 3 is a preferred selection for the cleanup of VOCs in groundwater. Ecology suggests proposing the decommissioning of monitoring wells as the remediation progresses based on quarterly monitoring data trends.	The <i>Groundwater Classification and Proposed Cleanup Standards</i> report demonstrates that the groundwater in the Vashon till is nonpotable based on sustainable yield, and contamination would be unlikely to reach potable sources of groundwater at concentrations above applicable standards. Method A soil cleanup levels are recommended for the entire Site, Method A groundwater cleanup levels are recommended for the advance outwash, and applicable groundwater cleanup levels are proposed for the Vashon till in accordance with MTCA.

Table 1. Response to Comments from Ecology	
Ecology comments (November 8, 2016)	Response
	We recommend preparing a focused feasibility study to evaluate cleanup alternatives after cleanup standards are established for the Site.
15. None of the remedial alternatives in the Feasibility Study address petroleum hydrocarbon contamination and arsenic in groundwater above Method A cleanup levels. The FS must address these contaminants.	We recommend preparing a focused feasibility study after cleanup standards are established for the Site. The concentrations of TPH are below the proposed cleanup standards for soil and groundwater. Soil arsenic concentrations are below proposed soil cleanup levels and groundwater arsenic concentrations are representative of background concentrations.
16. Please show and label the surrounding industrial property locations (described in Section 2.3) that are adjacent or near the Site on Figure 2 (Production Plating is shown but two addresses are provided in the text) or on a separate figure. Industrial land uses on adjacent parcels should be described.	A new figure can be added to the revised FFS that shows the locations of the surrounding properties cited in Section 2.3 of the RI/FS. Production Plating operates in two buildings. 4330 Russell Road is shown in the Figure 2, whereas 4416 Russell Road is southwest of this building and beyond the extent of the map. Industrial use of the adjacent parcels is described in Section 2.3 of the RI/FS.
17. In Table 4.2, please indicate in the notes the meaning of the detections flagged with an 'x'. The last note in the table has a typographical error in the date.	Section 5.1.2 of the RI/FS states "All TPH detections were flagged with an "x" in the laboratory analytical reports, which indicates that the chromatographs do not match the calibration standards for gasoline-, diesel-, and oil-range-TPH." This note can be added to Table 4.2. The June 14, 2005 date in the Table 4.2 note is correct. Laboratory analytical reports for groundwater samples from SP-1 to SP-10 indicate "NWTPH-DX W/ CLEANUP."
18. As noted in Section 5.3.1 of the RI, a vapor intrusion threat may exist at the Site. An evaluation of the soil to vapor pathway is therefore required. MTCA and Ecology's current guidance on soil vapor intrusion do not provide an explicit method for establishing soil cleanup levels protective of indoor air, and instead rely on empirical demonstrations of air quality or modeling. Proof that contamination is not causing an exceedence of air cleanup standards will therefore be the basis for establishing that Site soil and groundwater are protective of indoor air.	Agreed.

Table 1. Response to Comments from Ecology

Ecology comments (November 8, 2016)	Response
19. Section 11 indicates that the preferred cleanup action, Alternative 2 which includes completed actions, biostimulation and monitored natural attenuation, would require an environmental covenant once a portion of the impacted parcels are cleaned up. Ecology would not be able to issue an environmental covenant for a stable and/or shrinking plume which can be further remediated to below MTCA cleanup levels. A disproportionate cost analysis would be required if an environmental covenant is requested.	A Property-specific NFA is requested for the 4493 Russell Road parcel after removal on the heating oil UST with confirmation sampling. This parcel is outside of the recommended Site boundary described in Comment 1. In an October 18, 2012 opinion, Ecology stated that "petroleum-contaminated soil associated with the UST was excavated with confirmational sampling indicating soil where the former tank was located is compliant with MTCA." We recommend preparing a focused feasibility study to evaluate cleanup alternatives after cleanup standards are established for the Site.
20. Ecology's recommended Remedial Investigation (RI) report format consolidates all pertinent Site historical information, collected soil and groundwater data, and completed soil cleanup data. Ecology requests that all RI reports follow this format. See the following Ecology web page for the RI report format and content requirements: http://www.ecy.wa.gov/programs/tcp/policies/checklists	This is a retroactive requirement. The RI/FS was submitted to Ecology on November 10, 2015 and Ecology responded with an opinion on November 8, 2016. Ecology issued the RI Checklist (Publication No. 16-09-006) in May 2016 and requires RI's submitted after June 1, 2016, to abide by this format. The submitted RI/FS includes all of the requested information in the May 2016 RI checklist.
21. The completed Site characterization (RI) should be the basis for preparation of a Feasibility Study (FS) that meets the MTCA requirements for selection of a cleanup action. See the following Ecology web page for FS report format and content requirements: http://www.ecy.wa.gov/programs/tcp/policies/checklists	This is a retroactive requirement. The RI/FS was submitted to Ecology on November 10, 2015, and Ecology responded with an opinion on November 8, 2016. Ecology issued the FS Checklist (Publication No. 16-09-007) in May 2016, and requires FS's submitted after June 1, 2016, to abide by this format. The submitted RI/FS includes all of the requested information in the May 2016 FS checklist.
22. Electronic submittal of all sampling data collected in or post-2005 into Ecology's electronic Environmental Information Management (EIM) database is a requirement in order to receive a final Ecology opinion for this Site. Erica Pot (email efot461@ecy.wa.gov, or via telephone at 360-407-6692) is Ecology's contact and resource on entering data into EIM.	The analytical results collected from January 2005 to August 2015 were submitted to the EIM database in March 2016.
23. Evaluation of Nonpotable Groundwater. This was not addressed in Ecology's review comments.	

Table 1. Response to Comments from Ecology	
Ecology comments (November 8, 2016)	Response
	Aspect discussed the demonstration and implications of a potential nonpotable groundwater designation for the weathered Vashon till in a meeting with the VCP Site manager on May 24, 2016. The following items were discussed for this potential designation, and summarized in email to the VCP Site manager on May 25, 2016: • Slug tests conducted by Riley in MW-7 indicate a hydraulic conductivity of 1.58E-4 cm/sec, which is consistent with low-yield groundwater, and Riley's analysis overestimated the hydraulic conductivity. Using TRRP-8 guidance, this equates to a well yield of 208 gallons per day for a 4-inch equivalent well. • We discussed TRRP-8 Groundwater Classification guidance from the Texas Commission on Environmental Quality and the application of yield testing using a representative number of slug tests (per TRRP-8) and a possible pumping test of a nonimpacted well to confirm that the formation has less than a 0.5 gpm sustainable yield for low yield designation (TRRP-8 describes several test methods). • If determined to be low yield (<0.5 gpm in WAC 173-340-720(2)(b)(i)), we can demonstrate that hazardous substances are unlikely to impact potential sources of drinking water (WAC 173-340-720(2)(c)) using MW-2D. MW-2D documents 177-foot thick Vashon till, is downgradient and completed in the underlying advance outwash, and the 163-foot-depth to groundwater demonstrates that saturated portions of the Vashon till are not hydraulically connected to the advance outwash. Additionally, there are no groundwater receptors in advance outwash downgradient from the Site, or likely to be because of the geology, outcrops, and water levels, along with public water supply system connections. • We discussed the removal of the groundwater ingestion exposure pathway and the surface water exposure pathway within groundwater. The only remaining exposure route would be vapor intrusion groundwater screening levels for PCE, TCE, and vinyl chloride, which is largely encountered below the asphalt parking lot where the vapor intrusion pathway is incomplete. We discussed applying Method B direct contact CULs for soil, which we do not exceed for VOCs. The <i>Groundwater Classification and Proposed Cleanup Standards</i> report was prepared to describe the regional and Site geography and hydrogeology, to provide a demonstration of nonpotable groundwater, and to propose applicable cleanup standards for the Site. The proposed cleanup levels are developed in accordance with MTCA and supersede the cleanup levels discussed above with Ecology.

APPENDIX B

Selected U.S. Geological Survey (1997) Report Figures

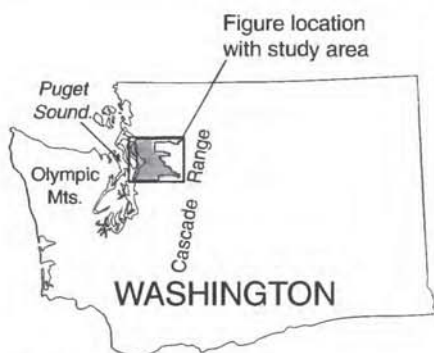
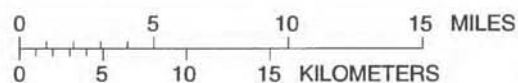
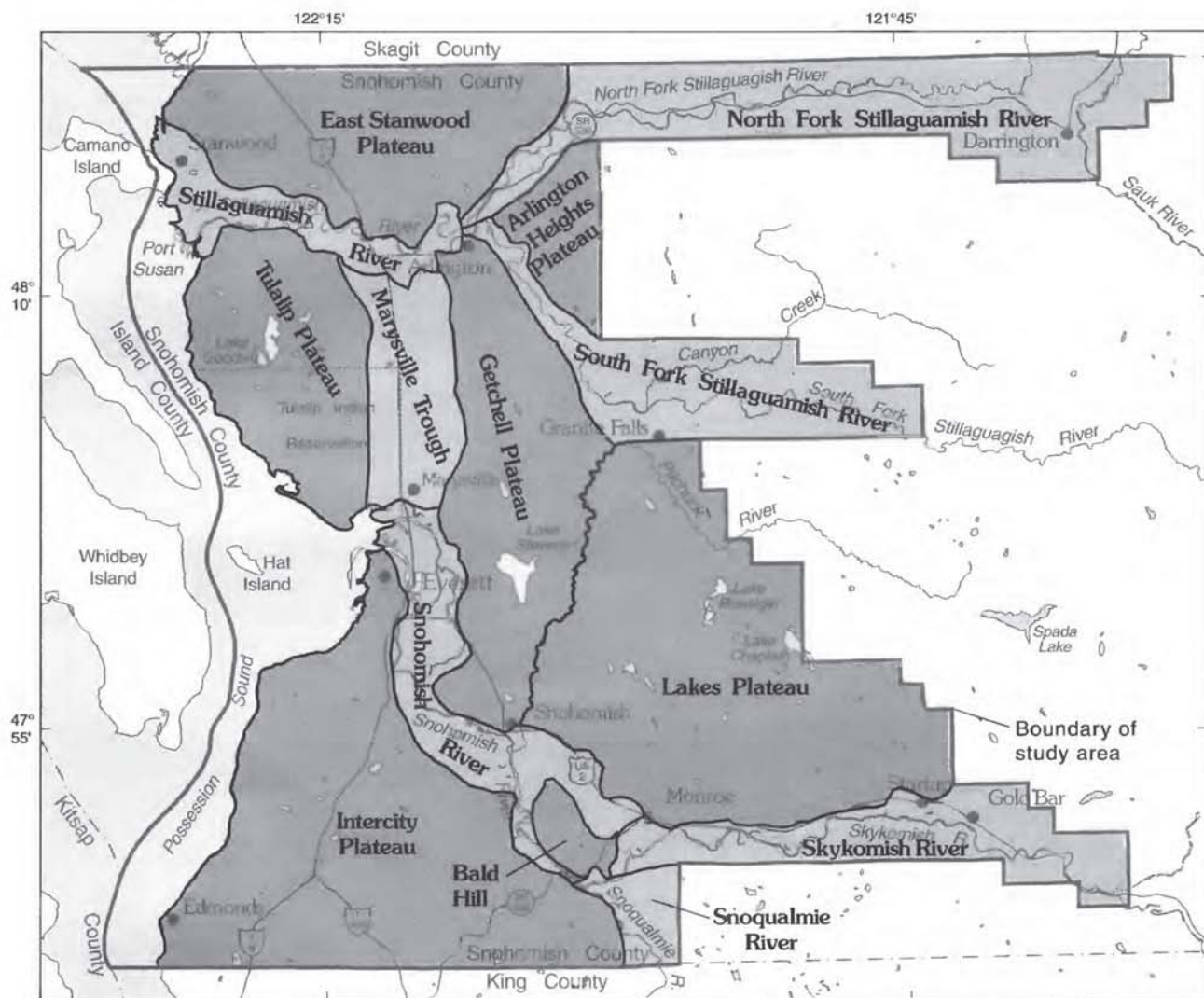


Figure 5. Topographic features.

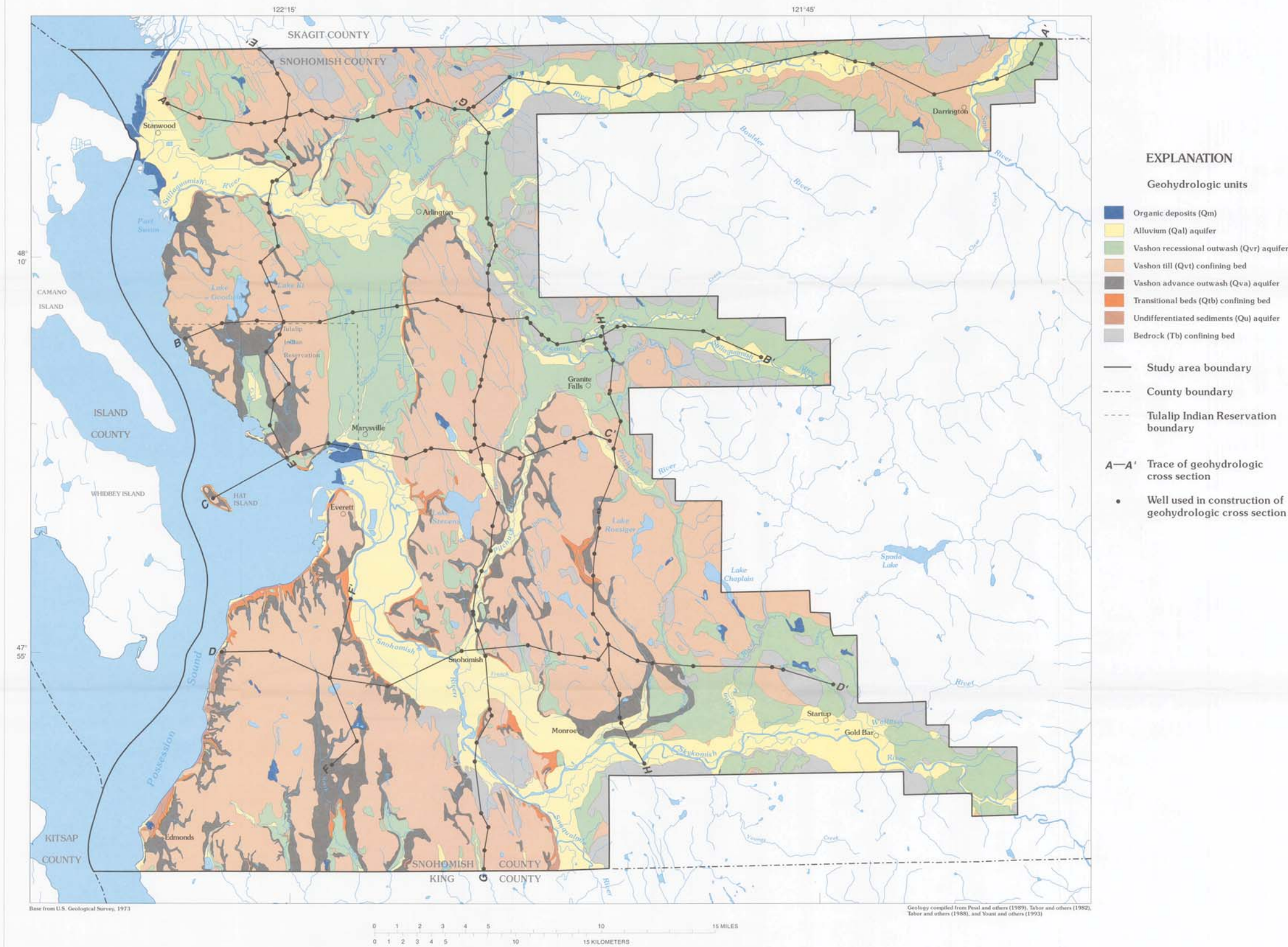


PLATE 2. GENERALIZED SURFICIAL GEOHYDROLOGY AND LOCATIONS OF GEOHYDROLOGIC CROSS SECTIONS
WESTERN SNOHOMISH COUNTY, WASHINGTON

By
B.E. Thomas, J.M. Wilkinson, and S.S. Embrey
1997

By
B.E. Thomas, J.M. Wilkinson, and S.S. Embrey
1997

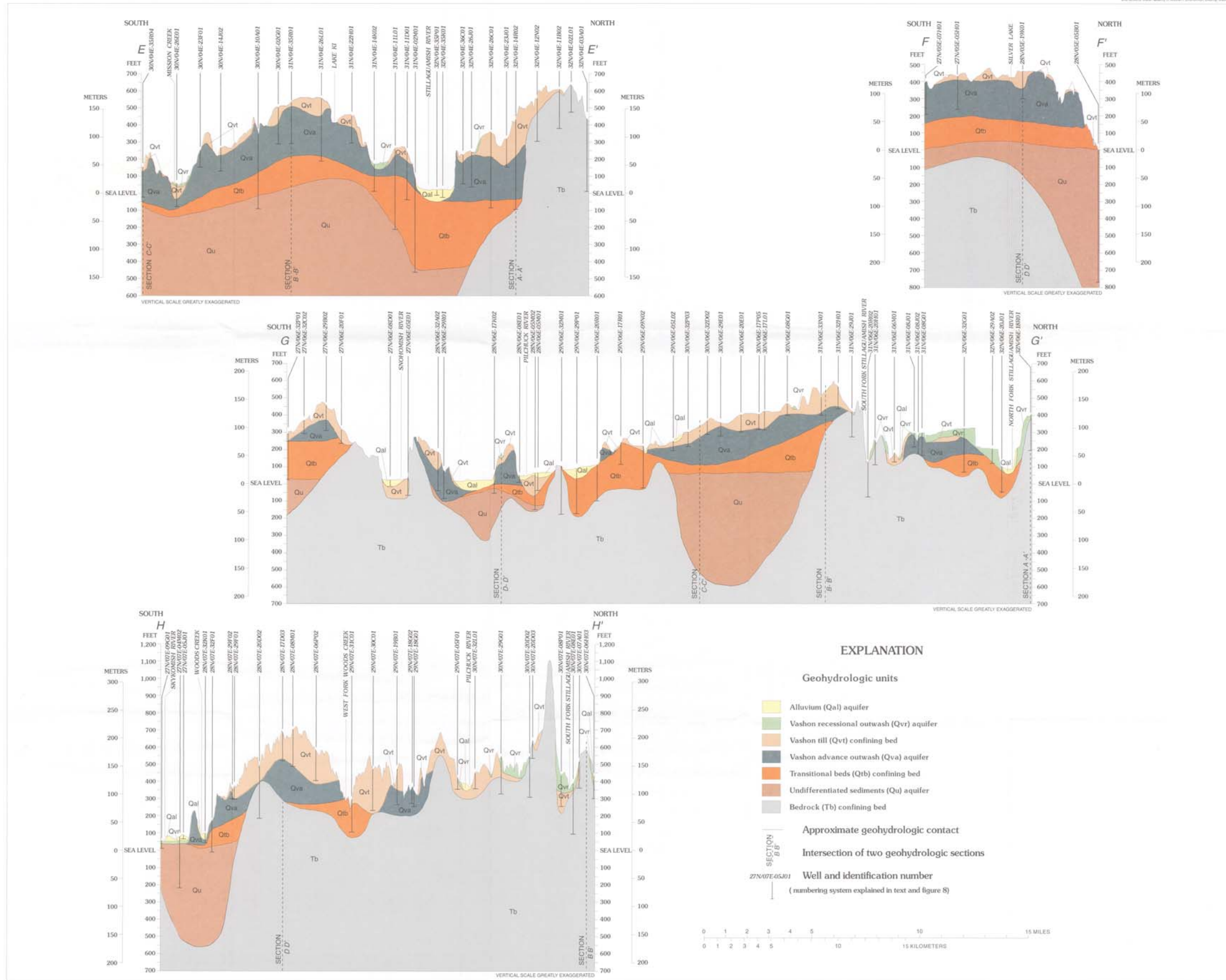


PLATE 4. GEOHYDROLOGIC CROSS SECTIONS, E-E' TO H-H', WESTERN SNOHOMISH COUNTY, WASHINGTON

By
B.E. Thomas, J.M. Wilkinson, and S.S. Embrey
1997

Appendix C – Well Construction and Boring Logs

C.1 – Well Construction Logs for MW-1 to MW-8 (Riley, 2005)

C.2 – Well Construction Logs for MW-9 to MW-15 (NOT AVAILABLE)

C.3 – Soil Boring Logs AB-1 to AB-4

C.4 – Well Construction Logs for MW-2D, MW-16, MW-16D, and MW-17 to MW-22

BORING/WELL NO. MW-3	TOP OF CASING (TOC) ELEVATION: 102.56
LOCATION : west of 4403 Warehouse	START DATE: 9/11/05 START TIME: 12:30 PM
DRILLING SUBCONTRACTOR: Northwest Probe, Inc.	WEATHER: Partly cloudy
DRILLING METHOD/EQPMT: Truck mounted hollow stem auger	
logged by: TN	

Sample #	Graphic Log	Construction of Well Detail	SPT	PID (ppm)	Soil Description & Other Notes
	5 10 15 20 25 30 35	1-inch PVC blank pre-packed well screen (0.020 slot) bottom of casing	n/a	n/a	silty SAND with gravel KEY ◁ groundwater encountered during drilling ◼ groundwater encountered during sampling ◻ silica sand pack ◼ bentonite plug ▤ 2-inch PVC well screen (20 slot)

BORING/WELL NO. MW-5			TOP OF CASING (TOC) ELEVATION: 103.69		
LOCATION : south of 4403 Warehouse			START DATE: 9/11/05 START TIME: 4:30 PM		
DRILLING SUBCONTRACTOR: Northwest Probe, Inc.			WEATHER: Partly cloudy		
DRILLING METHOD/EQPMT: Truck mounted hollow stem auger				logged by: TN	
Sample #	Graphic Log	Construction of Well Detail	SPT	PID (ppm)	Soil Description & Other Notes
			n/a	n/a	silty SAND with gravel KEY - groundwater encountered during drilling - groundwater encountered during sampling - silica sand pack - bentonite plug 2-inch PVC well screen (20 slot)

Site Address: 4403 Russell Road, Mukilteo, Washington

BORING/WELL NO. MW-7	TOP OF CASING (TOC) ELEVATION: 99.76
LOCATION : east of 4403 Warehouse	START DATE: 10/4/05 START TIME: 11:30 AM
DRILLING SUBCONTRACTOR: Northwest Probe, Inc.	WEATHER: Partly cloudy

DRILLING METHOD/EQPMT: Truck mounted hollow stem auger	logged by: TN
--	---------------

Sample #	Graphic Log	Construction of Well Detail	SPT	PID (ppm)	Soil Description & Other Notes
	5 10 15 20 25 30 35	SCH 5 304 SS blank 2-inch SCH 5 304 SS well screen (20 slot) bottom of casing	n/a	n/a	silty SAND with gravel KEY ◁ groundwater encountered during drilling ◼ groundwater encountered during sampling ◻ silica sand pack ◼ bentonite plug ▤ 2-inch PVC well screen (20 slot)



The Riley Group, Inc.
17522 BOTHELL WAY NE
BOTHELL, WASHINGTON 98011

Groundwater Monitoring Well Log

Lithologic Contact (where shown)

Site Address: 4403 Russell Road, Mukilteo, Washington

BORING/WELL NO. MW-8	TOP OF CASING (TOC) ELEVATION: 99.97
LOCATION : northeast of 4403 Warehouse	START DATE: 10/4/05 START TIME: 2:30 PM
DRILLING SUBCONTRACTOR: Northwest Probe, Inc.	WEATHER: Partly cloudy
DRILLING METHOD/EQPMT: Truck mounted hollow stem auger	
logged by: TN	

Sample #	Graphic Log	Construction of Well Detail	SPT	PID (ppm)	Soil Description & Other Notes
			n/a	n/a	silty SAND with gravel
5					
10					
15					
20					
25					
30					
35					

KEY

◁	groundwater encountered during drilling
◀	groundwater encountered during sampling
□	silica sand pack
▒	bentonite plug
▤	2-inch PVC well screen (20 slot)



The Riley Group, Inc.
 17522 BOTHELL WAY NE
 BOTHELL, WASHINGTON 98011

Groundwater Monitoring Well Log

Lithologic Contact (where shown)

Site Address: 4403 Russell Road, Mukilteo, Washington

Coarse-Grained Soils - More than 50% ⁽¹⁾ Retained on No. 200 Sieve		Gravels - More than 50% ⁽¹⁾ of Coarse Fraction Retained on No. 4 Sieve		GW	Well-graded gravel and gravel with sand, little to no fines
				GP	Poorly-graded gravel and gravel with sand, little to no fines
		$\geq 15\%$ Fines ⁽⁵⁾		GM	Silty gravel and silty gravel with sand
				GC	Clayey gravel and clayey gravel with sand
Sands - 50% ⁽¹⁾ or More of Coarse Fraction Passes No. 4 Sieve		$\leq 5\%$ Fines ⁽⁵⁾		SW	Well-graded sand and sand with gravel, little to no fines
				SP	Poorly-graded sand and sand with gravel, little to no fines
				SM	Silty sand and silty sand with gravel
				SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50% ⁽¹⁾ or More Passes No. 200 Sieve		Silt and Clays Liquid Limit Less than 50		ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
				CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
				OL	Organic clay or silt of low plasticity
		Silt and Clays Liquid Limit 50 or More		MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
				CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
				OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils				PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency		
Coarse-Grained Soils	Density	SPT ⁽²⁾ blows/foot
	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
Fine-Grained Soils	Consistency	SPT ⁽²⁾ blows/foot
	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Component Definitions	
Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

⁽³⁾ Estimated Percentage	
Percentage by Weight	Modifier
<5	Trace
5 to 15	Slightly (sandy, silty, clayey, gravelly)
15 to 30	Sandy, silty, clayey, gravelly
30 to 49	Very (sandy, silty, clayey, gravelly)

Moisture Content	
Dry - Absence of moisture, dusty, dry to the touch	
Slightly Moist - Perceptible moisture	
Moist - Damp but no visible water	
Very Moist - Water visible but not free draining	
Wet - Visible free water, usually from below water table	

Symbols	
	Blows/6" or portion of 6"
	Sampler Type
	Description
	Continuous Push
	Non-Standard Sampler
	3.0" OD Thin-Wall Tube Sampler (including Shelby tube)
	Grouted Transducer

(1) Percentage by dry weight	(5) Combined USCS symbols used for fines between 5% and 15% as estimated in General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(2) (SPT) Standard Penetration Test (ASTM D-1586)	
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)	
(4) Depth of groundwater	ATD = At time of drilling Static water level (date)
	BGS = below ground surface

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.



Boring Log

Project Number
140252

Boring Number
AB-1

Sheet
1 of 1

Project Name: HERS Industrial Park

Ground Surface Elev. _____

Location: 4403 Russell Rd, Mukilteo, Washington

Driller/Method: Holt Drilling, Inc / Geoprobe - Direct Push

Depth to Water (ft BGS) _____

Sampling Method: Continuous Core

Start/Finish Date 7/30/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	Concrete surface repair			4.0			Concrete overlying crushed gravel	1
2	Backfilled with bentonite chips	S1	Soil: AB-1-2.5	6.1			Moist, brown, gravelly, sandy SILT (ML); fine sand, fine subrounded gravel, no odor	2
3				5.5				3
4								4
5							Bottom of boring at 5', not enough overhead clearance to go deeper	5
6								6
7								7
8								8
9								9
10								10
11								11
12								12
13								13
14								14
15								15
16								16
17								17
18								18
19								19

Sampler Type:

PID - Photoionization Detector (Headspace Measurement)

Logged by: **MML**

☐ No Recovery

☒ Static Water Level

Approved by: **AN**

☒ Continuous Core

☐ Water Level (ATD)

Figure No.



Boring Log

Project Number
140252

Boring Number
AB-2

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Geoprobe - Direct Push**

Depth to Water (ft BGS) _____

Sampling Method: **Continuous Core**

Start/Finish Date **7/30/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)	
1	Concrete surface repair Backfilled with bentonite chips	S1		0.0		Concrete overlying crushed gravel		1	
2				0.0		Moist, brown, sandy SILT (ML); fine sand, trace fine rounded gravel		2	
3				0.0				3	
4				0.0				4	
5			S2		0.0				5
6				0.0		Moist, brown SAND (SP); trace silt, predominantly medium sand, no odor		6	
7				0.0		Moist, brown, sandy SILT (ML) to silty SAND (SM); fine sand, trace fine rounded gravel		7	
8				0.0				8	
9			0.0				9		
10			S3		0.0		Brown, wet, silty SAND (SM); predominantly medium sand		10
11				0.0		Moist, brown, sandy SILT (ML) to silty SAND (SM); fine sand, trace fine rounded gravel		11	
12				0.0				12	
13				0.0				13	
14					0.0				14
15						Bottom of boring, refusal at 14.5' bgs		15	
16								16	
17								17	
18								18	
19								19	

Sampler Type:

PID - Photoionization Detector (Headspace Measurement)

Logged by: **MML**

☐ No Recovery

☒ Static Water Level

Approved by: **AN**

☒ Continuous Core

☐ Water Level (ATD)

Figure No.



Boring Log

Project Number
140252

Boring Number
AB-3

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Geoprobe - Direct Push**

Depth to Water (ft BGS) _____

Sampling Method: **Continuous Core**

Start/Finish Date **7/30/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	Concrete surface repair			0.0			Concrete overlying crushed gravel	1
2				0.0			Moist, brown, gravelly sandy SILT (ML) to silty SAND (SM); fine sand, trace coarse sand, fine subrounded gravel, no odor	2
3				0.0				3
4								4
5								5
6	Backfilled with bentonite chips	S1		0.0			Orange mottling, no odor at 6' bgs	6
7				0.0				7
8				0.0				8
9				0.0				9
10				0.0				10
11				0.1			No odor at 10' bgs	11
12			Soil: AB-3-11	0.6				12
13		S2		0.4				13
14				0.0				14
15				0.0				15
16								16
17								17
18								18
19								19
		S3						
							Bottom of boring, refusal at 13.5' bgs	

Sampler Type:

PID - Photoionization Detector (Headspace Measurement)

Logged by: **MML**

☐ No Recovery

☒ Static Water Level

Approved by: **AN**

☒ Continuous Core

☐ Water Level (ATD)

Figure No.



Boring Log

Project Number
140252

Boring Number
AB-4

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Geoprobe - Direct Push**

Depth to Water (ft BGS) _____

Sampling Method: **Continuous Core**

Start/Finish Date **7/30/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	Concrete surface repair			0.0			Concrete overlying crushed gravel	1
2				0.0			Moist, brown, sandy SILT (ML) to silty SAND (SM); trace fine rounded gravel, no odor	2
3				0.0				3
4								4
5				0.0				5
6				0.0				6
7				0.0				7
8				0.0				8
9				0.0				9
10				0.0			Wet, brown SAND (SP); trace silt, no odor	10
11				0.0				11
12				0.0			Moist, brown, sandy SILT (ML) to silty SAND (SM); trace fine rounded gravel, no odor	12
13				0.0				13
14							Bottom of boring, refusal at 13.5' bgs	14
15								15
16								16
17								17
18								18
19								19

Sampler Type:

PID - Photoionization Detector (Headspace Measurement)

Logged by: **MML**

☐ No Recovery

☒ Static Water Level

Approved by: **AN**

☒ Continuous Core

☐ Water Level (ATD)

Figure No. _____



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
1 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	8" Flushmount monument in concrete 0' - 1' bgs Thermos style cap					Asphalt		1
2							WEATHERED VASHON TILL Medium dense, moist, brown, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded to subangular gravel, oxide staining around gravels, diamict fabric, no odor	2
3								3
4	Backfilled with bentonite chips 1'-173' bgs							4
5	2" Schedule 40 PVC casing 0'-176' bgs							5
6		S1		0.2	9 16 23			6
7								7
8								8
9								9
10								10
11		S2		0.0	16 26 40		Becomes very dense at 10' bgs	11
12								12
13								13
14								14
15		S3		0.0	50/6"		VASHON TILL Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	15
16								16
17								17
18								18
19								19

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
2 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
21	Backfilled with bentonite chips 1'-173' bgs	S4		0.0	50/4"		Very dense, moist, gray, gravelly, sandy, SILT (ML); predominantly fine sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	21
22								22
23								23
24								24
25	2" Schedule 40 PVC casing 0'-176' bgs	S5		0.0	50/4"		Fine to coarse sand, no odor at 25' bgs	25
26								26
27								27
28								28
29								29
30		S6		0.0	50/4"		Coarse sand content becomes trace fraction, no odor at 30' bgs	30
31								31
32								32
33								33
34								34
35		S7		0.0	50/4"			35
36								36
37								37
38								38
39								39

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
3 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
41	Backfilled with bentonite chips 1'-173' bgs	 S8		0.0	50/4"		Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	41
42							Scattered small pockets of medium sand, no odor	42
43								43
44								44
45	2" Schedule 40 PVC casing 0'-176' bgs	 S9		0.2	50/5"			45
46								46
47								47
48								48
49								49
50		 S10		0.0	50/5"			50
51								51
52								52
53								53
54								54
55		 S11	Soil: MW-2D-55	0.4	50/4"			55
56								56
57								57
58								58
59								59

Sampler Type:

-  No Recovery
-  Standard Penetration Test (ASTM D1586)
-  Modified California Sampler

PID - Photoionization Detector

-  Static Water Level
-  Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
4 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
61	Backfilled with bentonite chips 1'-173' bgs	S12		0.1	50/3"		Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	61
62								62
63								63
64								64
65		S13		0.1	50/3"			65
66	2" Schedule 40 PVC casing 0'-176' bgs							66
67								67
68								68
69								69
70		S14		0.0	50/1"			70
71								71
72								72
73								73
74								74
75		S15		0.0	50/2"			75
76							Becomes slightly gravelly, no odor at 75' bgs	76
77								77
78								78
79								79

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
5 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
81	Backfilled with bentonite chips 1'-173' bgs	S16		0.0	50/2"		Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	81
82								82
83								83
84								84
85	2" Schedule 40 PVC casing 0'-176' bgs	S17		0.0	50/2"		Very dense, very moist, gray, slightly gravelly, very silty SAND (SM); fine to medium sand, trace coarse sand, fine subrounded gravel, no odor	85
86								86
87								87
88								88
89								89
90		S18		0.0	50/4"		Predominantly fine sand, no odor at 90' bgs	90
91								91
92								92
93								93
94								94
95		S19		0.0	50/1"		No recovery, crushed coarse gravel in sampler shoe	95
96								96
97								97
98								98
99								99

Sampler Type:

- ☐ No Recovery
- ☒ Standard Penetration Test (ASTM D1586)
- ☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
- ☒ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

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6 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
101		S20		0.0	50/1"		Very dense, moist, gray slightly gravelly, sandy SILT (ML); fine to medium sand, trace coarse sand, fine subrounded gravel, no odor	101
102								102
103	Backfilled with bentonite chips 1'-173' bgs							103
104								104
105	2" Schedule 40 PVC casing 0'-176' bgs	S21		0.0	50/2"		Crushed coarse gravel in sampler shoe	105
106								106
107								107
108								108
109								109
110		S22		0.0	50/2"			110
111								111
112								112
113								113
114								114
115		S23		0.0	50/2"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	115
116								116
117								117
118								118
119								119

Sampler Type:

- ☐ No Recovery
- ☒ Standard Penetration Test (ASTM D1586)
- ☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
- ☒ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
7 of 11

Project Name: HERS Industrial Park

Ground Surface Elev. _____

Location: 4403 Russell Rd, Mukilteo, Washington

Top of Casing Elev. _____

Driller/Method: Holt Drilling, Inc / Mud Rotary with CME 85

Depth to Water (ft BGS) 162.25 - 8/10/2015

Sampling Method: SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop

Start/Finish Date 7/27/2015 - 7/31/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
121	Backfilled with bentonite chips 1'-173' bgs	S24		0.0	50/1"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	121
122								122
123								123
124								124
125	2" Schedule 40 PVC casing 0'-176' bgs	S25		0.0	50/2"			125
126								126
127								127
128								128
129								129
130		S26		0.0	50/4"			130
131								131
132								132
133								133
134								134
135		S27		0.0	50/5"			135
136								136
137								137
138								138
139								139

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
8 of 11

Project Name: HERS Industrial Park

Ground Surface Elev. _____

Location: 4403 Russell Rd, Mukilteo, Washington

Top of Casing Elev. _____

Driller/Method: Holt Drilling, Inc / Mud Rotary with CME 85

Depth to Water (ft BGS) 162.25 - 8/10/2015

Sampling Method: SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop

Start/Finish Date 7/27/2015 - 7/31/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
141	Backfilled with bentonite chips 1'-173' bgs	S28		0.0	50/6"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	141
142								142
143								143
144								144
145	2" Schedule 40 PVC casing 0'-176' bgs	S29		0.0	35 42 50/6"			145
146								146
147								147
148								148
149								149
150								150
151		S30		0.0	50/1"			151
152								152
153								153
154								154
155		S31		0.0	50/3"			155
156								156
157								157
158								158
159								159

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
9 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
161		S32		0.0	65 110/6"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	161
162	▼ 8/10/2015							162
163	Backfilled with bentonite chips 1'-173' bgs							163
164								164
165	2" Schedule 40 PVC casing 0'-176' bgs	S33		0.0	100/3"		Very dense, moist, gray brown SAND (SP); fine sand, trace silt, no odor	165
166								166
167								167
168								168
169								169
170		S34		0.0	100/3"		Very dense, moist, gray brown, gravelly, silty SAND (SM); fine sand, trace coarse sand, fine subrounded gravel, scattered very thin laminae of medium sand, vague stratification features, no odor	170
171								171
172								172
173	10/20 Colorado silica sand 173'-196' bgs							173
174								174
175		S35		0.0	100/3"		Very thin medium sand laminae become frequent with stronger stratification features	175
176								176
177	2" Schedule 40 PVC 20-slot screen 176'-196' bgs						ESPERANCE SAND Very dense, very moist, brown, slightly silty SAND (SP-SM); predominantly medium sand, silt in ~4mm clasts, no odor	177
178								178
179								179

Sampler Type:

- ☐ No Recovery
- ☒ Standard Penetration Test (ASTM D1586)
- ☒ Modified California Sampler

PID - Photoionization Detector

- ▼ Static Water Level
- ▽ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.

MONITORING WELL HERS INDUSTRIAL PARK GPJ August 17, 2015



Monitoring Well Construction Log

Project Number

140252

Well Number

MW-2D

Sheet

10 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**Depth to Water (ft BGS) **162.25 - 8/10/2015**Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
181		 S36		0.0	44 50/5"		Very dense, very moist, brown, slightly silty SAND (SP-SM); predominantly medium sand, no odor	181
182								182
183	Backfilled with bentonite chips 1'-173' bgs							183
184								184
185	2" Schedule 40 PVC casing 0'-196' bgs						Trace silt and iron oxide mottling, no odor at 185' bgs	185
186								186
187								187
188								188
189								189
190		 S37	Soil: MW-2D-190	0.0	47 50/3"			190
191								191
192								192
193								193
194								194
195								195
196	Threaded PVC endcap							196
197	Native soil						Very dense, moist, gray, slightly clayey, silty SAND (SM); fine sand, homogenous, no odor	197
198								198
199								199

Sampler Type:

-  No Recovery
 Standard Penetration Test (ASTM D1586)
 Modified California Sampler

PID - Photoionization Detector

-  Static Water Level
 Water Level (ATD)

Logged by: **MML**Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
11 of 11

Project Name: HERS Industrial Park

Ground Surface Elev. _____

Location: 4403 Russell Rd, Mukilteo, Washington

Top of Casing Elev. _____

Driller/Method: Holt Drilling, Inc / Mud Rotary with CME 85

Depth to Water (ft BGS) 162.25 - 8/10/2015

Sampling Method: SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop

Start/Finish Date 7/27/2015 - 7/31/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
201		S38		0.0	17 35 50/5"			201
202							Bottom of boring at 200.5' bgs, well tag: BJE-570	202
203								203
204								204
205								205
206								206
207								207
208								208
209								209
210								210
211								211
212								212
213								213
214								214
215								215
216								216
217								217
218								218
219								219

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No. _____



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Depth to Water (ft BGS) **6.62 - 8/10/2015**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **1/21/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	5" Flushmount monument in concrete, thermos cap			0.1			Asphalt overlying crushed rock	1
2							Moist, brown, silty, gravelly SAND (SM); crushed rock gravel	2
3	Backfilled with bentonite chips	S1		0.4	4 5 10		Moist, brown gray, gravelly, silty SAND (SM); fine sand, fine subrounded gravel, trace wood at 1'	3
4	Colorado silica sand 4'-15' bgs							4
5	1/21/2015	S2		1.5	3 5 5		Becomes very moist, iron oxide staining	5
6								6
7								7
8	1-inch Schedule 40 PVC casing, 10 slot screen 5'-15' bgs in prepacked sand	S3		2.4	4 8 30			8
9								9
10		S4		12.5	30 34 50/5.5"		Chemical odor at 10' bgs	10
11								11
12								12
13		S5		21.3	19 34 43		Becomes wet between 12.5' to 13' bgs and brown with iron oxide staining	13
14							Becomes gray at 13.25	14
15	Threaded end-cap	S6	Soil: MW-16-15.5	61.5	19 50/6"			15
16							Bottom of boring at 16 ft bgs	16
17								17
18								18
19								19

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
1 of 6

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	8" Flushmount monument in concrete, thermos cap						Asphalt overlying crushed rock	1
2							Very moist, dark brown, silty SAND (SM); predominantly fine sand, trace fine subangular gravel, iron oxide staining	2
3								3
4	Backfilled with bentonite chips 1.5'-12' bgs							4
5							Becomes loose, moist, and gray brown with diamict fabric at 5' bgs	5
6		S1		0.1	3			6
7				0.1	4			7
8					5			8
9								9
10							Becomes very dense	10
11		S2		2.7	10			11
12				2.9	20			12
13					38			13
14	Backfilled with bentonite grout 12'-77.5' bgs							14
15							Becomes blue gray at 15' bgs	15
16		S3	Soil: MW-16D-10	5.0	37		1 inch pocket of brown, silty sand at 15.5' bgs	16
17					50/5"			17
18								18
19								19

Sampler Type:

- ☐ No Recovery
- ☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
- ☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
2 of 6

Project Name: **HERS Industrial Park**

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
21	Backfilled with bentonite grout 12'-77.5' bgs	S4	Soil: MW-16D-25	0.3	22 50/4"			21
22								22
23								23
24								24
25		S5						25
26								26
27								27
28								28
29								29
30		S6		0.0	50/4"			30
31								31
32								32
33								33
34								34
35		S7		0.5	37 50/5"			35
36								36
37								37
38								38
39								39

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test
(ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
3 of 6

Project Name: **HERS Industrial Park**

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
41	Backfilled with bentonite grout 12'-77.5' bgs	S8	Soil: MW-16D-45	0.0	50/5"			41
42								42
43								43
44								44
45		S9		15.4	50/5"			45
46								46
47								47
48								48
49								49
50		S10		10.1	50/3"			50
51								51
52								52
53								53
54								54
55		S11		0.4	50/3"			55
56								56
57								57
58								58
59								59

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
4 of 6

Project Name: **HERS Industrial Park**

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
61	Backfilled with bentonite grout 12'-77.5' bgs	S12	Soil: MW-16D-65	0.3	50/3"			61
62								62
63								63
64								64
65		S13		0.0	50/3"		Cuttings become a wet slurry	65
66								66
67								67
68								68
69								69
70		S14		0.0	50/3"		Broken gravel in sampler shoe	70
71								71
72								72
73								73
74								74
75		S15		0.0	50/4"			75
76								76
77								77
78	Colorado silica sand 77.5-100.33' bgs							78
79								79

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
5 of 6

Project Name: **HERS Industrial Park**

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
81	2-inch Schedule 40 PVC casing, 10 slot screen 80'-100' bgs	S16		0.0	50/4"			81
82								82
83								83
84								84
85		S17		0.0	50/4"		2-inch pocket of silty medium sand at 85.25' bgs	85
86								86
87								87
88								88
89								89
90		S18	Soil: MW-16D-90	0.0	50/5"			90
91								91
92								92
93								93
94								94
95		S19		0.0	50/3"			95
96								96
97								97
98								98
99	Threaded end-cap							99

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
6 of 6

Project Name: HERS Industrial Park

Ground Surface Elev. _____

Location: 4403 Russell Rd, Mukilteo, Washington

Top of Casing Elev. _____

Driller/Method: Holt Drilling, Inc / Truck Mounted HSA

Depth to Water (ft BGS) 57.65 - 8/10/2015

Sampling Method: Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop

Start/Finish Date 4/9/2015 - 4/10/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
101		 S20		0.0	50/4"		Very dense, moist to very moist, gray, very sandy SILT (ML); fine sand Bottom of boring at 100.33' bgs	101
102								102
103								103
104								104
105								105
106								106
107								107
108								108
109								109
110								110
111								111
112								112
113								113
114								114
115								115
116								116
117								117
118								118
119								119

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

-  Static Water Level
 Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-17

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Depth to Water (ft BGS) **4.93 - 8/10/2015**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **1/21/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	5" Flushmount monument in concrete, thermos cap						Asphalt overlying crushed rock	1
2	Backfilled with bentonite chips						Moist, brown, slightly gravelly, sandy SILT (ML); predominantly fine sand, fine subangular to subrounded gravel	2
3	1/21/2015							3
4	Colorado silica sand 4'-15' bgs							4
5	8/10/2015							5
6	1-inch Schedule 40 PVC casing, 10 slot screen 5'-15' bgs in prepacked sand						Becomes gray brown at 6' bgs	6
7								7
8								8
9								9
10							Becomes wet at 10' bgs	10
11		S1	Soil: MW-17-10	0.0	6 26 43			11
12								12
13								13
14								14
15	Threaded end-cap						Bottom of boring at 15 ft bgs	15
16								16
17								17
18								18
19								19

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-18

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Depth to Water (ft BGS) **6.27 - 8/10/2015**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **1/21/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	5" Flushmount monument in concrete, thermos cap	S1		0.0	1 1 2		Asphalt overlying crushed rock	1
2							Moist, brown, gravelly, sandy SILT (ML); predominantly fine sand, fine subrounded to rounded gravel, scattered clasts of gray sandy silt, no odor	2
3	Backfilled with bentonite chips	S2		0.3	1 2 2		Becomes very moist at 2.5' bgs with iron oxide staining and trace gravel content	3
4								4
5	Colorado silica sand 4'-15' bgs							5
6	1/21/2015	S3		0.0	0 0 1		Becomes wet at 5' bgs, no odor	6
7								7
8		S4		0.1	5 19 24		Becomes very moist, brown and gray, and gravelly at 7.5' bgs with no odor	8
9	1-inch Schedule 40 PVC casing, 10 slot screen 5'-15' bgs in prepacked sand							9
10								10
11		S5	Soil: MW-18-10.5	1.8	9 14 29			11
12								12
13		S6		0.4	10 33 50/5"		Becomes wet and very sandy at 12.5' bgs	13
14								14
15	Threaded end-cap	S7		0.0	28 50/5"		Wet, brown, gravelly, very sandy SILT (ML) to very silty SAND (SM); fine to medium sand, fine subrounded gravel	15
16							Bottom of boring at 15.9' bgs	16
17								17
18								18
19								19

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-19

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Depth to Water (ft BGS) _____

- 1/23/2015

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date _____

1/21/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	5" Flushmount monument in concrete, thermos cap						Asphalt overlying crushed rock	1
2	Backfilled with bentonite chips						Moist, brown, slightly gravelly, sandy SILT (ML); fine sand, fine subangular to subrounded grave, trace partially burned wood organics	2
3	▼ 1/23/2015						Becomes gray brown at 3' bgs	3
4	Colorado silica sand 4'-15' bgs							4
5							Returns to brown at 5' bgs	5
6	1-inch Schedule 40 PVC casing, 10 slot screen 5'-15' bgs in prepacked sand							6
7								7
8								8
9								9
10							Becomes wet at 10' bgs	10
11								11
12								12
13							Becomes moist and gray at 13' bgs	13
14								14
15	Threaded end-cap							15
16							Bottom of boring at 16' bgs	16
17								17
18								18
19								19

Sampler Type:

☐ No Recovery

PID - Photoionization Detector

▼ Static Water Level

▽ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number

140252

Well Number

MW-20

Sheet

1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Depth to Water (ft BGS) _____

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	5" Flushmount monument in concrete, thermos cap						Asphalt overlying crushed rock gravel	1
2							Moist, brown, silty SAND (SM); predominantly fine sand, trace subangular gravel, diamict fabric	2
3	Backfilled with bentonite chips							3
4								4
5	Colorado silica sand 4'-15' bgs			0.0	3		Becomes medium dense at 5' bgs	5
6		S1		0.0	12			6
7	1-inch Schedule 40 PVC casing, 10 slot screen 5'-15' bgs in prepacked sand				15			7
8								8
9								9
10				0.0	7		Becomes dense and wet at 10' bgs	10
11		S2	Soil: MW-20-10	0.0	22			11
12					50/6"			12
13								13
14								14
15	Threaded end-cap	S3		0.0	28		Becomes very dense, moist, and gray at 15' bgs	15
16				0.0	50/3"		Bottom of boring at 15.75' bgs	16
17								17
18								18
19								19

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-21

Sheet
1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / HSA with CME 85**

Depth to Water (ft BGS) **6.21 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date

7/24/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	8" Flushmount monument in concrete 0' - 1' bgs Thermos style cap					Asphalt	Dense, moist, brown, sandy, gravelly SILT (ML); fine to medium sand, trace coarse sand, fine subrounded to subangular gravel, diamict fabric, no odor	1
2	Bentonite chips 1'-3' bgs							2
3	Colorado silica sand 3'-15' bgs							3
4								4
5	2" Schedule 40 PVC casing 0'-15' bgs	S1		0.0	4 14 24			5
6	▼ 8/10/2015							6
7								7
8								8
9								9
10	2" Prepack screen 5'-15' bgs	S2	Soil: MW-21-9-10	1.3	10 25 50/5"		Becomes very dense at 9' bgs	10
11								11
12								12
13								13
14								14
15	Threaded PVC endcap Native soil	S3		0.1	50/5.5"		Becomes gray at 15' bgs	15
16							Bottom of boring at 15.5' bgs, well tag: BJE-599	16
17								17
18								18
19								19

Sampler Type:

- No Recovery
- ◼ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ▼ Static Water Level
- ▽ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number

140252

Well Number

MW-22

Sheet

1 of 1

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / HSA with CME 85**

Depth to Water (ft BGS)

5.22 - 8/10/2015

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date

7/24/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	8" Flushmount monument in concrete 0' - 1' bgs Thermos style cap Bentonite chips 1'-3' bgs					Asphalt	Medium dense, moist, brown, gravelly, silty SAND (SM); fine to medium sand, fine subrounded to subangular gravel, trace orange mottling, no odor	1
2								2
3	Colorado silica sand 3'-15' bgs	S1		0.0	6 9 12		Dense, moist, brown, gravelly, sandy SILT (ML); fine to medium sand, fine subrounded to subangular gravel, trace orange mottling, oxidation on gravels, diamict fabric, no odor	3
4	2" Schedule 40 PVC casing 0'-15' bgs							4
5	8/10/2015	S2		0.0	9 19 21			5
6								6
7								7
8								8
9								9
10	2" Prepack screen 5'-15' bgs	S3	Soil: MW-22-10-11	0.0	17 33 50/4"		Becomes very dense at 10' bgs	10
11								11
12								12
13								13
14								14
15	Threaded PVC endcap Native soil	S4		0.0	33 50/4"		Becomes gray at 15' bgs	15
16							Bottom of boring at 16' bgs, well tag: BJE-598	16
17								17
18								18
19								19

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

▼ Static Water Level

▽ Water Level (ATD)

Logged by: **MML**Approved by: **AN**

Figure No.

APPENDIX D

Regional Well Construction and Soil Boring Logs

460387

Please print, sign and return to the Department of Ecology

RESOURCE PROTECTION WELL REPORT

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Construction/Decommission ("x" in box)

☒ Construction☐ Decommission

ORIGINAL INSTALLATION Notice of Intent Number: _____

Consulting Firm _____

Unique Ecology Well IDTag No. _____

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ TraineeName (Print Last, First Name) Fadich, NickDriller/Engineer/Trainee Signature Nick FadichDriller or Trainee License No. 2862

If trainee, licensed driller's Signature and License Number: _____

CURRENT Notice of Intent No. SE45224

Type of Well ("x" in box)

☐ Resource Protection☒ Geotech Soil BoringProperty Owner Johnathan BerettaSite Address 10948 E. Villa Monte DrCity Mukilteo County SnohomishLocation NE 1/4-1/4 SE 1/4 Sec 20 Twn 28 R 4EWM ☒ or WWM ☐

Lat/Long (s, t, r) Lat Deg _____ Min _____ Sec _____

still REQUIRED) Long Deg _____ Min _____ Sec _____

Tax Parcel No. _____

Cased or Uncased Diameter 6" Static Level _____Work/Decommission Start Date 5/3/12Work/Decommission Completed Date 5/3/12

Construction Design

Well Data

Formation Description

0 ft to 20 ftbentonite chips0 ft to 10 fttan brown gray soft organic w/occasional gravel fill10 ft to 20 ftmedium dense clean fine tan brown sand w/occasional gravel

_____ ft to _____ ft

_____ ft to _____ ft

FADICH, NICK

APR 31 2012

DEPT OF ECOLOGY
NWRO - WRSCALE: 1"= NTS PAGE 1 OF 2

State Card # LE07486

WELL NO

Address 12123 Harbour Reach Dr. Ste 106
City Mukilteo State WA Zip 98275

☒ New construction ☐ Alteration (Repair/Recondition)
☐ Conversion ☐ Deepening ☐ Abandonment

☐ Rotary Air ☐ Rotary Mud ☐ Cable
☒ Hollow Stein Auger ☐ Other _____

Special Standards ☐ Yes ☒ No Depth of Completed Well 153 ft.

The diagram illustrates a cross-section of a well casing and seal assembly. The casing is shown as a vertical pipe with various components labeled on the right side. The seal is shown as a horizontal section with a central pipe and a surrounding sealant. The filter pack is shown as a section with a central pipe and a surrounding filter material. The diagram includes handwritten specifications for material, dimensions, and sealant.

Vault
 Special Standards
 TO
 ft.

Seal
 TO
 ft.

Filter pack
 TO
 ft.

Water-tight cover
Surface flush vault
Locking cap
 Casing diameter 2.75
 Material PVC
 Welded ☐ Threaded ☒ Grooved ☐

Well Seal:
 Material Cement
 Amount Benton
 Grout weight Geom

Borehole diameter:
12 in. from ft. to ft.
 in. from ft. to ft.

Bentonite plug at least 3

Screen:
 Material
 From ft. to ft.
 Slot size in.

Filter pack:
 Material
 Size

☐ Pump ☒ Sailer ☐ Air ☐ Flowing Artesian

Permeability _____ Yield _____ GPM
Conductivity _____ PH _____
Temperature of water _____ OF/C Depth Artesian flow found _____ ft.
Was water analysis done? ☐ Yes ☐ No
By whom? _____
Depth of strata to be analyzed. From _____ ft. to _____ ft.
Remarks: _____
Name Of Supervising Geologist/Engineer _____

County Snodgrass Latitude _____ Longitude _____
Township 28N (N or S) Range 4E (E or W) Section 28
SE 1/4 of NW 1/4 of above section.
Street address of well location 12123 Harbore Peach Dr
Mukilteo, WA 98275
Tax lot number of well location _____

_____ ft. below land surface. Date _____

Artesian Pressure _____ lb./sq. in. Date _____

Depth at which water was first found _____

From	To	Est. Flow Rate	SWL

Ground Elevation

[illegible]

Date started 09/13/12 Completed 09/14/12

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Type or Print Name Math Graham License No. 2671
 Trainee Name _____ License No. _____
 Drilling Company Holocene Drilling Inc.
 (Signed) Math License No. 2671
 Address 11412 62nd Ave. E. Puyallup, WA 98373
 Registration No. HOLCDI044KH Date 09/20/12

105759
RESOURCE PROTECTION WELL REPORT

23-4E-21Q

Client Well # _____ Start Card # R 58736
 Project Name: Slope Indicator County: Snohomish
 State Identification # A6R 123 Location: SW1/4 SE1/4 Sec 21 Twn 28N R 4E
 Drilling Method: HSA Street Address of Well: _____
 Driller: Brian Gose 12123 Harbour Reach Dr., Mukilteo, WA
 Firm: Cascade Drilling, Inc. Water Level Elevation: _____
 Signature: _____ Ground Surface Elevation: N/A
 Consulting Firm: Slope Indicator Date Installed: 11/19/01
 Representative: Bob Kenly Date Developed: No
 1782

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	Well Cover	
	Concrete Surface Seal Depth = 1/ft	<u>0 - 15 ft</u> <u>Brown silty sand + gravel</u>
	Blank Casing <u>3.34" x 75'</u> Material <u>Slope indicator pipe</u>	<u>15 - 75 ft</u> <u>Grey silty sand + gravel</u>
	Backfill _____ ft. Type: <u>Portland cement</u>	
	Seal _____ Material _____	
	Gravel Pack <u>N/A</u> ft Material: _____	
	Screen _____" x _____" Slot Size _____ Material <u>N/A</u>	
	Well Depth <u>75'</u>	
	Backfill _____ Material _____	
	Total Hole Depth _____	

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DEPT OF ECOLOGY

Coarse-Grained Soils - More than 50% ⁽¹⁾ Retained on No. 200 Sieve	Gravels - More than 50% ⁽¹⁾ of Coarse Fraction Retained on No. 4 Sieve		GW	Well-graded gravel and gravel with sand, little to no fines
			GP	Poorly-graded gravel and gravel with sand, little to no fines
			GM	Silty gravel and silty gravel with sand
			GC	Clayey gravel and clayey gravel with sand
	Sands - 50% ⁽¹⁾ or More of Coarse Fraction Passes No. 4 Sieve		SW	Well-graded sand and sand with gravel, little to no fines
			SP	Poorly-graded sand and sand with gravel, little to no fines
			SM	Silty sand and silty sand with gravel
			SC	Clayey sand and clayey sand with gravel
			ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
			CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			OL	Organic clay or silt of low plasticity
Fine-Grained Soils - 50% ⁽¹⁾ or More Passes No. 200 Sieve	Silt and Clays Liquid Limit Less than 50		MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			OH	Organic clay or silt of medium to high plasticity
	Highly Organic Soils		PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	<u>Density</u>	<u>SPT ⁽²⁾ blows/foot</u>	<u>Test Symbols</u>
Coarse-Grained Soils	Very Loose	0 to 4	FC = Fines Content
	Loose	4 to 10	GS = Grain Size
	Medium Dense	10 to 30	MC = Moisture Content
	Dense	30 to 50	AL = Atterberg Limits
	Very Dense	>50	C = Consolidation
Fine-Grained Soils		<u>SPT ⁽²⁾ blows/foot</u>	DD = Dry Density
	<u>Consistency</u>		K = Permeability
	Very Soft	0 to 2	Str = Shear Strength
	Soft	2 to 4	Env = Environmental
	Medium Stiff	4 to 8	PID = Photoionization Detector
	Stiff	8 to 15	
	Very Stiff	15 to 30	
	Hard	>30	

Component Definitions

<u>Descriptive Term</u>	<u>Size Range and Sieve Number</u>
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

⁽³⁾ Estimated Percentage

<u>Percentage by Weight</u>	<u>Modifier</u>	<u>Moisture Content</u>
<5	Trace	Dry - Absence of moisture, dusty, dry to the touch
5 to 15	Slightly (sandy, silty, clayey, gravelly)	Slightly Moist - Perceptible moisture
15 to 30	Sandy, silty, clayey, gravelly	Moist - Damp but no visible water
30 to 49	Very (sandy, silty, clayey, gravelly)	Very Moist - Water visible but not free draining
		Wet - Visible free water, usually from below water table

Symbols

Sampler Type	Description
2.0" OD Split-Spoon Sampler (SPT)	Continuous Push
Bulk sample	Non-Standard Sampler
Grab Sample	3.0" OD Thin-Wall Tube Sampler (including Shelby tube)
	Portion not recovered

(1) Percentage by dry weight

(2) (SPT) Standard Penetration Test (ASTM D-1586)

(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

(4) Depth of groundwater

ATD = At time of drilling

Static water level (date)

(5) Combined USCS symbols used for fines between 5% and 15% as estimated in General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

BGS = below ground surface

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

Aspect consulting
earth+water
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Exploration Log Key

DATE:	PROJECT NO.
DESIGNED BY:	
DRAWN BY:	FIGURE NO.
REVISED BY:	A-1

Q:\ACAD Standards\Standard Details\Exploration Log Key A1.dwg



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
1 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	8" Flushmount monument in concrete 0' - 1' bgs Thermos style cap					Asphalt		1
2							WEATHERED VASHON TILL Medium dense, moist, brown, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded to subangular gravel, oxide staining around gravels, diamict fabric, no odor	2
3								3
4	Backfilled with bentonite chips 1'-173' bgs							4
5								5
6	2" Schedule 40 PVC casing 0'-176' bgs	S1		0.2	9 16 23			6
7								7
8								8
9								9
10								10
11		S2		0.0	16 26 40		Becomes very dense at 10' bgs	11
12								12
13								13
14								14
15		S3		0.0	50/6"		VASHON TILL Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	15
16								16
17								17
18								18
19								19

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
2 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
21	Backfilled with bentonite chips 1'-173' bgs	S4		0.0	50/4"		Very dense, moist, gray, gravelly, sandy, SILT (ML); predominantly fine sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	21
22								22
23								23
24								24
25	2" Schedule 40 PVC casing 0'-176' bgs	S5		0.0	50/4"		Fine to coarse sand, no odor at 25' bgs	25
26								26
27								27
28								28
29								29
30		S6		0.0	50/4"		Coarse sand content becomes trace fraction, no odor at 30' bgs	30
31								31
32								32
33								33
34								34
35		S7		0.0	50/4"			35
36								36
37								37
38								38
39								39

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
3 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
41	Backfilled with bentonite chips 1'-173' bgs	 S8		0.0	50/4"		Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	41
42							Scattered small pockets of medium sand, no odor	42
43								43
44								44
45	2" Schedule 40 PVC casing 0'-176' bgs	 S9		0.2	50/5"			45
46								46
47								47
48								48
49								49
50		 S10		0.0	50/5"			50
51								51
52								52
53								53
54								54
55		 S11	Soil: MW-2D-55	0.4	50/4"			55
56								56
57								57
58								58
59								59

Sampler Type:

-  No Recovery
-  Standard Penetration Test (ASTM D1586)
-  Modified California Sampler

PID - Photoionization Detector

-  Static Water Level
-  Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
4 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
61	Backfilled with bentonite chips 1'-173' bgs	S12		0.1	50/3"		Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	61
62								62
63								63
64								64
65		S13		0.1	50/3"			65
66	2" Schedule 40 PVC casing 0'-176' bgs						Crushed coarse gravel in sampler shoe	66
67								67
68								68
69								69
70		S14		0.0	50/1"			70
71								71
72								72
73								73
74								74
75		S15		0.0	50/2"			75
76								76
77								77
78								78
79								79

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
5 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
81	Backfilled with bentonite chips 1'-173' bgs	S16		0.0	50/2"		Very dense, moist, gray, gravelly, sandy, SILT (ML); fine to medium sand, trace coarse sand, fine subrounded - subangular gravel, diamict fabric, no odor	81
82								82
83								83
84								84
85	2" Schedule 40 PVC casing 0'-176' bgs	S17		0.0	50/2"		Very dense, very moist, gray, slightly gravelly, very silty SAND (SM); fine to medium sand, trace coarse sand, fine subrounded gravel, no odor	85
86								86
87								87
88								88
89								89
90		S18		0.0	50/4"		Predominantly fine sand, no odor at 90' bgs	90
91								91
92								92
93								93
94								94
95		S19		0.0	50/1"		No recovery, crushed coarse gravel in sampler shoe	95
96								96
97								97
98								98
99								99

Sampler Type:

- ☐ No Recovery
- ☒ Standard Penetration Test (ASTM D1586)
- ☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
- ☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
6 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
101		S20		0.0	50/1"		Very dense, moist, gray slightly gravelly, sandy SILT (ML); fine to medium sand, trace coarse sand, fine subrounded gravel, no odor	101
102								102
103	Backfilled with bentonite chips 1'-173' bgs							103
104								104
105	2" Schedule 40 PVC casing 0'-176' bgs	S21		0.0	50/2"		Crushed coarse gravel in sampler shoe	105
106								106
107								107
108								108
109								109
110		S22		0.0	50/2"			110
111								111
112								112
113								113
114								114
115		S23		0.0	50/2"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	115
116								116
117								117
118								118
119								119

Sampler Type:

- ☐ No Recovery
- ☒ Standard Penetration Test (ASTM D1586)
- ☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
- ☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
7 of 11

Project Name: HERS Industrial Park

Ground Surface Elev. _____

Location: 4403 Russell Rd, Mukilteo, Washington

Top of Casing Elev. _____

Driller/Method: Holt Drilling, Inc / Mud Rotary with CME 85

Depth to Water (ft BGS) 162.25 - 8/10/2015

Sampling Method: SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop

Start/Finish Date 7/27/2015 - 7/31/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
121	Backfilled with bentonite chips 1'-173' bgs	S24		0.0	50/1"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	121
122								122
123								123
124								124
125	2" Schedule 40 PVC casing 0'-176' bgs	S25		0.0	50/2"			125
126								126
127								127
128								128
129								129
130		S26		0.0	50/4"			130
131								131
132								132
133								133
134								134
135		S27		0.0	50/5"			135
136								136
137								137
138								138
139								139

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
8 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
141	Backfilled with bentonite chips 1'-173' bgs	S28		0.0	50/6"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	141
142								142
143								143
144								144
145	2" Schedule 40 PVC casing 0'-176' bgs	S29		0.0	35 42 50/6"			145
146								146
147								147
148								148
149								149
150		S30		0.0	50/1"			150
151								151
152								152
153								153
154								154
155		S31		0.0	50/3"			155
156								156
157								157
158								158
159								159

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- No Recovery
 Standard Penetration Test (ASTM D1586)
 Modified California Sampler

- Static Water Level
 Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
9 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
161		S32		0.0	65 110/6"		Very dense, wet, gray brown, gravelly, very silty SAND (SM); fine sand, trace medium to coarse sand, trace coarse sand, fine to coarse subrounded gravel diamict fabric, no odor	161
162	▼ 8/10/2015							162
163	Backfilled with bentonite chips 1'-173' bgs							163
164								164
165	2" Schedule 40 PVC casing 0'-176' bgs	S33		0.0	100/3"		Very dense, moist, gray brown SAND (SP); fine sand, trace silt, no odor	165
166								166
167								167
168								168
169								169
170		S34		0.0	100/3"		Very dense, moist, gray brown, gravelly, silty SAND (SM); fine sand, trace coarse sand, fine subrounded gravel, scattered very thin laminae of medium sand, vague stratification features, no odor	170
171								171
172								172
173	10/20 Colorado silica sand 173'-196' bgs							173
174								174
175		S35		0.0	100/3"		Very thin medium sand laminae become frequent with stronger stratification features	175
176								176
177	2" Schedule 40 PVC 20-slot screen 176'-196' bgs						ESPERANCE SAND Very dense, very moist, brown, slightly silty SAND (SP-SM); predominantly medium sand, silt in ~4mm clasts, no odor	177
178								178
179								179

Sampler Type:

- ☐ No Recovery
- ☒ Standard Penetration Test (ASTM D1586)
- ☒ Modified California Sampler

PID - Photoionization Detector

- ▼ Static Water Level
- ▽ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.

MONITORING WELL HERS INDUSTRIAL PARK GPJ August 17, 2015



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
10 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
181		 S36		0.0	44 50/5"		Very dense, very moist, brown, slightly silty SAND (SP-SM); predominantly medium sand, no odor	181
182								182
183	Backfilled with bentonite chips 1'-173' bgs							183
184								184
185	2" Schedule 40 PVC casing 0'-196' bgs						Trace silt and iron oxide mottling, no odor at 185' bgs	185
186								186
187								187
188								188
189								189
190		 S37	Soil: MW-2D-190	0.0	47 50/3"			190
191								191
192								192
193								193
194								194
195								195
196	Threaded PVC endcap							196
197	Native soil						Very dense, moist, gray, slightly clayey, silty SAND (SM); fine sand, homogenous, no odor	197
198								198
199								199

Sampler Type:

-  No Recovery
-  Standard Penetration Test (ASTM D1586)
-  Modified California Sampler

PID - Photoionization Detector

-  Static Water Level
-  Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-2D

Sheet
11 of 11

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Mud Rotary with CME 85**

Depth to Water (ft BGS) **162.25 - 8/10/2015**

Sampling Method: **SPT / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **7/27/2015 - 7/31/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
201		S38		0.0	17 35 50/5"			201
202							Bottom of boring at 200.5' bgs, well tag: BJE-570	202
203								203
204								204
205								205
206								206
207								207
208								208
209								209
210								210
211								211
212								212
213								213
214								214
215								215
216								216
217								217
218								218
219								219

Sampler Type:

PID - Photoionization Detector

Logged by: **MML**

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)
☒ Modified California Sampler

- ☒ Static Water Level
☐ Water Level (ATD)

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
1 of 6

Project Name: **HERS Industrial Park**

Ground Surface Elev. _____

Location: **4403 Russell Rd, Mukilteo, Washington**

Top of Casing Elev. _____

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
1	8" Flushmount monument in concrete, thermos cap						Asphalt overlying crushed rock	1
2							Very moist, dark brown, silty SAND (SM); predominantly fine sand, trace fine subangular gravel, iron oxide staining	2
3								3
4	Backfilled with bentonite chips 1.5'-12' bgs							4
5							Becomes loose, moist, and gray brown with diamict fabric at 5' bgs	5
6		S1		0.1	3			6
7				0.1	4			7
8					5			8
9								9
10				2.7	10		Becomes very dense	10
11		S2		2.9	20			11
12					38			12
13								13
14	Backfilled with bentonite grout 12'-77.5' bgs							14
15							Becomes blue gray at 15' bgs	15
16		S3	Soil: MW-16D-10	5.0	37		1 inch pocket of brown, silty sand at 15.5' bgs	16
17					50/5"			17
18								18
19								19

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
2 of 6

Project Name: **HERS Industrial Park**

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
21	Backfilled with bentonite grout 12'-77.5' bgs	S4	Soil: MW-16D-25	0.3	22 50/4"			21
22								22
23								23
24								24
25		S5						25
26								26
27								27
28								28
29								29
30		S6		0.0	50/4"			30
31								31
32								32
33								33
34								34
35		S7		0.5	37 50/5"			35
36								36
37								37
38								38
39								39

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test
(ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
3 of 6

Project Name: **HERS Industrial Park**

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
41	Backfilled with bentonite grout 12'-77.5' bgs	S8	Soil: MW-16D-45	0.0	50/5"			41
42								42
43								43
44								44
45		S9		15.4	50/5"			45
46								46
47								47
48								48
49								49
50		S10		10.1	50/3"			50
51								51
52								52
53								53
54								54
55		S11		0.4	50/3"			55
56								56
57								57
58								58
59								59

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
4 of 6

Project Name: **HERS Industrial Park**

Location: **4403 Russell Rd, Mukilteo, Washington**

Driller/Method: **Holt Drilling, Inc / Truck Mounted HSA**

Sampling Method: **Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop**

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) **57.65 - 8/10/2015**

Start/Finish Date **4/9/2015 - 4/10/2015**

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
61	Backfilled with bentonite grout 12'-77.5' bgs	S12	Soil: MW-16D-65	0.3	50/3"			61
62								62
63								63
64								64
65		S13		0.0	50/3"		Cuttings become a wet slurry	65
66								66
67								67
68								68
69								69
70		S14		0.0	50/3"		Broken gravel in sampler shoe	70
71								71
72								72
73								73
74								74
75		S15		0.0	50/4"			75
76								76
77								77
78	Colorado silica sand 77.5-100.33' bgs							78
79								79

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
5 of 6

Project Name: HERS Industrial Park

Location: 4403 Russell Rd, Mukilteo, Washington

Driller/Method: Holt Drilling, Inc / Truck Mounted HSA

Sampling Method: Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop

Ground Surface Elev. _____

Top of Casing Elev. _____

Depth to Water (ft BGS) 57.65 - 8/10/2015

Start/Finish Date 4/9/2015 - 4/10/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
81	2-inch Schedule 40 PVC casing, 10 slot screen 80'-100' bgs	S16		0.0	50/4"			81
82								82
83								83
84								84
85		S17		0.0	50/4"		2-inch pocket of silty medium sand at 85.25' bgs	85
86								86
87								87
88								88
89								89
90		S18	Soil: MW-16D-90	0.0	50/5"			90
91								91
92								92
93								93
94								94
95		S19		0.0	50/3"			95
96								96
97								97
98								98
99	Threaded end-cap							99

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

- ☒ Static Water Level
☐ Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Monitoring Well Construction Log

Project Number
140252

Well Number
MW-16D

Sheet
6 of 6

Project Name: HERS Industrial Park

Ground Surface Elev. _____

Location: 4403 Russell Rd, Mukilteo, Washington

Top of Casing Elev. _____

Driller/Method: Holt Drilling, Inc / Truck Mounted HSA

Depth to Water (ft BGS) 57.65 - 8/10/2015

Sampling Method: Split Spoon / Hammer Weight: 140 lbs / Hammer Drop: 30" Drop

Start/Finish Date 4/9/2015 - 4/10/2015

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
101		 S20		0.0	50/4"		Very dense, moist to very moist, gray, very sandy SILT (ML); fine sand Bottom of boring at 100.33' bgs	101
102								102
103								103
104								104
105								105
106								106
107								107
108								108
109								109
110								110
111								111
112								112
113								113
114								114
115								115
116								116
117								117
118								118
119								119

Sampler Type:

- ☐ No Recovery
☒ Standard Penetration Test (ASTM D1586)

PID - Photoionization Detector

-  Static Water Level
 Water Level (ATD)

Logged by: **MML**

Approved by: **AN**

Figure No.



Type of Well: Geotech Soil Boring
Number of Wells in Group 2: 1 well
Type of Work: New
Method: Rotary
Drilling Start Date: 8/19/2014
Drilling Completion Date: 8/20/2014
Received by Ecology: 10/28/2014 11:02 AM

Borehole Diameter: 6 in
Depth of completed well: 100 ft 6 in

From Depth	To Depth	Type	Diameter	Stickup
N/A				

Type	Size	Total Perforations	From Depth	To Depth
N/A				

Manufacturer	Type	Dia- meter	Slot Size	From Depth	To Depth
N/A					

Material	From Depth	To Depth
N/A		

Well	Driller's Identifier	Water Level
1	B1A	Dry Hole

None

Tax parcel No.:

[illegible]

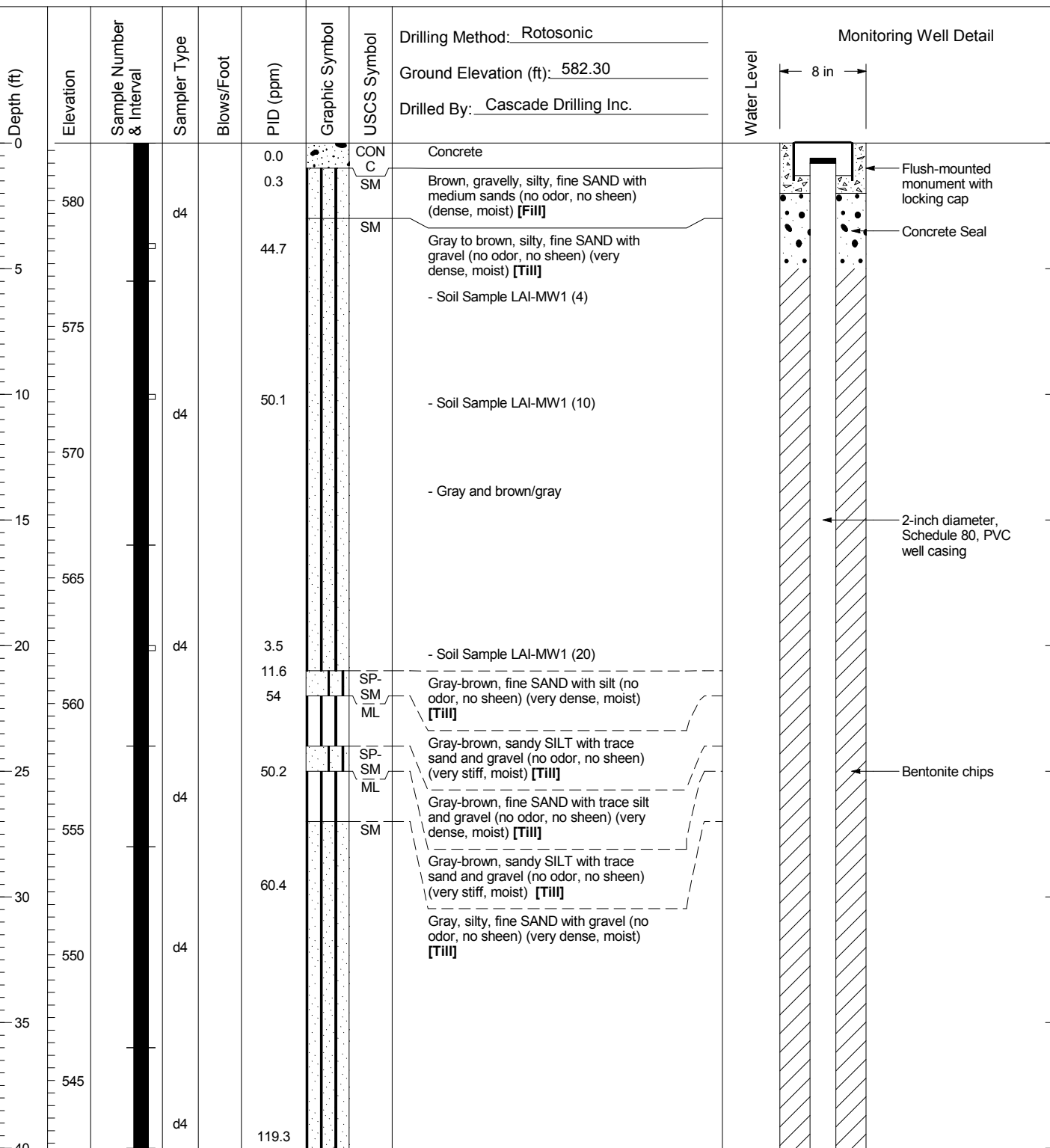
City, State, Zip: Puyallup, WA, 98373

LAI-MW1

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

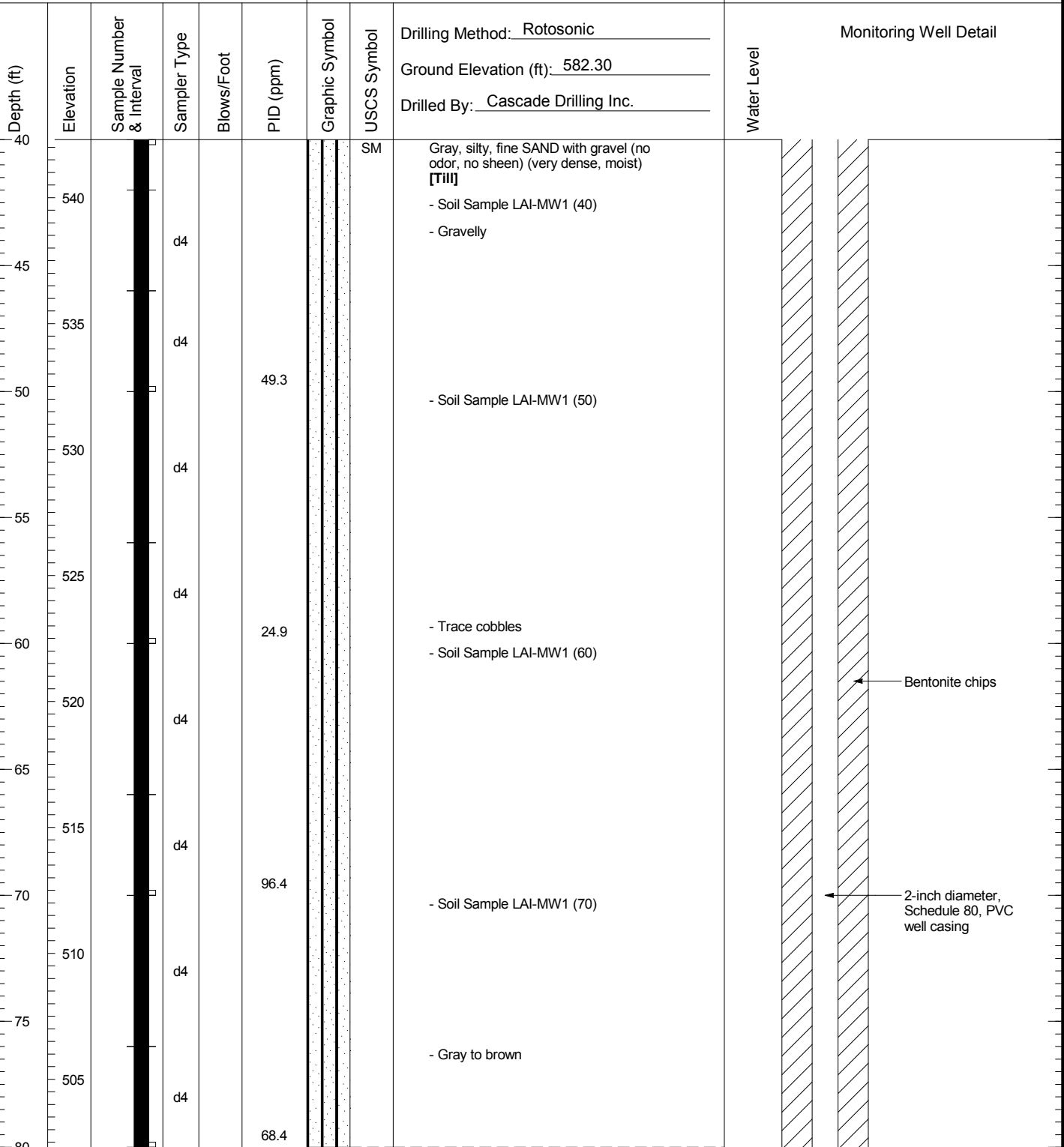
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW1

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



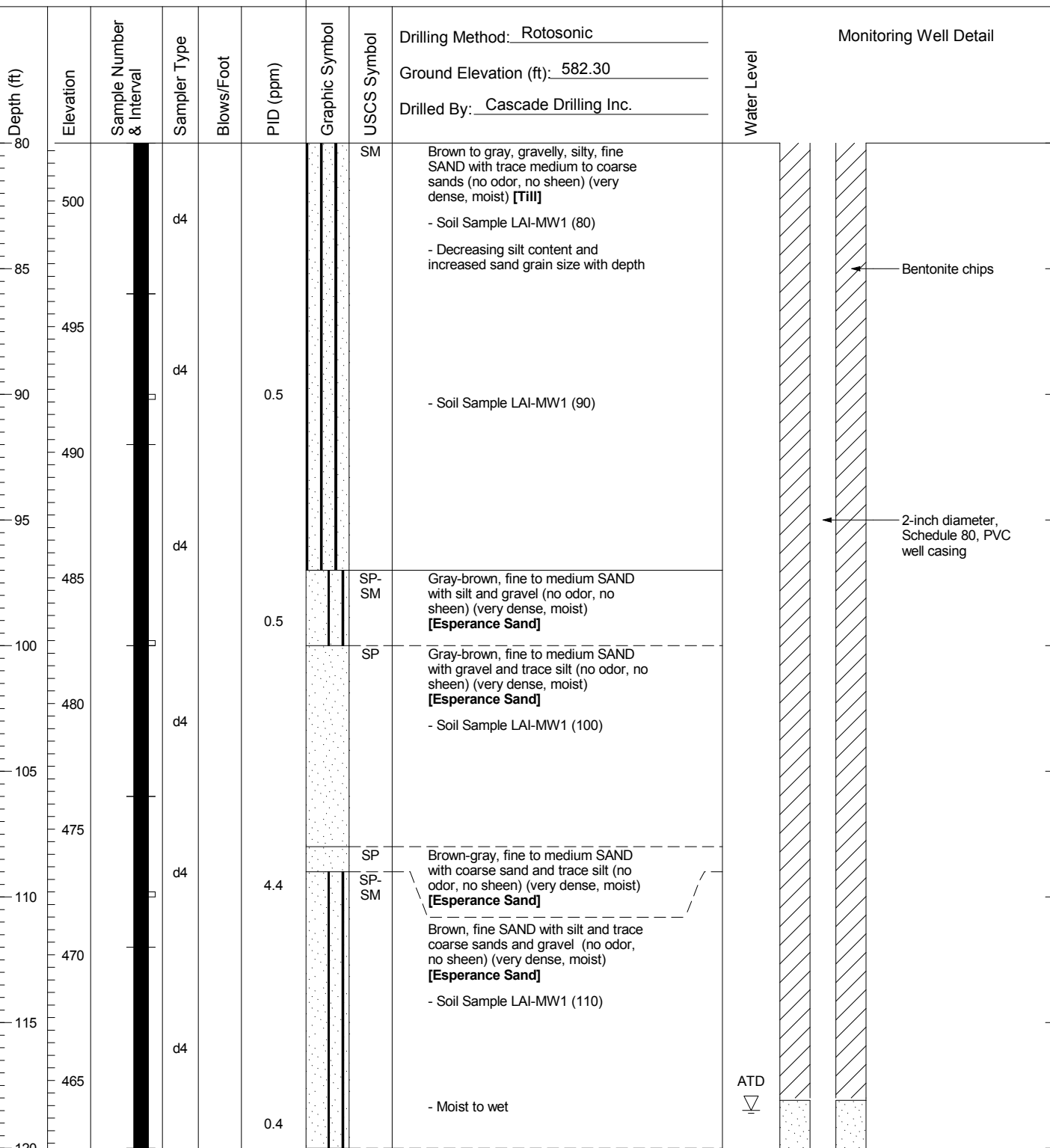
25198.04 1/18/13 \\EDM\DATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW1

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\046.GPJ WELL LOG W/ ELEVATION



LANDAU
ASSOCIATES

ATS Hangar 3 Property
Everett, Washington

Log of Monitoring Well LAI-MW1

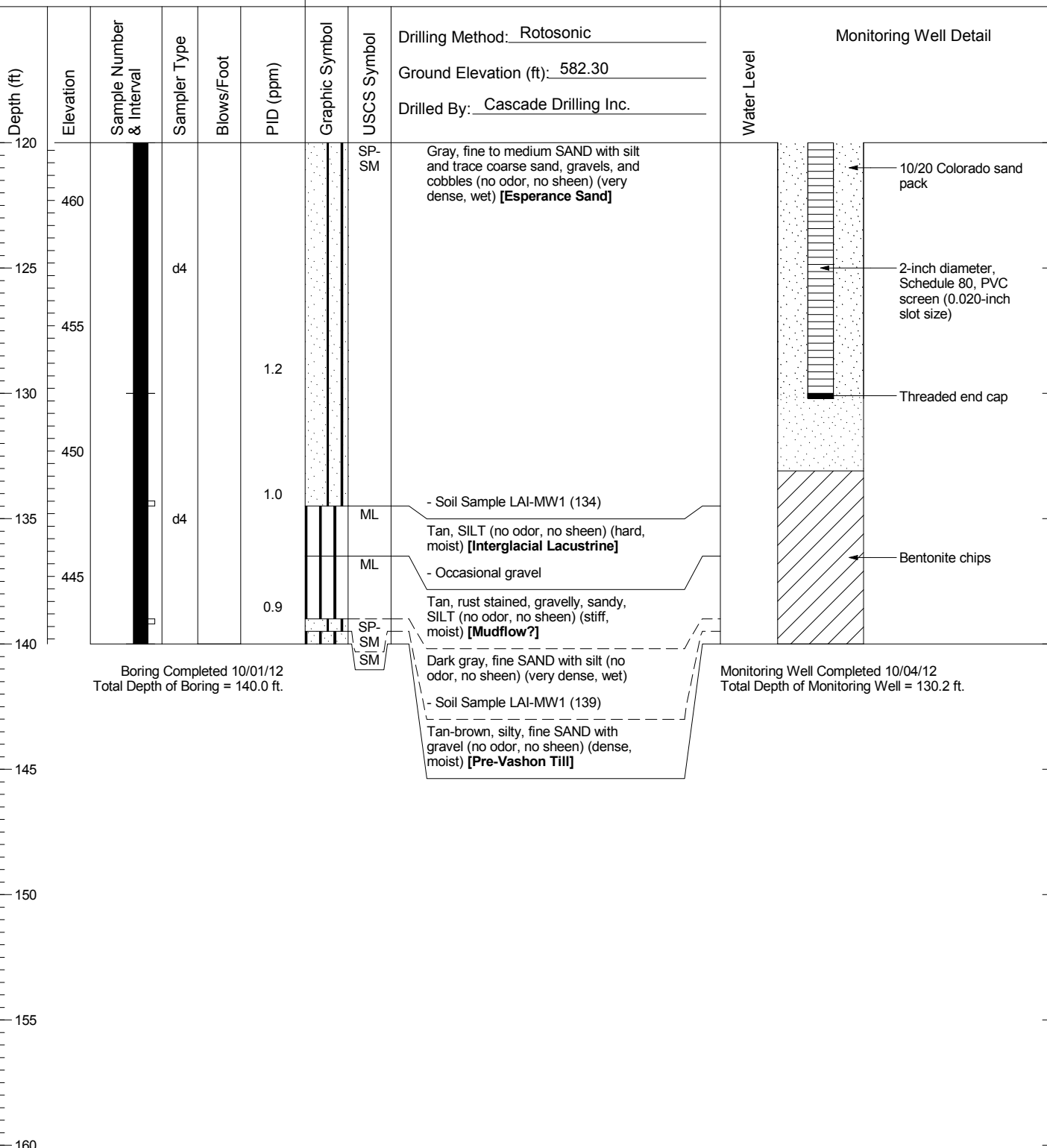
Figure
B-30
(3 of 4)

LAI-MW1

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION



LANDAU
ASSOCIATES

ATS Hangar 3 Property
Everett, Washington

Log of Monitoring Well LAI-MW1

Figure

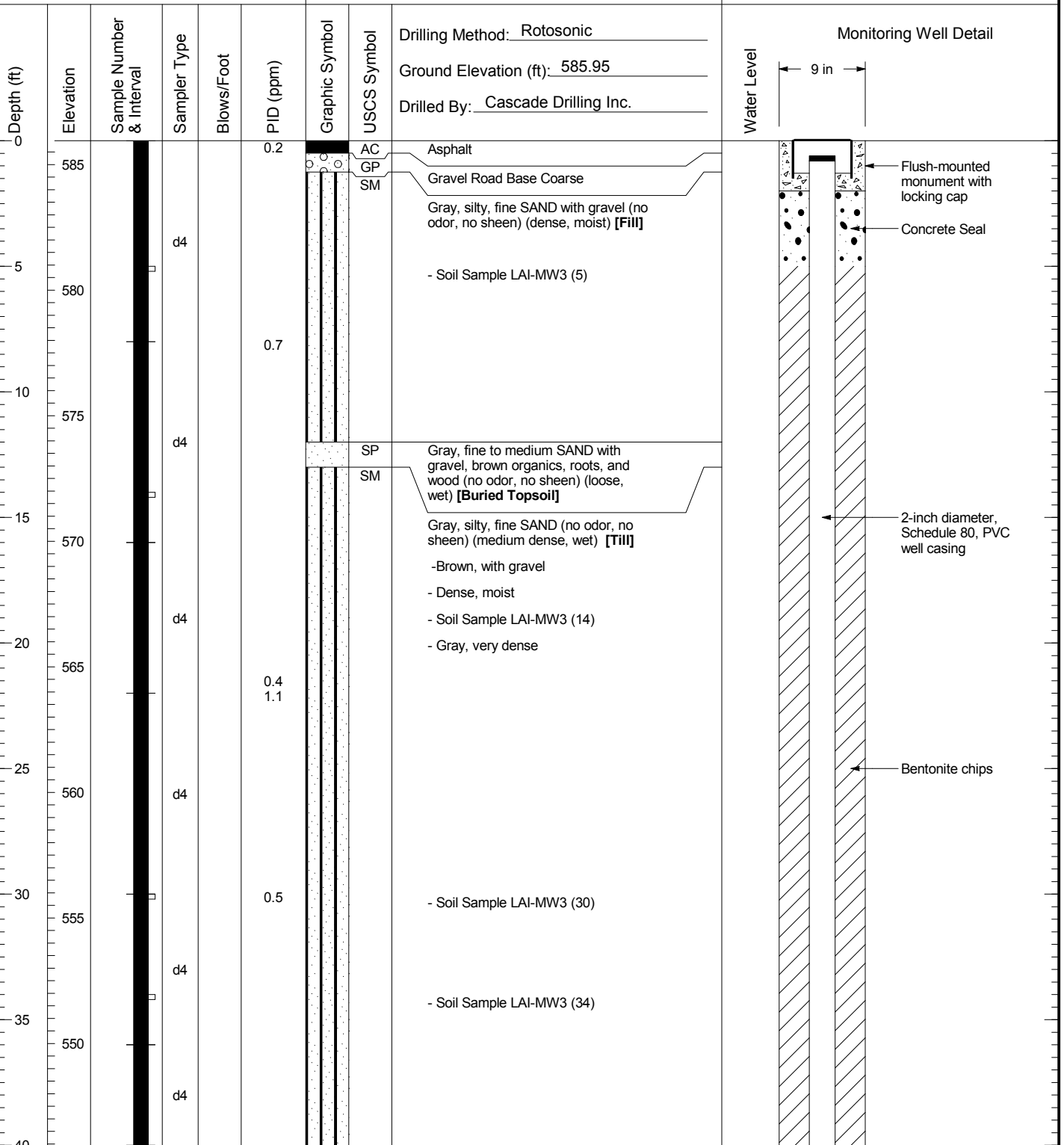
B-30
(4 of 4)

LAI-MW3

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW3

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Rotosonic</u>	Ground Elevation (ft): <u>585.95</u>	Drilled By: <u>Cascade Drilling Inc.</u>	Water Level	Monitoring Well Detail
40	545				2.6		SM	Gray, silty, fine SAND (no odor, no sheen) (medium dense, wet) [Till]				
			d4					- With cobbles				
45	540							- No cobbles				
			d4					- Soil Sample LAI-MW3 (45)				
50	535											
			d4		0.6							
55	530							- Soil Sample LAI-MW3 (55)				
			d4									
60	525											
			d4		1.9			- Soil Sample LAI-MW3 (65)				
65	520							- Increasing sand content but still silty				
			d4									
70	515											
			d4									
75	510							- Soil Sample LAI-MW3 (75)				
			d4		1.6			- Mottled brown and gray				
								- Gray				
80												

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION



LANDAU
ASSOCIATES

ATS Hangar 3 Property
Everett, Washington

Log of Monitoring Well LAI-MW3

Figure

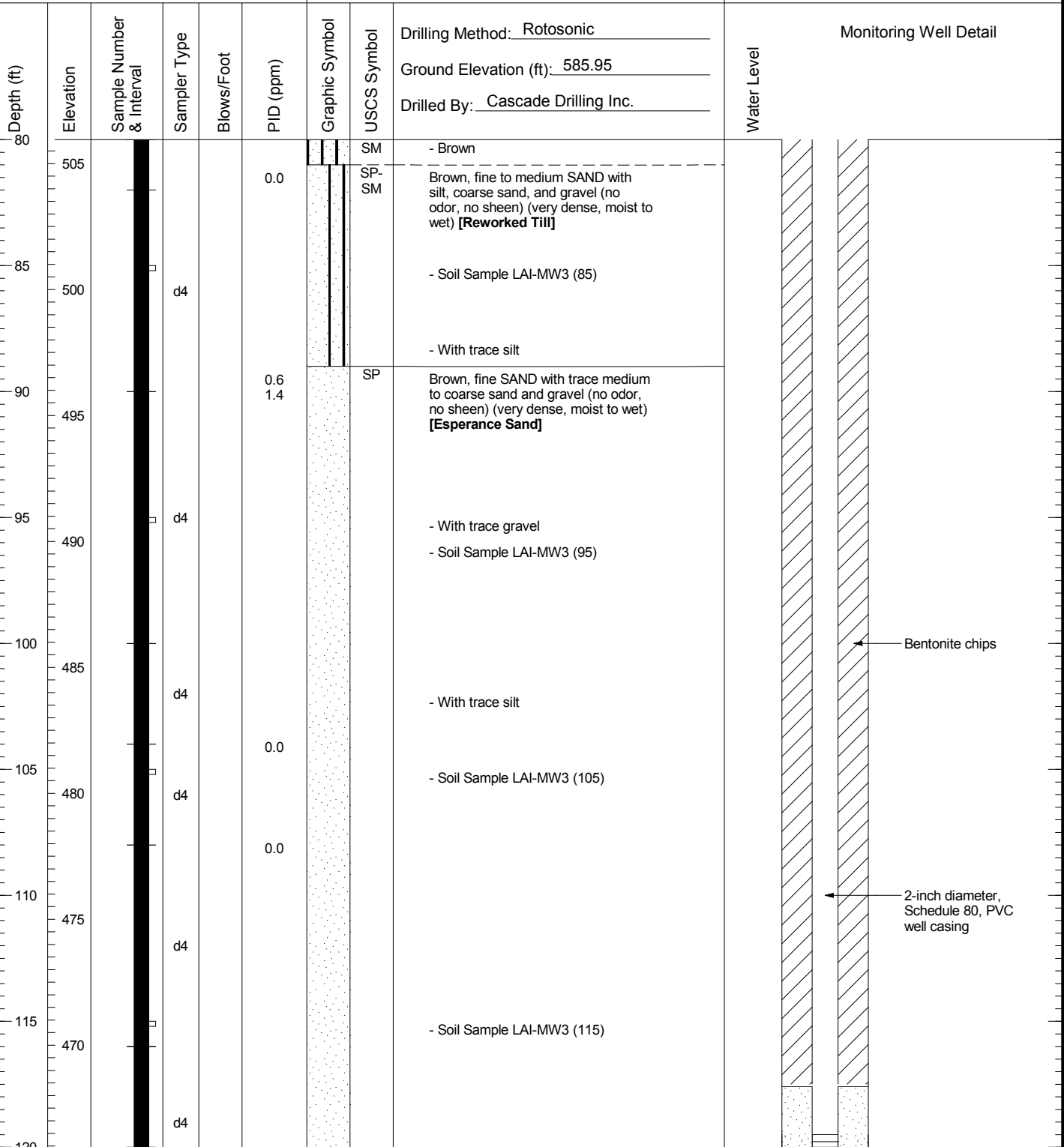
B-32
(2 of 4)

LAI-MW3

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

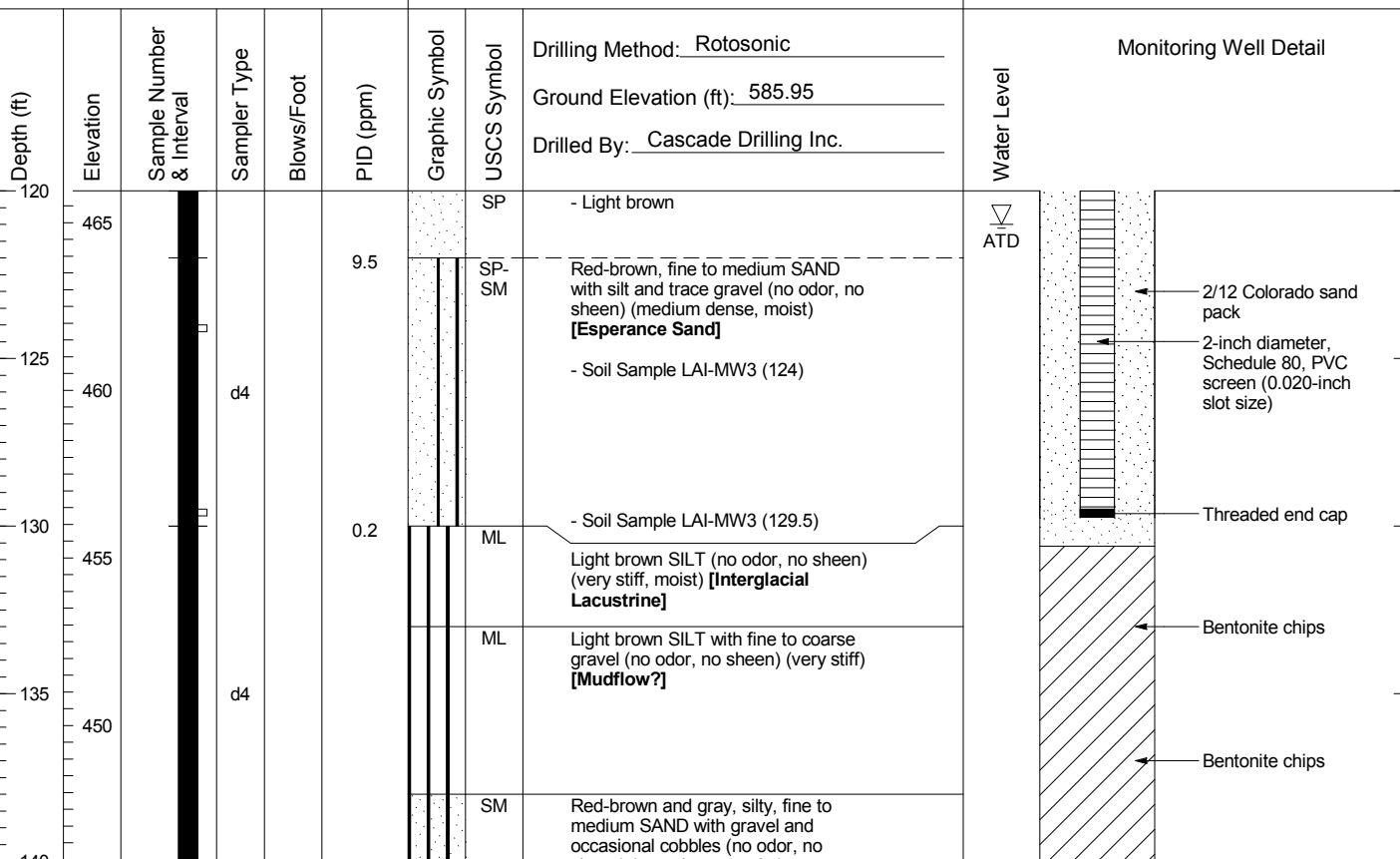
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW3

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



Boring Completed 10/04/12
Total Depth of Boring = 140.0 ft.

Monitoring Well Completed 10/06/12
Total Depth of Monitoring Well = 129.8 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

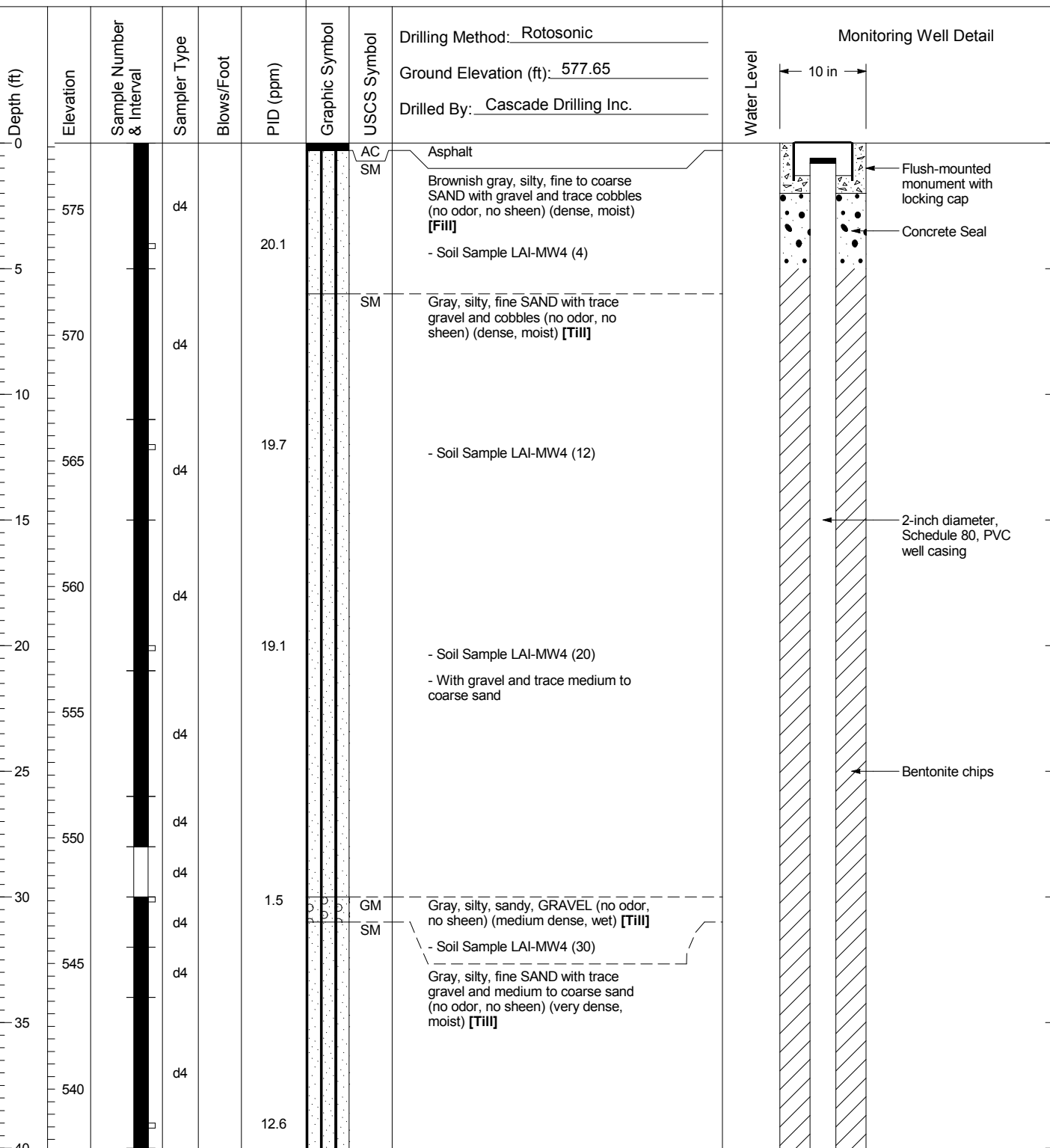
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW4

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

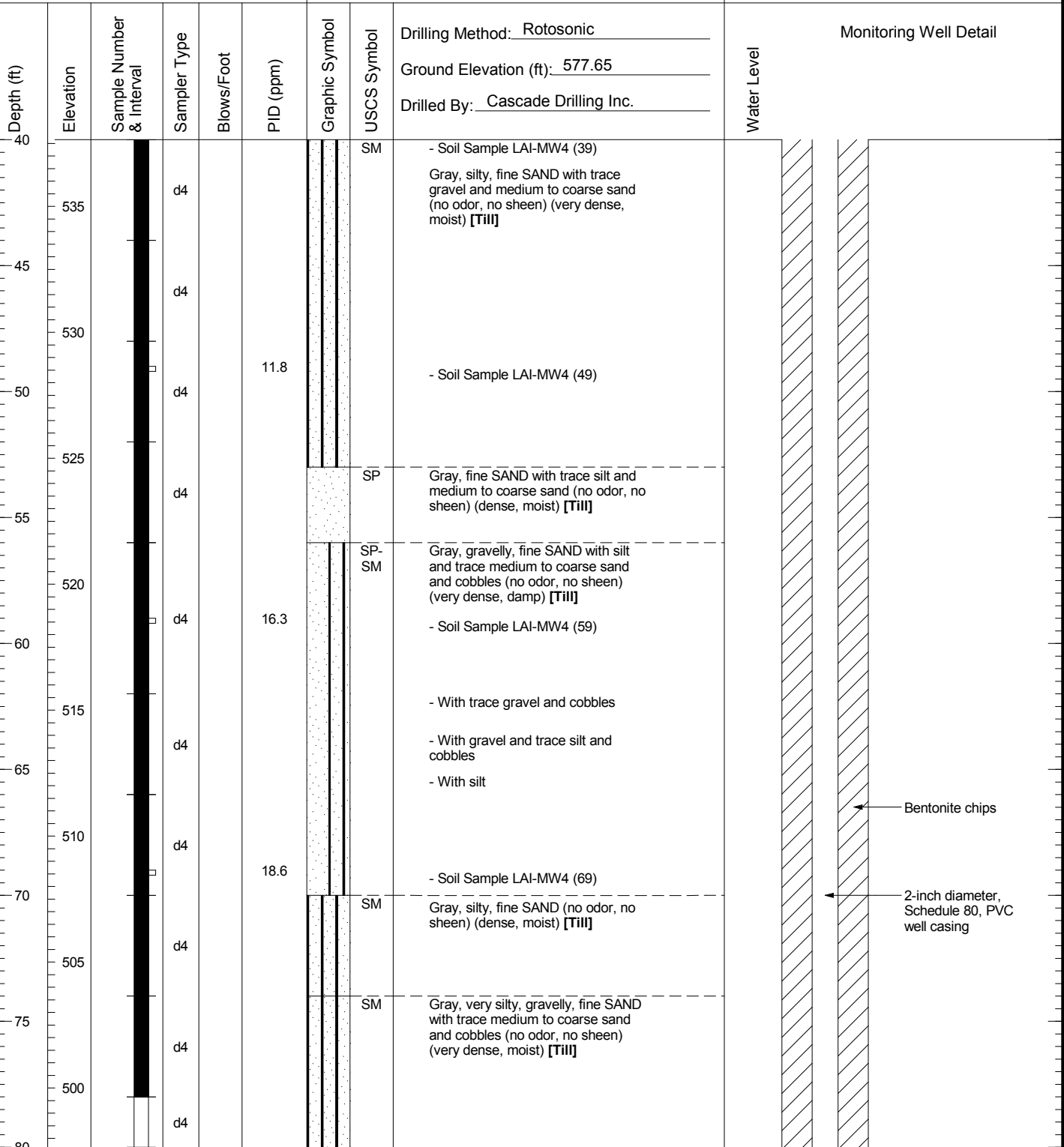
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW4

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

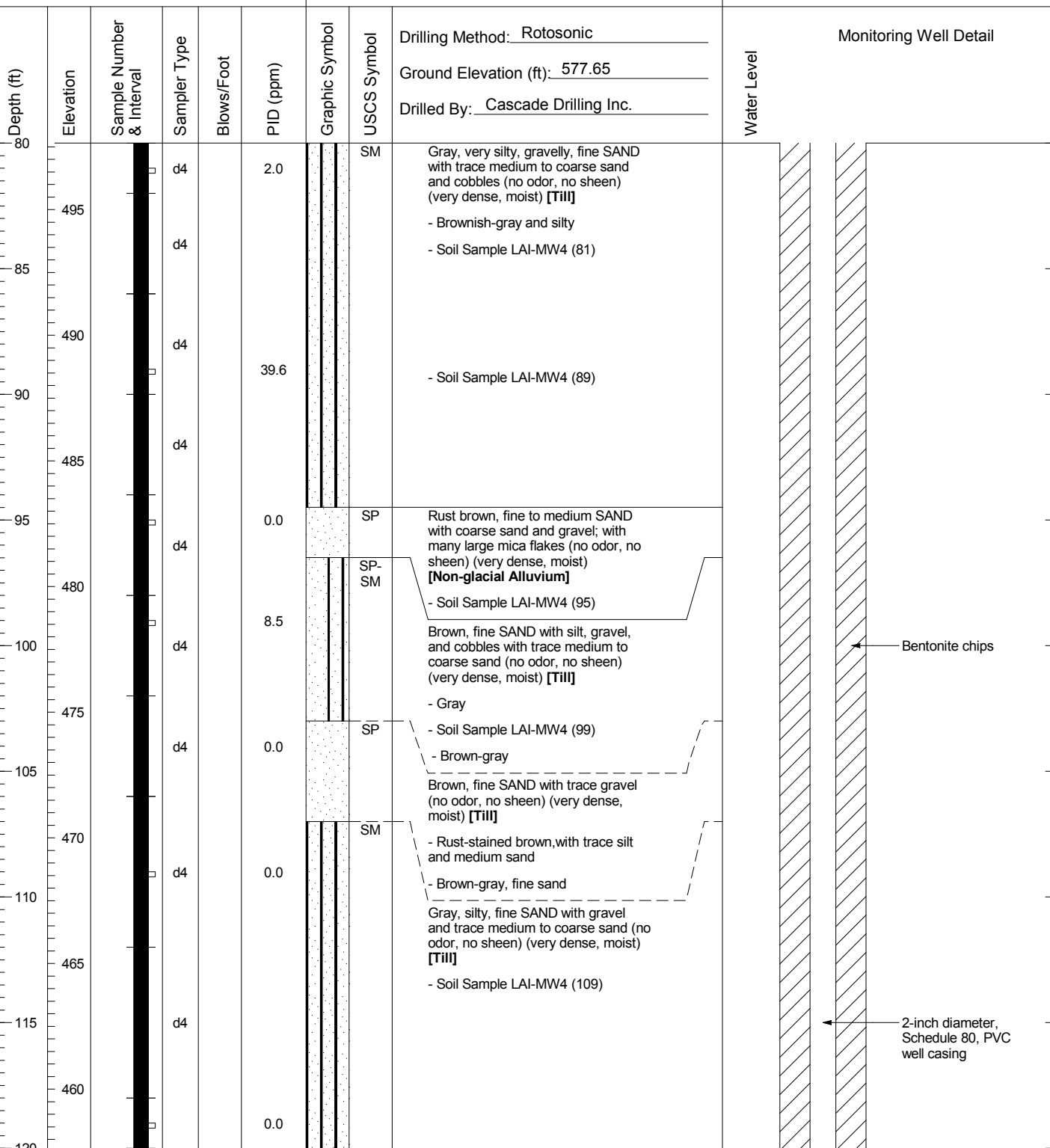
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW4

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

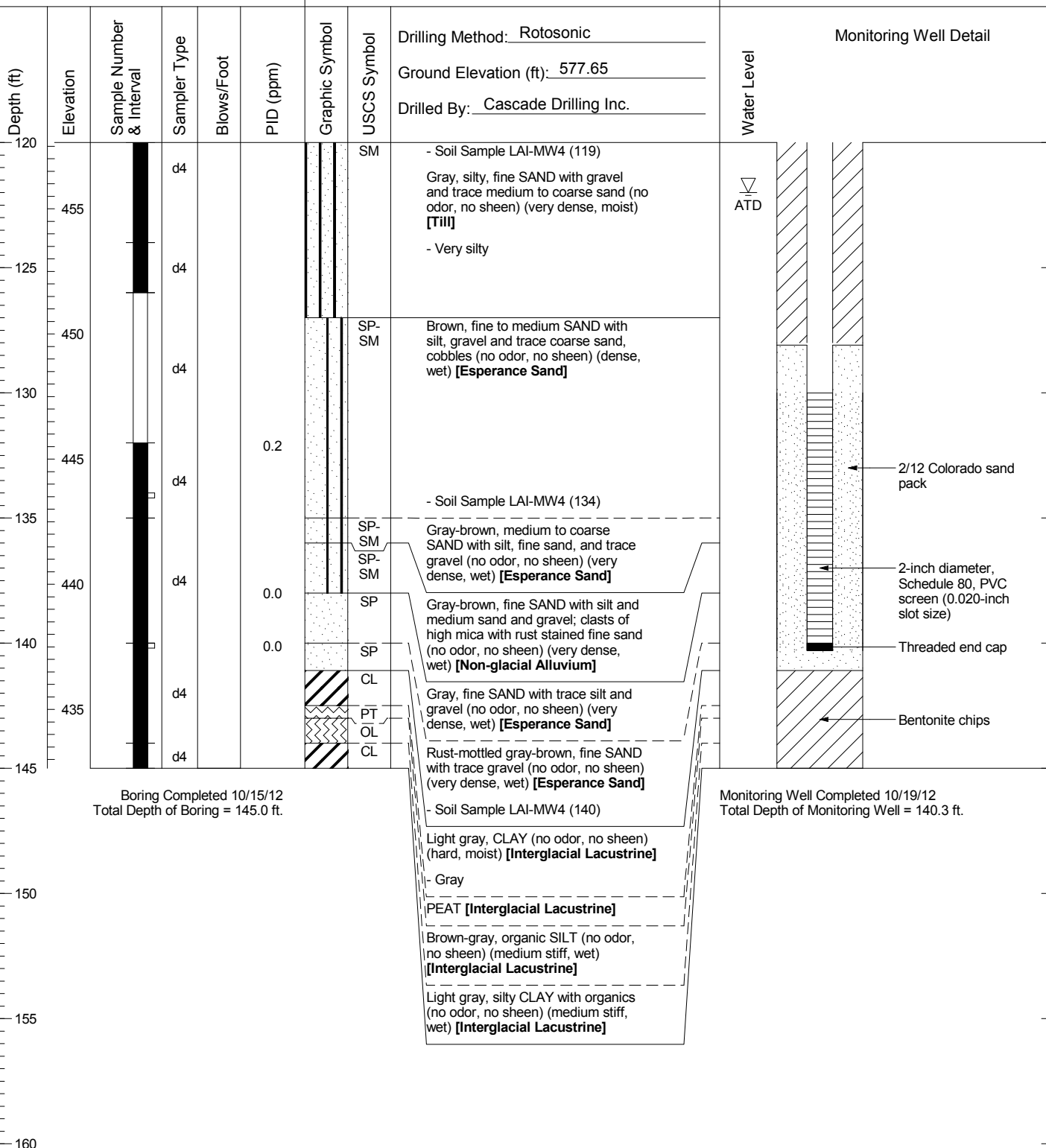
25198.04 1/18/13 \\EDM\DATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW4

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION



LANDAU
ASSOCIATES

ATS Hangar 3 Property
Everett, Washington

Log of Monitoring Well LAI-MW4

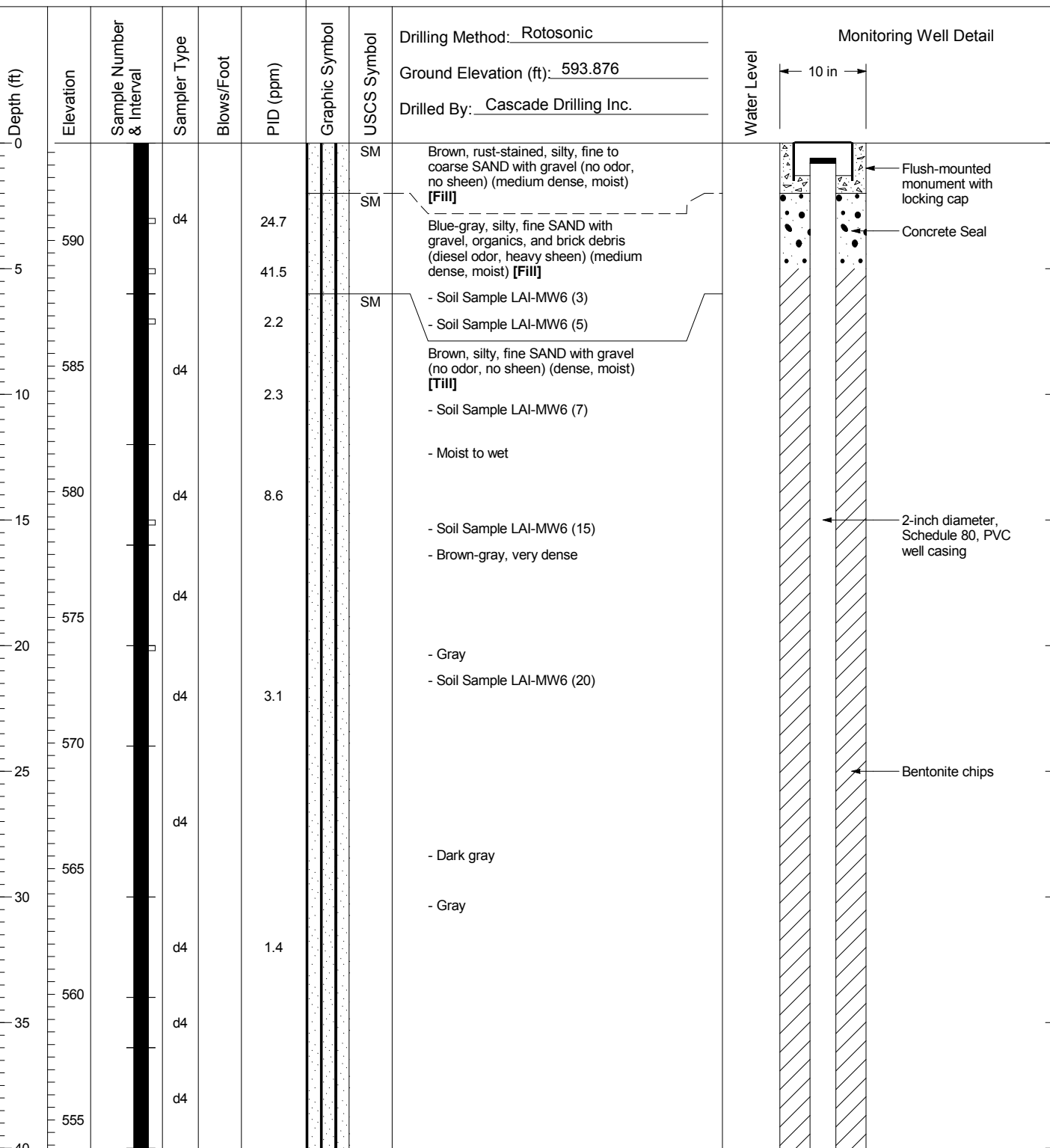
Figure
B-33
(4 of 4)

LAI-MW6

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

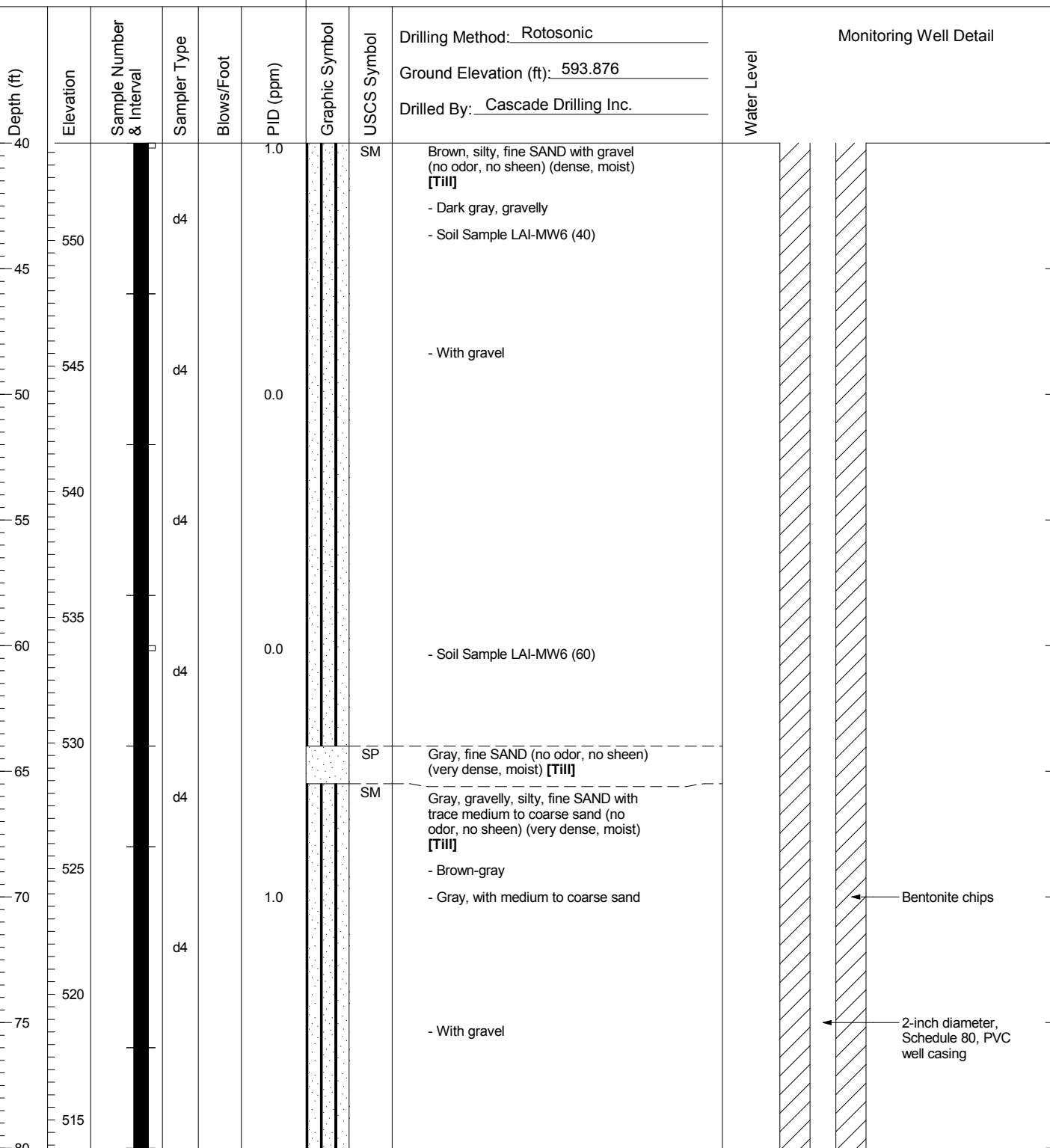
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW6

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

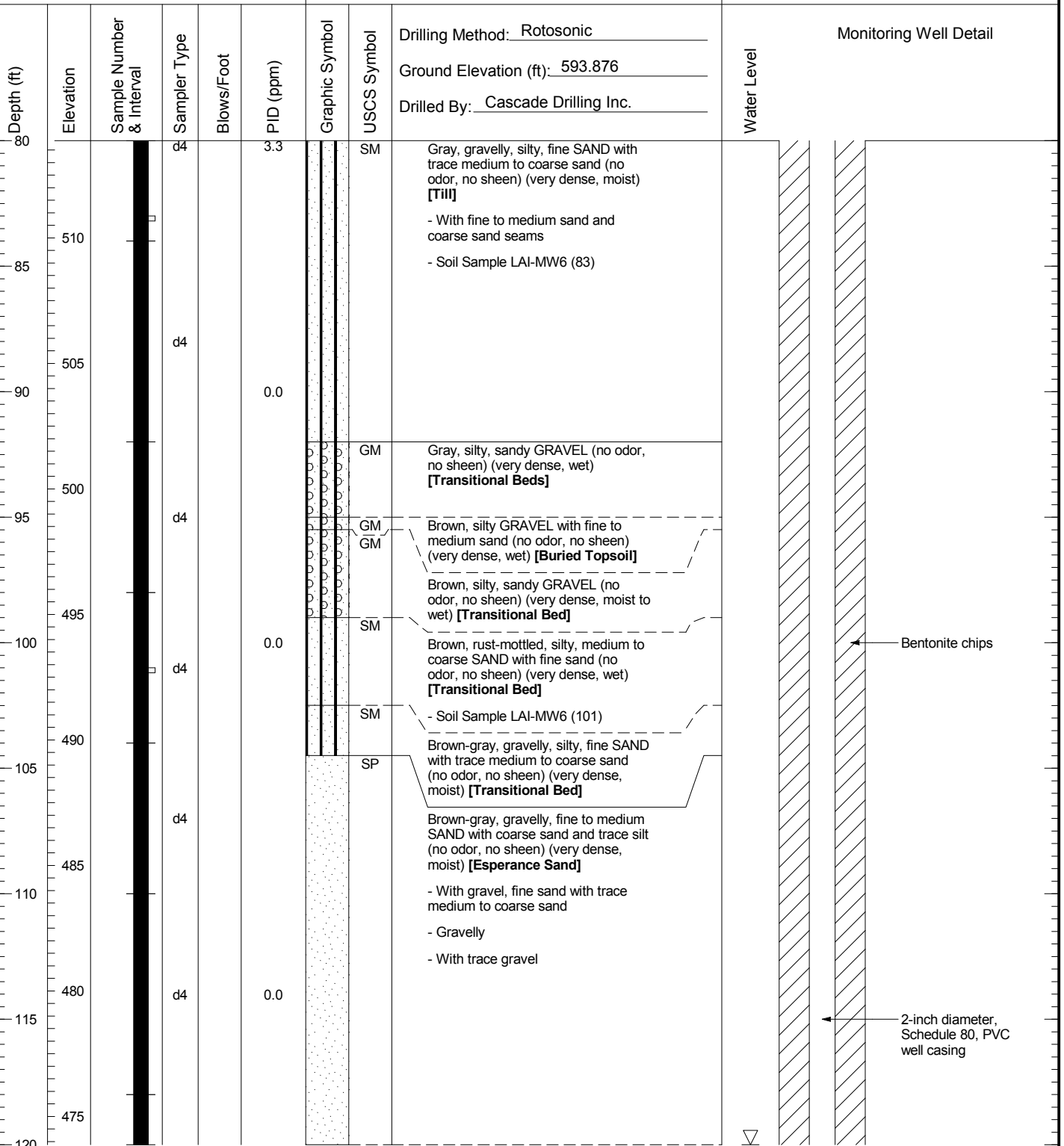
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW6

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



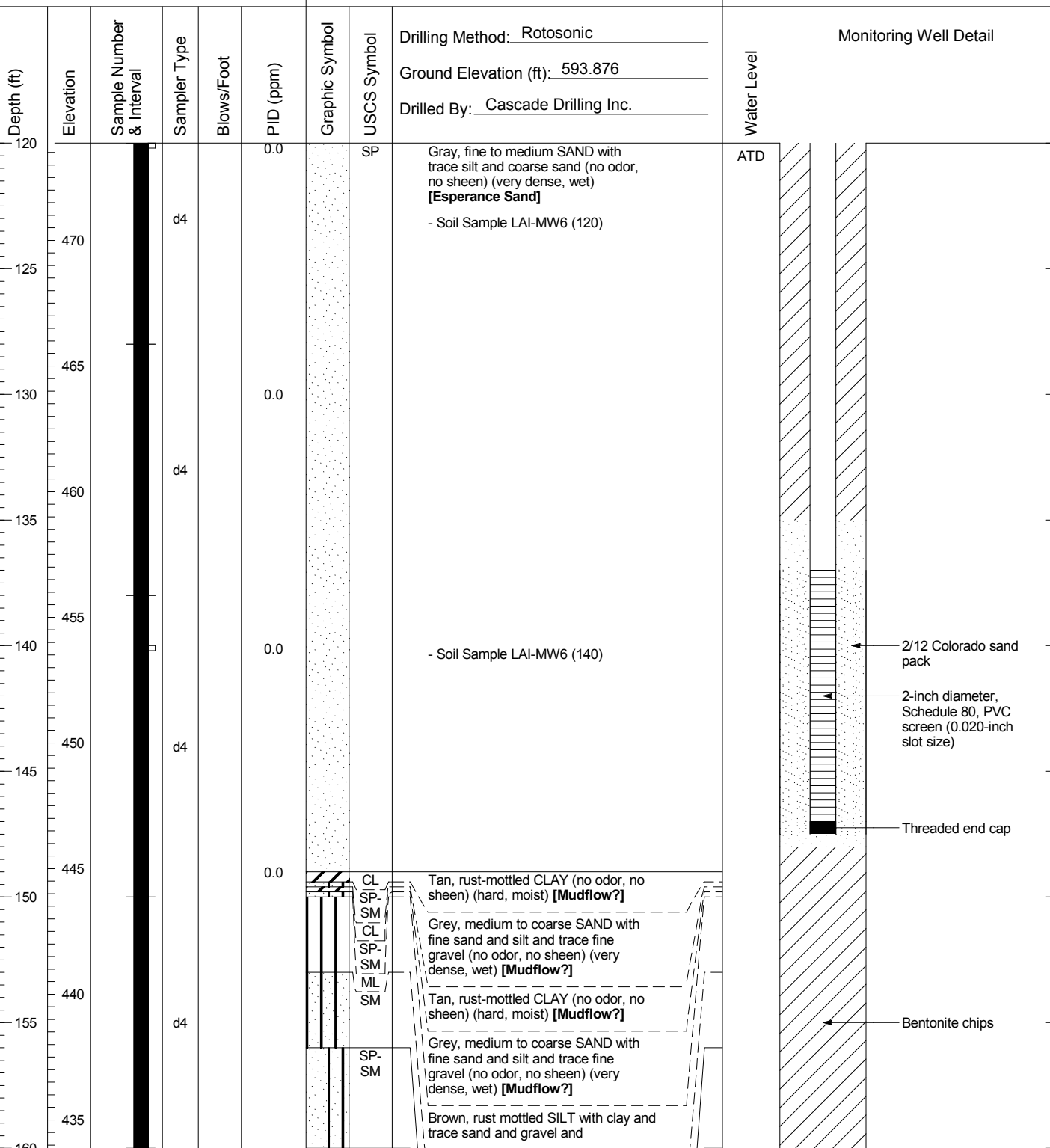
25198.04 1/18/13 \\EDM\DATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW6

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

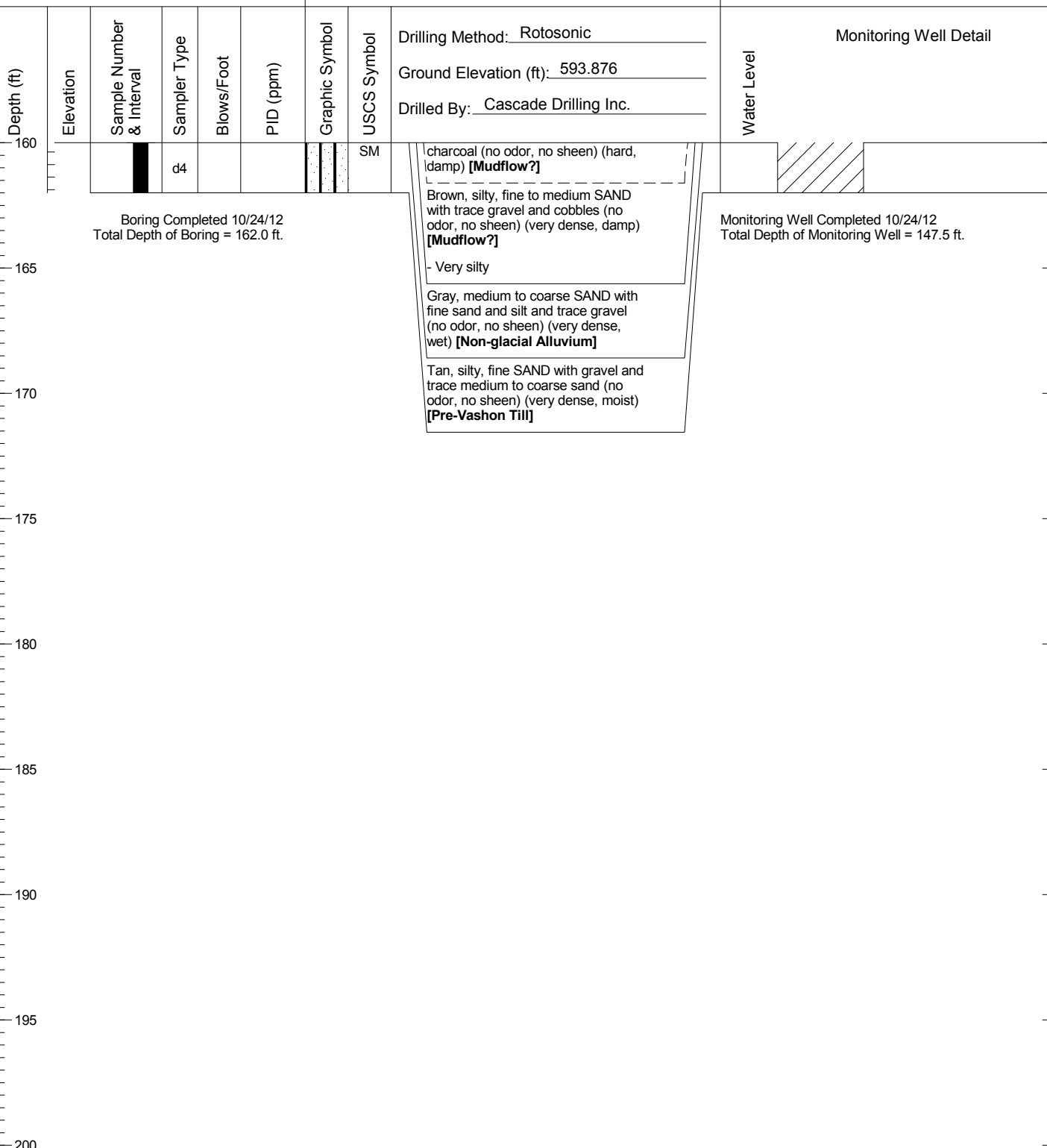
25198.04 1/18/13 \\EDM\DATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW6

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION



LANDAU
ASSOCIATES

ATS Hangar 3 Property
Everett, Washington

Log of Monitoring Well LAI-MW6

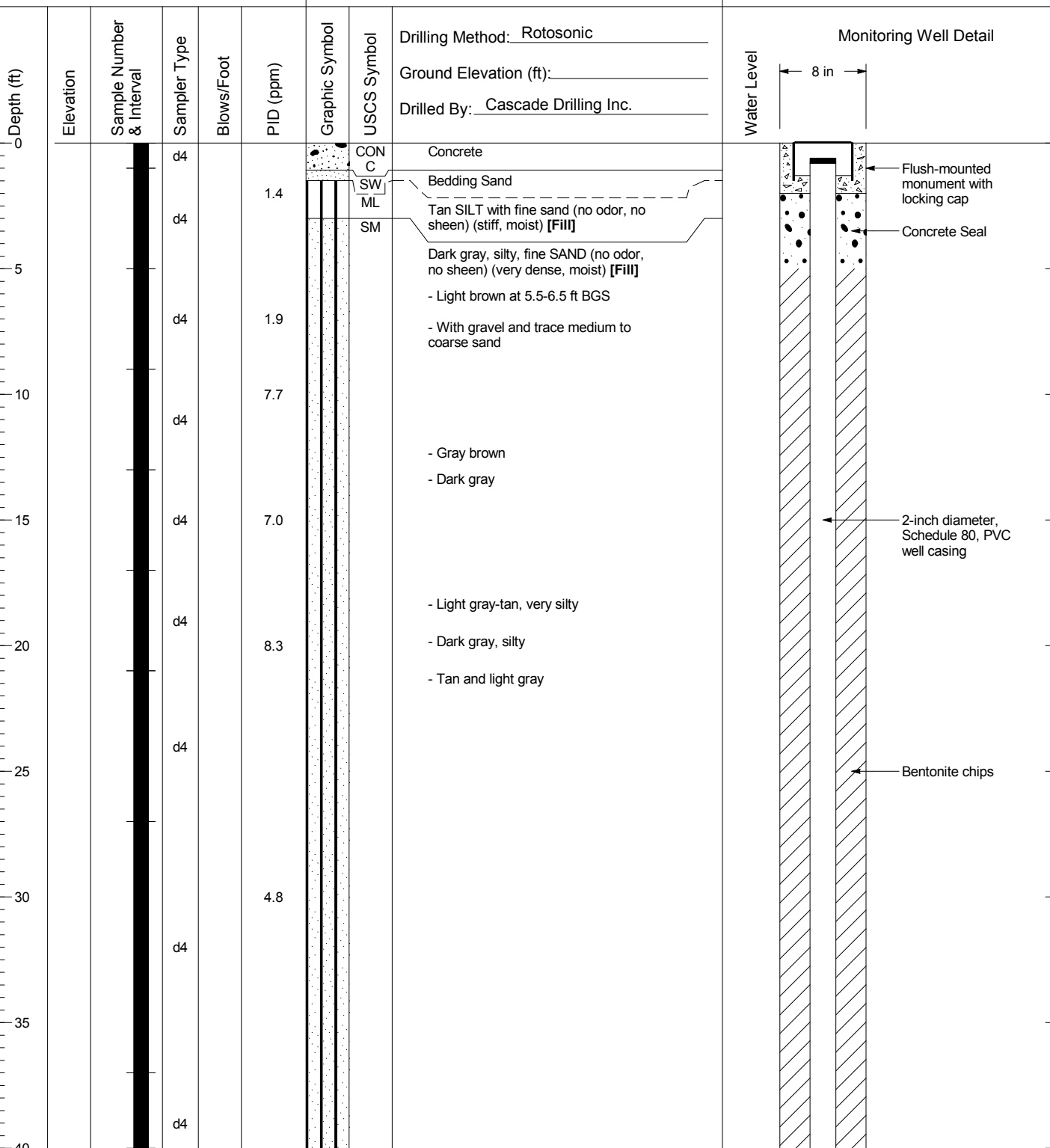
Figure
B-35
(5 of 5)

LAI-MW7

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW7

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Rotosonic</u>	Ground Elevation (ft): _____	Drilled By: <u>Cascade Drilling Inc.</u>	Water Level	Monitoring Well Detail
40					10.8		SM	Dark gray, silty, fine SAND (no odor, no sheen) (very dense, moist) [Fill]				
			d4					- Soil Sample LAI-MW7 (40)				
45												
			d4									
50					9.2			- Soil Sample LAI-MW7 (50)				
			d4					- Gravelly, with cobbles and trace medium to coarse sand				
55								- Abundant cobbles at 57-58 ft BGS				
			d4					- Occasional cobbles, gravelly				
60					7.1			- Soil Sample LAI-MW7 (60)				
			d4					- With gravel, no cobbles				
65								- 8" diameter cobble at 65 ft BGS				
			d4					- Gravelly				
70					3.3							
			d4					- With gravel				
75												
								- Silt content is approximately 20%; still silty				
80												

- Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

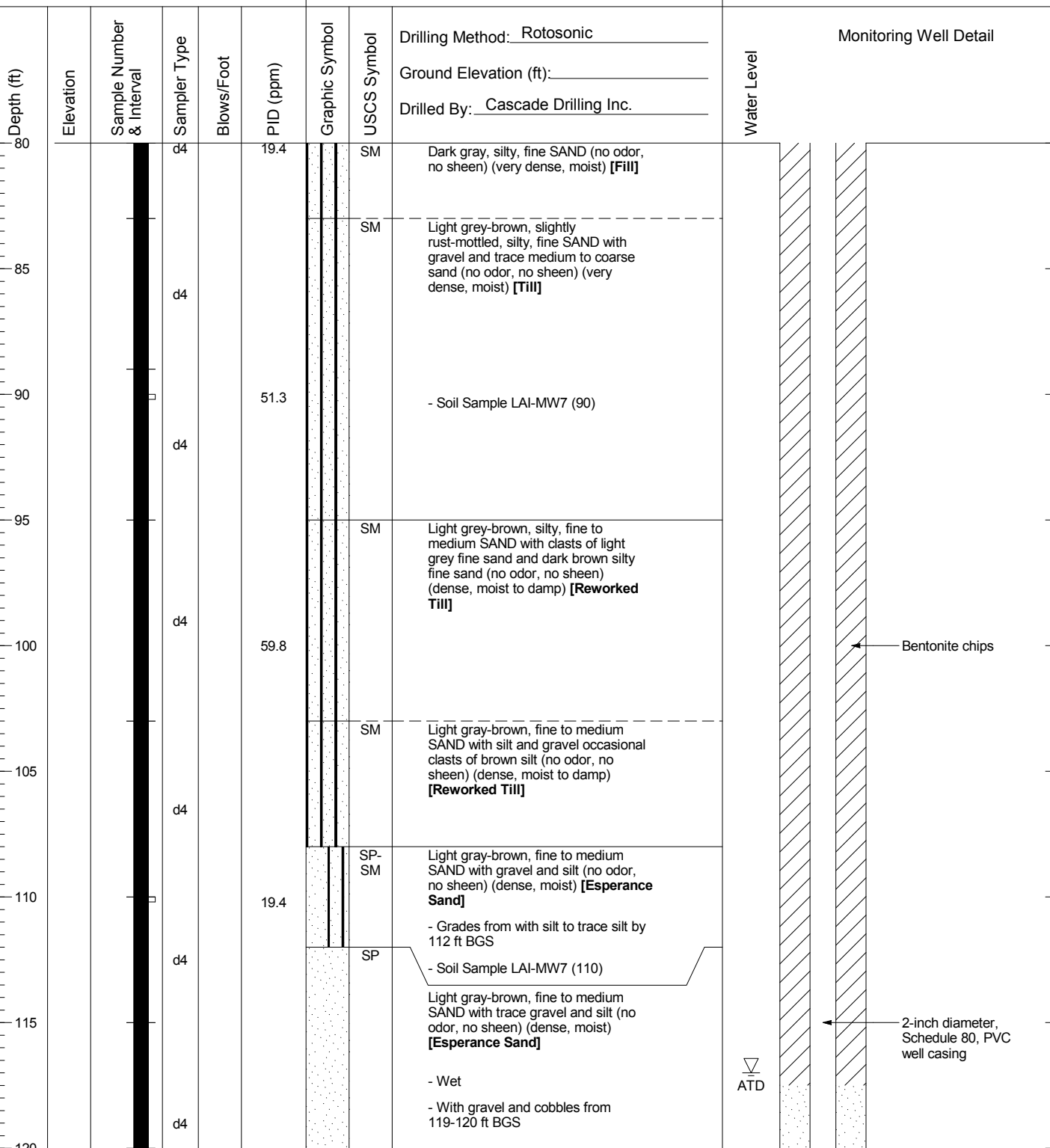
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW7

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

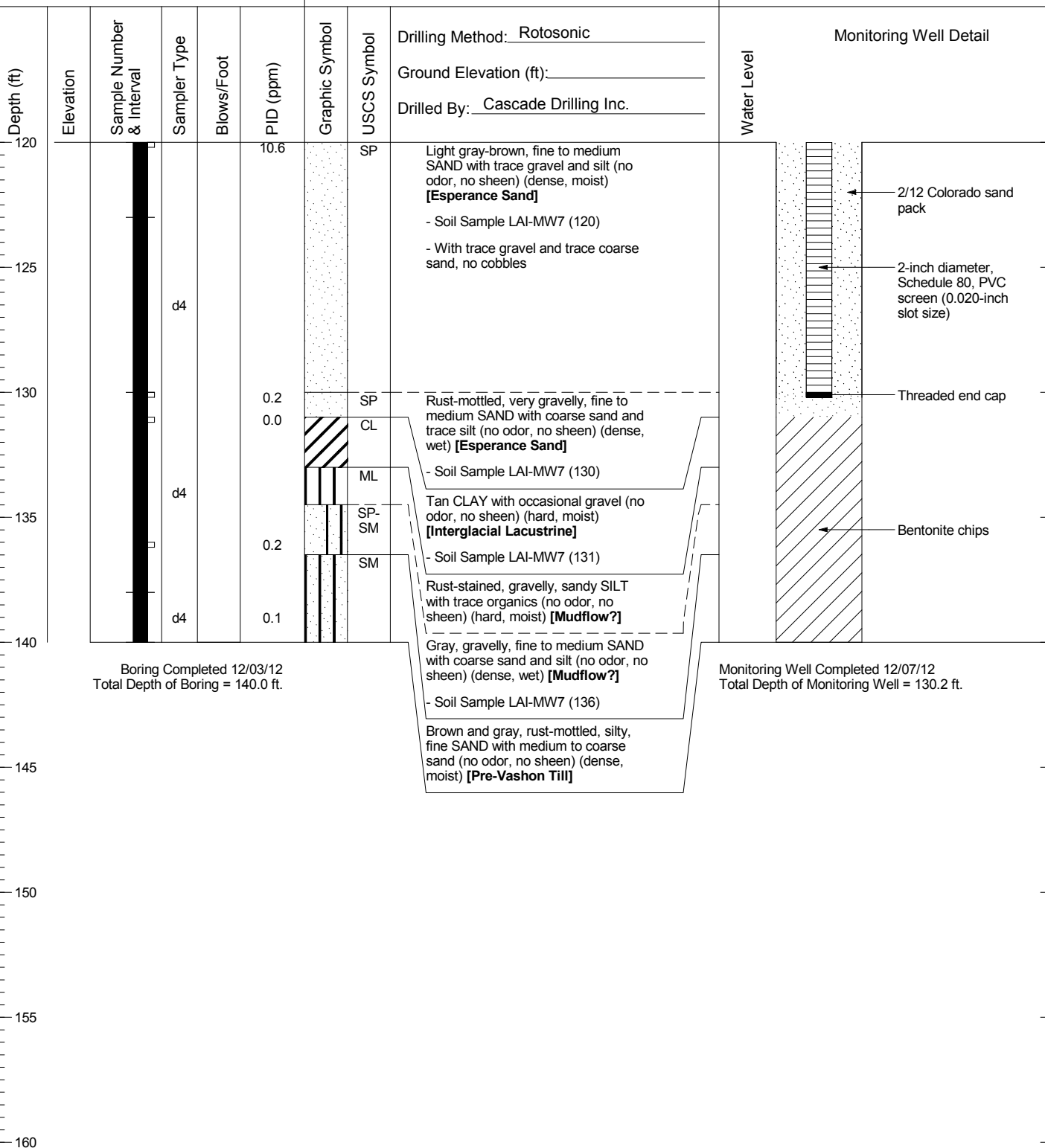
25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION

LAI-MW7

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

25198.04 1/18/13 \\EDMDATA01\GINT\PROJECTS\0025198.04\0.046.GPJ WELL LOG W/ ELEVATION



LANDAU
ASSOCIATES

ATS Hangar 3 Property
Everett, Washington

Log of Monitoring Well LAI-MW7

Figure

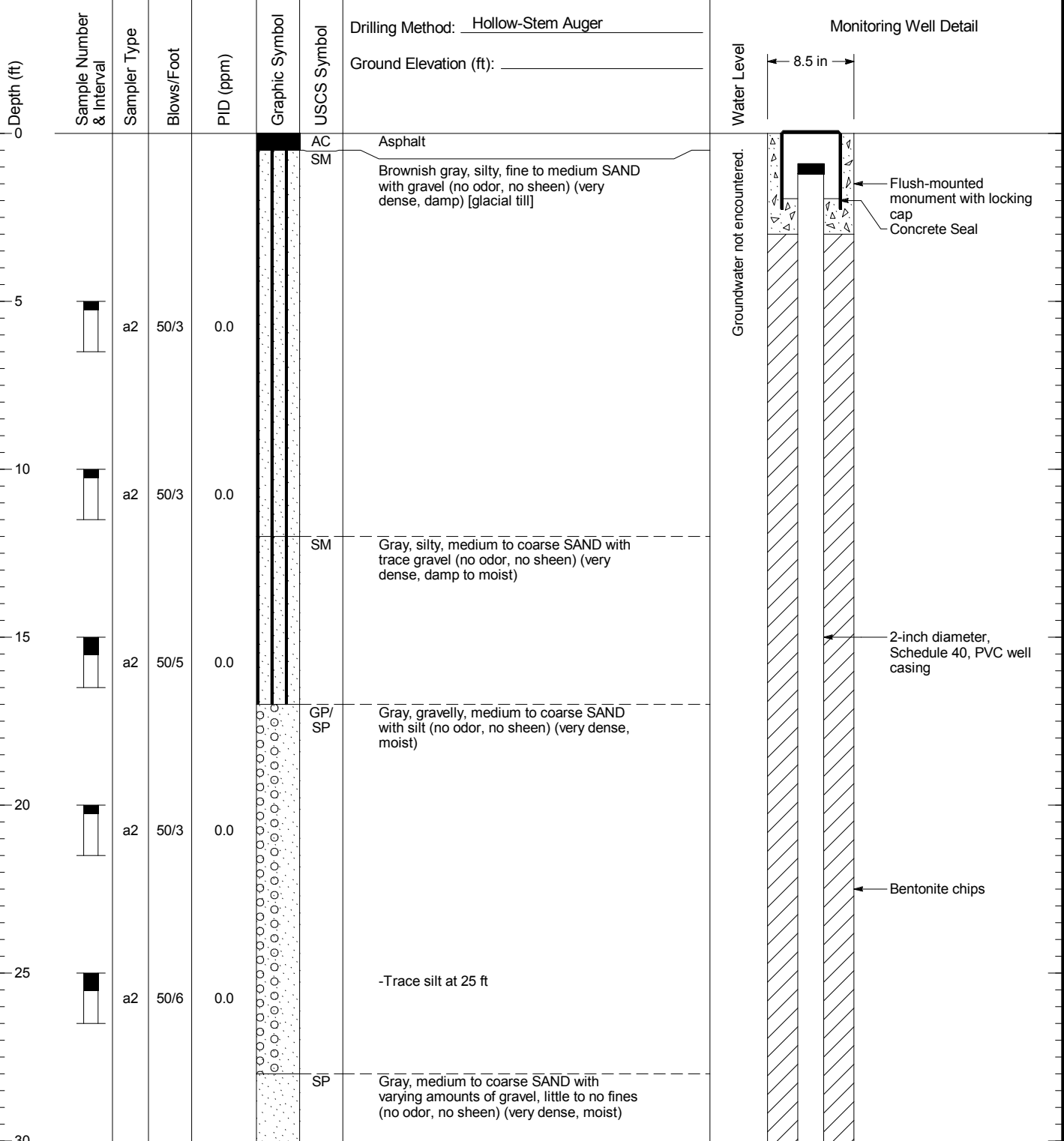
B-36
(4 of 4)

HP-30D

SAMPLE DATA

SOIL PROFILE

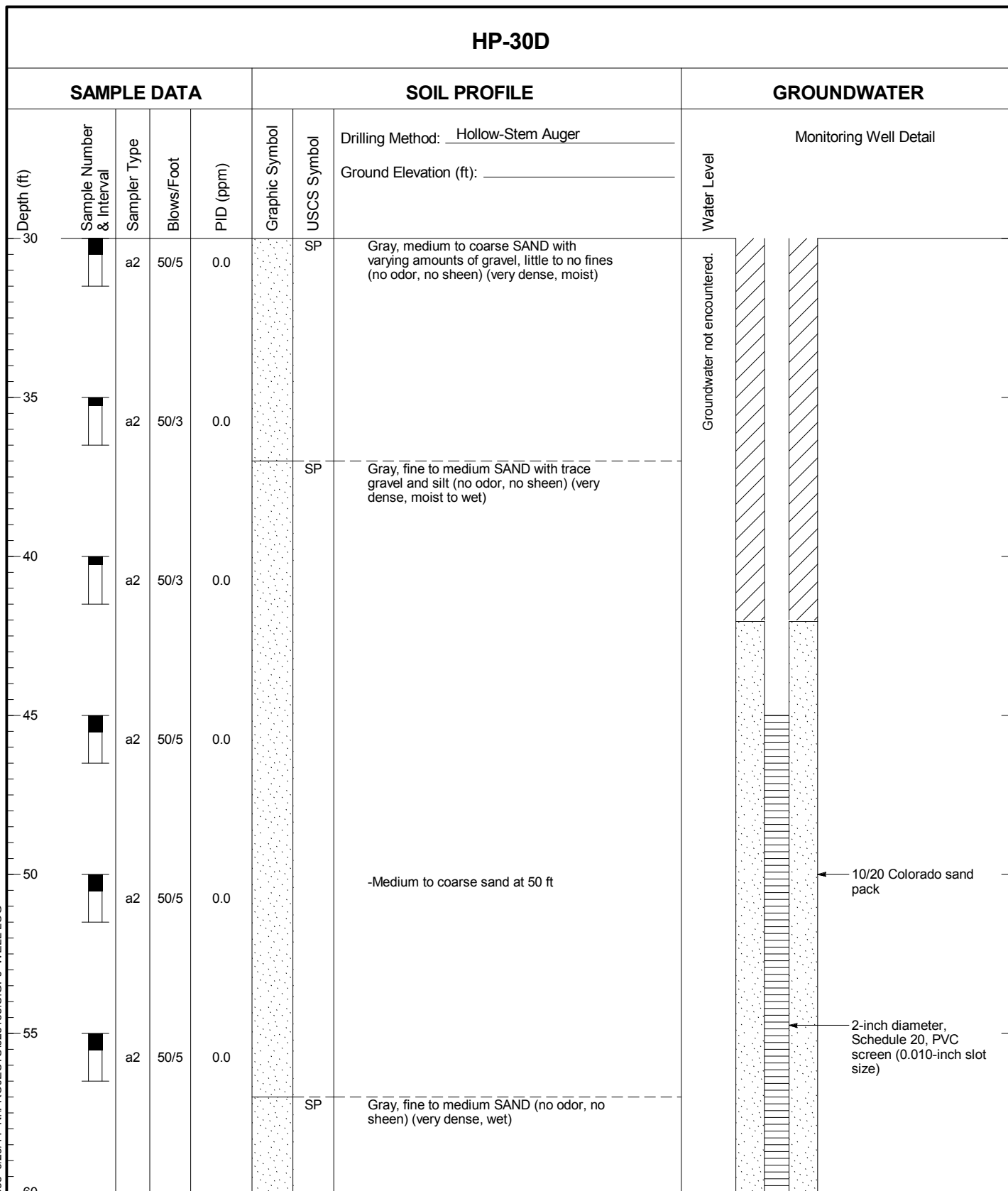
GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

025158.030.035 6/29/11 N:\PROJECTS\025158.C.GPJ WELL LOG

025158.030.035 6/29/11 N:\PROJECTS\025158.C.GPJ WELL LOG



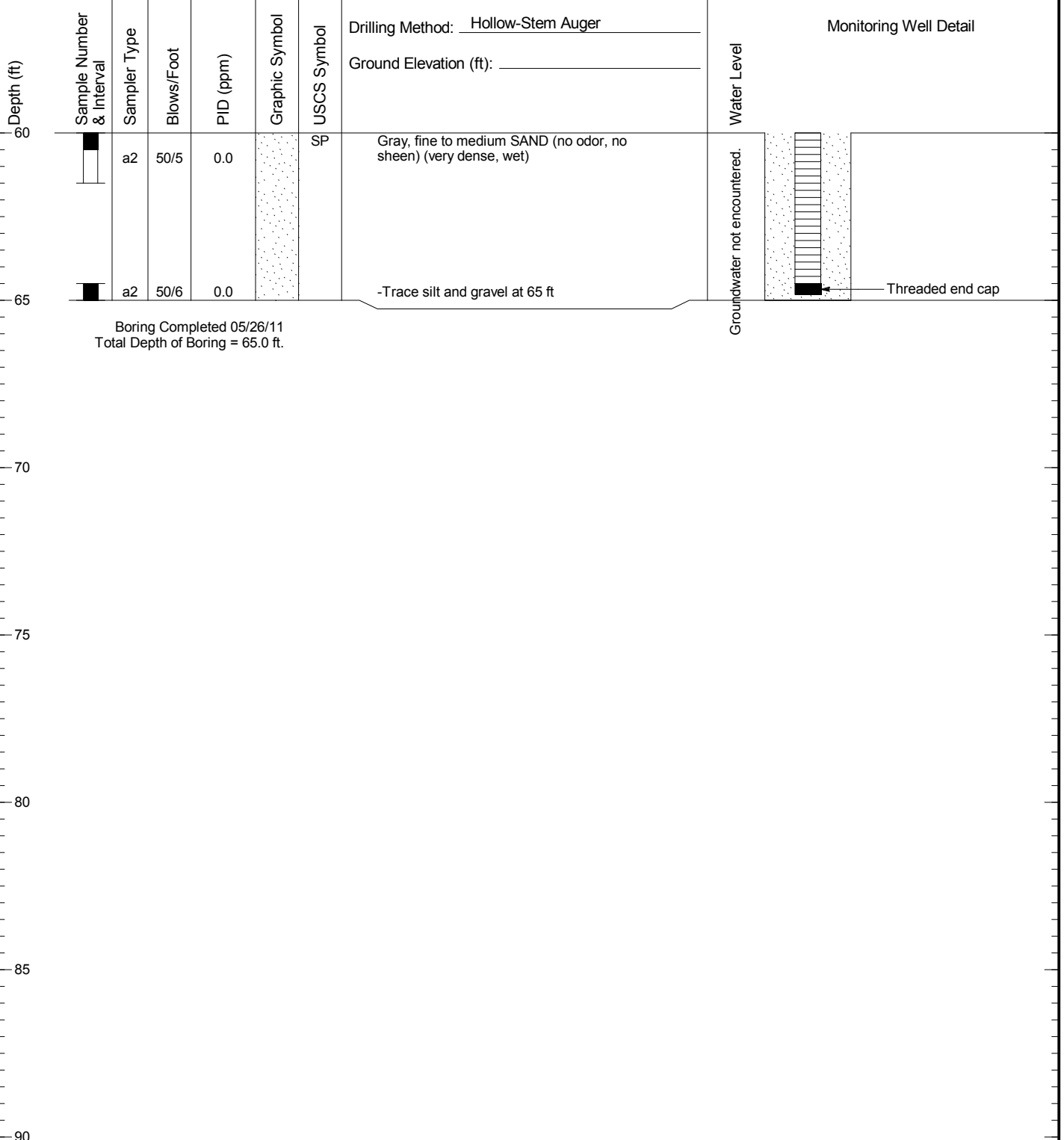
- Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

HP-30D

SAMPLE DATA

SOIL PROFILE

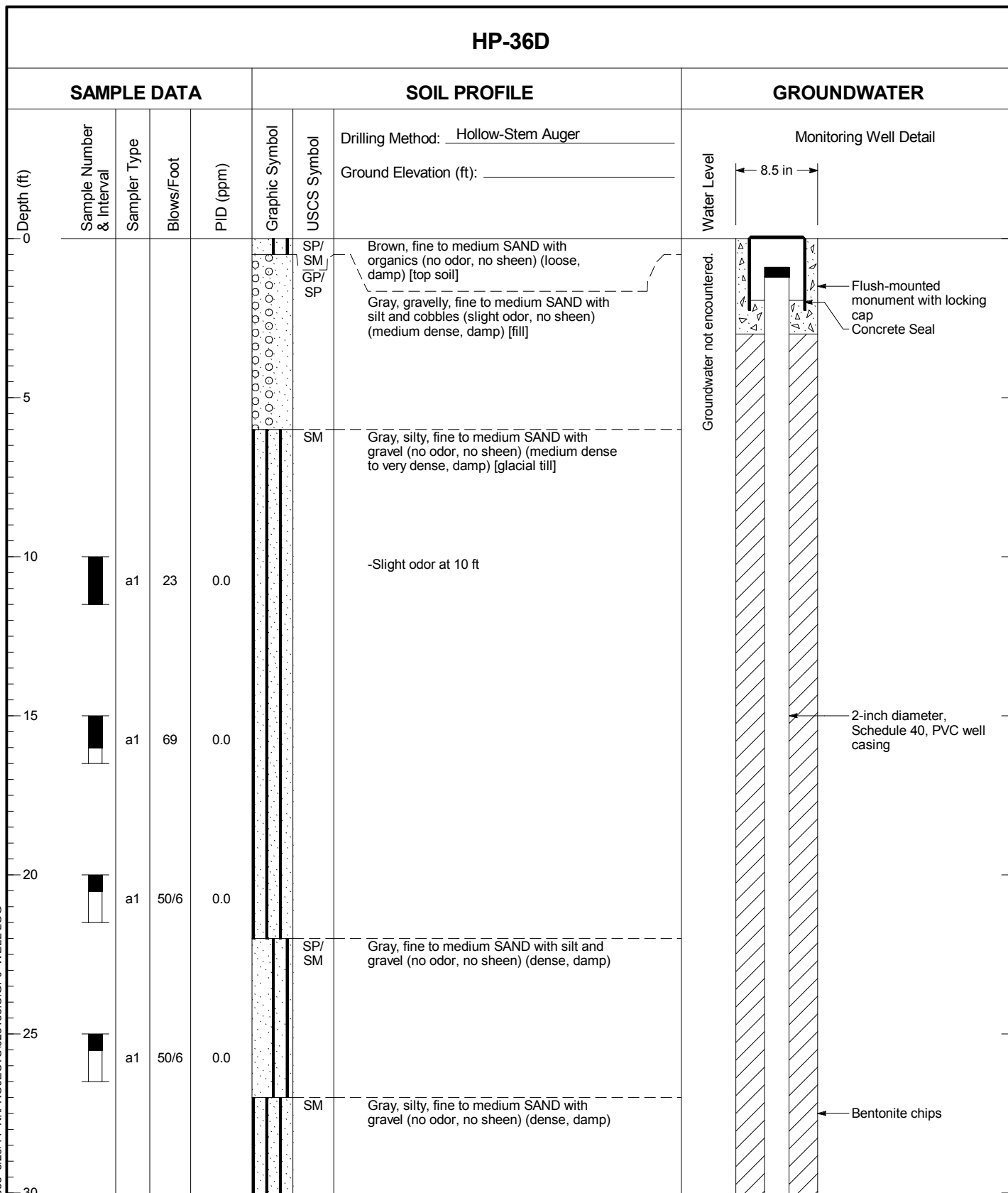
GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

025158.030.035 6/29/11 N:\PROJECTS\025158.C.GPJ WELL LOG

025158.030.035 6/29/11 N:\PROJECTS\025158.C.GPJ WELL LOG



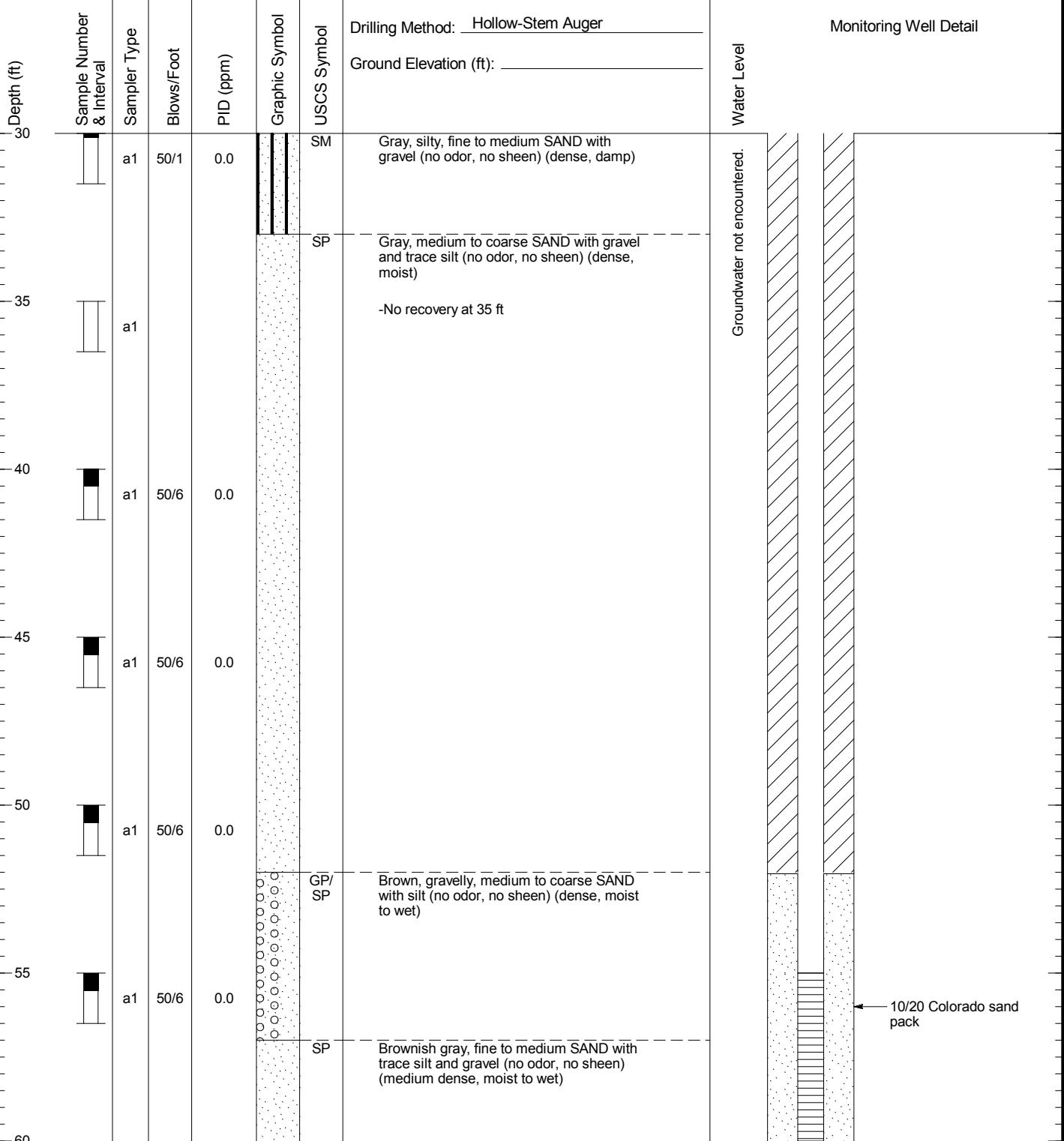
- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

HP-36D

SAMPLE DATA

SOIL PROFILE

GROUNDWATER



- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

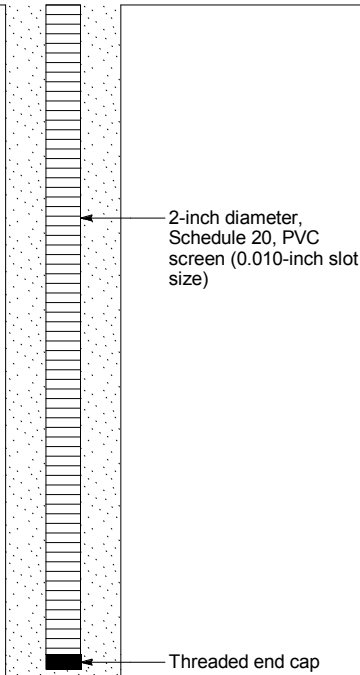
025158.030.035 6/29/11 N:\PROJECTS\025158.C.GPJ WELL LOG

HP-36D

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: <u>Hollow-Stem Auger</u>		Water Level	Monitoring Well Detail	
							Ground Elevation (ft): _____				
60		a1	28	0.0		SP	Brownish gray, fine to medium SAND with trace silt and gravel (no odor, no sheen) (medium dense, moist to wet)		Groundwater not encountered.		
65		a1	38	0.0							
70		a1	16	0.0							
75		a1	16	0.0							

Boring Completed 06/01/11
Total Depth of Boring = 75.0 ft.

- Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
 2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
 3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

025158.030.035 6/29/11 N:\PROJECTS\025158.C.GPJ WELL LOG

346817

GROUND SOURCE HEAT PUMP BORING

28-4E-27D

START CARD NO. 6036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: CHRIS GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 T28N R4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
Mukilteo 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/1/08
 DEVELOPED: N/A

Soil Type Depth (in feet below ground surface) Well Tag BBK-408

0-166'
 silt & GRAVEL

0

Surface Seal/#Sacks

N/A

66'-200'
 sand & GRAVEL

200'-300'

silt w/ GRAVEL

Bentonite Seal/#Sacks

15 Grout
45 Sand #70

Diameter of Borehole

6"

Remarks:

All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

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JUL 11 2009
 Water Resources Program
 Department of Ecology

346818

GROUND SOURCE HEAT PUMP BORING

28-4E-27D

START CARD NO. G036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: Chris GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
Mukilteo 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/2/08
 DEVELOPED: N/A

Soil Type

Depth (in feet below ground surface) Well Tag BBK-409

0-166'
 Silt & GRAVEL
 166'-200'
 sand & GRAVEL
 200'-300'
 silt w/ GRAVEL

0



Surface Seal/#Sacks

N/A

Bentonite Seal/#Sacks

15 Grout
45 Sand #70

Diameter of Borehole

6"

Remarks:

All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

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 Water Resources Program
 Department of Ecology

346819

GROUND SOURCE HEAT PUMP BORING

SB-4E-27D

START CARD NO. 6036008

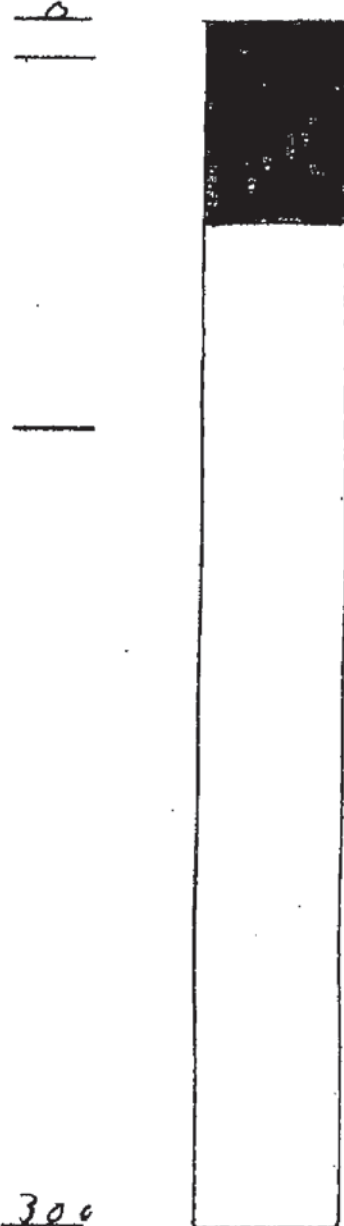
PROJECT NAME: MUKILTEO City Mall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: Chris GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: N/A
 DEVELOPED: N/A

Water Resources Program
 Department of Ecology
 JUL 01 2009

Soil Type _____ Depth (in feet below ground surface) WELL TAG BBK-410

0-166'
 silt & GRAVEL
 166'-200'
 sand & GRAVEL
 200'-300'
 silt w/ GRAVEL



Surface Seal/#Sacks N/A

Bentonite Seal/#Sacks 15 Grout
45 Sand #70

Diameter of Borehole 6"

300

Remarks: All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

346820

GROUND SOURCE HEAT PUMP BORING

28-4E-27D

START CARD NO. 6036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: Chris GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/3/08
 DEVELOPED: N/A

Water Resources Program
 Department of Ecology
 JUL 01 2008

Soil Type Depth (in feet below ground surface) WELL TAG BBK-411

0-166'
 silt & GRAVEL
 166'-200'
 sand & GRAVEL
 200'-300'
 silt w/ GRAVEL



Surface Seal/#Sacks N/A

Bentonite Seal/#Sacks 15 Grout
45 Sand #70

Diameter of Borehole 6"

Remarks:

All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

346821

GROUND SOURCE HEAT PUMP BORING

START CARD NO. 6036008

PROJECT NAME: MUKILTEO C. Ty MAIL
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: CHRIS GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/7/08
 DEVELOPED: N/A

Soil Type Depth (in feet below ground surface) Well TAB BBK-414

0'-166'
 silt & GRAVEL

166'-200'
 sand & GRAVEL

200'-300'
 silt w/ GRAVEL

Surface Seal/#Sacks

N/A

Bentonite Seal/#Sacks

15 Grout
45 Sand #70

Diameter of Borehole

6"

300

Remarks:

All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

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 Water Resources Program
 Department of Ecology

GROUND SOURCE HEAT PUMP BORING

28-4E-27D

346822

START CARD NO. G036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: CHRIS GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/9/08
 DEVELOPED: N/A

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 Water Resources Program
 Department of Ecology

Soil Type _____ Depth (in feet below ground surface) Well TAG BBK-415

0-166'
 silt & GRAVEL

166'-200'
 sand & GRAVEL

200'-300'
 silt w/ GRAVEL

Surface Seal/#Sacks

N/A

Bentonite Seal/#Sacks

15 Grout
45 Sand #70

Diameter of Borehole

6"

300

Remarks:

All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

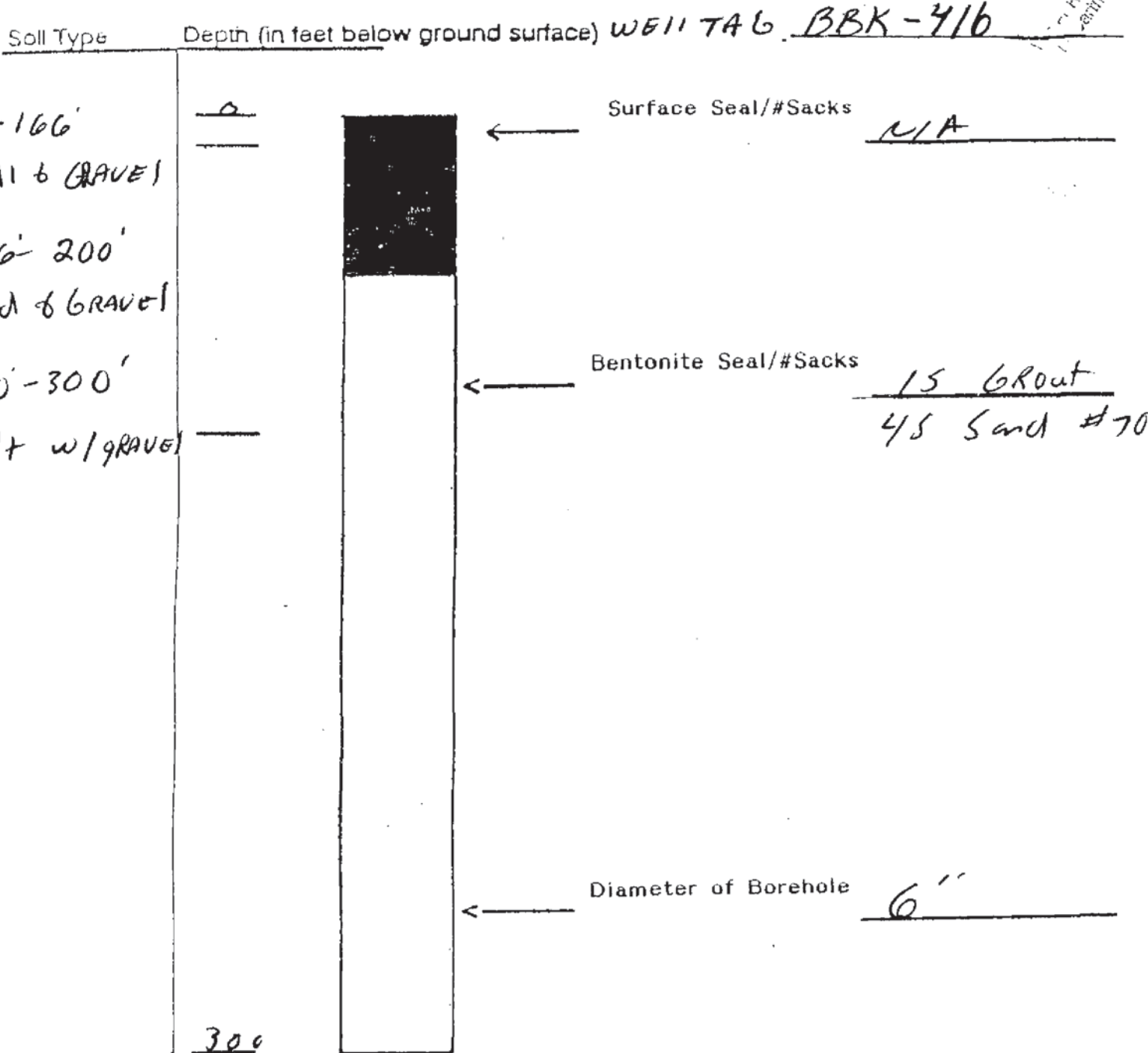
346823 GROUND SOURCE HEAT PUMP BORING 08-4E-27D

START CARD NO. G036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: Chris Gregory
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
Mukilteo 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/10/08
 DEVELOPED: N/A

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 Resources Program
 Department of Ecology



Remarks: All holes drilled to 300'. Installed 1" loop pipe and grout from the bottom to the top.

346825 GROUND SOURCE HEAT PUMP BORING 88-4E-27D

START CARD NO. G036008

PROJECT NAME: MUKILTEO City Hall
WELL IDENTIFICATION NO. N/A
DRILLING METHOD: Mud Rotary
DRILLER: CHRIS GREGORY
FIRM: GREGORY Drilling Inc
SIGNATURE: [Signature]
CONSULTING FIRM: N/A
REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
LOCATION: NW 1/4 NW 1/4 S27 T28N R4E
STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 5/12/08
DEVELOPED: N/A

Soil Type Depth (in feet below ground surface) WELL TAG BBK-417

0-166'
Silt & GRAVEL

166'-200'
Silt & GRAVEL

200'-300'
Silt w/ GRAVEL

Surface Seal/#Sacks

N/A

Bentonite Seal/#Sacks

15 Grout
45 Sand #70

Diameter of Borehole

6"

Remarks:

All holes drilled to 300'. Installed
1" Loop pipe and grout from the bottom
to the top.

JUL 01 2009
Ecology Resources Program
Department of Ecology

346826 GROUND SOURCE HEAT PUMP BORING 3848-27D

START CARD NO. 6036008

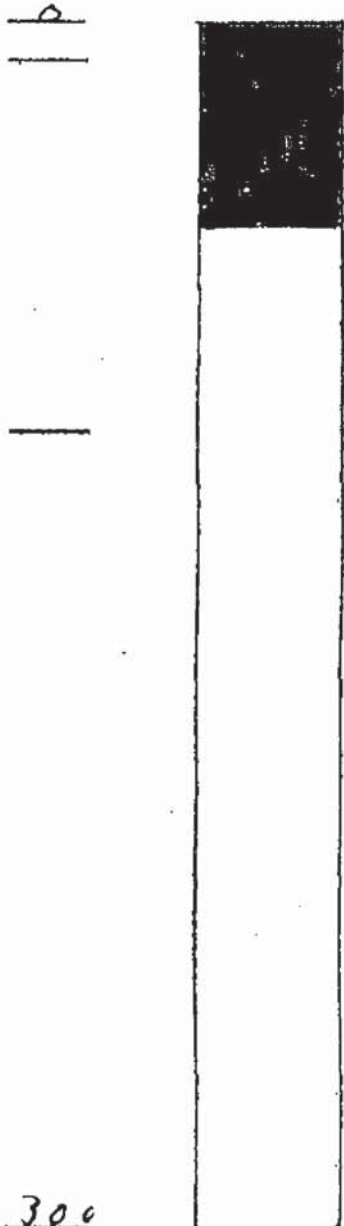
PROJECT NAME: MUKILTEO City Hall
WELL IDENTIFICATION NO. N/A
DRILLING METHOD: Mud Rotary
DRILLER: CHRIS GREGORY
FIRM: GREGORY Drilling Inc
SIGNATURE: [Signature]
CONSULTING FIRM: N/A
REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 5/13/08
DEVELOPED: N/A

Water Resources Program
Department of Ecology
JUL 01 2009

Soil Type _____ Depth (in feet below ground surface) Well TAG BBK-418

0-166'
Silt & GRAVEL
166'-200'
sand & GRAVEL
200'-300'
Silt w/ GRAVEL



Surface Seal/#Sacks N/A

Bentonite Seal/#Sacks 15 Grout
45 Sand #70

Diameter of Borehole 6"

300

Remarks: All holes drilled to 300'. Installed
1" Loop pipe and grout from the bottom
to the top.

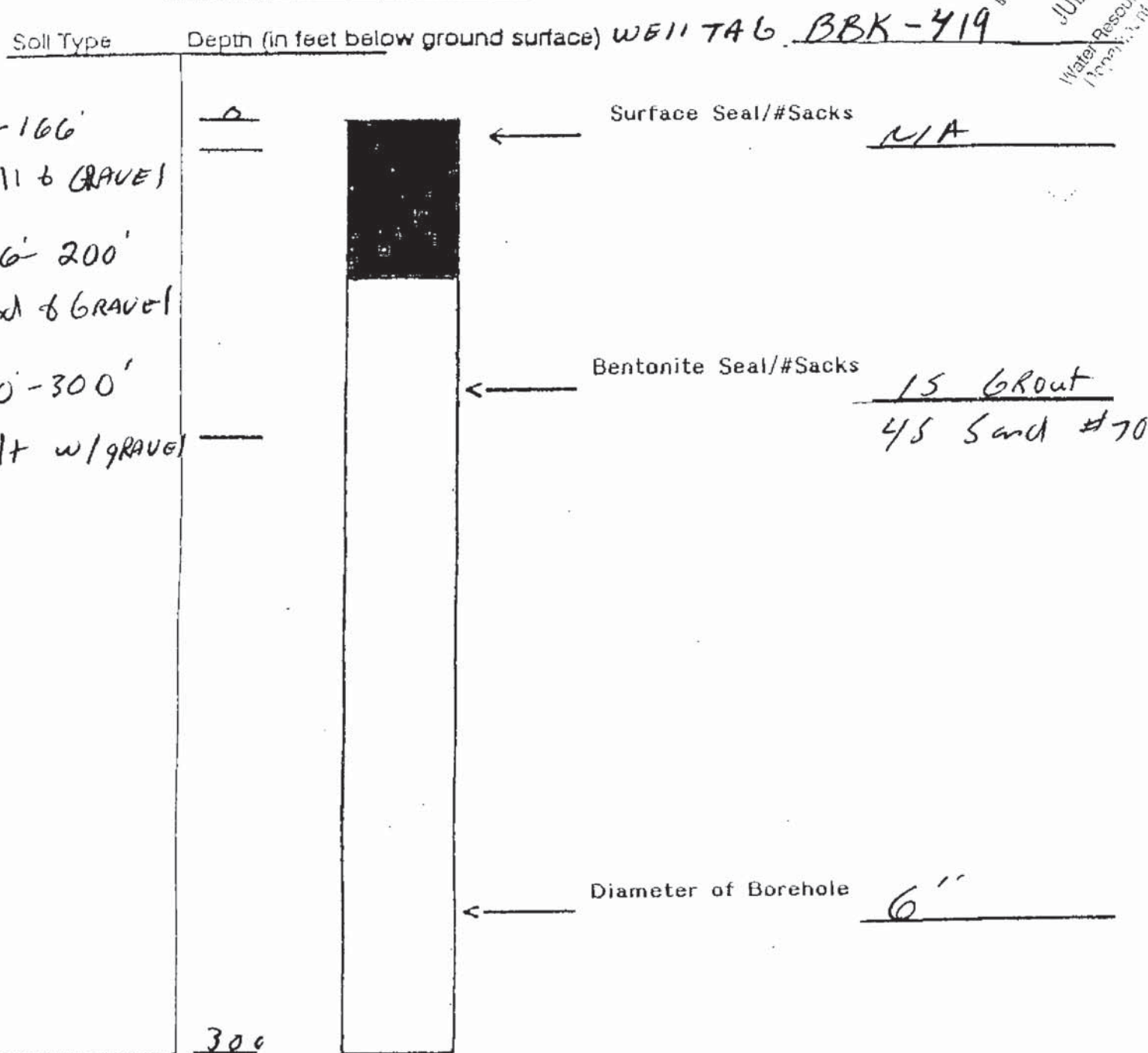
346827 GROUND SOURCE HEAT PUMP BORING 38-4E-27D

START CARD NO. 6036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO.: N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: Chris Gregory
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/14/08
 DEVELOPED: N/A

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 Water Resources Program
 Permit Unit (F&E)



Remarks: All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

346828

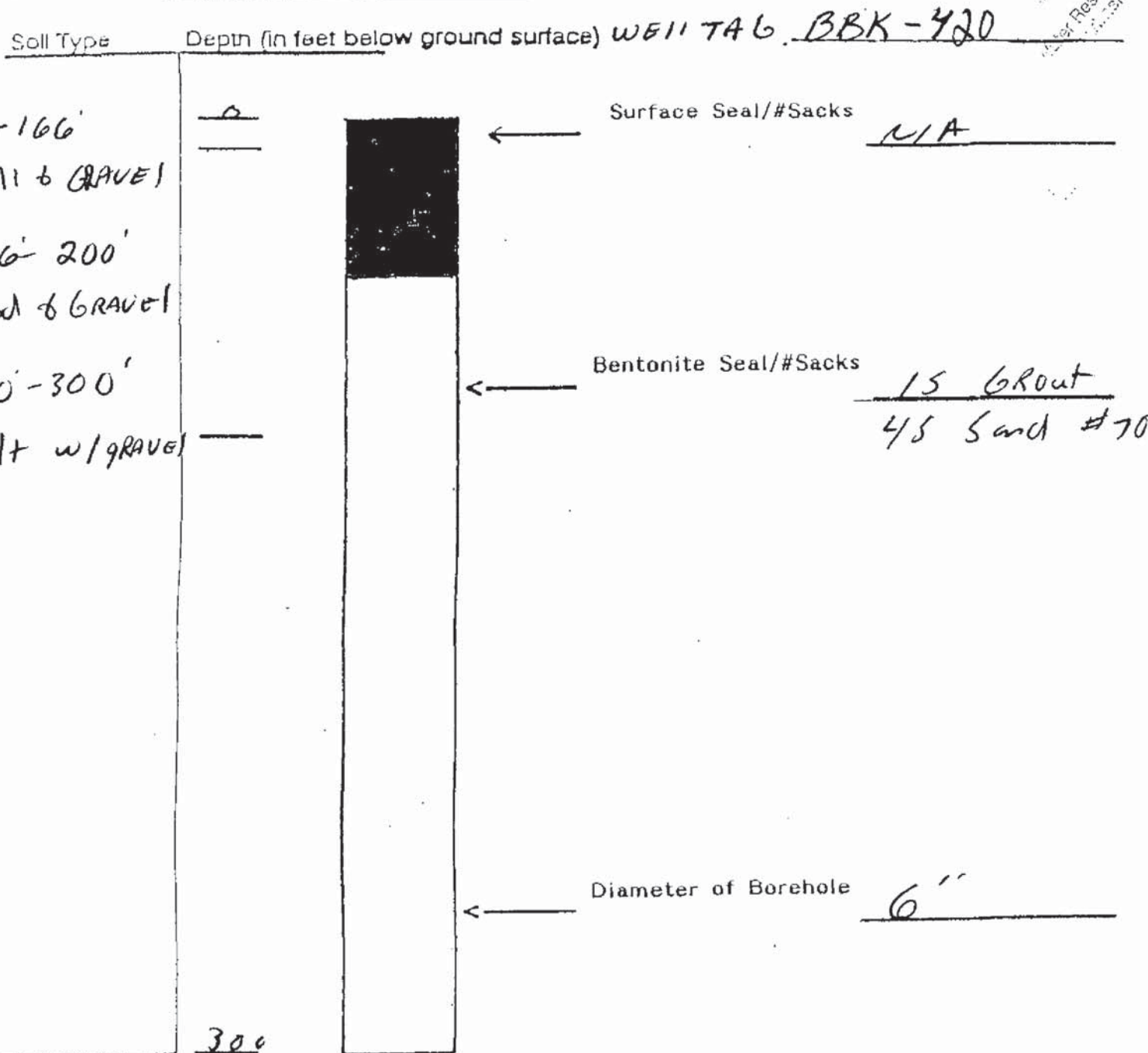
GROUND SOURCE HEAT PUMP BORING

START CARD NO. G036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: Chris Gregory
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/15/08
 DEVELOPED: N/A

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 JUL 11 2009
 Water Resources Program
 Department of Ecology



Remarks: All holes drilled to 300'. Installed
1" Loop pipe and grout from the bottom
to the top.

346829 GROUND SOURCE HEAT PUMP BORING 28-4E-27D START CARD NO. G036008

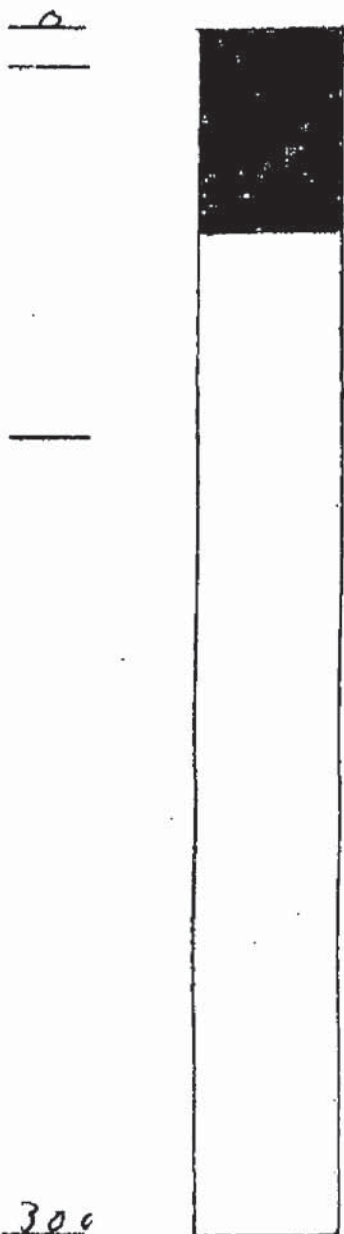
PROJECT NAME: MUKILTEO City Hall
WELL IDENTIFICATION NO: N/A
DRILLING METHOD: Mud Rotary
DRILLER: CHRIS GREGORY
FIRM: GREGORY Drilling Inc
SIGNATURE: [Signature]
CONSULTING FIRM: N/A
REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 5/16/08
DEVELOPED: N/A

Water Resources Program
Department of Ecology
JUL 01 2009

Soil Type _____ Depth (in feet below ground surface) Well TAG BBK-421

0-166'
Silt & GRAVEL
166'-200'
sand & GRAVEL
200'-300'
silt w/ GRAVEL



Surface Seal/#Sacks

N/A

Bentonite Seal/#Sacks

15 Grout
45 Sand #70

Diameter of Borehole

6"

Remarks:

All holes drilled to 300'. Installed
1" Loop pipe and grout from the bottom
to the top.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

346830

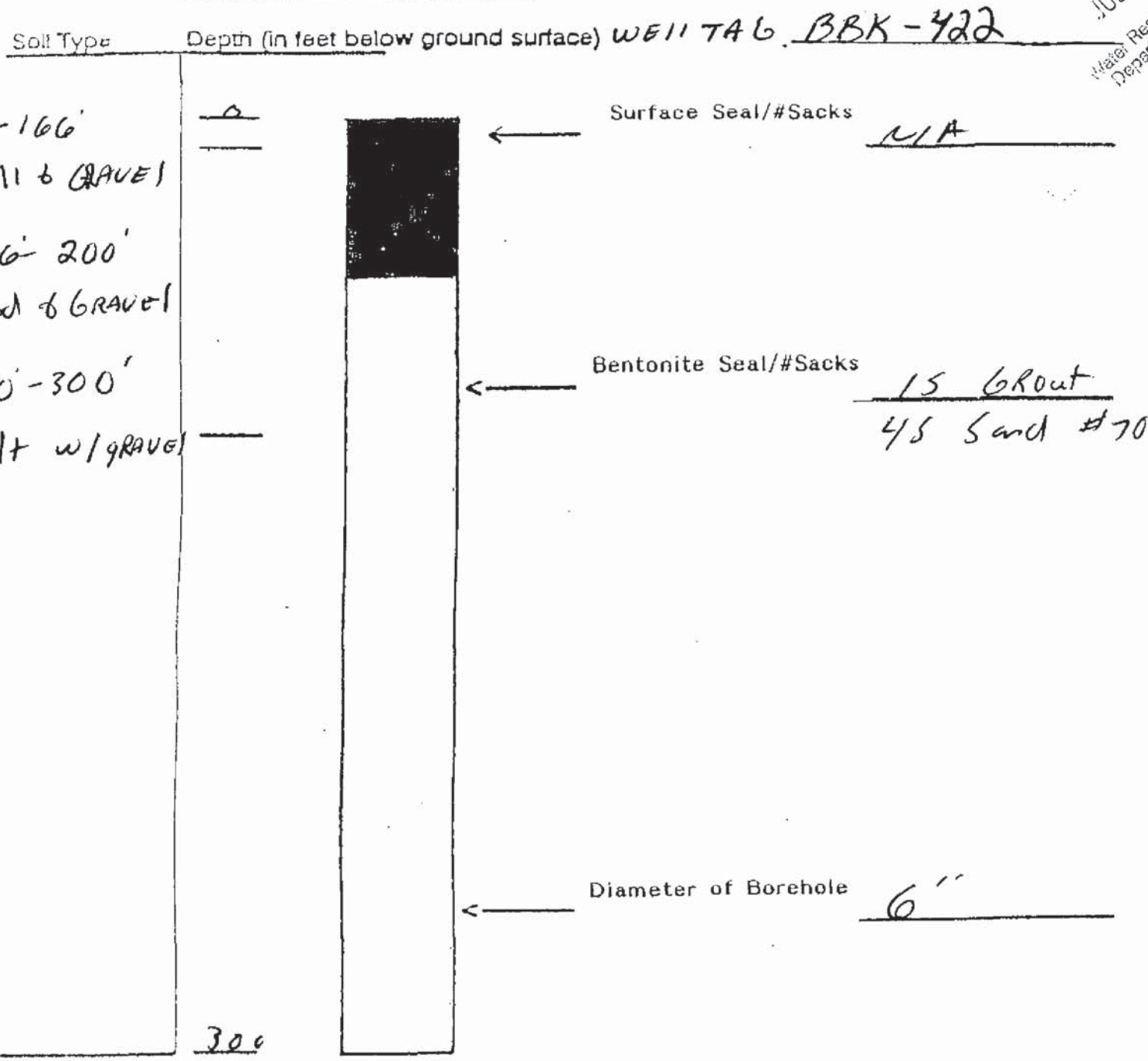
GROUND SOURCE HEAT PUMP BORING 28-4E-27D

START CARD NO. 6036008

PROJECT NAME: MUKILTEO City Hall
WELL IDENTIFICATION NO. N/A
DRILLING METHOD: Mud Rotary
DRILLER: Chris Gregory
FIRM: GREGORY Drilling Inc
SIGNATURE: [Signature]
CONSULTING FIRM: N/A
REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 5/17/08
DEVELOPED: N/A

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JUL 01 2009
Water Resources
Department of Ecology



Remarks: All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

346831

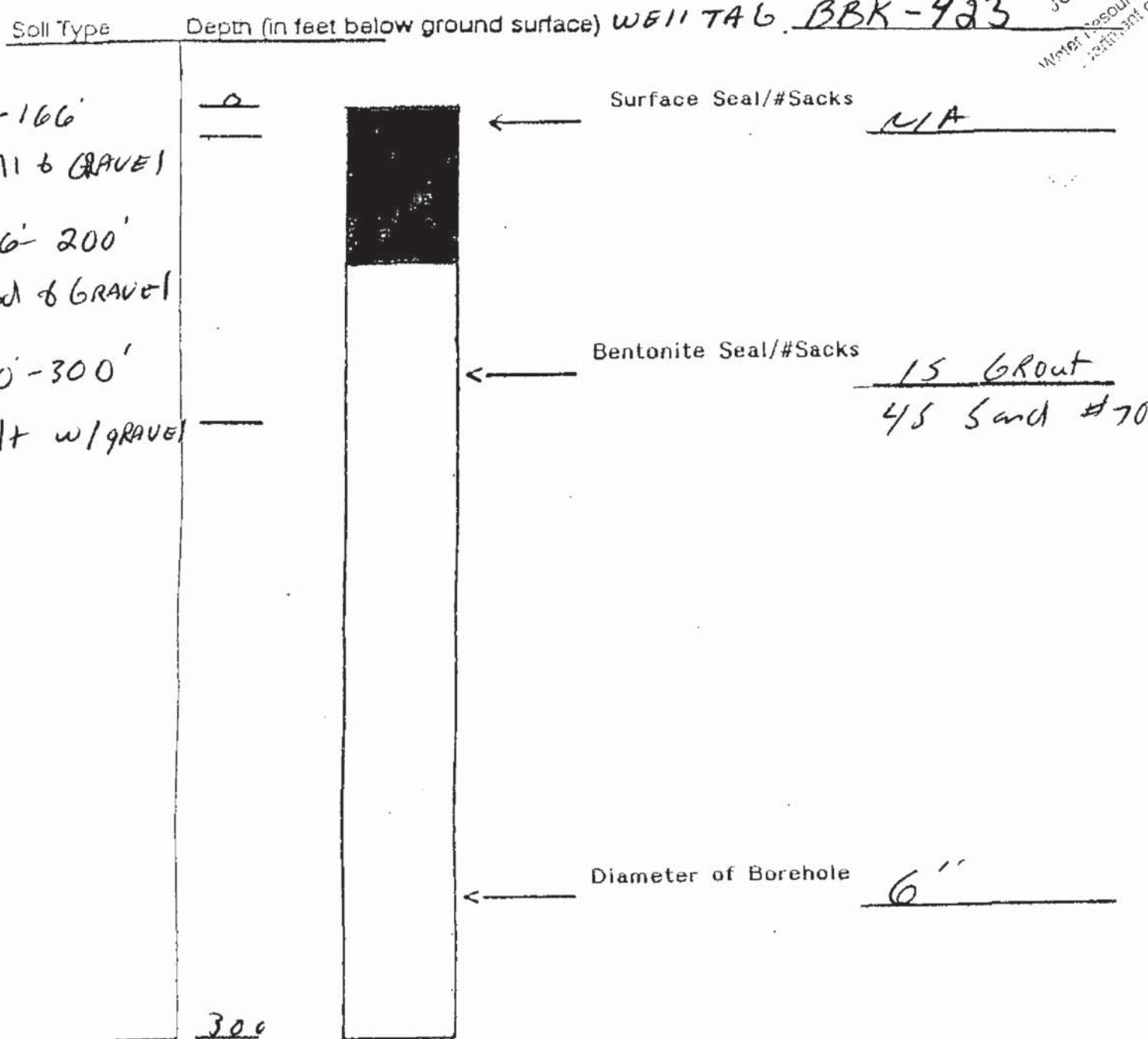
GROUND SOURCE HEAT PUMP BORING

START CARD NO. 0036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: Chris Gregory
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/14/08
 DEVELOPED: N/A

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 Water Resources Program
 Department of Ecology



Remarks: All holes drilled to 300'. Installed
1" Loop pipe and grout from the bottom
to the top.

346832

GROUND SOURCE HEAT PUMP BORING

START CARD NO.

28-4E-27D
G036008

PROJECT NAME: MUKILTEO City Hall
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: CHRIS GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/20/08
 DEVELOPED: N/A

Soil Type _____ Depth (in feet below ground surface) Well TAG BBK-424

0-166'
 silt & GRAVEL

166'-200'
 sand & GRAVEL

200'-300'
 silt w/ GRAVEL

Surface Seal/#Sacks

N/A

Bentonite Seal/#Sacks

15 Grout
45 Sand #70

Diameter of Borehole

6"

Remarks:

All holes drilled to 300'. Installed
1" Loop pipe and grout from the bottom
to the top.

JUL 1 2009
 Department of Ecology
 Resources Program

346833

GROUND SOURCE HEAT PUMP BORING

START CARD NO. 6036008

PROJECT NAME: MUKILTEO City HALL
 WELL IDENTIFICATION NO. N/A
 DRILLING METHOD: Mud Rotary
 DRILLER: CHRIS GREGORY
 FIRM: GREGORY Drilling Inc
 SIGNATURE: [Signature]
 CONSULTING FIRM: N/A
 REPRESENTATIVE: N/A

COUNTY: 31-Snohomish
 LOCATION: NW 1/4 NW 1/4 Sec 27 Twn 28N R 4E
 STREET ADDRESS OF WELL: 11930 CYRUS WAY
MUKILTEO 98257
 WATER LEVEL ELEVATION: N/A
 GROUND SURFACE ELEVATION: N/A
 INSTALLED: 5/21/08
 DEVELOPED: N/A

Soil Type _____ Depth (in feet below ground surface) Well TAB BBK-425

0-166'
 Silt & GRAVEL

166'-200'
 sand & GRAVEL

200'-300'
 silt w/ GRAVEL

Surface Seal/#Sacks

N/A

Bentonite Seal/#Sacks

15 Grout45 Sand #70

Diameter of Borehole

6"

Remarks:

All holes drilled to 300'. Installed
1" loop pipe and grout from the bottom
to the top.

JUL 01 2009
 Resources Program
 Department of Ecology

APPENDIX E

Rising Head Slug Test Results for MW-7

Attachment C

Soil Hydraulic Conductivity Testing Results

Slug Testing Test Methods

The Riley Group, Inc. (Riley) conducted rising head slug tests on one Site monitoring well (MW7)) to obtain information on the hydraulic parameters of the shallow unconfined water-bearing zone underlying the Site. The slug tests were conducted on October 12, 2005. The locations of the monitoring wells are provided in Figure 1.

All slug tests were performed with slug bar. For this, a 3-foot-long by 1-inch diameter rod was lowered below the water level in the well. After allowing the initial displacement to reach equilibrium, the bar was quickly removed from the well, and the water level recovery was monitored with the transducer-datalogger system.

Aquifer Response and Slug Test Analyses

Results of the rising head pneumatic slug test are shown on attached semi-log time-displacement plots. Several tests were performed at each well. Most tests were complete with a period of 30 to 40 minutes. The curves generally showed similar aquifer responses at differing initial displacements. Rising head slug test results were analyzed using the Bouwer and Rice (1976) method.

The time-displacement plots generally conformed to the straightforward aquifer response envisioned for the original Bouwer and Rice (1976) method with the exception that greater displacement was observed in the early part of the tests than expected based on the position of the line fitted to the straight line (later) portion of the tests used for parameter estimation. The excess displacement at the start of these tests may be a result of well bore storage or well efficiency effects. The parameters, coefficients, and the results of the analysis are tabulated in Table A-1.

Results and Conclusions

The slug tests measured the hydraulic conductivity (K) within an estimated radius of approximately 10 feet of the wells. The range estimated K values between 1.48×10^{-4} and 1.68×10^{-4} centimeter/second (cm/s). No horizontal trend in K was apparent across the area.

References

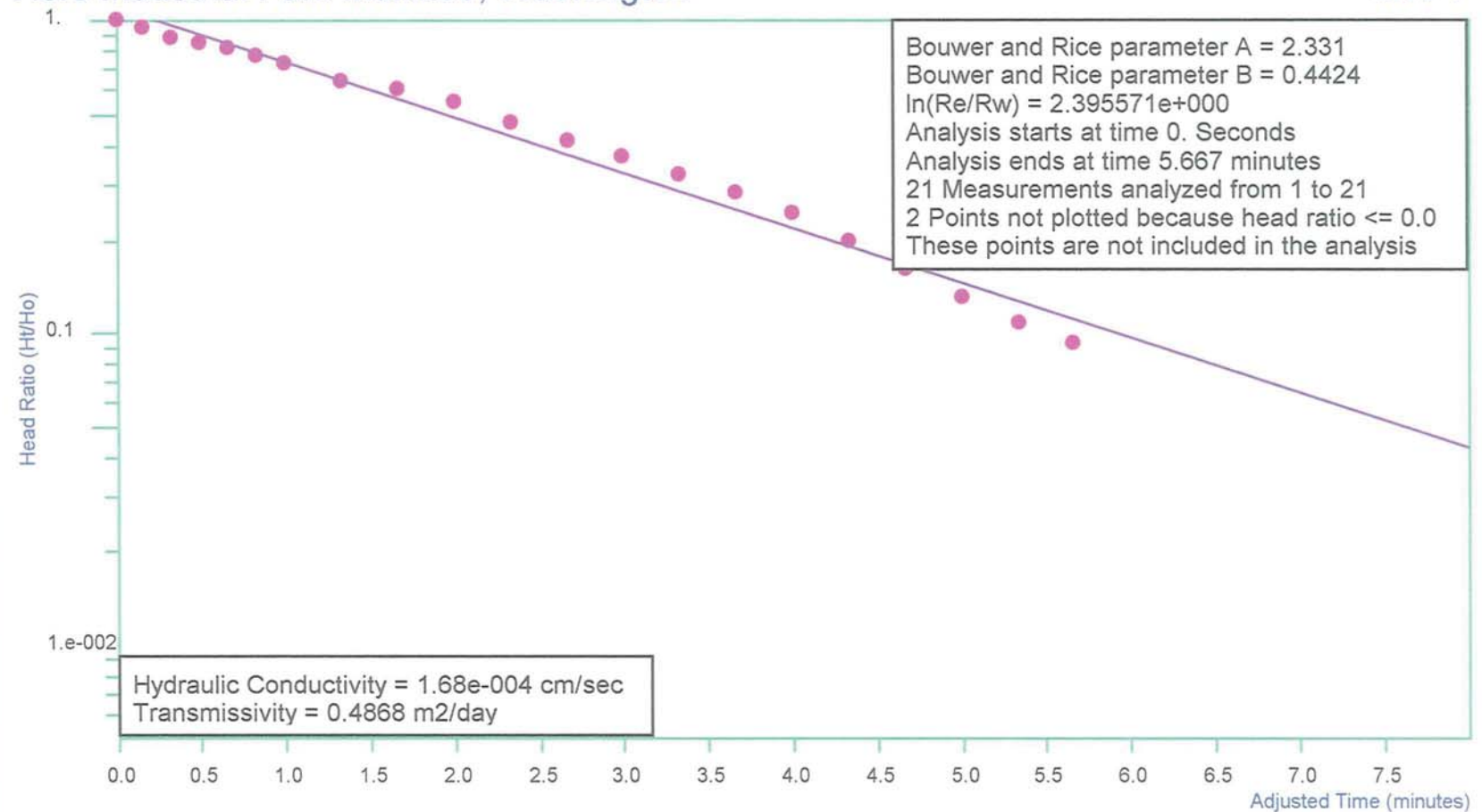
Bouwer, H. and R.C. Rice, 1976, A Slug Test for Determining Hydraulic Conductivity Of Unconfined Aquifers With Completely Or Partially Penetrating Wells, Water Resources Research, Vol.12, pg. 423-428.

Slug Test #1

Hers Industrial Park Mukilteo, Washington

Bouwer and Rice Graph

MW-7



Project Number: 2005-087c for Romeo Gonyea
Analysis by Starpoint Software

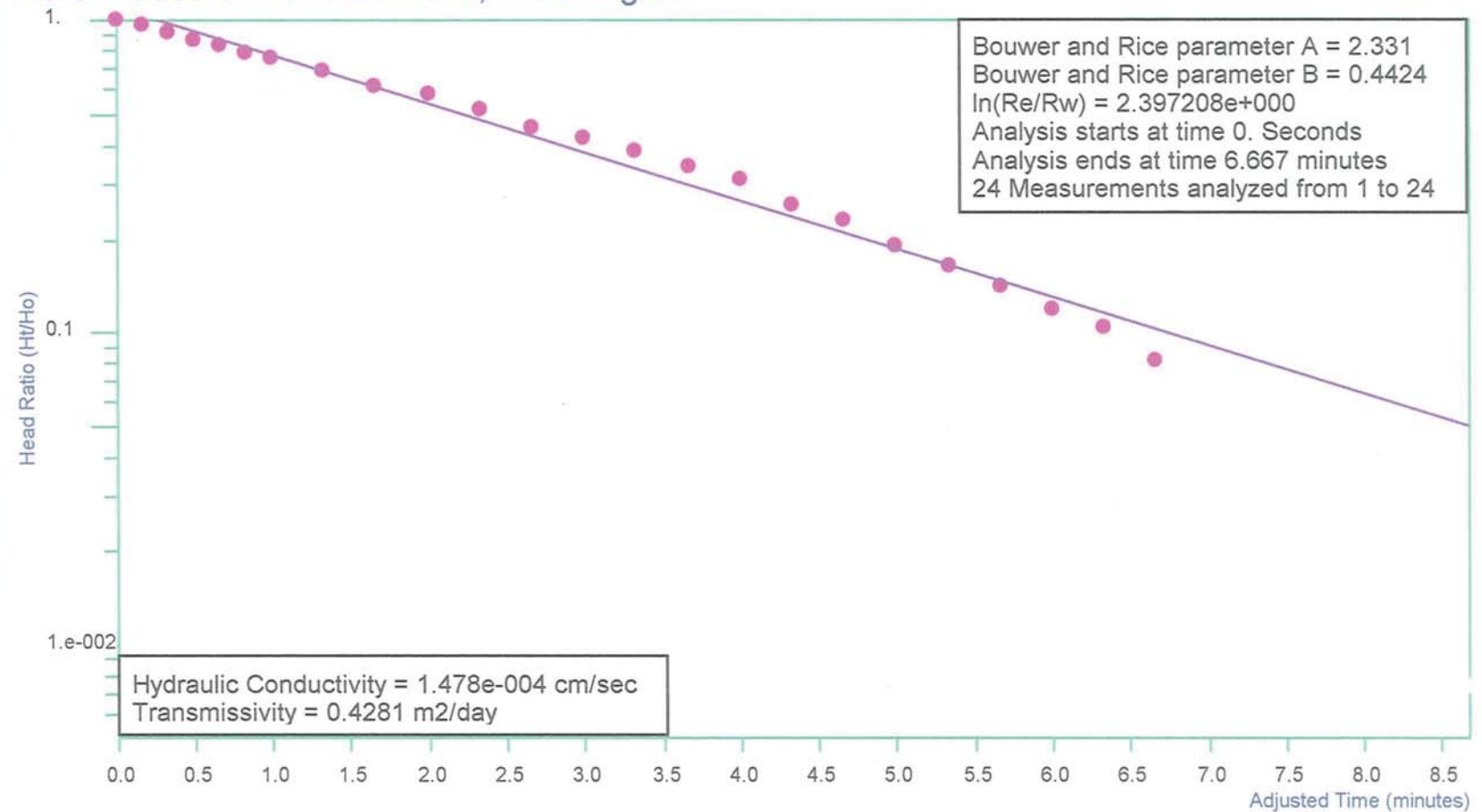
H_o is 1.3 feet at 0. Seconds

Slug Test #2

Hers Industrial Park Mukilteo, Washington

Bouwer and Rice Graph

MW-7



Project Number: 2005-087c for Romeo Gonyea
Analysis by Starpoint Software

H_o is 1.35 feet at 0. Seconds