HWA GEOSCIENCES INC.

Geotechnical Engineering • Hydrogeology • Geoenvironmental Services • Inspection and Testing

November 9, 2018
HWA Project No. 2007 098- 2012

Ms. Sunny Becker
Washington Department of Ecology
Toxics Cleanup Program, Northwest Regional Office
3190 - 160th SE Bellevue, WA 98008

Subject: **ADDITIONAL SOIL AND GROUND WATER SAMPLING**
BOTHELL RIVERSIDE SITE HVOC AREA
Riverside HVOC Site
Bothell, Washington

Dear Ms. Becker:

This memorandum summarizes additional soil and ground water sampling, and evaluation of hydraulic control at the Riverside Site HVOC area.

ADDITIONAL SAMPLING

On October 24 and 25, 2018, HWA advanced and sampled eight soil borings at the Riverside Site HVOC area, at locations selected in discussions with Department of Ecology. The objectives of the explorations included exploring 1) the apparent upgradient source area around RMW-12, 2) the area in and near the 180th street roadway at the east end of the HVOC area, and 3) the area slightly downgradient of RMW-7. Figure 1 shows the boring locations.

Borings were advanced with a direct push drilling rig to depths of 20 to 25 feet below grade. At each boring, one unsaturated soil sample was submitted for analysis of halogenated volatile organic compounds (HVOCs) based on field screening results. At each boring, a temporary ground water monitoring well was installed and one shallow (first encountered) reconnaissance ground water sample was collected and submitted for HVOC analysis. Boring logs are attached to this report.

Temporary PVC well screen and casing was left in each hole for one to four hours prior to measuring stabilized ground water levels. Ground elevations at each boring were surveyed relative to the existing surveyed monitoring wells, in order to prepare a ground water gradient map (see below).

Tables 1 and 2 summarize the soil and ground water results. Figures 2 and 3 show the new boring ground water results, along with the most recent HVOC data from the monitoring wells.

Table 1 Soil Analytical Results

Boring	Depth	Date Sampled	Tetrachloro-ethene (mg/kg)	Trichloro-ethene (mg/kg)	(cis) 1,2-Dichloro-ethene (mg/kg)	Vinyl chloride (mg/kg)
		Cleanup Levels*	**0.05**	**0.03**	**160 (B)**	**175**
RB-25-13	13	10/24/2018	**0.46**	**0.052**	<.0016	<.0016
RB-26-8.5	8.5	10/24/2018	<0.00094	<0.00094	<0.00094	<0.00094
RB-27-10	10	10/24/2018	<0.0011	<0.0011	<0.0011	<0.0011
RB-28-10	10	10/24/2018	**0.0017**	<0.00078	<0.00078	<0.00078
RB-29-8	8	10/24/2018	<0.00082	<0.00082	<0.00082	<0.00082
RB-30-9	9	10/24/2018	<0.00077	<0.00077	<0.00077	<0.00077
RB-31-7.75	7.75	10/25/2018	<0.0010	<0.0010	<0.0010	<0.0010
RB-32-15	15	10/25/2018	<0.00080	<0.00080	<0.00080	<0.00080

Bold - analyte detected at concentration greater than the laboratory reporting limit
< - Not detected at laboratory reporting limit
Highlighted – Value exceeds cleanup level
*Cleanup Levels: Ecology MTCA Method A / B soil cleanup levels, Chapter 173-340 WAC

Table 2 Ground Water Analytical Results

Boring	Screened Interval (ft bgs)	Date Sampled	Depth to Water	Tetrachloro-ethene (µg/L)	Trichloro-ethene (µg/L)	(cis) 1,2-Dichloro-ethene (µg/L)	Vinyl chloride (µg/L)
Site Cleanup Levels*				**0.69**	**2.5**	**16 (B)**	**0.25**
RB-25	15-25	10/24/2018	17.5	**200**	**88**	**92**	**1**
RB-26	15-25	10/24/2018	16.6	**2.4**	**1.6**	**3.5**	<0.02
RB-27	15-25	10/24/2018	14.8	**29**	**19**	**7.1**	**1**
RB-28	10-20	10/24/2018	15.3	**15**	**6.4**	**4.7**	**0.34**
RB-29	15-25	10/24/2018	19.7	**2.6**	**1**	**1.4**	<0.02
RB-30	15-25	10/24/2018	18.8	**0.56**	**1.3**	**8.1**	**0.28**
RB-31	15-25	10/25/2018	15.6	**63**	**11**	**43**	**13**
RB-32	15-25	10/25/2018	17.9	**110**	**44**	**76**	<0.02

Bold - analyte detected at concentration greater than the laboratory reporting limit
< - Not detected at laboratory reporting limit
Highlighted – Value exceeds cleanup level
*Site specific cleanup Levels:

- Tetrachloroethene: Surface Water Applicable or Relevant and Appropriate Requirements (ARARs)- Human Health - Fresh Water - Clean Water Act § 304
- Trichloroethene: Surface Water ARARs- Human Health - Fresh Water - Clean Water Act § 304
- (cis) 1,2- Dichloroethene: Ground Water, Method B, Non-carcinogen, Standard Formula Value
- Vinyl chloride: Practical Quantitation Limits / Reporting Limits Achievable by Local Accredited Labs

Of the eight borings, only one had HVOCs in soil exceeding cleanup levels; RB-25, near the presumed source area. All eight borings had at least one ground water HVOC exceeding site cleanup levels, with RB-25 showing the highest overall HVOC concentrations. Results indicate a source area in the vicinity of RB-25 and MW-12, likely extending under the SR-522 roadway. Soil and ground water samples from prior borings in and north of the roadway suggest the source area does not extend past the north edge of SR-522, and is relatively localized. The limits of the HVOC ground water plume based on the new borings are similar to those previously interpreted, i.e., within the capture area of the existing extraction wells.

The observed HVOC concentration gradients (similar for PCE, TCE, DCE and VC) suggest the plume centerline extends from the source area near RB-25 and RMW-12, through EW-3, then turns to the east towards RMW-7 and EW-6. Of the six extraction wells, EW-3 historically has had the highest HVOC concentrations and exhibited the greatest variability. This plume migration pattern might be due to a combination of geology (localized more permeable layers) and local gradients induced by pumping (e.g., EW-5 is currently out of service and not pumping). Elevated HVOC concentrations downgradient (south) of the northern line of pumping wells (EW-1 through -4) may suggest the plume is migrating past these extraction wells, particularly at EW-3, although HVOCs in RMW-7 south of the wells were elevated prior to any pumping, and concentrations at RMW-7 have been steady or overall decreasing, suggesting that any breakthrough at or near EW-3 has not appreciably increased HVOCs in ground water near the river.

Elevated concentrations of vinyl chloride (higher than in the source area) around RMW-7 and RB-31 may be due to natural biodegradation of the existing PCE in this area, possibly due to the presence of more peaty and organic soils. Organic soils may enhance natural biodegradation of PCE to TCE and DCE, but the reductive dechlorination process would likely "stall out" at the final step from vinyl chloride to ethene, which is biologically and physically (kinetically) more difficult.

HYDRAULIC CONTROL

Introduction

Ground water cleanup to address HVOC impacts to surface water (i.e., the Sammamish River) was initiated in 2014, per the Focused Feasibility Study (HWA, 2012) and Interim Action Work Plan (HWA, 2013). This included design and installation of a ground water pump-and-treat system to capture and treat HVOC-impacted ground water at the Riverside Site HVOC area. The treatment system was designed to maintain hydraulic control of HVOC-impacted ground water discharging to the Sammamish River. Per the Interim Action Work Plan:

> *The cleanup method selected for this interim action was gradient control via pumping, with treatment via discharge to sanitary sewer. In situ and reactive barrier methods were ruled out due to the high potential for adversely impacting the nearby river. Gradient control via a series of pumping wells was determined to be the preferred option for capturing the HVOC plume before it reaches the river. Discharge of the pumped ground water to sanitary sewer, for treatment at an off site wastewater treatment plant was the preferred treatment option due to its simplicity, reliability, and straightforward permitting requirements.*

Achieving hydraulic control of the ground water involves a sufficient number, location, and spacing of wells, with pumping rates that are designed to modify the gradient such that impacted ground water flows into the wells, not into the river. Well spacing and pumping rates were initially determined via a capture zone analysis using numerical ground water modeling. Actual pumping rates are adjusted during operation of the system based on well performance and water levels.

Confirmation of ground water capture was evaluated via an interference pumping test in 2015, as described in the Remedial Investigation report. The test included continuously measuring ground water levels in pumping and monitoring wells during periods of pumping and non-pumping.

2018 Gradient Study

Because there are not enough permanent monitoring wells near the pumping wells to create a ground water gradient map accurately depicting the capture area, HWA measured ground water levels in all existing monitoring wells and the eight temporary wells installed on October 26, 2018. All locations were surveyed for relative ground elevation and the ground water measurements normalized to a common site datum. Figure 3 shows the interpreted ground water gradient. At the time of these measurements, extraction wells EW-1, -2, -3, -4, and -6 were pumping, with total system discharge around 11,000 gallons per day. Well EW-5 is not pumping due to a damaged and stuck pump, which would require pulling the casing and redrilling the well to repair. The measured ground water levels show an overall gradient to the south/southwest, towards and perpendicular to the river, as would be expected for shallow ground water adjacent to a river, and as previously measured. The ground water levels also show drawdown (depression of the water table) around the original four extraction wells EW-1, -2, -3, and -4, with a localized cone of depression around EW-6. This gradient suggests that upgradient ground water from somewhere east of EW-1 to RMW-6 (west of EW-4), which encompasses the east-west extents of the HVOC plume, is effectively captured by the pumping wells.

RECOMMENDATIONS

Per discussions with Ecology, the City will explore alternative cleanup remedies for the Riverside HVOC plume, likely focusing on the apparent source area, but possibly including additional extraction wells (e.g., near EW-3, or replacing the damaged EW-5 well), if the pump and treat system is to be maintained. If so, selection of a remedy will also require consideration of potential impacts of the pump and treat system.

The King County Industrial Waste Division has notified the City that they expect the City to cease discharge to sanitary sewer by summer 2019. If the pump and treat system is to remain in service, the best alternative is filtration through granular activated carbon, with discharge to storm drain. Due to the iron fouling issues, using disposable (not refillable) carbon canisters is recommended. Other forms of treatment (e.g., air stripping) would also be very costly to maintain due to the biofouling issues.

◆

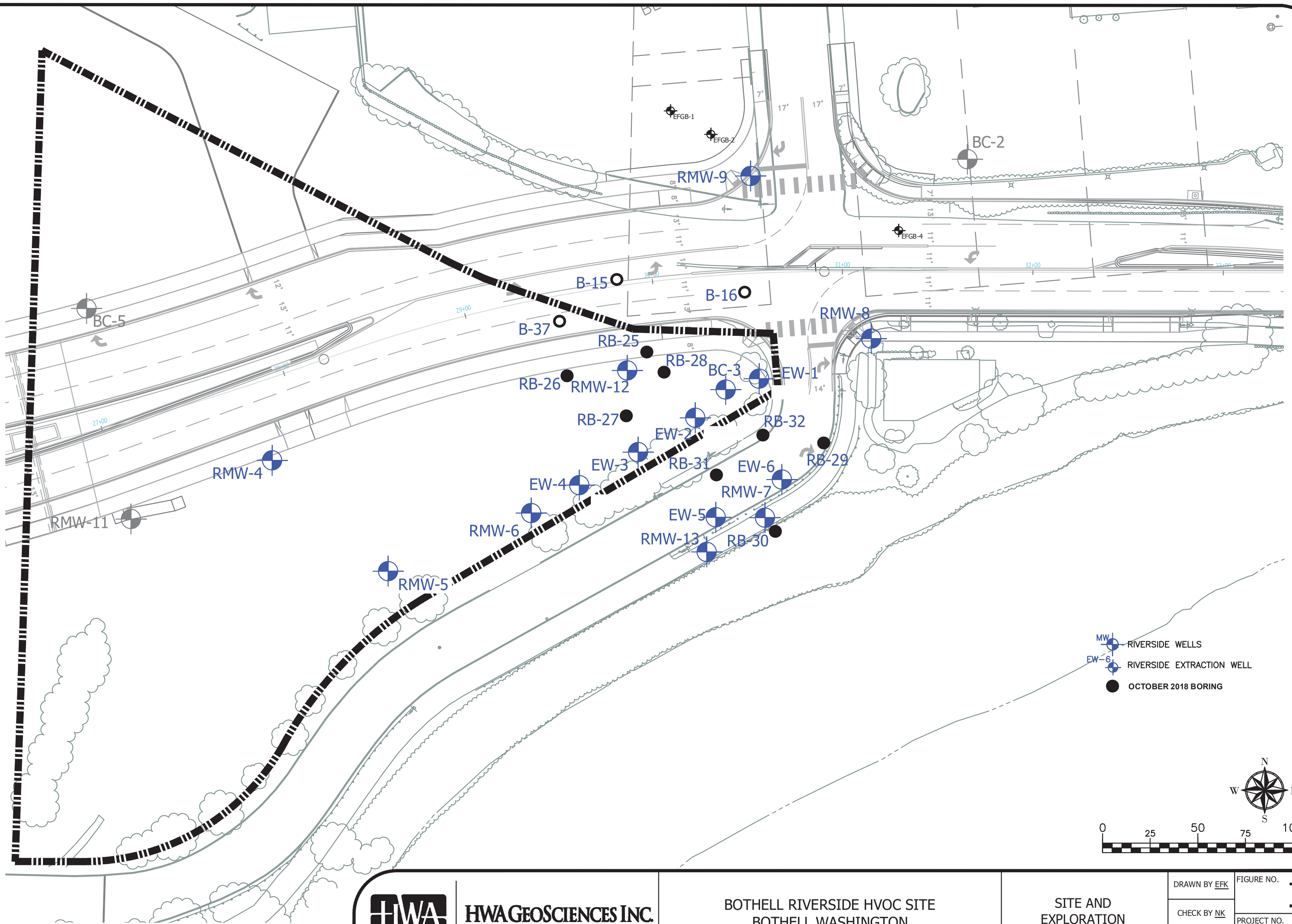
Please feel free to contact me if you have any questions or need additional information.

Sincerely,
HWA GEOSCIENCES INC.

Arnie Sugar, LG, LHG
Principal Hydrogeologist

Attachments:
Figure 1 Site and exploration plan
Figure 2 October 2018 ground water PCE results
Figure 3 October 2018 ground water Vinyl Chloride results
Figure 4 Ground water gradient, October 2018

Boring logs



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BOTHELL RIVERSIDE HVOC SITE
BOTHELL WASHINGTON

SITE AND
EXPLORATION
PLAN

DRAWN BY EFK	FIGURE NO. 1
CHECK BY NK	PROJECT NO.
10.29.18	2007-098 T2012

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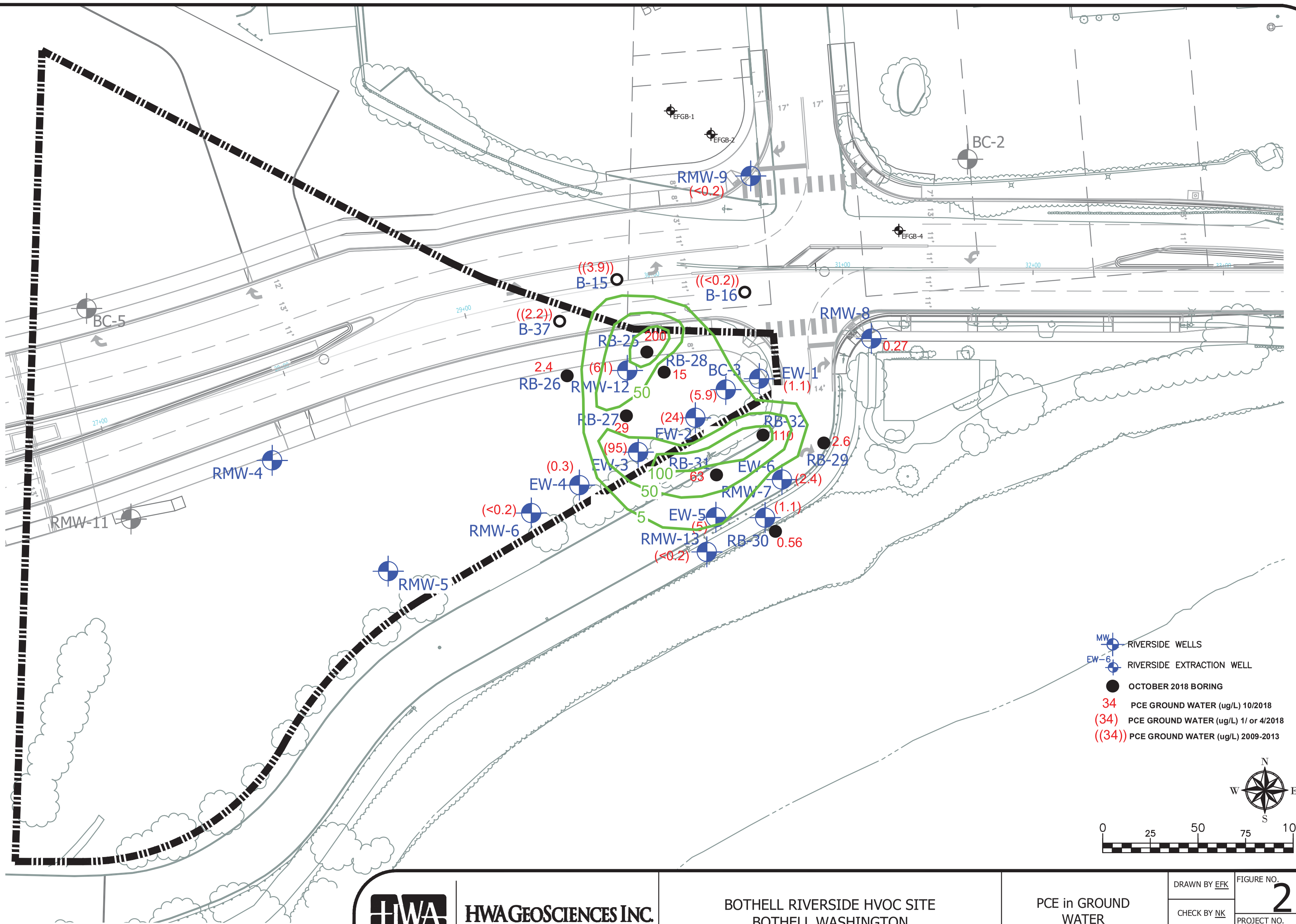

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BOTHELL RIVERSIDE HVOC SITE
BOTHELL WASHINGTON

PCE in GROUND WATER

DRAWN BY EFK	FIGURE NO. 2
CHECK BY NK	PROJECT NO.
10.29.18	2007-098 T2012

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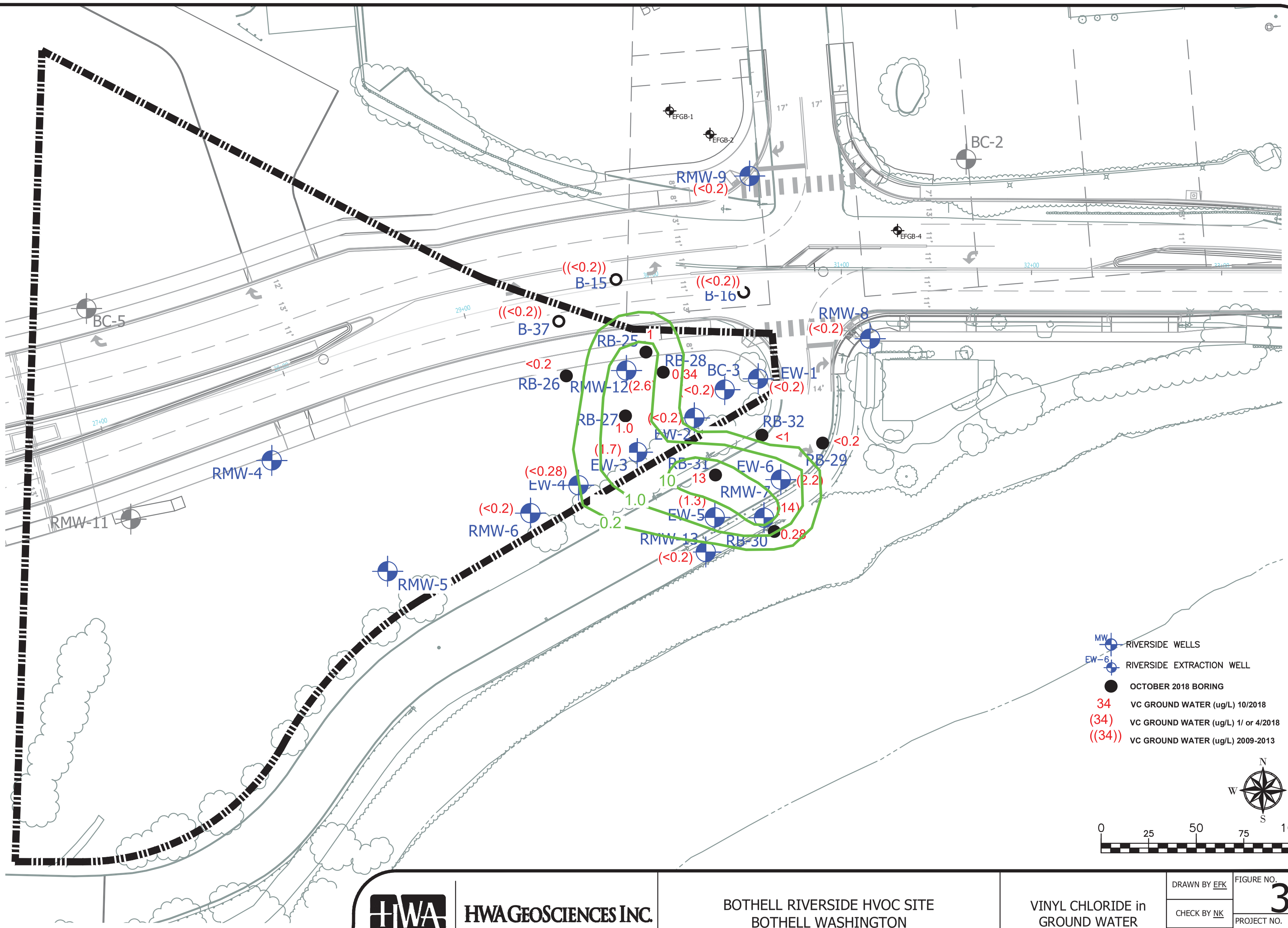

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BOTHELL RIVERSIDE HVOC SITE
BOTHELL WASHINGTON

VINYL CHLORIDE in
GROUND WATER

DRAWN BY EFK	FIGURE NO. 3	
CHECK BY NK	PROJECT NO.	
10.29.18	2007-098 T2012	

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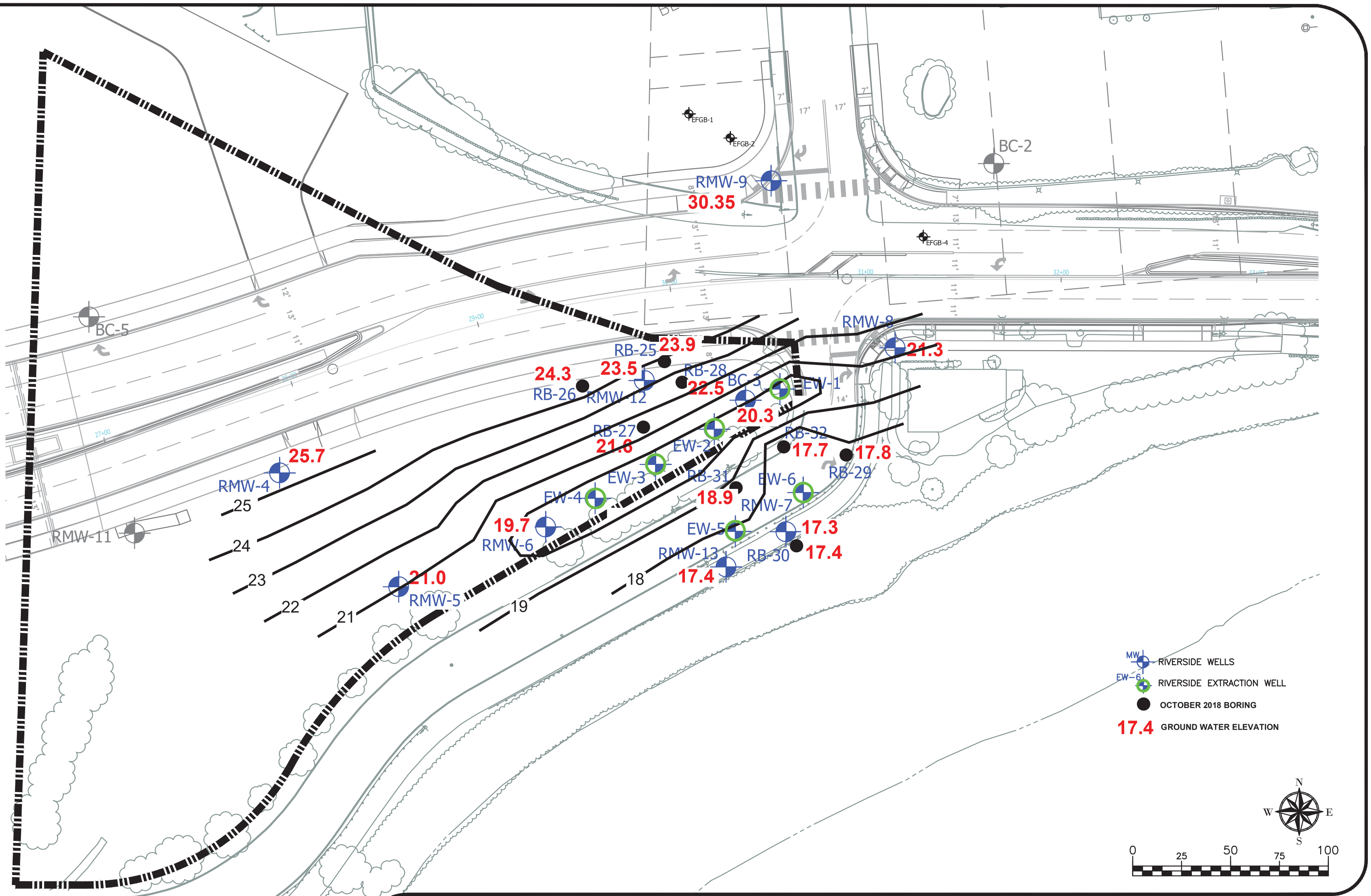

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BOTHELL RIVERSIDE HVOC SITE
BOTHELL WASHINGTON

GROUND WATER
GRADIENT 10/25/18

DRAWN BY EFK
CHECK BY NK
10.29.18

FIGURE NO.
4

PROJECT NO.
2007-098 T2012

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RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS		
Coarse Grained Soils More than 50% Retained on No. 200 Sieve Size	Gravel and Gravelly Soils More than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravel (little or no fines)	▨	GW	Well-graded GRAVEL
			▨	GP	Poorly-graded GRAVEL
		Gravel with Fines (appreciable amount of fines)	▨	GM	Silty GRAVEL
			▨	GC	Clayey GRAVEL
	Sand and Sandy Soils 50% or More of Coarse Fraction Passing No. 4 Sieve	Clean Sand (little or no fines)	▨	SW	Well-graded SAND
			▨	SP	Poorly-graded SAND
		Sand with Fines (appreciable amount of fines)	▨	SM	Silty SAND
			▨	SC	Clayey SAND
Fine Grained Soils 50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit Less than 50%	▨	ML	SILT
			▨	CL	Lean CLAY
			▨	OL	Organic SILT/Organic CLAY
	Silt and Clay	Liquid Limit 50% or More	▨	MH	Elastic SILT
			▨	CH	Fat CLAY
			▨	OH	Organic SILT/Organic CLAY
Highly Organic Soils			▨	PT	PEAT

TEST SYMBOLS

%F	Percent Fines	
AL	Atterberg Limits:	PL = Plastic Limit LL = Liquid Limit
CBR	California Bearing Ratio	
CN	Consolidation	
DD	Dry Density (pcf)	
DS	Direct Shear	
GS	Grain Size Distribution	
K	Permeability	
MD	Moisture/Density Relationship (Proctor)	
MR	Resilient Modulus	
PID	Photoionization Device Reading	
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)	
SG	Specific Gravity	
TC	Triaxial Compression	
TV	Torvane Approx. Shear Strength (tsf)	
UC	Unconfined Compression	

SAMPLE TYPE SYMBOLS

☒	2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
I	Shelby Tube
▣	3-1/4" OD Split Spoon with Brass Rings
○	Small Bag Sample
▚	Large Bag (Bulk) Sample
▮	Core Run
▱	Non-standard Penetration Test (3.0" OD split spoon)

GROUNDWATER SYMBOLS

▽	Groundwater Level (measured at time of drilling)
▼	Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)

Components are arranged in order of increasing quantities.

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch.
MOIST	Damp but no visible water.
WET	Visible free water, usually soil is below water table.

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BOTHELL RIVERSIDE HVOC SITE
FALL 2018 BORINGS
BOTHELL, WASHINGTON

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

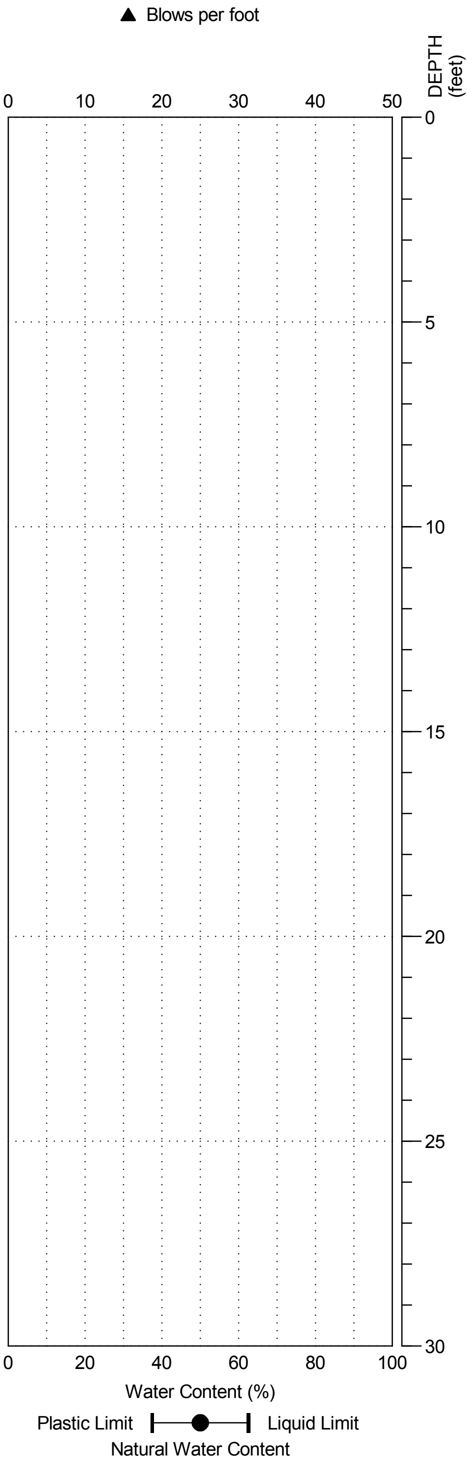
PROJECT NO.: 2007-098-T2052 FIGURE: 1

DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: North of Gravel Parking Lot

DATE STARTED: 10/24/2018
DATE COMPLETED: 10/24/2018
LOGGED BY: N. Kapise

USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER
SM	Loose, gray-brown, gravelly, silty fine to coarse SAND, dry to moist. Gravel is medium to coarse and rounded.	
SP	Loose, brown, fine to medium SAND with trace rounded gravel, dry to moist.	
SW	Loose, gray-brown, gravelly, fine to coarse SAND with silt, dry to moist.	
SP	Loose, brown, fine to medium SAND with trace rounded gravel, dry to moist. Organics and styrofoam at 7.5-7.75'.	
GW	Loose, gray GRAVEL, dry to moist.	
SP	Loose to medium dense, brown, fine to medium SAND with trace rounded gravel, dry to moist. **(FILL)**	RB25-13.0
ML	Soft to medium stiff, dark brown SILT with rounded gravel, moist.	RB25-18.0
SM	Medium dense, olive-gray to light yellow-brown, silty fine SAND, moist to slightly wet at 19-19.5'. Iron oxide staining at 22-22.5'.	

Exploration terminated at 25 feet. Groundwater encountered at 19.5 feet. No visual or olfactory signs of contamination in soil. Temporary well screen installed from 15 to 25 feet.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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Bothell Riverside HVOC Site
Bothell, Washington

BORING:
RB-25

PAGE: 1 of 1

PROJECT NO.: 2007-098-T2052 FIGURE: 2

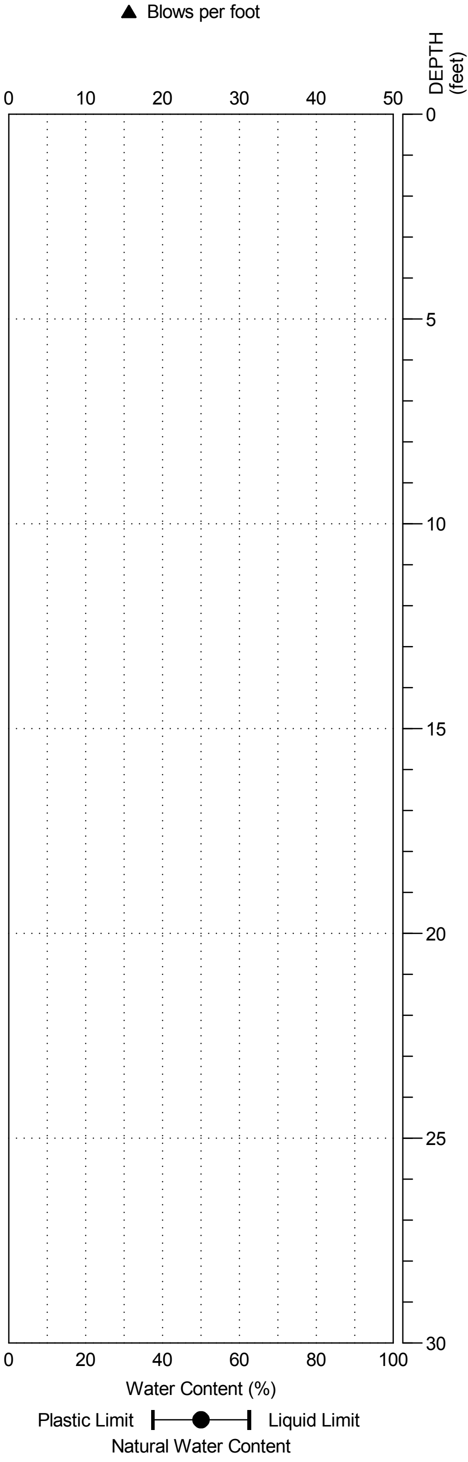
DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: North of Gravel Parking Lot

DATE STARTED: 10/24/2018
DATE COMPLETED: 10/24/2018
LOGGED BY: N. Kapise

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	SAMPLE RECOVERY (REC, %)	ROCK QUALITY DESIGNATION (RQD, %)	OTHER TESTS	GROUNDWATER
0 5		SW	Loose, olive-brown, gravelly fine to coarse SAND with silt, dry to moist. Gravel is medium to coarse and rounded. 2" of asphalt at 4'.		RB26-8.5					
10		SM	Loose, dark brown to dark gray, silty fine SAND with rounded gravel, dry to moist. 6" lense of concrete and brick debris at 9.5'. Very woody from 10-11'							
15		SW	Loose, dark yellow-brown to dark brown, fine to coarse SAND with silt and rounded gravel to trace rounded gravel with depth, moist. Concrete debris from 11.5-12'. Low recovery 10-15'. **(FILL)**		RB26-19.5					
		ML	Medium dense, red-brown to dark brown, SILT with very fine to fine sand and organics, moist.							▼
		SW	Medium dense, red-brown, gravelly fine to coarse SAND with silt, moist to slightly wet.							
20		SP	Medium dense, olive-gray to olive-brown, very fine to fine SAND with iron oxide staining, moist to slightly wet.							▽
25			No recovery							

Exploration terminated at 25 feet.
Groundwater encountered at 19 to 20 feet.
No visual or olfactory signs of contamination in soil. Temporary well screen installed from 15 to 25 feet.

30



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Bothell Riverside HVOC Site
Bothell, Washington

BORING:
RB-26

PAGE: 1 of 1

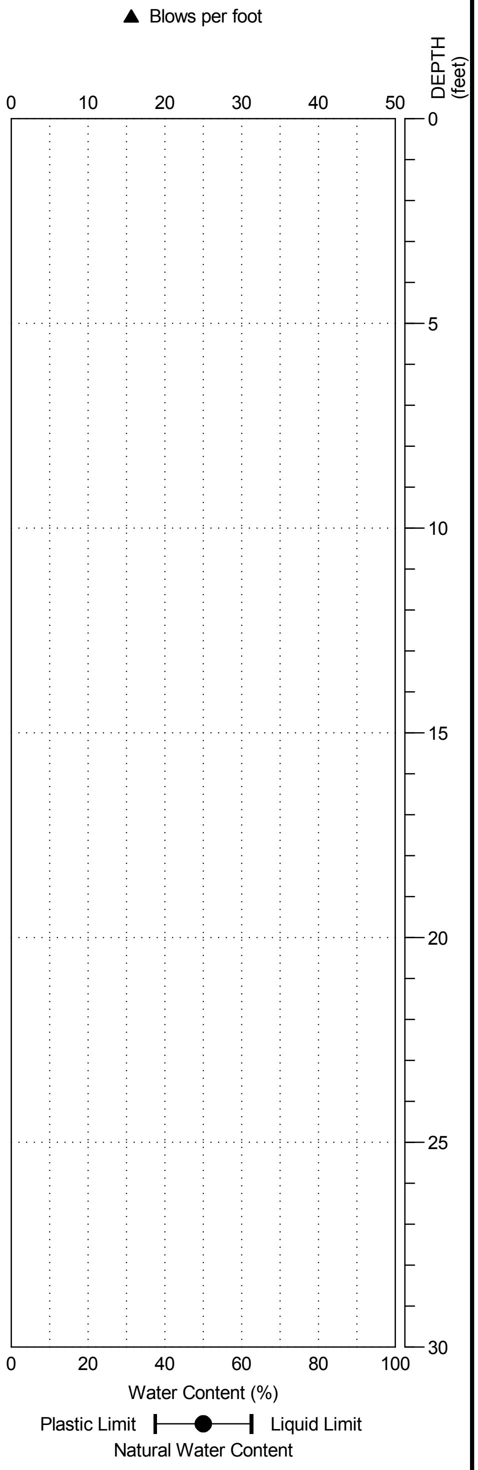
PROJECT NO.: 2007-098-T2052 FIGURE: 3

DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: Gravel Parking Lot

DATE STARTED: 10/24/2018
DATE COMPLETED: 10/24/2018
LOGGED BY: N. Kapise

USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	SAMPLE RECOVERY (REC, %)	ROCK QUALITY DESIGNATION (RQD, %)	OTHER TESTS	GROUNDWATER
SW	Loose, gray-brown, gravelly fine to coarse SAND with silt, dry to moist. Gravel is angular.							
SP	Loose, gray-brown to brown, fine to medium SAND with silt and rounded gravel, dry to moist.							
	Asphalt debris from 6-6.5, concrete debris from 6.5-7.5.							
SP	Medium dense, olive-gray, very fine to fine SAND with silt and rounded gravel, dry to moist. **(FILL)**		RB27-10.0					
ML	Medium stiff, dark gray to dark brown SILT with trace very fine sand and rounded gravel, moist. 4" organic lense at 13'							
ML	Medium stiff, dark brown to gray SILT, moist. Wood debris and burnt wood debris from approximately 15 to 19.5'		RB27-17.0					▼
SP	Medium dense, gray, very fine to medium SAND with silt and trace gravel, moist to slightly wet.							
SW	Medium dense, gray, gravelly fine to coaurse SAND with silt, wet.							▽
SP	Medium dense, olive-gray to olive-brown, very fine to fine SAND with silt, moist to slightly wet.							

Exploration terminated at 25 feet. Groundwater encountered at 20.5 feet. No visual or olfactory signs of contamination in soil. Temporary well screen installed from 15 to 25 feet.



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Bothell Riverside HVOC Site
Bothell, Washington

BORING:
RB-27

PAGE: 1 of 1

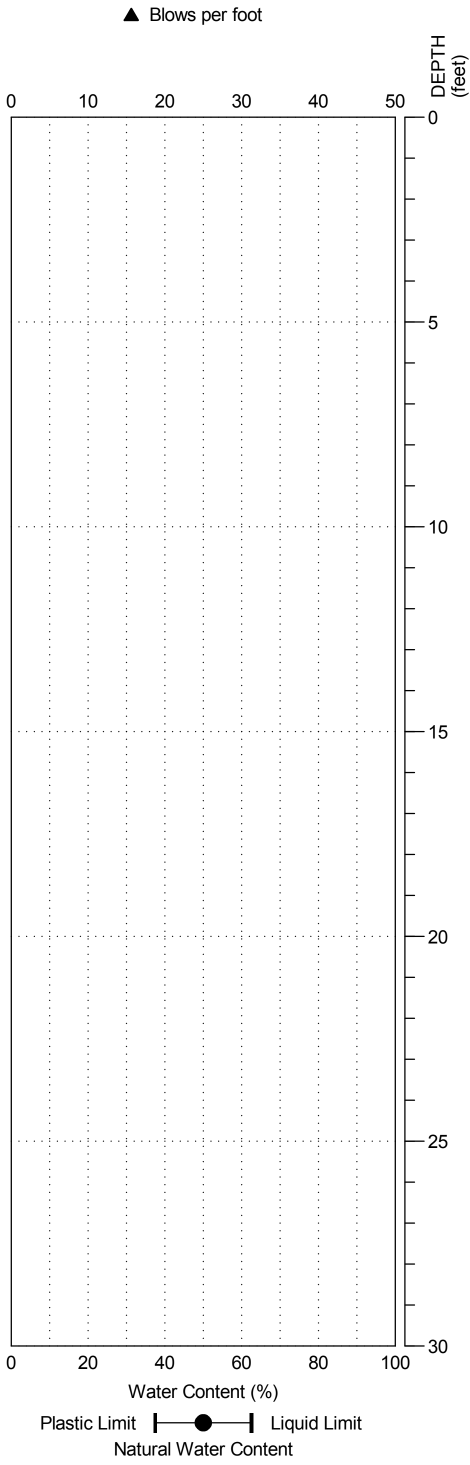
PROJECT NO.: 2007-098-T2052 FIGURE: 4

DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: North of RMW-10

DATE STARTED: 10/24/2018
DATE COMPLETED: 10/24/2018
LOGGED BY: N. Kapise

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	SAMPLE RECOVERY (REC, %)	ROCK QUALITY DESIG-NATION (RQD, %)	OTHER TESTS	GROUNDWATER
0	SW	Loose, brown to olive-brown, fine to coarse SAND with silt and rounded gravel, dry to moist. **(FILL)**							
5									
	ML	Soft, yellow-brown to brown, SILT with trace rounded gravel, moist. Iron oxide staining from 6.5-7.5'. Woody debris from 7.5-9'							
10	SP	Loose, olive-gray, very fine to fine SAND with silt, coarse sand and rounded gravel, moist.		RB28-10.0					
	ML	Medium stiff, dark brown, SILT with very fine sand, coarse sand, and rounded gravel, moist.							
15	SM	Medium dense, olive-brown, silty fine to coarse SAND with rounded gravel, moist.		RB28-16.0					▼
	SM	Medium dense, olive-brown to olive-gray, silty very fine to fine SAND with rounded gravel, moist to wet. Gravel decreases to trace amounts with depth.							▽
20									
25									
30									

Exploration terminated at 20 feet. Groundwater encountered at 17.5 feet. No visual or olfactory signs of contamination in soil. Temporary well screen installed from 10 to 20 feet.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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Bothell Riverside HVOC Site
Bothell, Washington

BORING:
RB-28

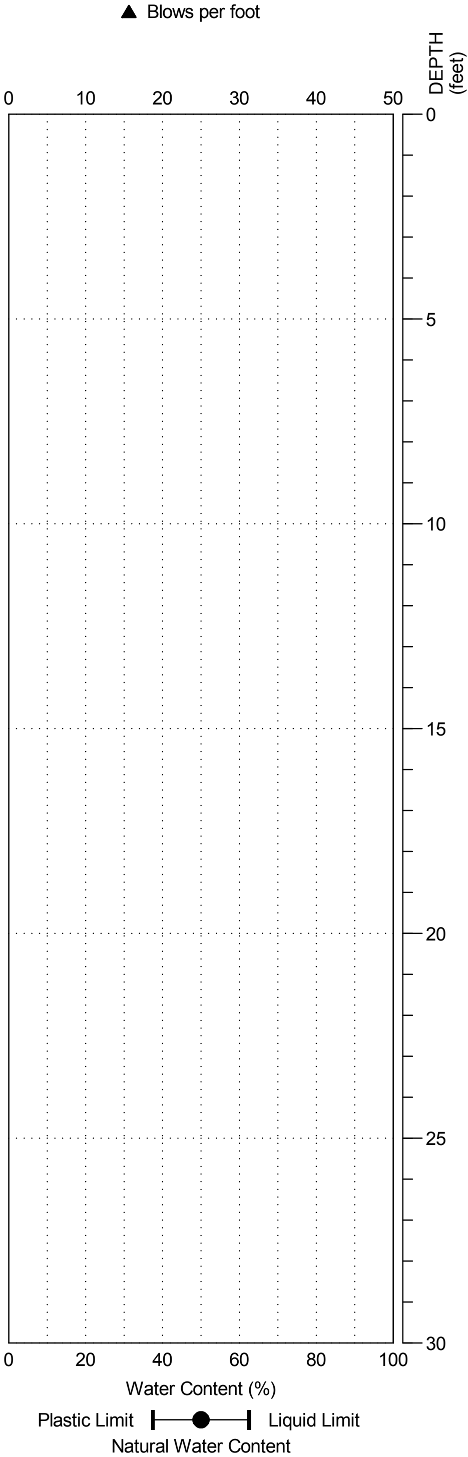
PAGE: 1 of 1

PROJECT NO.: 2007-098-T2052 FIGURE: 5

DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: South side of NE 180th St

DATE STARTED: 10/24/2018
DATE COMPLETED: 10/24/2018
LOGGED BY: N. Kapise

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	SAMPLE RECOVERY (REC, %)	ROCK QUALITY DESIGNATION (RQD, %)	OTHER TESTS	GROUNDWATER
0			Asphalt over roadway base/crushed rock.							
		SW	Loose, olive-brown, fine to coarse SAND with silt and gravel, dry to moist.							
5					RB29-8.0					
10										
		SW	color change to yellow-brown **(FILL)**							
15					RB29-19.0					
		PT	Soft, red-brown PEAT, moist.							
		ML	Medium soft, red-brown SILT with trace organics and wood debris, moist.							
20		SP	Medium dense, gray, very fine to fine SAND with silt, moist to slightly wet.							▼
		SW	Medium dense, yellow-brown, fine to coarse SAND with silt and rounded gravel, moist to slightly wet.							
		SP	Medium dense, gray to olive-gray/brown, very fine to fine SAND with silt and trace coarse sand and gravel, wet. Wood debris at 23.5'.							▽
25		SW	Medium dense, yellow-brown, gravelly, fine to coarse SAND with silt, wet.							
30			Exploration terminated at 25 feet. Groundwater encountered at 22.5 feet. No visual or olfactory signs of contamination in soil. Temporary well screen installed from 15 to 25 feet.							



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Bothell Riverside HVOC Site
Bothell, Washington

BORING:
RB-29

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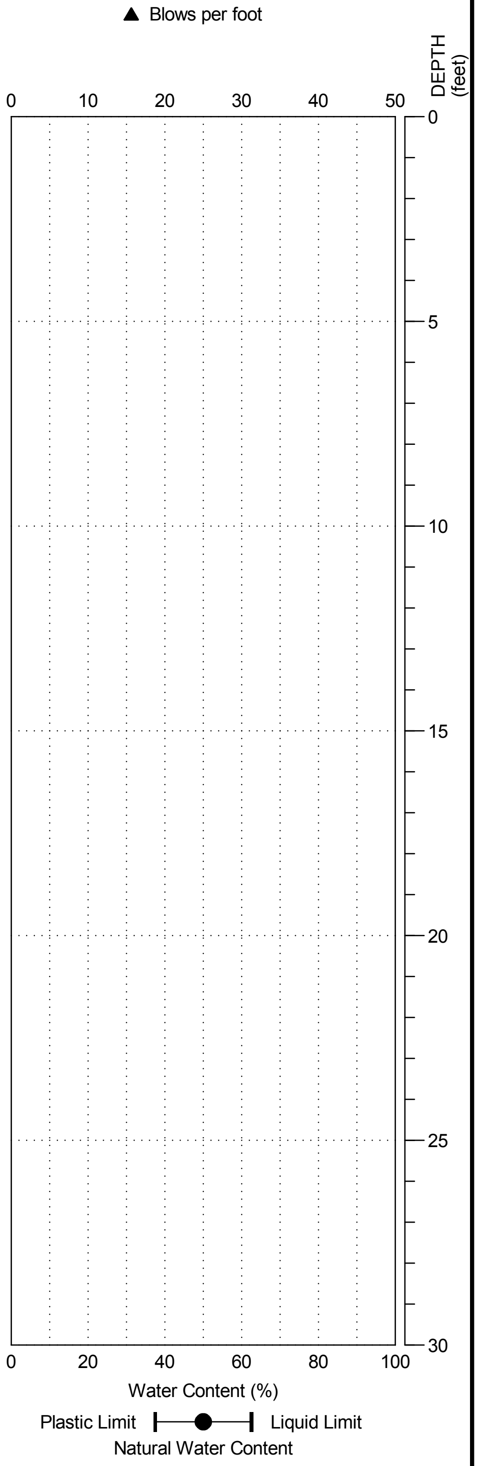
PROJECT NO.: 2007-098-T2052 FIGURE: 6

DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: South of RMW-7

DATE STARTED: 10/24/2018
DATE COMPLETED: 10/24/2018
LOGGED BY: N. Kapise

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	SAMPLE RECOVERY (REC, %)	ROCK QUALITY DESIGNATION (RQD, %)	OTHER TESTS	GROUNDWATER
0	■		Asphalt over crushed rock base.							
		SW	Loose to medium dense, olive-brown to olive-gray, fine to coarse SAND with rounded gravel and silt, dry to moist. **(FILL)**		RB30-9.0 RB30-18.0					
		SM	Medium dense, olive-brown, silty fine to medium SAND with rounded gravel, moist.							▼
20		SW	Medium dense, olive-brown to olive-gray, fine to coarse SAND with silt and rounded gravel, moist.							▽
		SP	Medium dense, olive-gray, gravelly, fine to coarse SAND with silt, wet.							
25										

Exploration terminated at 25 feet. Groundwater encountered at 23 feet. No visual or olfactory signs of contamination in soil. Temporary well screen installed from 15 to 25 feet.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Bothell Riverside HVOC Site
Bothell, Washington

BORING:
RB-30

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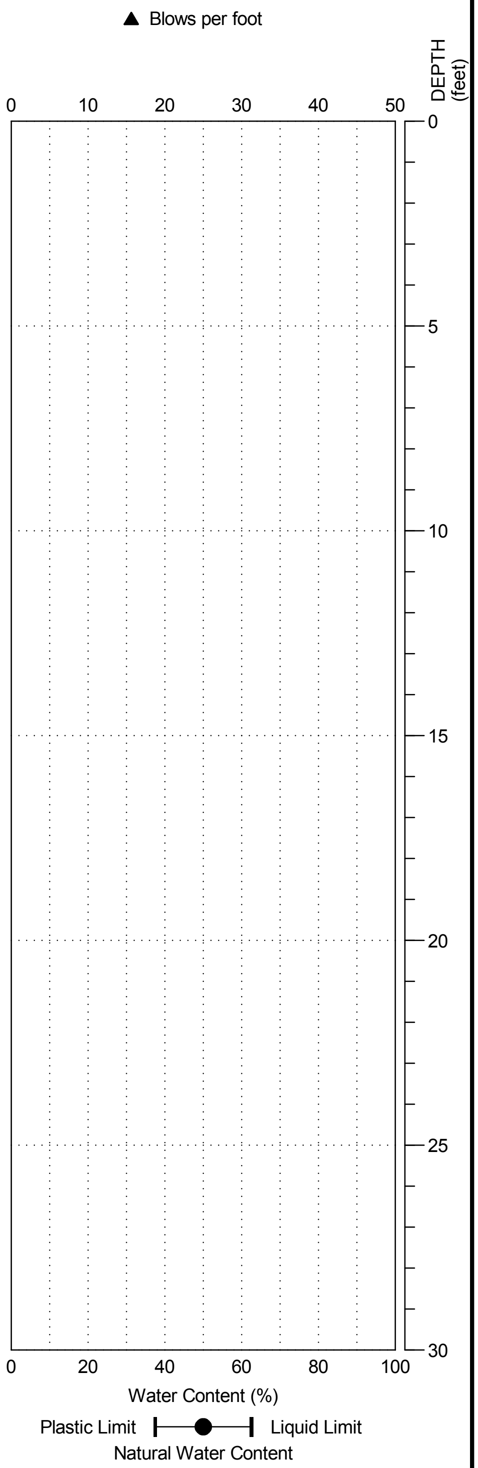
PROJECT NO.: 2007-098-T2052 FIGURE: 7

DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: North side of NE 180th St.

DATE STARTED: 10/25/2018
DATE COMPLETED: 10/25/2018
LOGGED BY: N. Kapise

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	SAMPLE RECOVERY (REC, %)	ROCK QUALITY DESIGNATION (RQD, %)	OTHER TESTS	GROUNDWATER
0			Asphalt over roadway base/crushed rock.							
5		SP	Loose, olive-brown, fine to medium SAND with silt, coarse sand and rounded gravel, dry to moist. **(FILL)**		RB31-7.75					
		ML	Soft, light yellow-brown, SILT, dry.							
10		ML	Soft to medium stiff, light yellow-brown to olive-gray, SILT with coarse sand and rounded gravel, dry.							
		SM	Medium dense, brown to yellow-brown, silty, fine to medium SAND with rounded gravel, dry.							
		SM	Medium dense, brown, silty, fine to medium SAND with coarse sand and rounded gravel, moist.							
15		SW	Medium dense, olive-brown to dark olive-brown, gravelly, fine to coarse SAND with silt, moist.		RB31-17.5					▼
		SP	Medium dense, gray, fine to medium SAND, moist.							
20		ML	Medium stiff, red brown SILT, moist to wet at 21'.							
25		SP	Medium dense, olive-gray to yellow-brown, very fine to fine SAND with silt, moist.							▽

Exploration terminated at 25 feet. Groundwater encountered at 21 feet. No visual or olfactory signs of contamination in soil. Temporary well screen installed from 15 to 25 feet.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Bothell Riverside HVOC Site
Bothell, Washington

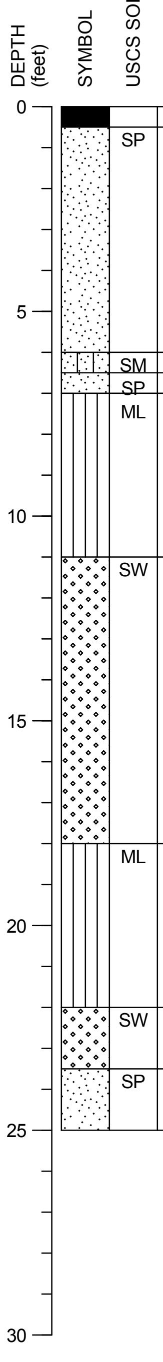
BORING:
RB-31

PAGE: 1 of 1

PROJECT NO.: 2007-098-T2052 FIGURE: 8

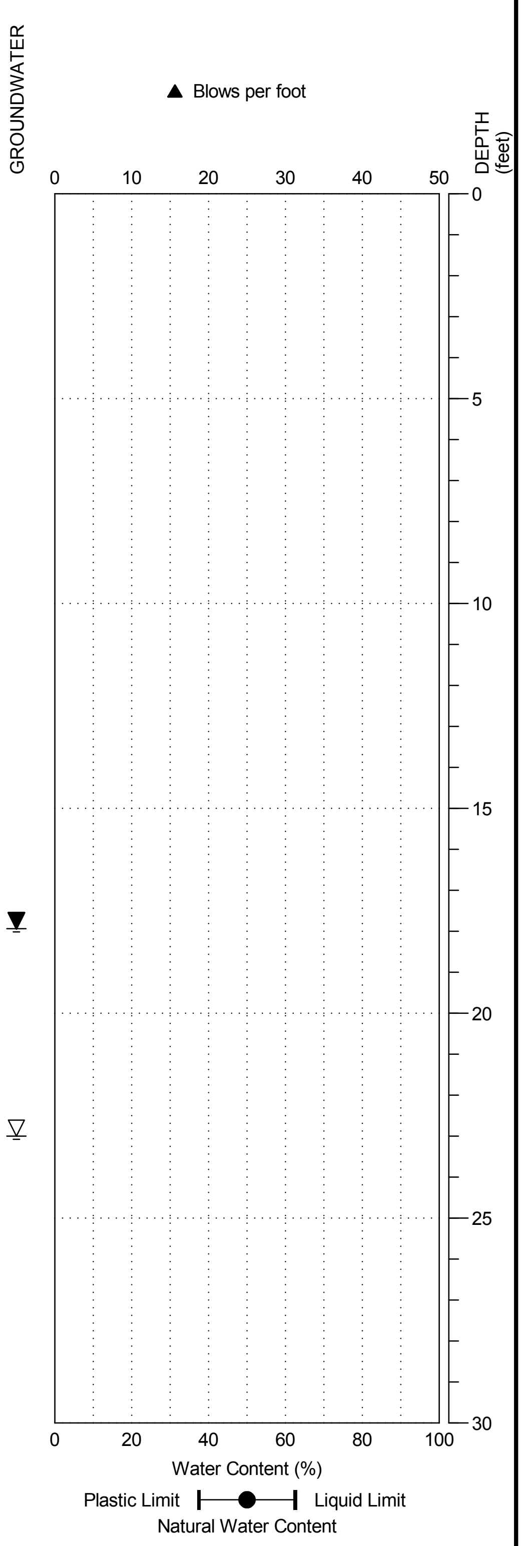
DRILLING COMPANY: Cascade Drilling, Inc.
DRILLING METHOD: Geoprobe
SAMPLING METHOD: Continuous
LOCATION: North side of NE 180th St.

DATE STARTED: 10/25/2018
DATE COMPLETED: 10/25/2018
LOGGED BY: N. Kapise



USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER
	Asphalt over roadway base/crushed rock.	
SP	Loose, olive-brown, fine to medium SAND with silt, coarse sand and rounded gravel, dry to moist.	RB32-5.25
SM SP	Loose, dark brown to red-brown, silty, fine to coarse SAND with gravel and metal debris, dry.	
ML	Loose, light yellow-brown, very fine SAND with silt, dry. **(FILL)**	
	Medium stiff, light yellow-brown SILT with sand and trace gravel and organics, dry.	
SW	Medium dense, brown to olive-brown, gravelly, fine to coarse SAND with silt, dry. Decrease in gravel with depth. Wood debris at 17.5'.	RB32-15.0
ML	Medium stiff, red-brown SILT with very fine sand and wood debris, moist. Wood debris decreases with depth. 4" gray, very fine sand lenses at 19.75 and 22'.	
SW	Medium dense, olive-gray, fine to coarse SAND with silt and rounded gravel, wet.	
SP	Medium dense, yellow-brown, laminated, very fine SAND with silt, moist.	

Exploration terminated at 25 feet. Groundwater encountered at 23 feet. No visual or olfactory signs of contamination in soil. Temporary well screen installed from 15 to 25 feet.



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HWA GEOSCIENCES INC.

Bothell Riverside HVOC Site
Bothell, Washington

BORING:
RB-32

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PROJECT NO.: 2007-098-T2052 FIGURE: 9