SGW-63812
Revision 0

Borehole Summary Report for the Installation of Two Wells in the 200-ZP-1 Operable Unit, FY2019

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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T. Mallgren
Freestone Environmental, Inc.

Date Published
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Terms

Bay West	Bay West LLC
bgs	below ground surface
Carpenter	Carpenter Drilling, LLC.
CCU	Cold Creek unit
CHPRC	CH2M Hill Plateau Remediation Company
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ft	feet
HCl	hydrochloric acid
HEIS	Hanford Environmental Information System
ID	identification
IH	Industrial Hygiene
in.	inch
hp	horsepower
mm	millimeter
NMLS	Neutron Moisture Logging System
OD	outer diameter
OU	operable unit
P&T	Pump and treat
ppmv	parts per million by volume
RCT	Radiological Control Technician
RLM	Ringold Formation, member of Wooded Island - lower mud unit
Rwia	Ringold Formation, member of the Wooded Island - unit A
Rwie	Ringold Formation, member of the Wooded Island - unit E
SGLS	Spectral Gamma Logging System
TD	total depth
VOC	volatile organic compound
WAC	Washington Administrative Code
Yellow Jacket	Yellow Jacket Drilling Services

Metric Conversion Chart

Into Metric Units			Out of Metric Units		
If you know	*Multiply by*	*To get*	*If you know*	*Multiply by*	*To get*
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0394	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles (statute)	1.609	kilometers	kilometers	0.621	miles (statute)
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.0929	sq. meters	sq. meters	10.764	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.591	sq. kilometers	sq. kilometers	0.386	sq. miles
acres	0.405	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces (avoir)	28.349	grams	grams	0.0353	ounces (avoir)
pounds	0.454	kilograms	kilograms	2.205	pounds (avoir)
tons (short)	0.907	ton (metric)	ton (metric)	1.102	tons (short)
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.034	ounces (U.S., liquid)
tablespoons	15	milliliters	liters	2.113	pints
ounces (U.S., liquid)	29.573	milliliters	liters	1.057	quarts (U.S., liquid)
cups	0.24	liters	liters	0.264	gallons (U.S., liquid)
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts (U.S., liquid)	0.946	liters	cubic meters	1.308	cubic yards
gallons (U.S., liquid)	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
Radioactivity			**Radioactivity**		
picocurie	37	millibecquerel	millibecquerel	0.027	picocurie

1 Introduction

This report presents field-generated records and summarizes field activities performed during the installation of one injection well and one extraction well in the 200-ZP-1 groundwater Operable Unit (OU). Injection well 699-47-78B (C9879) is being installed to support the expansion of the existing 200-ZP-1 OU pump-and-treat well network. Extraction well 699-48-70 (C9988) is being installed to maintain remedy containment of the existing 200-ZP-1 OU pump-and-treat well network in that area. Field activities carried out during the installation of the new injection and extraction well included drilling, soil and groundwater sampling, well construction, and development.

The 200-ZP-1 OU underlies the northern portion of the 200-West Area, which is on the western end of the Columbia Plateau, located in the western portion of the Hanford Site, approximately 25 miles north-northwest of Richland, Washington. The 200-ZP-1 OU underlies the Z Plant and T Plant facilities, located in the northern half of the 200-West Area.

In 1995, a 200-ZP-1 OU interim Pump and Treat (P&T) system was brought on-line to remove carbon tetrachloride, chloroform and trichloroethylene from groundwater. According to the *Treatability Test to Remove Technetium-99 from the 200-ZP-1 Groundwater Unit, Hanford Site* (DOE/RL-2008-25), the interim P&T system was incapable of extracting technetium-99 found to exist within the influence of the P&T system. To meet corrective measure standards and timelines, a new P&T system was devised under the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (EPA et al. 2008) as the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*-approved remedial action for the 200-ZP-1 OU. The remedial action P&T system was set forth in concurrence with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) and other vested regulatory parties associated with cleanup at the Hanford Site.

Drilling and construction activities occurred from March 26, 2019 to November 25, 2019 and was performed by Yellow Jacket Drilling Services (Yellow Jacket) and its' subcontractor Carpenter Drilling LLC (Carpenter) under the direction of CH2M HILL Plateau Remediation Company (CHPRC). Well development occurred from August 6, 2019 to August 7, 2019 at C9988 and from November 14, 2019 to November 18, 2019 at C9879. Well development at both C9988 and C9879 was performed by Yellow Jacket. Freestone Environmental Services Incorporated, provided well site geology and well construction documentation services. Bay West LLC (Bay West) provided geophysical logging services.

1.1 Purpose and Scope

This document summarizes the observations and measurements made during the drilling and installation of one injection and one extraction well in the 200-ZP-1 OU. This summary report includes copies of the field notes and forms prepared during the drilling, sampling, construction, and development of the wells. Additional information provided in this report includes geologic observations, geophysical log data reports, results of the well location and elevation civil survey, descriptions of the management and disposition of drilling-derived waste, and a summary of the well acceptance activity.

Technical requirements, applicable CHPRC procedures, and other supporting information were summarized in SGW-62775, *Description of Work for the Installation of One Injection Well and One Extraction Well in the 200-ZP-1 Groundwater Operable Unit, FY2019*. Soil and groundwater samples were collected as described in DOE/RL-2010-72, *Sampling and Analysis Plan for the Remediation Wells in the 200-ZP-1 Operable Unit* (TPA-CN-0818).

Appendices A (C9879) and B (C9988) contain the Well Summary Sheet, borehole geologic log, drill cutting photographs, Well Development and Testing Data, Log Data Report, and Well Survey Data Report for each respective well. The well construction variance for greater than 5 feet of filter pack above the screen at both wells can be found in Appendix C.

All drilling data are reported in the original units recorded at the time of measurement. Table 1-1 lists the wells' identification numbers and names, and Figure 1-1 presents the well locations. The one injection well and one extraction well will hereafter be referred to in the text by the borehole identification

Table 1-1. Identification and Location of New Wells in the 200-ZP-1 Operable Unit

Borehole ID	Well Name	Ecology Tag ID	Northing[a]	Easting[a]	Elevation of Brass Survey Marker[b]	Field Activity Dates	
			meters			Initiate Drilling	Conclude Field Work
C9879	699-47-78B	BLD006	137926.66	566046.29	208.129	March 26, 2019	November 25, 2019 [c]
C9988	699-48-70	BKG078	138200.91	568501.64	208.548	April 02, 2019	October 2, 2019[c]

a. Final survey coordinates are in Washington State Plane South (FIPS 4602) using the *North American Datum of 1983* (NAD83).

b. Elevation values are based on *North American Vertical Datum of 1988* (NAVD88).

c. This date does not include installation of well pad and posts.

Ecology = Washington State Department of Ecology.

ID = identification.

number (e.g. C9879).

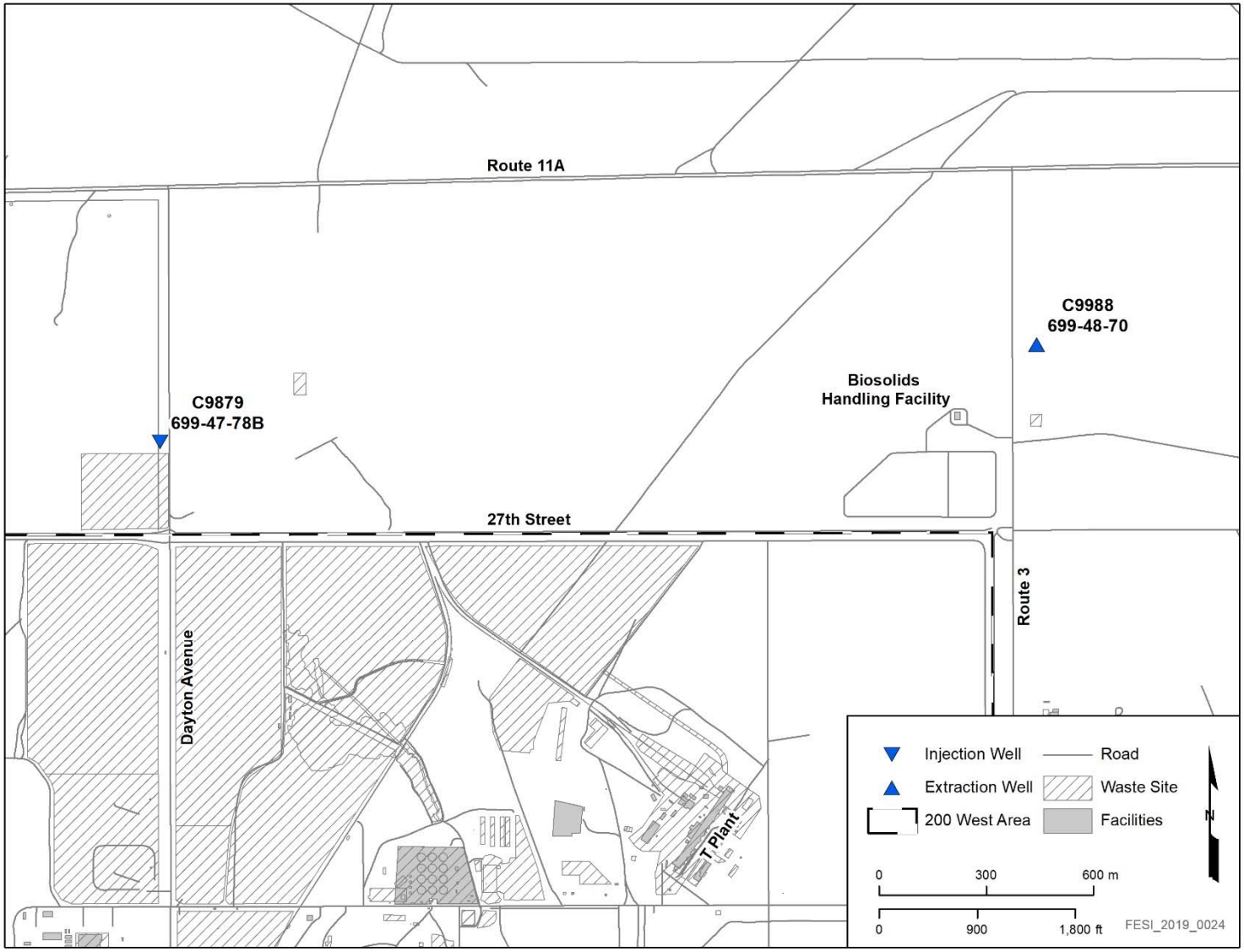

Figure 1-1. New Well Locations in the 200-ZP-1 Operable Unit

2 Drilling, Sampling, and Well Construction Activities

This section summarizes field activities associated with one injection well and one extraction well. Drilling, sampling, well construction, and development details common to all the wells are summarized in Section 2.1 and well-specific information is presented in Section 2.2.

2.1 General Information

The new wells were constructed in compliance with the substantive standards of Washington Administrative Code (WAC) 173-160, *Minimum Standards for Construction and Maintenance of Wells* except where noted. Well construction and development activities were recorded, and borehole geology was logged in accordance with applicable procedures.

2.1.1 Drilling, Sampling, and Borehole Logging

Figure 2-1. Bucyrs-Erie Model 22-W Series Three Cable Tool Drilling Rig.

The boreholes were advanced to depths between 401.8 and 480.7 feet below ground surface (ft bgs), extending between 142.2 and 241.4 ft below the static water level. Borehole C9879 was drilled with a Bucyrus-Erie Model 22-W Series Three Cable Tool drilling rig (Figure 2-1) and 8 5/8-inch (in.) outer-diameter (O.D.) to 83.0 ft bgs before being backfilled to ground surface and redrilled with a Foremost DR-24HD dual rotary drill rig (Figure 2-2). Borehole C9988 was drilled using a Foremost DR-24HD dual rotary drill rig. Two strings of temporary, welded, carbon steel casing with outer diameters of 16-in. and 14-in. were used for both the redrilling of C9879 and at C9988 to ensure the annulus had a “minimum of four inches greater in diameter than the nominal size of the permanent casing”, in accordance with the substantive standards of WAC 173-160.

Archive grab samples were collected from the drill cuttings at each borehole at 5-ft intervals and at changes in lithology. Samples were placed in labeled one-pint glass jars and sequential chip tray compartments for archive storage. Scaled digital photographs of drill cuttings were taken during archive sample collection to accompany the field descriptions. Borehole geologic logs and drill cutting photographs for each borehole are presented in Appendices A and B.

Figure 2-2. Yellow Jacket Foremost DR-24HD Drill Rig.

Sediment samples were collected for sieve analysis throughout the saturated zone every 5 ft and subsequently composited over 20-ft intervals. A sieve analysis was performed on each composite sample and results were used to determine the appropriate screen slot size for each completed well.

During drilling, depth-discrete groundwater samples were collected using a 1.5-horsepower (hp) Grundfos temporary submersible pump. Samples were submitted for laboratory analysis to determine the vertical profile of groundwater contamination and subsequent plume characterization. Groundwater samples were collected by CHPRC nuclear chemical operators after a minimum of one borehole volume had been purged and field parameters (temperature, pH, conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential) stabilize within 10 % of variance over three consecutive measurements. Final groundwater samples also were collected at the end of well development for laboratory analysis. All groundwater sample depths and associated Hanford Environmental Information System (HEIS) numbers are included in Section 2.2.

Each borehole was logged using Bay West's Spectral Gamma Logging System (SGLS) and Neutron Moisture Logging System (NMLS) to identify natural and man-made gamma-emitting radionuclides and moisture levels in near-borehole sediments. Before temporary casing was down-sized and after total depth (TD) was achieved prior to well construction, the temporary casing strings were logged individually to produce a geophysical log of the entire length of the borehole. Log Data Reports of all geophysical logging results, provided by Bay West, are presented in Appendices A and B.

2.1.2 Health and Safety Screening

A radiological control technician (RCT) performed radiological surveys of the drill cuttings, geologic samples, temporary drive casing, and drillers' control station using standard field screening instruments. The boreholes were surveyed every morning and afternoon. The field screening instruments were used to detect and measure alpha, beta, and gamma radiological contamination, if present. No field measurements above background levels were reported during drilling activities.

Air quality monitoring was performed by an industrial hygiene (IH) technician using a hand-held multi-gas meter and a photoionization detector. Monitoring was performed at least twice daily of the drillers' breathing zone near the wellhead, any fresh drill cuttings, geologic samples, and any other areas of potential concern. Field measurements of contaminant concentrations above background levels are discussed in Section 2.2.

2.1.3 Well Construction and Development

The wells were constructed with a Pulstar P38000 Completion Rig using 8-in. nominal diameter, Schedule 10S, Type 304/304L stainless steel casing, 50-slot (0.050-in.) screen at C9988, and 75-slot (0.075-in.) screen at C9879, and sump with end cap. The primary filter pack consists of 8-16 mesh and 6-9 mesh silica sand extending from below the well sump to 10.3 to 14.5 ft above the top of the screen. A variance was issued on November 6, 2018, to allow for the two 200-ZP-1 OU wells to have more than 5 feet of sand filter pack installed and extending above the screened interval (Appendix C). Following the placement of each 10-ft interval of filter pack within a saturated zone, the filter pack was surged using a dual surge block in 10-ft increments until measured settling met CHPRC well development specifications (i.e. less than 0.1 ft of settling in 15 minutes of surging). Annular seal materials include 1/4-in. bentonite pellets, 3/8-in. bentonite chips, and type I/II/V cement grout. Well specific installation and construction depths are presented in Section 2.2 and in Table 2-1.

The surface completion consists of a stainless steel protective casing, a 4- by 4-ft concrete pad, and a protective cap with locking hasp. Four painted 3-in. diameter steel posts were installed at each corner of the cement pad, extending 3 ft above the ground surface. Well tags with unique Ecology identification numbers were affixed to the protective casing of each well. These identification (ID) numbers are found in Table 1-1.

Well development occurred at each well following placement of the filter pack. Development was performed in four intervals at C9988 and seven intervals at C9879 using a 40-hp Grundfos motor and Grundfos submersible pump. Each interval was pumped until water was less than 5.0 nephelometric turbidity units (NTU) and additional water quality parameters (conductivity, pH, and temperature) stabilized. The water level was monitored using an In-Situ Inc., Level TROLL[1] 700 pressure transducer accompanied by a Rugged Reader[2]. Final development data is summarized in Table 2-2.

2.2 Well-Specific Information

This section summarizes borehole drilling, sampling, geophysical logging, well construction, and well development activities specific to each well. Well construction information for each well is summarized in Table 2-1. Well development information for each well is summarized in Table 2-2.

[1] Level TROLL® Instrument is a registered trademark of In-Situ, Inc., Fort Collins, Colorado.

[2] RuggedReader® Handheld Computer is a registered trademark of In-Situ, Inc., Fort Collins, Colorado.

Table 2-1. Well Construction Information

Borehole ID	Total Depth (ft bgs)	Permanent Casing and Screen					Annulus: Seal and Filter Pack				Filter Pack Size (mesh)
		Screen and Casing Diameter (inch)	Screen Slot Size (inch)	Blank Casing[a]	Screen[a]	Sump/ End Cap[a]	Cement Surface Seal[b]	Granular Bentonite Seal[c]	Pellet Bentonite Seal[d]	Filter Pack[e]	
				Interval (ft bgs)							
C9879	480.7	8	0.075	+2.00 – 240.45	240.45 – 395.43	395.43 – 405.43	0.0 – 10.1	10.1 – 225.1 405.8 – 479.0	225.1 – 230.2	230.2 – 405.8	6 - 9
C9988	401.8	8	0.050	+2.02 – 260.47	260.47 – 360.48	360.48 – 370.48	0.0 – 10.0	10.0 – 241.2 371.1 – 401.8	241.2 – 246.0	246.0 – 371.1	8 - 16

a. Schedule 10, Type 304/304L Stainless Steel.

b. Type I/II/V cement grout.

c. Medium bentonite chips (3/8-in.).

d. Bentonite pellets (1/4-in.).

e. Premier silica sand.

+ = above ground surface.

ft bgs = feet below ground surface.

ID = identification.

Table 2-2. Well Development Information

Borehole ID	Static Water Level ft bgs / date		Intake Depth (ft bgs)	Duration (min)	Average Flow Rate (gpm)	Final Turbidity (NTU)	Maximuim Drawdown (ft)	Total Gallons Pumped[a]	Specific Capacity (gpm/ft)
C9879	239.55	11/14/2019	389.1	56	179	35.7	16.30	10,024	10.98
			389.1	55	120	3.90	11.28	6,600	10.64
			368.0	55	150	3.20	14.12	8,250	10.62
			346.9	53	170	2.92	16.19	9,010	10.50
	239.55	11/18/2019	325.8	41	135	4.01	10.20	5,535	13.24
			320.7	57	135	2.03	11.91	7,695	11.34
			304.7	29	135	1.62	12.16	3,915	11.10
			304.7 [b]	21	302	-	30.40	6,342	9.93
			283.6	30	150	3.70	13.97	4,500	10.73
C9988	259.17	08/6/2019	341.1	49	180	24.2	19.84	8,820	9.1
			341.1	38	100	24.8	9.59	3,800	10.4
	259.27	08/7/2019	341.1	113	129	3.86	12.53	14,577	10.3
			320.0	31	180	1.71	18.74	5,580	9.6
			320.0 [b]	34	290	-	32.11	9,860	9.0
			298.9	25	180	1.75	17.61	4,500	10.2
			277.8	25	138	0.98	13.43	3,450	10.1

Table 2-2. Well Development Information

Borehole ID	Static Water Level ft bgs / date	Intake Depth (ft bgs)	Duration (min)	Average Flow Rate (gpm)	Final Turbidity (NTU)	Maximuim Drawdown (ft)	Total Gallons Pumped[a]	Specific Capacity (gpm/ft)

a. Total gallons pumped calculated based on duration and average flow rate unless otherwise noted.

b. Pumping at this depth was a stress test.

ft bgs = feet below ground surface.

gpm = gallons per minute.

ID = identification.

min = minutes

NTU = nephelometric turbidity unit.

2.2.1 Well 699-47-78B (C9879)

Borehole C9879 was drilled from March 26, 2019 through April 9, 2019 to depth of 83.0 ft bgs with a cable tool drill rig and 8 5/8-in. threaded carbon steel casing. The 8 5/8-in. casing was removed, and the borehole was backfilled to ground surface with 8-12 mesh sand. The borehole was re-drilled from May 22, 2019 through June 26, 2019 to a TD of 480.7 ft bgs. The borehole was drilled using 16-in. welded carbon steel casing to a depth of 236.0 ft bgs and 14-in. welded carbon steel casing to a depth of 469.5 ft bgs. Drilling continued with a 12 1/4-in. diameter inner drill rod to a TD of 480.7 ft bgs. Approximately 77 gallons of water was added to the borehole during drilling operations in the vadose zone to aid in advancement of the borehole and provide dust suppression.

On May 22, 2019 IH measured 3 parts per million by volume (ppmv) of ammonia at a depth of approximately 20.0 ft bgs. On May 28, 2019 IH measured 1 ppmv ammonia at a depth of 200.0 ft bgs. On June 10, 2019 IH measured 2.3 ppmv of volatile organic compounds (VOCs) at a depth of 278.0 ft bgs. On June 20, 2019 IH measured 1 ppmv of ammonia at a depth 415.0 ft bgs. On June 24, 2019 IH measured 1 ppmv of ammonia at a depth of 430.0 ft bgs and 8 ppmv of ammonia at a depth of 455.0 ft bgs. On June 25, 2019 IH measured 1 ppmv ammonia at a depth of 456.0 ft bgs. On June 26, 2019 IH measured 4 ppmv ammonia at a depth of 480.0 ft bgs.

Eleven split spoon soil samples were collected and are detailed in Table 2-3. Seven groundwater samples were collected and are summarized in Table 2-4. The last groundwater sample was collected during well development.

Following placement of the 16-in. temporary casing, the borehole was logged by Bay West using SGLS and NMLS. SGLS logging occurred from May 29, 2019 through May 31, 2019 from ground surface to 237.0 ft bgs, and NMLS logging occurred on May 31, 2019 from ground surface to 236.5 ft bgs. Following placement of the 14-in. temporary casing, the borehole was logged using SGLS from July 1, 2019 through July 2, 2019 from 235.0 to 471.0 ft bgs and NMLS on July 2, 2019 from 232.0 to 242.5 ft bgs.

A borehole straightness test was successfully performed on August 28, 2019. Well construction took place from August 27, 2019 through November 25, 2019. The well was constructed as an 8-in. nominal diameter well with 242.93 ft of stainless steel blank casing, 154.98 ft of 75-slot (0.075-in.) screen, and a 10.00 ft sump with end cap. The well was placed at 405.43 ft bgs, extending 2.00 feet above ground surface. Stainless steel centralizers were installed above and below the screen every 40 ft. From TD to surface, the annulus was filled with 1.7-ft of natural fill, a 73.2-ft interval of 3/8-in. medium bentonite chips, 175.6-ft interval of 6-9 mesh sand, 5.1-ft interval of 1/4-in. bentonite pellets, 215.0-ft interval of 3/8-in. medium bentonite chips, and 10.1-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on November 25, 2019. Well construction information is summarized in Table 2-1 and documentation is provided in Appendix A.

Well development occurred from November 14, 2019 through November 18, 2019 using a 40-hp Grundfos submersible pump. Static water level was measured before well development at 239.45 ft bgs on November 14, 2019. Well development is summarized in Table 2-2.

Table 2-3. C9879 Split Spoon Sample Collection Summary

Date	Sample Interval	Sample Depth Interval (ft bgs)	Sample Method	Media	Recovery %	HEIS Number
04/03/2019	I-001	48.0 – 50.5	Split spoon	Soil	100	B3NN14
04/03/2019	I-002	50.4 – 52.9	Split spoon	Soil	100	B3NN15
04/08/2019	I-003	55.1 – 57.6	Split spoon	Soil	100	B3NN16
04/08/2019	I-004	57.8 – 60.3	Split spoon	Soil	100	B3NN17
04/08/2019	I-005	65.6 – 68.1	Split spoon	Soil	100	B3NN18
04/08/2019	I-006	68.4 – 70.9	Split spoon	Soil	100	B33N19
04/09/2019	I-007	79.4 – 81.9	Split spoon	Soil	100	B3NN20
04/09/2019	I-008	81.3 – 83.8	Split spoon	Soil	100	B3NN21
05/29/2019	I-010	235.9 – 238.4	Split spoon	Soil	90	B3NN22
06/12/2019	I-015	337.5 – 340.0	Split spoon	Soil	100	B3NN23
06/18/2019	I-017	397.5 – 400.0	Split spoon	Soil	100	B3NN24

ft bgs = feet below ground surface.

HEIS = *Hanford Environmental Information System*.

Table 2-4. C9879 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
06/05/2019	I-011	257.2	Submersible Pump	3	413	62.9	8.58	B3NN29, B3NN27, B3NN28, B3PJ97, B3PJ98, B3NN30, B3NN31, B3NN32
06/10/2019	I-012	277.1	Submersible Pump	11	665	27.3	8.07	B3NN33, B3NN34, B3NN36, B3PJ99, B3NN35

Table 2-4. C9879 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
06/11/2019	I-013	297.0	Submersible Pump	11	1,307	5.26	6.25	B3NN39, B3NN37, B3NN38, B3PJB0, B3NN40
06/12/2019	I-014	337.5	Submersible Pump	15	1,249	6.76	8.20	B3NN43, B3NN41, B3NN42, B3PJB1, B3PJB2, B3NN44, B3NN45, B3NN46
06/18/2019	I-016	397.5	Submersible Pump	15	1,980	4.84	8.31	B3NN49, B3NN47, B3NN48, B3PJB3, B3NN50, B3NN51
06/25/2019	I-018	456.8	Submersible Pump	15	2,960	7.84	2.77	B3NN52, B3NN53, B3PJB4, B3NN54, B3NN55
11/14/2019	Post Development	320.7[b]	Submersible Pump	135	7,695	3.50	7.23	B3NN59, B3NN60, B3NN61, B3PJB6, B3TM40

a. Total gallons pumped calculated based on duration and average flow rate unless otherwise noted.

b. Sample collected during well development.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

2.2.2 Well 699-48-70 (C9988)

Borehole C9988 was drilled from April 2, 2019 through May 14, 2019 to a TD of 401.8 ft bgs. The borehole was drilled using 16-in. diameter welded carbon steel casing to a depth of 214.2 ft bgs, 14-in. diameter welded carbon steel casing to a depth of 390.7 ft bgs, and inner drill rods with a 12 1/4-in. diameter bit to a TD of 401.8 ft bgs. Approximately 16 gallons of water were added to the borehole during drilling operations in the vadose zone to aid in the advancement of the borehole and provide dust suppression.

Seven groundwater samples were collected and are summarized in Table 2-5. The last groundwater sample was collected during well development.

Following placement of the 16-in. temporary casing, the borehole was logged by Bay West using SGLS and NMLS. SGLS logging occurred on April 11, 2019 from ground surface to 213.01 ft bgs, and NMLS logging occurred on April 12, 2019 from ground surface to 214.51 ft bgs. Following placement of the 14-in. temporary casing, the borehole was logged using SGLS on May 20, 2019 from 212.0 to 392.01 ft bgs. NMLS logging occurred on May 21, 2019 from 213.0 to 260.01 ft bgs.

A borehole straightness test was successfully performed on July 10, 2019. Well construction took place from July 10, 2019 through October 2, 2019. The well was constructed as an 8-in. nominal diameter well with 262.49 ft of stainless steel blank casing, 100.01 ft of 50-slot (0.050-in.) screen, and a 10.00 ft sump with end cap. The well was placed at 370.48 ft bgs, extending 2.02 feet above ground surface. Stainless steel centralizers were installed above and below the screen every 40 ft. From TD to surface, the annulus was filled with a 30.7-ft interval of 3/8-in. medium bentonite chips, a 125.1-ft interval of 6-9 mesh sand, a 4.9-ft interval of 1/4-in. bentonite pellets, a 231.2-ft interval of 3/8-in. medium bentonite chips, and a 10.0-ft interval of cement grout. The protective casing was installed on September 26, 2019. Well construction information is summarized in Table 2-1 and documentation is provided in Appendix B.

Well development occurred from August 6, 2019 through August 7, 2019 using a 40-hp Grundfos submersible pump. Well development information is summarized in Table 2-2. Static water level was measured before well development at 259.17 ft bgs on August 6, 2019.

Table 2-5. C9988 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
05/02/2019	I-001	275.4	Submersible Pump	10	1,310	60.2	10.46	B3NJ32, B3NJ33, B3NJ34, B3PJ90, B3NJ35, B3NJ36, B3PJ91
05/07/2019	I-002	295.2	Submersible Pump	15	1,110	4.76	11.25	B3NJ37, B3NJ38, B3PJ92, B3NJ39, B3NJ40

Table 2-5. C9988 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
05/07/2019	I-003	315.4	Submersible Pump	10	960	153	8.69	B3NJ41, B3NJ42, B3PJ93, B3NJ43
05/08/2019	I-004	335.4	Submersible Pump	13	1,417	25.1	8.09	B3NJ44, B3NJ45, B3PJ94, B3NJ46
05/09/2019	I-005	355.5	Submersible Pump	12	1,572	39.0	9.49	B3NJ47, B3NJ48, B3PJ95, B3NMX9
05/14/2019	Contingency #1	375.6	Submersible Pump	94	1,410	9.10	4.76	B3PP86, B3PP87, B3PP88, B3PP89
08/07/2019	Post Development	341.1[b]	Submersible Pump	129	14,577	3.09	8.24	B3NJ49, B3NJ50, B3NJ51, B3NJ52, B3PJ96

a. Total gallons pumped calculated based on duration and average flow rate unless otherwise noted.

b. Sample collected during well development.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

3 Geologic Observations

This section summarizes the general geology in the 200-West Area near the new well locations, and presents the stratigraphy encountered during the drilling of each well.

3.1 Geology of the 200-ZP-1 Operable Unit

The major stratigraphic units encountered during drilling in the 200-ZP-1 OU are sand and gravel of the Hanford formation and/or surficial deposits, sand and gravel of the Cold Creek unit (CCU), sand and gravel of the Ringold Formation, member of the Wooded Island - unit E (Rwie), clay and silt of the Ringold Formation, member of Wooded Island - lower mud unit (RLM), sand and gravel of Ringold Formation, member of the Wooded Island - unit A (Rwia), and basalt.

Holocene eolian deposits at the surface are considered recent deposits and are present across most of the Hanford Site. These deposits consist of a discontinuous veneer of silty sand or backfill mixtures of sand and gravel. The Hanford formation underlies any anthropogenically-disturbed sediment and largely consists of cataclysmic flood deposits related to episodic ice dam failures at glacial Lake Missoula that resulted in varying grain size from high-energy gravel rich deposits to low-energy silts and sands. Floodwaters scoured hundreds of miles of the Columbia River Flood basalts, resulting in sediments predominately composed of sandy gravel or gravelly sand lithology, and occasionally finer lithology formed from slackwater facies. The sand fraction consists of loose, fine-to-course-grained sand, composed of, on average, 50% mafic-rich minerals and 50% silicates. This gives many of the Hanford formation sediments a “salt and pepper” appearance (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*).

The CCU disconformably underlies the Hanford formation within the area. The CCU is generally fine-grained calcareous sediments and represent mainstream alluvial, calcic paleosol, side stream alluvial, colluvial, and overbank-aeolian environments. The CCU is only encountered at C9879.

Disconformably underlying the CCU is the Ringold Formation. The Ringold Formation, in the project area, comprises the deepest portion of the sedimentary sequence and consists of (in descending order): semi-consolidated fluvial silt, sand, and mostly gravels of Rwie; paleosol and lacustrine clay and silt of the RLM; and quartz-feldspar-lithic gravel, sand, and paleosols of the basal Rwia. The RLM underlies sediments of the Rwie and consists of fluvial overbank sediments, paleosols, lacustrine silt and clay deposits, and minor sand and gravel lenses. The RLM extends under the south, west, and central portion of the 200 West Area. However, the RLM is eroded away along the northern border of the 200 West Area and is absent in a north-south oriented channel extending from the coal plant to the northeast corner of the 200 West Area. The RLM is the base of the unconfined aquifer and is only encountered at C9879. The Rwia underlies sediments of the RLM in various thicknesses and extends to the top of the Columbia River Basalt Group.

Underlying the 200-ZP-1 OU is the Elephant Mountain Member of the Saddle Mountains Basalt. The uppermost surface of the Elephant Mountain Member basalt is considered the base of the suprabasalt aquifer system (bedrock) because of its low permeability relative to the overlying sediments.

3.2 Borehole Geology

The following discussion focuses on the geologic conditions encountered at individual boreholes. Copies of the original borehole logs are presented in Appendices A and B.

Stratigraphic unit contacts included in this document are based on field drill cuttings examination (i.e., lithology, texture, color based on Munsell® soil color chart[3], reaction to 10% dilute hydrochloric acid [HCl], etc.) and drilling observations (i.e., drill rate) in the field. As such, the unit contacts included herein should not be considered final. It should be noted that geologic field descriptions of Dual Rotary drill cuttings may not be completely representative of the geologic formation due to sorting, crushing, and binding as the cuttings exit the borehole. Final stratigraphic unit contact depths will be determined during data review and will incorporate the field observations, borehole geophysical logging information, and regional stratigraphic interpretations. The basis for the field stratigraphic unit contacts is included in the individual borehole summaries below.

3.2.1 Borehole Geology for C9879 (699-47-78B)

Stratigraphic units encountered during drilling of C9879 are the Hanford formation, CCU, Rwie, RLM, and Rwia. Recovered sediments from C9879 are primarily sandy gravel, gravelly sand, gravel, sand, and silt.

The sediments encountered from ground surface to 50.0 ft bgs consist of Hanford formation sandy gravel, gravelly sand, slightly silty gravelly sand, and sand. Sandy gravel is present from ground surface to 10.0 ft bgs, 20.0 to 25.0 ft bgs, and 31.0 to 40.0 ft bgs, consisting of 30 to 53% gravel, 23 to 63% sand, and 7% silt. Gravelly sand is encountered from 10.0 to 20.0 ft bgs consisting of 25% gravel, 68% sand, and 7% silt. Slightly silty gravelly sand is present from 25.0 to 30.0 ft bgs and consists of 20% gravel, 69% sand, and 11% silt. Sand is encountered from 30.0 to 31.0 ft bgs and from 40.0 to 50.0 ft bgs, and consists of 5 to7% gravel, 88 to 90% sand, and 3 to 7% silt. The gravels within the Hanford formation are composed of poorly to moderately sorted, subangular to subround clasts, ranging from very fine pebbles to occasional large cobbles that are 80 to 90% mafic in composition. The sand within the Hanford formation is moderately sorted, very fine to very coarse grained and consists of 80 to 90% mafic grains. The Hanford formation sediments display a strong reaction to HCl. Sediments recovered from ground surface to 15.0 ft bgs are light brownish gray (2.5Y 6/2) in color, from 15.0 to 25.0 ft bgs sediments are light yellowish brown (2.5Y 6/3), and from 25.0 to 50.0 ft bgs sediments are olive brown (2.5Y 4/4) in color.

The Hanford formation to CCU contact is interpreted to be at 50.0 ft bgs. The CCU extends to 120.0 ft bgs and consists of sandy gravel, sandy silt, slightly silty gravelly sand, and gravelly sand. The sediments in the CCU displayed a weak to strong reaction to HCl. From 50.0 to 55.0 ft bgs, sandy gravel is present consisting of 49% gravel, 49% sand, and 2% silt. The silt content increases at 55.0 ft bgs and sandy silt is encountered. The sandy silt continues to 60.0 ft bgs and consists of 8% gravel, 32% sand and 60% silt. The silt content in the sediment decreases at 60.0 ft bgs and slightly silty gravelly sand is encountered and consists of 29% gravel, 60% sand, and 11% silt. As the silt content continues to decrease with depth sand is encountered from 80.0 to 120.0 ft bgs with a layer of gravelly sand encountered from 80.0 to 83.0 ft bgs. The sand consists of up to 5% gravel, 92 to 100% sand, and up to 3% silt. The gravelly sand layer consists of 25% gravel, 72% sand, and 3% silt. The gravels within the CCU are composed of poorly to moderately sorted, sub angular to subround, very fine to coarse pebbles with occasional small cobbles that are 80 to 95% mafic in composition. The sand within the CCU is moderately sorted, very fine to very coarse grained and consists of 50 to 90% mafic grains. The CCU sediments display a strong reaction to HCL from 55.0 to 70.0 ft bgs and 75.0 to 85.0 ft bgs. The CCU sediments are olive brown (2.5Y 4/4).

The CCU to Rwie contact is interpreted to be at 120.0 ft bgs. The Rwie is predominantly made up of sandy gravel until 400.0 ft bgs, with occasional gravel, sand, and gravelly sand layers throughout. Sandy

[3] Munsell® Soil Color Charts is a registered trademark of X-Rite, Inc. Grand Rapids, Michigan.

gravel is present from 120.0 to 125.0 ft bgs, 130.0 to 155.0 ft bgs, 160.0 to 205.0 ft bgs, 210.0 to 240.0 ft bgs, and 255.0 to 400.0 ft bgs. The sandy gravel consists of 30 to 75% gravel, 20 to 70% sand, and up to 10% silt. Gravel is encountered from 125.0 to 130.0 ft bgs, and 155.0 to 160.0 ft bgs. The gravel consists of 85 to 90% gravel, 10 to 15% sand, and trace silt. Sand is encountered from 205.0 to 210.0 ft bgs and consists of 2% gravel, 98% sand, and trace silt. Gravelly sand is present from 240.0 to 255.0 ft bgs and consists of 15 to 25% gravel, 70 to 80% sand, and 5% silt. The gravels within the Rwie are poorly to moderately sorted, angular to round clasts, ranging from very fine to very coarse pebbles with occasional small cobbles encountered from 210.0 to 240.0 ft bgs. The gravels range from 10 to 80% mafic in composition and display very high strength cementation from 365.0 to 370.0 ft bgs and 390.0 to 395.0 ft bgs. The sand within the Rwie is moderately to well sorted, very fine to very coarse, angular to round grains that are 30 to 60% mafic in composition. The Rwie sediments display a strong reaction to HCl from 120.0 to 130.0 ft bgs, and 240.0 to 250.0 ft bgs. The Rwie sediments are predominately light olive brown (2.5Y 5/4) in color.

The contact between Rwie and the RLM is interpreted to be at 400.0 ft bgs due to an increase in the silt content at 400.0 ft bgs with 3- to 30-mm clay nodules present from 400.0 to 405.0 ft bgs. Alternating layers of silty sandy gravel are encountered from 400.0 to 405.0 ft bgs, 410.0 to 412.0 ft bgs and 415.0 to 420.0 ft bgs. The silty sandy gravel is composed of 35 to 45% gravels, 30 to 40% sand, and 20 to 25% silt. From 405.0 to 410.0 ft bgs, gravelly sandy silt is encountered with 10 to 20% gravel, 30 to 35% sand, and 45 to 60% silt. From 412.0 to 415.0 ft bgs silty sand is encountered with 5% gravel, 50% sand, and 45% silt. The silt is non-plastic from 400.0 to 420.0 ft bgs and organics are present from 406.0 to 412.0 ft bgs. The gravels within the RLM are composed of poor to moderately sorted, angular to round clasts, ranging from very fine to coarse pebbles that are 40 to 85% mafic in composition. The sand within the RLM is well sorted from 400.0 to 405.0 ft bgs and 40% mafic in composition, and poorly sorted from 410.0 to 412.0 and 415.0 to 420.0 ft bgs and 80% mafic in composition. The sand is very fine to very coarse grained. The RLM sediments are light olive brown (2.5Y 5/4) in color from 400.0 to 405.0 ft bgs, pale yellow (2.5Y 7/3) from 405.0 to 406.0 ft bgs, pale yellowish brown (2.5Y 6/3) from 406.0 to 410.0 ft bgs, and is very dark gray (2.5Y 3/1) from 410.0 to 420.0 ft bgs.

The contact between the RLM and Rwia is interpreted to be at 420.0 ft bgs due to a decrease in silt content and the return of sandy gravel from 420.0 to 469.5 ft bgs. The sandy gravel is light olive brown (2.5Y 5/4) in color and composed of 70 to 75% gravel, 20 to 25% sand, and 5% silt from 420.0 to 425.0 ft bgs and 445.0 to 465.0 ft bgs. There is 45% gravel, 45% sand, and 10% silt from 425.0 to 445.0 ft bgs, 465.0 to 469.5 ft bgs. The gravel fraction of the sandy gravel from 420.0 to 469.5 ft bgs is composed of angular to sub-round, very fine to coarse, well to moderately sorted pebbles, with trace very coarse pebbles from 430.0 to 435.0 ft bgs. The gravel fraction of the sandy gravel is 40 to 60% mafic in composition, with green weathering and crystallization encountered in vesicles of basalt from 445.0 to 460.0 ft bgs and very high cementation present from 445.0 to 465.0 ft bgs. The sand fraction consists of very fine to very coarse, angular to subangular, well sorted, grains; the sand is 40 to 70% mafic in composition.

Iron oxidation is present in trace amounts from 465.0 to 469.5 ft bgs, where the contact between Rwia and basalt is encountered. At 469.5 ft bgs recovered sediments are 92% basalt with 8% felsic sand and gravels. The basalt is black (2.5Y 2.5/1) in color and was broken from drilling into angular, 2 to 30 millimeter (mm) sized cuttings. At 469.5 ft bgs the basalt displays green and gray clay-like weathering. At 470.0 ft bgs the basalt has blue and gray clay-like weathering. Trace amounts of vesicular basalt is present from 469.5 ft bgs until TD. Drilling in the basalt continued until TD was reached at 480.7 ft bgs.

3.2.2 Borehole Geology for C9988 (699-48-70)

Stratigraphic units encountered during drilling of C9988 were the Hanford formation, Rwie, and the basalt. Recovered sediments from C9988 are primarily gravel, sand, gravelly sandy, sandy gravel, slightly silty sand, silty sandy gravel, slightly silty gravelly sand, and basalt.

The sediments encountered from ground surface to 205.0 ft bgs consist of Hanford formation gravel, sand, gravelly sand, and sandy gravel. Gravel is present from ground surface to 25.0 ft bgs. The gravel is composed of 95% gravel, 5% sand, trace silt and is light olive brown (2.5Y 5/4) in color. The gravel displays a very weak reaction to HCl from 10.0 to 20.0 ft bgs. Sand is encountered from 25.0 to 50.0 ft bgs with a layer of gravelly sand from 35.0 to 40.0 ft bgs. The gravelly sand encountered from 35.0 to 40.0 ft bgs is composed of 10% gravel, 90% sand, and is light olive brown (2.5Y 5/4) in color. Gravel increases at 50.0 ft bgs and sandy gravel is present until 75.0 ft bgs. The sandy gravel is composed of 45% gravel, 50% sand, 5% silt and is olive brown (2.5Y 4/3) in color. The sand content in the sediment increases with depth and gravelly sand is present from 75.0 to 80.0 ft bgs, and sand is encountered from 80.0 to 90.0 ft bgs. The gravelly sand is composed 20% sand, 80% sand, trace silt and is olive brown (2.5Y 4/4) in color. The sand encountered from 80.0 to 90.0 ft bgs is composed of 5% gravel, 95% sand, trace silt and is light olive brown (2.5Y 5/4) in color. Sandy gravel is present from 90.0 to 130.0 ft bgs and consists of 35 to 70% gravel, 30 to 60% sand, and up to 5% silt. The sandy gravel is olive brown (2.5Y 4/3) in color from 90.0 to 110.0 ft bgs, light brownish gray (2.5Y 6/2) from 110.0 to 115.0 ft bgs, light olive brown (2.5Y 5/3) from 115.0 to 125.0 ft bgs, and olive brown (2.5Y 4/4) to 130.0 ft bgs. As gravel content in the sediment decreases gravelly sand is encountered from 130.0 to 135.0 ft bgs and sand is encountered from 135.0 to 140.0 ft bgs. The gravelly sand is composed of 15% gravel, 80% sand, 5% silt and is olive brown (2.5Y 4/3) in color. The sand present at 135.0 ft bgs is composed of 5% gravel, 95% sand, trace silt and is olive brown (2.5Y 4/3) in color. Sandy gravel is encountered at 140.0 ft bgs and extends to 205.0 ft bgs with a layer of gravel from 165.0 to 170.0 ft bgs. The sandy gravel is composed of 30 to 75% gravel, 24 to 65%, and up to 5% silt. The sandy gravel is grayish brown (2.5Y 5/2) in color from 140.0 to 155.0 ft bgs, yellowish brown (10YR 5/4) from 155.0 to 160.0 ft bgs, grayish brown (2.5Y 5/2) from 160.0 to 165.0 ft bgs, light grayish brown (2.5Y 6/3) from 170.0 to 175.0 ft bgs, light gray (7.5YR 7/1) from 175.0 to 180.0 ft bgs, pale brown (10YR 6/3) from 180.0 to 195.0 ft bgs, yellowish brown (10YR 5/4) from 195.0 to 200.0 ft bgs, and brown (7.5YR 4/3) from 200.0 to 205.0 ft bgs. The sandy gravel displayed a strong reaction to HCl from 155.0 to 160.0 ft bgs and a weak reaction from 185.0 to 190.0 ft bgs. The gravel layer encountered within the sandy gravel from 165.0 to 170.0 ft bgs is composed of 90% gravel, 10% sand, trace silt and is light gray (10YR 7/2) in color. The gravels within the Hanford formation are on average moderately sorted, subangular to angular clasts ranging from very fine to very coarse pebbles that are 50 to 90% mafic in composition. The sands within the Hanford formation are on average well to moderately sorted, subangular grains ranging from very fine to coarse with an average medium grain size and is 25 to 70% mafic in composition.

The transition from the Hanford formation to the Rwie is interpreted to start at 205.0 ft bgs where there is an increase in felsic percentage in the sediment. The Rwie extends to 389.0 ft bgs and consists of gravel, sandy gravel, gravelly sand, slightly silt sand, silty sandy gravel, and slightly silty gravelly sand. Gravel present from 205.0 to 220.0 ft bgs contains 80% gravel, 20% sand, and is yellowish brown (10YR 5/4) in color to 210.0 ft bgs, light gray (10YR 7/2) from 210.0 to 215.0 ft bgs, yellowish brown (10YR 5/4) from 215.0 to 220.0 ft bgs. Alternating layers of sandy gravel and gravelly sand are present from 220.0 to 295.0 ft bgs. Sandy gravel is encountered from 220.0 to 225.0 ft bgs, 230.0 to 255.0 ft bgs, and 265.0 to 275.0 ft bgs. Gravelly sand is encountered from 225.0 to 230.0 ft bgs, and 255.0 to 265.0 ft bgs. The sandy gravel layers are composed of 45 to 65% gravel, 35 to 50% sand, and up to 5% silt. The sandy gravel is olive brown (2.5Y 4/4) in color and displays a moderate reaction to HCl from 230.0 to 240.0 ft bgs. The gravelly sandy layers are composed of 20% gravel, 75% sand, and 5% silt. The gravelly sand is

olive brown (2.5Y 4/4) in color and displays a strong reaction to HCl from 260.0 to 265.0 ft bgs. Silt in the sediment increases and silty sandy gravel is present from 295.0 to 300.0 ft bgs and slightly silty gravelly sand is encountered from 300.0 to 310.0 ft bgs. The silty sandy gravel is composed of 65% gravel, 20% sand, 15% silt and is olive brown (2.5Y 4/3) in color. The slightly silty gravelly sand is composed of 15% gravel, 70% sand, 15% silt and is light olive brown (2.5Y 5/3) in color. The gravel fraction is moderately sorted, angular to subround clasts ranging from very fine to coarse pebbles that are 40% mafic in composition. The sand fraction is well sorted, very fine to coarse, angular to subangular grains that are 60% mafic in composition. Sandy gravel is present from 310.0 to 389.0 ft bgs with a layer of gravel from 345.0 to 360.0 ft bgs. The sandy gravel is composed of 40 to 80% gravel, 15 to 30% sand, and up to 10% silt. The gravel is composed of 80 to 90% gravel, 5 to 10% sand, and up to 10% silt. The gravels in the Rwie are on average poorly to moderately sorted, angular to rounded clasts ranging from very fine to very coarse pebbles that are 30 to 50% mafic in composition. The sands within the Rwie are on average poorly to moderately sorted, very fine to very coarse grains that are 30 to 60% mafic in composition.

Basalt was encountered at 389.0 ft bgs. The basalt is black (2.5Y 2.5/1) in color with occasional vesicles. The basalt displayed blue and gray weathering within the vesicles and light greenish white weathering on the outside of the vesicles. The basalt was broken from drilling into angular, 3 to 25 mm sized cuttings. Drilling in the basalt continued until TD was reached at 401.8 ft bgs.

4 Waste Management

Waste generated during the activities described in this document was managed in accordance with DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan* (TPA-0794) (Appendix B, "Waste Management Plan for the 200 West Pump and Treat") and was characterized to the extent necessary to meet the requirements of DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*, and DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*.

All vadose zone drill cuttings from above the historic high water mark were placed on sheets of plastic to dry. Cuttings were surveyed by RCT and IH personnel and were determined to meet Return to Earth criteria. These cuttings were then spread around the well location at the completion of well activities. Miscellaneous solid waste associated with vadose zone cuttings, including nitrile gloves, plastic bags, and other waste associated with sampling activities, were contained in black plastic bags and placed in the designated roll off box.

All drill cuttings collected at or below the water table were released into tip dumpsters, dewatered, and placed in designated waste roll off boxes. Dewatered fluid was treated as purgewater. Water-absorbing crystals were spread over the dewatered drill cuttings to absorb free liquids, allowing the waste container to be designated as solid waste. All waste was managed as investigation-derived waste and surveyed by RCTs and IH personnel prior to transfer and disposal at the Environmental Restoration Disposal Facility.

Purgewater and decontamination fluids were collected and contained at the well head until it was transported to the Modular Storage Unit.

5 Civil Survey

The well locations were surveyed in accordance with applicable procedures. Vertical survey data were recorded using *North American Vertical Datum of 1988* (NAVD88) and the horizontal coordinates were recorded using the Washington State Plane (South Zone) *North American Datum of 1983* (NAD83), with the 1991 adjustment for horizontal coordinates. Surveyed coordinates and elevation for each well are presented in Table 1-1 and survey data reports are included in Appendices A and B, for each respective well.

6 Well Acceptance

Well acceptance is the final step in the well construction process and represents confirmation of meeting requirements of the work scope. Well acceptance also serves as the contractual completion of the finished product.

Representatives from CHPRC and Yellow Jacket (drilling contractor) participated in the acceptance inspection for C9988 on September 30, 2019 and C9879 on December 5, 2019. Final well acceptance was documented by completion of a checklist and signatures from representatives of the drilling contractor and CHPRC. A Quality Assurance Work Site Assessment is conducted for each well.

7 References

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Appendix A

Well Documentation for C9879 (699-47-78B)

Contents

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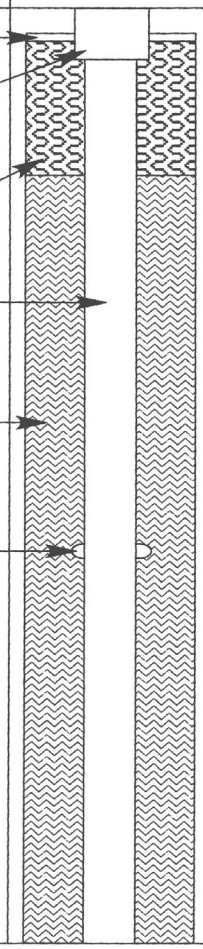
Well Survey Data Report …….....…..…..……....……...…....… A-54

WELL SUMMARY SHEET

Well ID : C9879	Well Name: 699-47-78B	Start Date: 3/26/2019
Project: Install 2 Wells in 200-ZP-1 OU	Location: 30 m North of 200-W-33	Finish Date: 11/25/2019

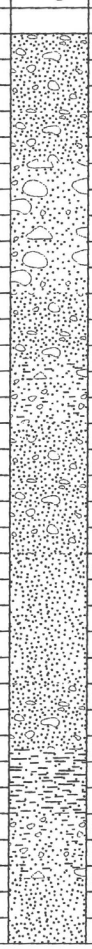
CONSTRUCTION DATA

Description	Diagram
Concrete Pad: 0.5 ft above ground surface (ags)	
10-in. Protective Casing: 2.99 ft ags - 2.01 ft below ground surface (bgs)	
Type I/II Portland Cement Grout: 0.0 - 10.1 ft bgs	
8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 240.45 ft bgs	
3/8-in Bentonite Crumbles: 10.1 - 225.1 ft bgs	
Stainless steel centralizer installed above and below screen and every 40 ft	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
0		0.0 - 10.0 Sandy Gravel (sG)
10		10.0 - 20.0 Gravelly Sand (gS)
20		20.0 - 25.0 Sandy Gravel (sG)
		25.0 - 30.0 Slightly Silty Gravelly Sand ((m)gS)
30		30.0 - 31.0 Sand (S)
		31.0 - 40.0 Sandy Gravel (sG)
40		40.0 - 50.0 Sand (S)
50		50.0 - 55.0 Sandy Gravel (sG)
		55.0 - 60.0 Sandy Silt (sM)
60		60.0 - 65.0 Slightly Silty Gravelly Sand ((m)gS)
		65.0 - 80.0 Sand (S)



Reported By:			
Lindsey Getchell	Geologist	Lindsey Getchell	11/26/2019
Print Name	*Title*	*Signature*	*Date*
Reviewed By:			
Jennifer Richart	Well Coordinator	J. Richart	12/30/19
Print Name	*Title*	*Signature*	*Date*

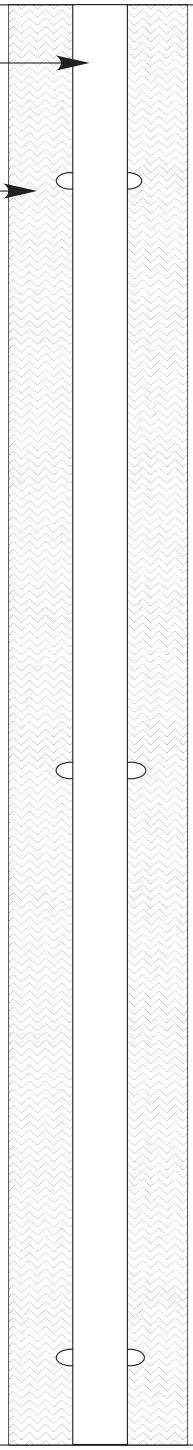
For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-643

WELL SUMMARY CONTINUATION SHEET			Page 2 of 6
Well ID: C9879	Well Name: 699-47-78B	Project: Install 2 Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 240.45 ft bgs		70		65.0 - 80.0 Sand (S)
3/8-in Bentonite Crumbles: 10.1 - 225.1 ft bgs		80		80.0 - 83.0 Gravelly Sand (gS)
				83.0 - 120.0 Sand (S)
		90		
		100		
		110		
		120		120.0 - 125.0 Sandy Gravel (sG)
				125.0 - 130.0 Gravel (G)
		130		130.0 - 155.0 Sandy Gravel (sG)
		140		
		150		
				155.0 - 160.0 Gravel (G)
		160		160.0 - 205.0 Sandy Gravel (sG)



A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET		Page 3 of 6
Well ID: C9879	Well Name: 699-47-78B	Project : Install 2 Wells in 200-ZP-1 OU

CONSTRUCTION DATA

Description

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 240.45 ft bgs

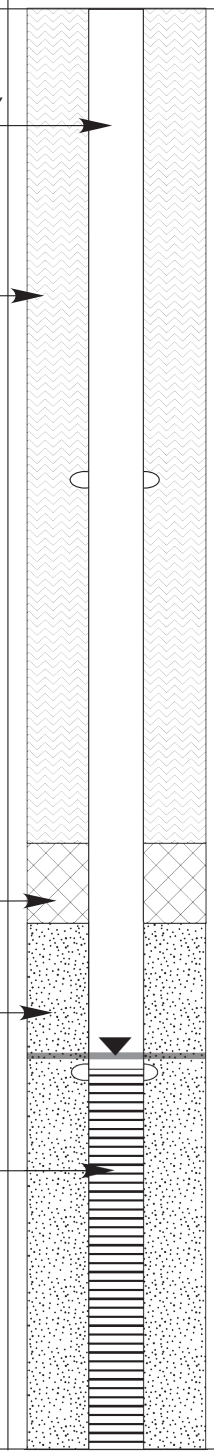
3/8-in Bentonite Crumbles: 10.1 - 225.1 ft bgs

1/4-in. Coated Bentonite Pellet Seal: 225.1 - 230.2 ft bgs

6-9 mesh Filter Pack Sand: 230.2 - 405.8 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 240.45 - 395.43 ft bgs

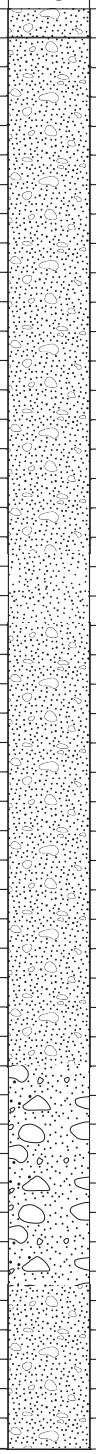
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 170, 180, 190, 200, 210, 220, 230, 240, 250, 260

Graphic Log



Lithologic Description (ft bgs)

160.0 - 205.0 Sandy Gravel (sG)

205.0 - 210.0 Sand (S)

210.0 - 240.0 Sandy Gravel (sG)

Water Level: 239.35 ft bgs (11/25/2019)

240.0 - 255.0 Gravelly Sand (gS)

255.0 - 400.0 Sandy Gravel (sG)

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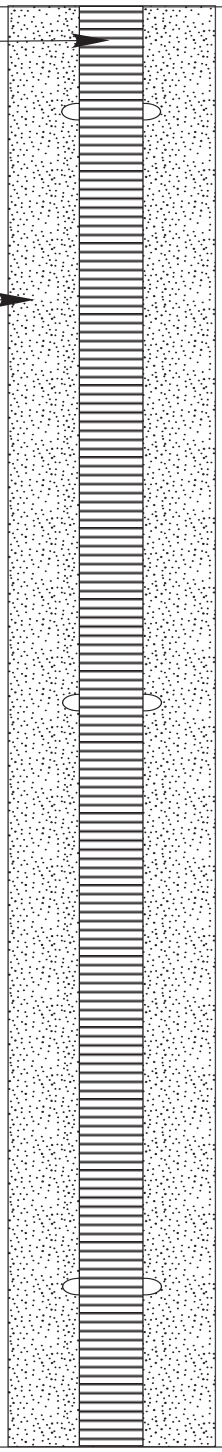
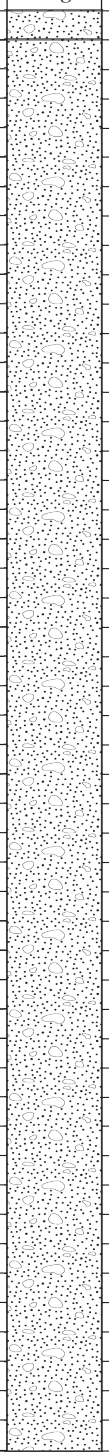
WELL SUMMARY CONTINUATION SHEET			Page 4 of 6
Well ID: C9879	Well Name: 699-47-78B	Project: Install 2 Wells in 200-ZP-1 OU	

CONSTRUCTION DATA			GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 240.45 - 395.43 ft bgs		270		255.0 - 400.0 Sandy Gravel (sG)
6-9 mesh Silica Filter Pack Sand: 230.2 - 405.8 ft bgs		280		
		290		
		300		
		310		
		320		
		330		
		340		
		350		
		360		

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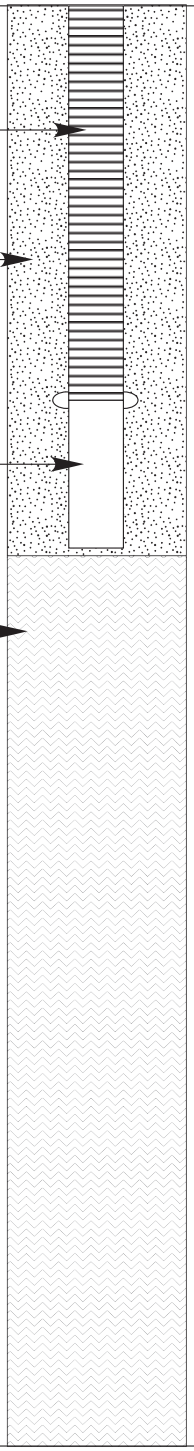
WELL SUMMARY CONTINUATION SHEET		Page 5 of 6
Well ID: C9879	Well Name: 699-47-78B	Project: Install 2 Wells in 200-ZP-1 OU

CONSTRUCTION DATA

Description	Diagram
8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 240.45 - 395.43 ft bgs	
6-9 mesh Silica Filter Pack Sand: 230.2 - 405.8 ft bgs	
8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 395.43 - 405.43 ft bgs	
3/8-in Bentonite Crumbles: 405.8 - 479.0 ft bgs	

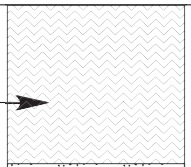
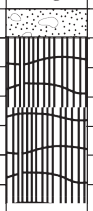


GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
370		255.0 - 400.0 Sandy Gravel (sG)
380		
390		
400		400.0 - 405.0 Silty Sandy Gravel (msG)
		405.0 - 410.0 Gravelly Sandy Silt (gsM)
410		410.0 - 412.0 Silty Sandy Gravel (msG)
		412.0 - 415.0 Silty Sand (mS)
		415.0 - 420.0 Silty Sandy Gravel (msG)
420		420.0 - 469.5 Sandy Gravel (sG)
430		
440		
450		
460		

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET			Page 6 of 6
Well ID: C9879	Well Name: 699-47-78B	Project: Install 2 Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
3/8-in Bentonite Crumbles: 405.8 - 479.0 ft bgs		470		420.0 - 469.5 Sandy Gravel (sG)
Natural fill: 479.0 - 480.7 ft bgs				469.5 - 480.7 Basalt
		480		Total depth: 480.7 (6/26/2019)
		490		
		500		
		510		
		520		
		530		
Straightness Test: Pass, 08/28/2019				
Depths are in ft below ground surface.				
Borehole drilled with 8 5/8-in. O.D. casing from 0.0 - 83.0 ft bgs and backfilled to ground surface with 12-20 mesh sand.		540		
Borehole re-drilled with 16-in. O.D. casing from 0.0 - 236.0 ft bgs and 14-in. O.D. casing from 236.0 - 469.4 ft bgs.		550		
Borehole drilled with 12 1/4-in. O.D. drill bit from 469.4 - 480.7 ft bgs.		560		
All temporary drill casing was removed from the ground.				

A-6006-992 (Rev 2)

BOREHOLE LOG

Page 1 of 13
Date: 4-16-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33
Project: Install 2 Wells in 200-ZP-1 OU | Reference Measure Point: Ground surface

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
0			0'-10': sandy Gravel (sG) g=30% s=63% m=7% gravel: v. fine to v. coarse peb w/v. occ. large cob, avg 5mm, max 160mm, mod sort, 20% fel 80% maf, sub-ang to sub-rd. sand: v. fine to v. coarse, avg v. fine/fine, poor sort, 20% fel 80% maf, sub-ang. Dry, strg rxn to HCl. 2.5Y 6/2, light brownish gray.	Cable Tool drilling with 8 5/8" OD/7 3/8" ID temporary casing 0.0'-77.98' bgs. 8 5/8" casing removed and backfilled to ground surface. Dual Rotary drilling with 16"/15 3/8" temporary casing 0.0'-235.9' bgs. D.R. with 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" OD drill rods and 12" OD tri-cone bit 469.5'-480.7' bgs. Grab samples collected every 5' or change in lithology.
5	G			
10	G		10'-20': gravelly Sand (gS) g=25% s=68% m=7% gravel: v. fine to v. coarse peb w/v. occ. large cob, avg 5mm, max 160mm, poor sort, 20% fel 80% maf, ang to sub-rd. sand: v. fine to v. coarse, avg fine, mod sort, 20% fel 80% maf, sub-ang. Dry, strg rxn to HCl. 2.5Y 6/2, lgt brownish gray.	0.0'-83.0' Cable tool 7" OD drive barrel. 0.0'-235.9' Dual Rotary 14" OD hammer bit.
15	G		@15': g comp ↓ to 10% fel, ↑ to 90% maf, g= sub-ang to sub-rd. s comp ↓ to 10% fel, ↑ to 90% maf. Color change: 2.5Y 6/3, light yellowish brown.	
20	G		20'-25': sandy Gravel (sG) g=53% s=40% m=7% gravel: v. fine to v. coarse peb w/v. occ. large cob, avg 5mm, max 130mm, poor sort, 20% fel 80% maf, sub-ang to sub-rd. sand: v. fine to v. coarse, avg fine, mod sort, 20% fel 80% maf, sub-ang. Dry, strg rxn to HCl. 2.5Y 6/3, light yellowish brown.	
25	G		25'-30': slightly silty gravelly Sand ((M)gS) g=20% s=69% m=11% gravel: v. fine to v. coarse peb w/v. occ. large cob, avg 5mm, max 140mm, poor sort, 10% fel 90% maf, sub-ang to sub-rd. sand: v. fine to coarse, avg v. fine/fine, mod sort, 10% fel 90% maf, sub-ang. Moist, strg rxn to HCl. 2.5Y 4/4, olive brown. Silt: mod plasticity.	
30	G G		30'-31': Sand (S) g=5% s=88% m=7% gravel: v. fine to v. coarse peb w/v. occ. large cob, avg 5mm, max 140mm, mod sort, 10% fel 90% maf, sub-ang to sub-rd. sand: v. fine to coarse, avg v. fine/fine, mod sort, 90% fel 10% maf, sub-ang, mica noticed. Some cemented gravel present. Dry, strg rxn to HCl. 2.5Y 4/4, olive brown. 31'-40': sandy Gravel (sG) g=70% s=23% m=7% gravel: v. fine to v. coarse peb, avg 3-5mm, max 35-45mm, mod sort, 10% fel 90% maf... (cont'd on page 2)	

Reported By:			
Beth Morter	Geologist	Beth Morter	7-3-19
Print Name	Title	Signature	Date

Reviewed By:			
Sarah Springer	Sr. Geologist	Sarah Springer	07-22-19
Print Name	Title	Signature	Date

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OR Doc Type:	WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 13

Date: 4-16-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
35	G		31'-40': sandy Gravel (sG) g=70% s=23% m=7% gravel: v.fine to v.coarse peb, avg 3-5mm, max 35-45mm, mod sort, 10% fel 90% maf, sub-ang to sub-rd. Sand: v.fine to v.coarse, avg v.fine/fine, mod sort, 20% fel 80% maf, sub-ang, mica noticed in v.fine/fine sand faction. Moist, strg rxn to HCl. 2.5Y 4/4, olive brown.	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" OD drill rods & 12" OD tri-cone 469.5'-480.7' bgs. Grab Samples every 5' or change in lithology.
			@35': avg sand ↑ to med/coarse. g=47.5% s=47.5% m=5% (~7%), Rxn to HCl is wk.	
40	G		40'-50': Sand (S) g=7% s=90% m=3% gravel: v.fine to med peb, avg 5mm, max 15mm, poor sort, 5% fel 95% maf, sub-ang to sub-rd. sand: v.fine to coarse, avg fine/med, mod sort, 20% fel 80% maf, sub-ang. Moist, strg rxn to HCl. 2.5Y 4/4, olive brown.	
45	G		@45': no gravel present, s↑ to 93%, m↑ to 7%, sand: avg v.fine/fine, well sort, fel ↑ to 70%, maf ↓ to 30%, mica noticed in v.fine/fine sand faction. Color change: 2.5Y 5/3, light olive brown.	
	SS		50'-55': sandy Gravel (sG) g=48.5% s=48.5% m=3% gravel: v.fine to coarse peb, avg 5mm, max 25mm, mod sort, 15% fel 85% maf, sub-ang to sub-rd. sand: v.fine to v.coarse, avg fine/med, mod sort, 50% fel 50% maf, sub-ang, v.coarse sand almost entirely maf. Moist, wk rxn to HCl. 2.5Y 4/4, olive brown.	Split Spoon Sample: 48.0'-50.5' bgs
50	G			
	SS			Split Spoon: 50.4'-52.9' bgs
55	G+SS		55'-60': sandy Silt (sM) g=8% s=32% m=60% gravel: v.fine to med peb, avg 5mm, max 10mm, mod sort, 5% fel 95% maf, sub-ang to sub-rd. sand: v.fine to v.coarse, avg v.fine to med, mod sort, 10% fel 90% maf, ang to sub-ang, v.coarse to coarse sand primarily ang. Mottled $CaCO_3$ throughout. Moist, strg rxn to HCl. 2.5Y 6/4, light yellowish brown.	Split spoon: 55.1-57.6' bgs
	SS			Split spoon: 57.8'-60.3' bgs
60	G		60'-65': slightly silty gravelly Sand ((m)gS) g=29% s=60% m=11% gravel: v.fine to med peb, avg 3mm, max 15mm, mod sort, 10% fel 90% maf, sub-ang to sub-rd. sand: v.fine to v.coarse, avg med/coarse, mod sort, 20% fel 80% maf, sub-ang. Moist, strg rxn to HCl. 2.5Y 3/3, dark olive brown.	
65	G		65'-80': Sand (S) g=5% s=92% m=3% gravel: v.fine to fine peb, avg 2mm, max 7mm, mod sort, 10% fel 90% maf, sub-ang to sub-rd. sand: v.fine to v.coarse, avg v.fine/fine, mod sort, 10% fel 90% maf, sub-ang. Moist, strg rxn to HCl. 2.5Y 4/3, olive brown.	Split spoon: 65.6'-68.1' bgs.
	SS			Split spoon: 68.4'-70.9' bgs.
70	G		@70': gravel: v.fine to med peb, avg ↑ to 3mm, max ↑ to 12mm, comp ↑ to 20% fel, ↓ to 80% maf. sand: comp ↑ to 20% fel, ↓ to 80% maf, cement-like $CaCO_3$ noticed in sand/silt faction, mica noticed in v.fine/fine sand faction. Wk rxn to HCl, but only in cement-like $CaCO_3$.	

Reported By:

Print Name	Title	Signature	Date
Beth Morter	Geologist	Beth Morter	7-3-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 13

Date: 4-22-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
75	G		65'-80': Sand (S)	Dual Rotary Drilling with
			@75': g=5% s=92% m=3% gravel: v. fine to v. coarse peb, avg 2mm, max 60mm, poor sort, 20% fel 80% maf, sub-ang to sub-rd. sand: v. fine to v. coarse w/up to 60mm well-cemented sand, avg v. fine/fine, poor sort, 20% fel 80% maf, sub-ang. Moist, strg rxn to HCl. 2.5Y 4/3, olive brown.	16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" OD drill rods & 12" OD tri-cone bit 469.5'-480.7' bgs. Grab samples every 5' or change in lithology.
	SS			
80	G		80'-83': gravelly Sand (gS) g=25% s=72% m=3% gravel: v. fine to v. coarse peb w/v. occ. small cob, avg 5mm, max 85mm, poor sort, 5% fel 95% maf, ang to sub-rd. Some cemented gravels present. Sand: v. fine to v. coarse, avg v. fine/fine, mod sort, 20% fel 80% maf, sub-ang, cement-like $CaCO_3$ noticed in sand fraction. Moist, strg rxn to HCl. 2.5Y 4/3, olive brown.	
	SS			
	G			Split Spoon Sample: 79.4'-81.9' bgs & 81.3'-83.8' bgs.
85	G		83'-120': Sand (S) g=5% s=92% m=3% gravel: v. fine to med peb, avg 2mm, max 10mm, mod sort, 10% fel 90% maf, sub-ang to sub-rd. sand: v. fine to v. coarse, avg v. fine/fine, mod sort, 50% fel 50% maf, sub ang, mica noticed in v. fine/fine fraction. Moist, strg rxn to HCl. 2.5Y 4/3, olive brown.	H_2O added: 80' bgs, ~10 gals. with DR rig.
			@85': g↓2% s↑98% m↓=T, gravel: VF-VC, 95% vf-fine, 5% med-VC, avg↑4mm, max↑42mm, poor sort, ang.-rnd. Sand: ↑90% coarse, well sort, ang-sub-ang., dry, no rxn HCl, 2.5Y 7/2 light gray, mica.	
90	G		@90': gravel: trace med-VC peb, ↑20% fel, 80%↓maf cementation present, mod. sort	
95	G		@95': g=T↓ s=100%↑, m=T↓ NLS 5-28-19, cementation	
100	G			
105	G		@105': g=2%↑ s=98%↓ m=T. gravel: VF-coarse, mod. sort, ↓10% fel, ↑90% maf, cementation	
110	G		@110': g↑5% s↓95% m=T. gravel: VF-med peb., avg. 4mm, max↓8mm, well sort, sand: Fine-VC, 90% coarse-VC, ↓40% fel, ↑60% maf, 2.5Y 6/1 gray	

Reported By: Beth Morter / Nicole Combs | Geologist | [signature] | 7-3-19

Print Name | Title | Signature | Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5-28-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
115	G		83'-120': Sand (S)	Dual Rotary Drilling with
			@115': g=5% s=95% m=T, gravel: VF-coarse,	16"/15 3/8" temp. casing 0.0'-235.9' bgs.
			avg. 4mm, max. 20mm, well sort, 10% fel, 90% maf,	14"/13 3/4" temp casing 235.9'-
			ang-rnd. Sand: fine-VC, trace fine, 90% coarse-VC,	469.5' bgs. 8 5/8" drill rods &
			well sort, 40% fel, 60% maf, ang.-subang., dry, no	12" tri-cone bit 469.5'-480.7' bgs.
120	G		rxn HCl, 2.5Y 6/1 gray, cementation	Grab samples every 5' or
			120'-125': Sandy Gravel (SG) g=50% s=50% m=T	change in lithology.
			Gravel: VF-VC, 10% VF, 80% fine-med., 10% coarse, trace VC,	
			avg. 5mm, max 50mm, mod sort, 20% fel, 80% maf, ang-rnd.	
			Sand: fine-VC, trace fine, 90% coarse-VC, well sort, 40% fel	
125	G		60% maf, ang.-subang., moist, strong rxn HCl, 2.5Y 4/2	
			dark grayish brown	125'-130' bgs added ~14gals
			125'-130': Gravel (G) g=85% s=15% m=T	H_2O
			Gravel: VF-VC, 80% VF-med peb., 20% coarse, trace VC, avg.	
			9mm, max 50mm, poor sort, 30% fel, 70% maf, ang-rnd.	
130	G		Sand: fine-VC, 30% fine-med., 70% coarse-VC, poor sort,	
			50% fel, 50% maf, ang-rnd., moist, strong rxn HCl, 2.5Y 5/2	
			grayish brown	
			130'-155': Sandy Gravel (SG) g=30% s=70% m=T	
			Gravel: VF-coarse, 5% VF, 45% fine, 45% med, 5% coarse, avg.	
135	G		9mm, max 29mm, mod sort, 50% fel, 50% maf, ang-rnd.	
			Sand: VF-VC, 90% coarse-VC, well sort, 60% fel, 40% maf,	
			ang-subang, dry, no rxn HCl, 2.5Y 6/1 gray	
			@135': gravel: max↑ 33mm. Sand: trace VF, 80%	
			fine-coarse, 10% VC, mod sort, strong rxn HCl on trace	
140	G		cemented pebs.	140'-145' bgs added ~14gals H_2O
			@140': g↑60% ~~sand~~ NCSM ↓40% m=T. gravel: avg↓7mm	
			Sand: fine-VC, 90% coarse-VC, well sort, 40% fel, 60% maf,	
			moist, mod. rxn HCl on cemented pebs, 2.5Y 4/2 NCSM dark grayish brown.	
145	G		@145': g↑75% s NCSM ↓25% m=T. Sand: VF-VC,	
			10% VF-med, 10% coarse, 80% VC, poor sort, no rxn HCl	
150	G		@150': g↓30% s↑65% m↑5%, gravel: max↑	
			45mm, ↑60% fel, ↓40% maf,	

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist		7-3-19

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BOREHOLE LOG (Cont.)

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Date: 5-29-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
155	G		155'-160': Gravel (G) g=90% s=10% m=T. Gravel: VF-VC, 15% VF, 15% fine, 60% med, 10% coarse, trace VC, avg 9mm, max 40mm, well sort, 40% fel, 60% maf, ang-rnd Sand: VF-VC, 70% VF-med, poor sort, 70% fel, 30% maf, ang-subang, moist, no rxn HCl, 2.5Y 5/2 grayish brown	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit 469.5'-480.7' bgs. Grab samples every 5' or change in lithology.
160	G		160'-205': sandy Gravel (SG) g=65% s=30% m=5% Gravel: VF-VC, 50% VF-fine, 50% med-coarse, trace VC, avg. 4mm, max 35mm, mod sort, 60% fel, 40% maf, ang-rnd. Sand: VF-VC, 50% VF-med, 50% med-VC, mod sort, 70% fel, 30% maf, ang-subang, moist, no rxn HCl, 2.5Y 5/2 grayish ~~g~~ brown NC 5-29-19	160' bgs ~14 gals H_2O added
165	G		@165': gravel max ↓32mm	
170	G		@170': g↓60%, s↑35% m=5%. Gravel: 70% med peb., avg. ↑9mm, max ↑48mm, Sand: ↓50% fel, ↑50% maf mod. rxn HCl, 2.5Y 6/4 light yellowish brown* ~~(once dry)~~ NC 5-29-19	175'-195' bgs ~15 gals H_2O
175	G		@175': g=60% s↑40% m↓T. Gravel: max↓45mm ↓50% fel, ↑50% maf, Sand: 70% VF-med, 30% coarse-VC, subang., no rxn HCl, 2.5Y 7/3 pale yellow* ~~(once dry)~~ NC 5-29-19	
180	G		@180': g↓35% s↑60% m↑5% Gravel: 70% VF-med peb, max↓35mm, ↑60% fel, ↓40% maf, Sand: trace coarse-VC, well sort, 2.5Y 6/3 light yellowish brown*	
185	G		@185': g↑75% s↓20% m=5%. Gravel: 10% VF-fine, 90% med-VC, avg ↑14mm, max ↑40mm, well sort, Sand: ~~90%~~ 95% NC 5-29-19 VF-med, 5% coarse-VC, mod sort, * NC 5-29-19 ~~↓50% fel, ↑50% maf~~ NC 5-29-19	
190	G		@190': Gravel: avg↓12mm, max↑50mm*	

*Sample collected moist, color decided when sample is dry.

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Print Name	Title	Signature	Date
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BOREHOLE LOG (Cont.)

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Date: 5-29-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
195	G		160'-205': sandy Gravel (sG) NC 5-29-19	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit 469.5'-480.7' bgs. Grab samples every 5' or change in lithology
			@195': g=30% s=65% m=5%. Gravel: VF-VC, 75% VF-med, 25% coarse-VC, avg 7mm, max 60mm, poor sort, 70% fel, 30% maf, ang-rnd. Sand: VF-VC, 95% VF-med, 5% coarse-VC, mod sort, 50% fel, 50% maf, subang-rnd, moist, no rxn HCl, 2.5Y 6/3 light yellowish brown	
200	G		@200': g↑70% s↓27% m↓3% Gravel: ↑85% VF-med, ↓15% coarse, trace VC, max ↓35mm, mod sort, ↓50% fel, NC 5-29-19 ↑50% maf. Sand: dry	
205	G		205'-210': Sand (S) g=2% s=98% m=T. Gravel: VF-VC, 98% VF-fine, 2% med, trace VC, avg. 3mm, max 35mm, well sort, 90% fel, 10% maf, ang-rnd (trace rnd). Sand: fine-VC, 85% coarse-VC, well sort, 70% fel, 30% maf, subang, moist, no rxn HCl, 2.5Y 6/3 light yellowish brown	205'-215' bgs ~10 gal H_2O
210	G		210'-240': sandy Gravel (sG) g=40% s=50% m=10% Gravel: VF-VC, avg 8mm, max 62mm, poor sort, 60% fel, 40% maf ang-subrnd. Sand: VF-VC, 85% VF-med, 15% coarse-VC, mod sort, 60% fel, 40% maf, subang, moist, no rxn HCl, 2.5Y 4/4 olive brown	
215	G		@215': g↑50% s↓47% m↓3% Gravel: 50% VF-fine, 50% med-coarse, trace VC, avg ↓7mm, max ↓39mm, mod sort, ang-rnd. Sand: 70% ↓VF-med, ↑30% coarse-VC, strong rxn HCl, 10Y 6/3 pale brown	
220	G		@220': Gravel: ↑60% VF-fine, ↓40% med-coarse, trace VC, pebb max ↓35mm, Sand: fine-VC, 50% fine-med, 50% coarse-VC, well sort, ↓30% fel, ↑70% maf, ang-subang, 10Y 6/4 light yellowish brown	
225	G		@225': Gravel: VF-~~VC~~ NC 5-30-19 Cobble, 60% VF-med, 40% med-VC trace cobble, avg ↑10mm, max ↑70mm, mod sort; Sand: VF-VC, 60% VF-med, 40% coarse-VC, ↑50% fel, ↓50% maf, no rxn HCl, 10Y 6/3 pale brown	
230	G		@230': g↓30% s↑70% m↓T. Gravel: VF-VC, avg↓ 7mm, max↓35mm, ↑65% fel, ↓~~45%~~ NC 5-30-19 35% maf. Sand: 90% VF-fine, 10% med-coarse, trace VC,	

Reported By:

Nicole Combs	Geologist		7-3-19
Print Name	Title	Signature	Date

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Date: 5-30-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
235	G SS+WS NC 6-19-19		210'-240': sandy Gravel (sG) @235': g=75% s=25% m=T. Gravel: VF-VC, 60% VF-med, 40% med-coarse, trace VC, avg. 7mm, max 32mm poor sort, 50% fel, 50% maf, ang-rnd. Sand: VF-VC, 80% VF-med, 20% coarse-VC, poor sort, 50% fel, 50% maf, subang, dry, mod rxn HCl, 2.5Y 6/3 light yellowish brown	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit 469.5'-480.7' bgs. Grab samples every 5' or change in lithology.
240	G		240'-255' gravelly Sand (gS) g=25% s=70% m=5% Gravel: VF-Coarse, 5% VF, 85% fine, 5% med, 5% coarse peb, avg. 5mm, max 17mm, well sort, 70% fel, 30% maf, ang-rnd. Sand: VF-VC, 80% VF-med, 20% coarse-VC, mod sort, 50% fel, 50% maf, sub-ang, dry, strong rxn HCl, 2.5Y 4/3 olive brown.	
245	G		@240': g↓15%, s↑80%, m=5%, avg. ↓4mm, max ↑20mm, ang-subrnd (Gravels).	235.9'-480.7' Dual Rot. 12" OD tri-cone bit. Split spoon: 235.9'-238.4' bgs.
250	G		@250': g↑25%, s↓70%, m=5%, Gravel: max↑ 23mm. Sand: moist, weak rxn HCl.	Water level: 239.6' bgs (6-6-19)
255	G WS		255'-400': Sandy Gravel (gS) g=45% s=50% m=5% Gravel: VF-coarse peb, 5% VF, 85% fine, 5% coarse, 5% VC, avg. 4mm, max 23mm, well sort, 60% fel, 40% maf, ang.-rnd. Sand: VF-VC, 60% VF-med, 40% med-VC, mod sort, 50% fel, 50% maf, subang, moist, weak rxn HCl, 2.5Y 4/3 olive brown.	Water sample: 257.2' bgs (I-011)
260	G		@260': g=45% s↓45% m↑10%. Gravel: 80% VF-fine, 10% med, 10% coarse pebs, avg↑4mm, max↑28mm, poor sort. Sand: 40% VF-med, 60% coarse-VC, wet, no rxn HCl, 2.5Y 5/4 light olive brown.	
265	G		@265': Gravel: avg ↓3mm	
270	G		@270': Gravel: max↑30mm. Sand: mod rxn HCl	

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Print Name	Title	Signature	Date
Nicole Combs	Geologist		7-3-19

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BOREHOLE LOG (Cont.)

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Date: 6-11-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
275	NC 6-11-19 ~~275~~ G		255'-400' : Sandy Gravel (sG) g=45%. s=45%. m=10%. Gravel: VF-VC, 80% VF-fine, NC 6-11-19 ~~20%~~ 10% med, 10% coarse, trace VC, avg. 3mm, max 35mm, poor sort, 60% fel, 40% maf, ang-rnd. Sand: VF-VC, 40% VF-med, 60% coarse-VC, mod sort, 50% fel, 50% maf, subang, wet, mod rxn HCl, 2.5Y 5/4 light olive brown.	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit 469.5'-480.7' bgs. Grab samples every 5' or change in lithology.
	WS			
280	NC 6-11-19 ~~280~~ G		@280': Gravel: VF-VC, ↓70% VF-fine, ↑15% med, 10% coarse, ↑5% VC, mod sort. Sand: VF-VC, ↓30% VF-med, ↑70% coarse-VC ang-subang, no rxn HCl.	
				Water sample: 277.0' bgs
285	G		@285': Gravel: poor sort.	
290	G		@290': g↑55% s↓35% m=10%. Gravel: ↑25% med, ↓5% coarse, ↓trace VC pebs.	
295	G		@295': g↑70% s↓25 m↓5%. Gravel: ↓15% VF, ↑70% fine-med, ↑10% coarse, ↑5% VC peb., mod sort. Sand: ↓trace VF, 20% fine-med, 80% coarse-VC, well sort, ang-subang.	Water sample: 297.0' bgs
	WS			
300	G		@300': g↓45% s↑45% m↑10%. Gravel: ↑70% VF-fine, ↓15% med, 10% coarse, 5% VC, avg ↑5mm, max ↑45mm. Sand: ↑30% VF-fine, 70% med-VC, mod sort, subang.	
305	G		@305': Gravel: ↓65% VF-fine, ↑30% med, ↓5% coarse, ↓trace VC peb, max ↓35mm.	
310	G		@310': g↑55% s↓35% m=10%. Gravel: VF peb-cobble, 60% VF-fine, 30% med, 5% coarse, 5% VC, trace cobble, avg ↑7mm, max ↑70mm. Sand: 25% VF-fine, 75% med-VC	

Reported By:

Nicole Combs	Geologist	[signature]	7-3-19
Print Name	Title	Signature	Date

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BOREHOLE LOG (Cont.)

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Date: 6-14-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
315'	G		255' - 400' : Sandy Gravel (SG)	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9' - 469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit, 469.5' - 480.7' bgs. Grab samples every 5' or change in lithology.
			@315': g = 50% s = 40% m = 10%. Gravel: VF-VC peb, 40% VF-fine, 55% med-coarse, 5% VC, avg. 7mm, max 40mm, mod sort, 60% fel, 40% maf, ang-rnd. Sand: VF-VC, 25% VF-fine, 75% med-VC, mod sort, 50% fel, 50% maf, subang., wet, no rxn HCl, ~~5/4~~ MCG 6-14-19 2.5Y 5/4 light olive brown	
320	G		@320': g↓ 40% s↑ 50% m = 10%. Gravel: avg ↓ 5mm, max ↓ 35mm. Sand: VF-fine ↑ 70%, med-VC ↓ 30%, well sort, ↑ 60% fel, ↓ 40% maf.	
325	G		@325': Gravel: VF-coarse, ↑ 60% VF-fine, 30% med, 10% coarse max ↓ 30mm, ↓ 40% fel, ↑ 60% maf. ~~Sand~~ 6-19-19 FINE	
330	G		@330': g↑ 50% s↓ 45% m↓ 5%. Sand: ↓ 50% VF-fine, ↑ 50% med-VC, mod sort,	
335	G		@335': g↓ 40% s↑ 55% m = 5%. Gravel: VF-VC peb, ↑ 65% VF-fine, ↓ 20% med, ↓ 5% coarse, ↑ 5% VC, max ↑ 40mm, poor sort.	
	WS+SS			Water sample: 337.5' bgs Split spoon: 337.5' - 340.0' bgs
340	G		@340': Gravel: VF-coarse, ↓ 60% VF-fine, ↑ 30% med, ↑ 10% coarse peb, max ↓ 30mm, ↑ 60% fel, ↓ 40% maf. Sand: ↓ 5% VF, ↓ 5% fine, ↑ 30% med, ↑ 60% coarse-VC	
345	G		@345': g↑ 50% s↓ 40% m↑ 10%. Gravel: VF-VC, ↓ 5% coarse, ↑ 5% VC, max ↑ 42mm. Sand: fine-VC, 5% fine, ↓ 25% med, ↑ 70% coarse-VC	
350	G		@350': Gravel: max ↓ 35mm. Sand: VF-VC, ↑ 80% VF-fine, ↓ 10% med, ↓ 5% coarse, ↓ 5% VC, well sort	

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	7-3-19

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BOREHOLE LOG (Cont.)

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Date: 6-19-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
355	G		255' - 400' : Sandy Gravel (SG)	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0' - 235.9' bgs. 14"/13 1/4 temp. casing 235.9' - 469.5' bgs. 8 5/8" drill rods & 12" tri-cone 469.5' - 480.7' bgs. Grab Samples every 5' or change in lithology.
			@355': g=45% s=45% m=10%. Gravel: VF-coarse, VF-fine 70%, 20% med, 10% coarse pebb, avg. 5mm, max. 30mm, mod sort, 60% fel, 40% maf, ang-rnd. Sand: VF-VC, 50% VF-fine, 50% med-VC, mod sort, 60% fel, 40% maf, subang, wet, no rxn HCl, 2.5Y 5/4 light olive brown.	
360	G		@360': Gravel: VF-VC, ↓65% VF-fine, ↑25% med, 10% coarse, trace VC, max ↑35mm. Sand: ang-subang	
365	G		@365': g↑65% s↓35% m=10%. Gravel: poor sort. Very high cementation in trace amounts	
370	G		@370': g↓45% s↓45% m=10%. Gravel: VF-coarse, 40% VF, 25% fine, 35% med, trace coarse, avg. ↓4mm, max ↓30mm	
375	G		@375': Gravel: VF-VC, ↑80% VF-fine, ↓15% med, ↑5% coarse, ↑ trace VC, max ↑41mm, mod. Sort	
380	G		@380': g↑60% s↓35% m↓5%. Gravel: VF-coarse, ↓65% VF-fine, ↑30% med, 5% coarse, max ↓28mm. Sand: ↓VF-med 30%, ↑60% coarse-VC	
385	G		@385': Gravel: VF-VC, ↓60% VF-fine, 30% med, ↑10% coarse, trace VC, max ↑35. Sand: VF-VC, ↓trace VF, 15% fine, 10% med, 75% coarse-VC	
390	G		@390': g↓45% s↑50% m=5%. Gravel: ↓20% VF-fine, ~~70%~~ ↑60% NC 6-25-19 med, ↑10% coarse, trace VC, avg ↑8mm, poor sort. Sand: ↑80% VF-fine, 10% med, ↓5% coarse, ↓5% VC, subang-rnd, very high cementation	

Reported By:

Nicole Combs	Geologist		7-3-19
Print Name	Title	Signature	Date

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BOREHOLE LOG (Cont.)

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Date: 6-25-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
395	G		255'-400': Sandy Gravel (sG) g=60%. s=30%. m=10%. @395': Gravel: VF-coarse peb, 70% VF-fine, 20% med, 10% coarse, avg. 8mm, max 25mm, mod sort, 60% fel, 40% maf, ang-subang. Sand: VF-VC, 70% VF-fine, 10% med, 10% coarse, 10% VC, mod sort, 60% fel, 40% maf, subang-rnd, wet, no rxn HCl, 2.5Y 5/4 light olive brown	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9'-469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit 465.9'-480.7' bgs.
	WS+SS			
400	G		400'-405': Silty Sandy Gravel (msG) g=40%. s=40%. m=20%. Gravel: VF-coarse, 80% VF-fine, 10% med, 10% coarse, avg 3mm, max 30mm, mod sort, 60% fel, 40% maf, ang-rnd. Sand: fine-VC, 5% fine, 10% med, 85% coarse-VC, well sort, 60% fel, 40% maf, subang, wet, no rxn HCl, 2.5Y 5/4 light olive brown, clay present, nonplastic	Grab samples every 5' or change in lithology. Water Sample: 397.5' bgs Split Spoon: 397.5'-400.0' bgs.
405	G		405'-410': gravelly sandy Silt (gsM) g=10%. s=30%. m=60%. Gravel: VF-coarse, avg. 2-3mm, trace coarse, max 11mm, mod sort, 60% fel, 40% maf, ang-subrnd. Sand: VF-VC, 90% VF-med, 10% coarse-VC, poor sort, 80% fel, 20% maf, subang, wet, no rxn HCl, 2.5Y 7/3 pale yellow, nonplastic	
	G			
410	G		@406': g↑20%. s↑35% NC 7.10.19 m↓45% NC 7.10.19. Gravel: max ↑25mm, ang-rnd. Sand: moist, 2.5Y 6/3 pale yellowish brown, nonplastic, wood	
	G		410'-412': silty sandy Gravel (msG) g=35%. s=40%. m=25%. Gravel: VF-coarse, avg 2-3mm, trace coarse, max 20mm, poor sort, 80% fel, 20% maf, ang-rnd. Sand: VF-VC, 80% VF-med, 20% coarse-VC, poor sort, 10% fel, 90% maf, subang, wet, no rxn HCl, 2.5Y 3/1 very dark gray, wood	
415	G		412'-415': silty Sand (mS) g=5%. s=50%. m=45%. Gravel: VF-fine, 70% VF, 30% fine, avg. 2-3mm, max 8mm, well sort, 15% fel, 85% maf, ang-subrnd. Sand: VF-VC, 80% VF-med, 20% coarse-VC, poor sort, 10% fel, 90% maf, subang, wet, no rxn HCl, 2.5Y 3/1 very dark gray.	
420	G		415'-420': silty sandy Gravel (msG) g=45%. s=35%. m=20%. Gravel: VF-coarse, 50% VF-fine, 50% med, trace coarse, avg. 2-3mm, max 30mm, mod sort, 20% fel, 80% maf, ang-rnd. Sand: VF-VC, poor sort, 20% fel, 80% maf, subang, wet, no rxn HCl, 2.5Y 3/1 very dark gray	
			420'-469.5': Sandy Gravel (sG) g=75%. s=20%. m=5%. Gravel: VF-coarse, 40% VF-fine, 60% med, trace coarse, avg. 2-3mm, max 30mm, mod sort, 40% fel, 60% maf, ang-subrnd. Sand: VF-VC, 10% VF-med, 90% coarse-VC, well sort, 30% fel, 70% maf, ang-subang, wet, no rxn HCl, 2.5Y 5/4 light olive brown	
425	G		@425': g↓45%. s↑45%. m↑10%. Gravel: ↑70% VF-fine, ↓30% med, trace coarse; Sand: ↑40% fel, ↓60% maf	
430	G		@430': Gravel: VF-VC, ↑80% VF-fine, ↓20% med, trace coarse-VC avg ↑5mm, max ↑45mm, ↑60% fel, ↓40% maf; Sand: ↑30% VF-fine, ↓70% med-VC, ↑60% fel, ↓40% maf	
			NOT USED; NC 6.27.19	

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist		7-3-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 12 of 13

Date: 6-26-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
435	G		420' - 469.5': Sandy Gravel (sG) g=45% s=45% m=10%	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/13 1/4" temp. casing 235.9' - ~~480.7~~ 469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit 469.5'-480.7' bgs. Grab sample every 5' or change in lithology.
			~~Gravel:~~ @435': Gravel: VF-med, 20% VF, 60% fine, 20% med, avg. 5mm, max 16mm, well-mod sort, 55% fel, 45% maf, ang-subrnd. Sand: VF-VC, 45% VF-fine, 40% med-coarse, 15% VC, mod sort, 60% fel, 40% maf, ang-subang, wet, no rxn HCl, 2.5Y 5/4 light olive brown.	
440	G		@440': Gravel: VF-coarse, 20% VF, 60% fine, 20% med, ↑trace coarse, max ↑30mm, mod sort, ang-rnd. Sand: VF-VC, ↑70% VF-med, 30% coarse-VC,	
445	G		@445': g↑70% s↓25% m↓5% Gravel: VF-VC, ↓20% VF-fine, ↓60% med, ↑15% coarse, ↑5% VC, max ↑42mm, ↓50% fel, ↑50% maf. Sand: VF-VC, ↑15% VF, 40% fine-med, ↑45% coarse-VC, ↓40% fel, ↑60% maf, very high cementation, green wx* & crystalization on vesicles of black clasts	
450	G		@450': g↑75% s↓20% m=5% Gravel: VF-coarse, 20% VF-fine, 60% med, ↑20% coarse, avg ↓30mm. Sand: fine-VC, 50% fine-med, 50% coarse-VC. ~~Sand:~~ very high cementation, green crystalization	
455	G WS		@455': Gravel: VF-coarse, ↑60% VF-fine ↓40% med, trace coarse, avg ↓3-4mm; Sand: ↓10% fine-med, ↑90% coarse-VC, well sort, very high cementation, loss of green crystalization	Water sample: 456.75' bgs.
460	G		@460': Sand: ↑trace VFine, 10% fine-med, 90% coarse-VC, very high cementation remains	
465	G		@465': g↓45% s↑50% m=5% Gravel: avg ↓25mm, ang-subrnd. Sand: VF-VC, trace VF, ↑60% fine-med, ↓40% coarse-VC, mod sort, iron oxidation in trace amounts	
470	G G		469.5'-480.7': Basalt Gravel: VF-fine ~3% in sample. Sand: VF-VC, ~5% present, wet, no rxn HCl, 2.5Y 2.5/1 black, 92% basalt, vesicular, green/gray weathering ~~present~~ present, 2-30mm @470': 100% Basalt, trace felsics, 2-25mm, blue wx	*"wx" shorthand for weathering.

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist		7-3-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 13 of 13

Date: 6-26-19

Well ID: C9879 | Well Name: 699-47-78B | Location: 30m N of 200-W-33

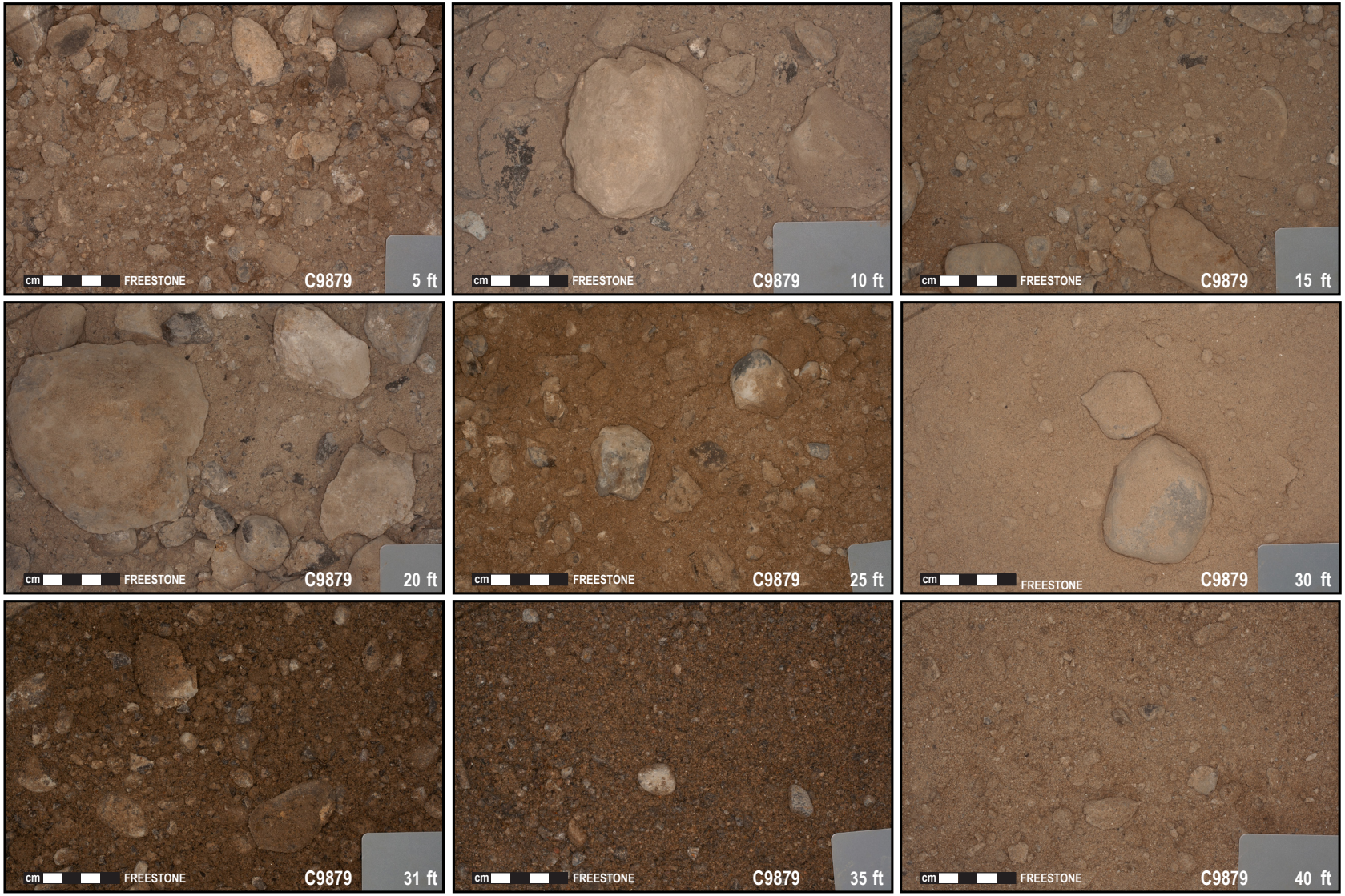
Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
475	G		469.5'-480.7': Basalt @475': 100% Basalt, trace felsics, trace green/gray weathering & trace vesicles present, wet, no rxn HCl, 2.5Y 2.5/1 black.	Dual Rotary Drilling with 16"/15 3/8" temp. casing 0.0'-235.9' bgs. 14"/~~13~~ NC 7-3-19 1/4" 13 1/4" temp casing 235.9'-469.5' bgs. 8 5/8" drill rods & 12" tri-cone bit 469.5'-480.7' bgs. Grab sample every 5' or change in lithology.
480	G			
				Total Depth: 480.7' bgs (6-26-19) Depth to Water: 239.6' bgs (6-6-19)

NOT USED
NC 7-3-19

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	7-3-19

A-6006-993 (REV 0)



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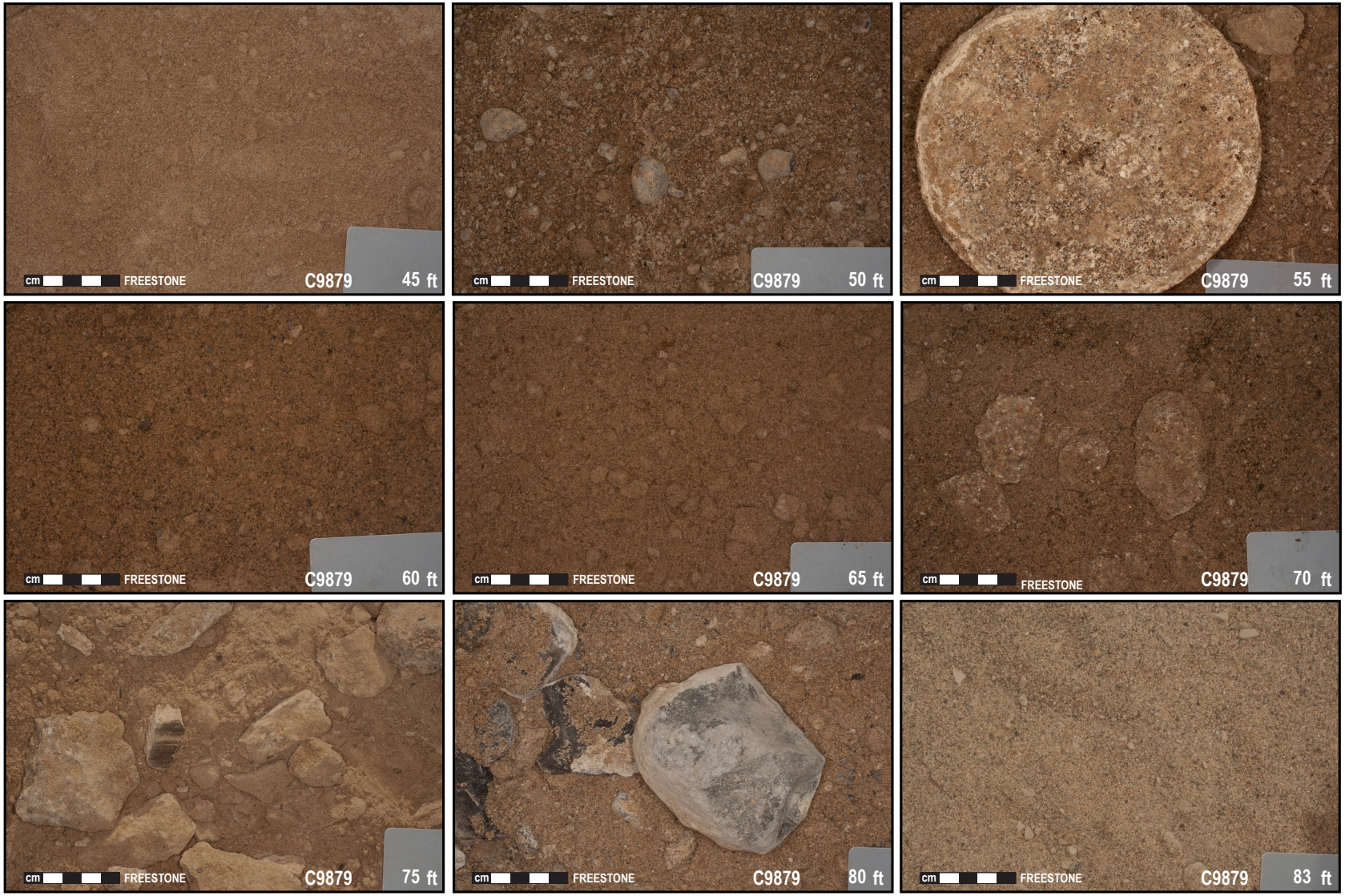
Drill Cutting Photographs for C9879 (699-47-78B)



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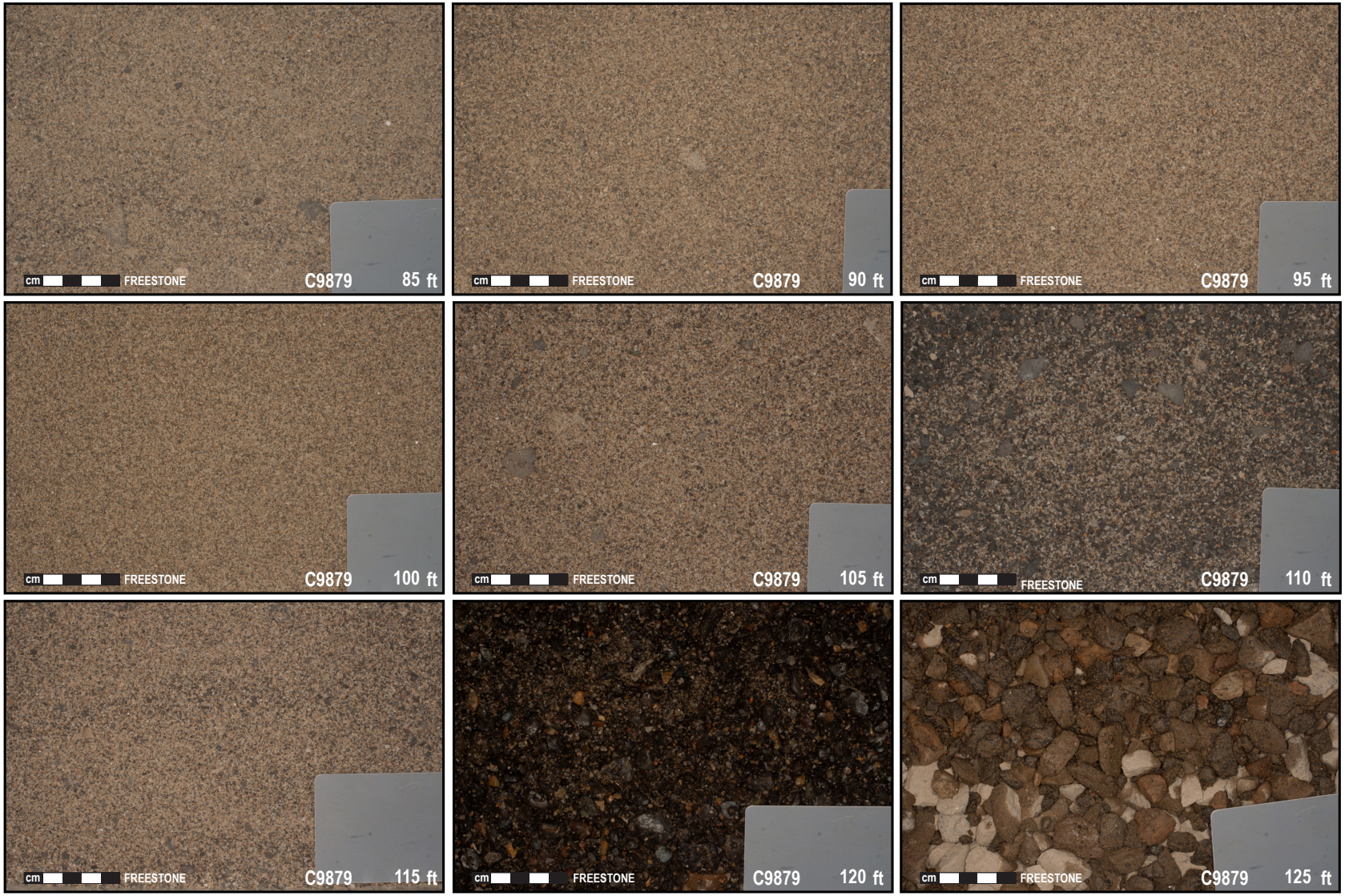
Drill Cutting Photographs for C9879 (699-47-78B)



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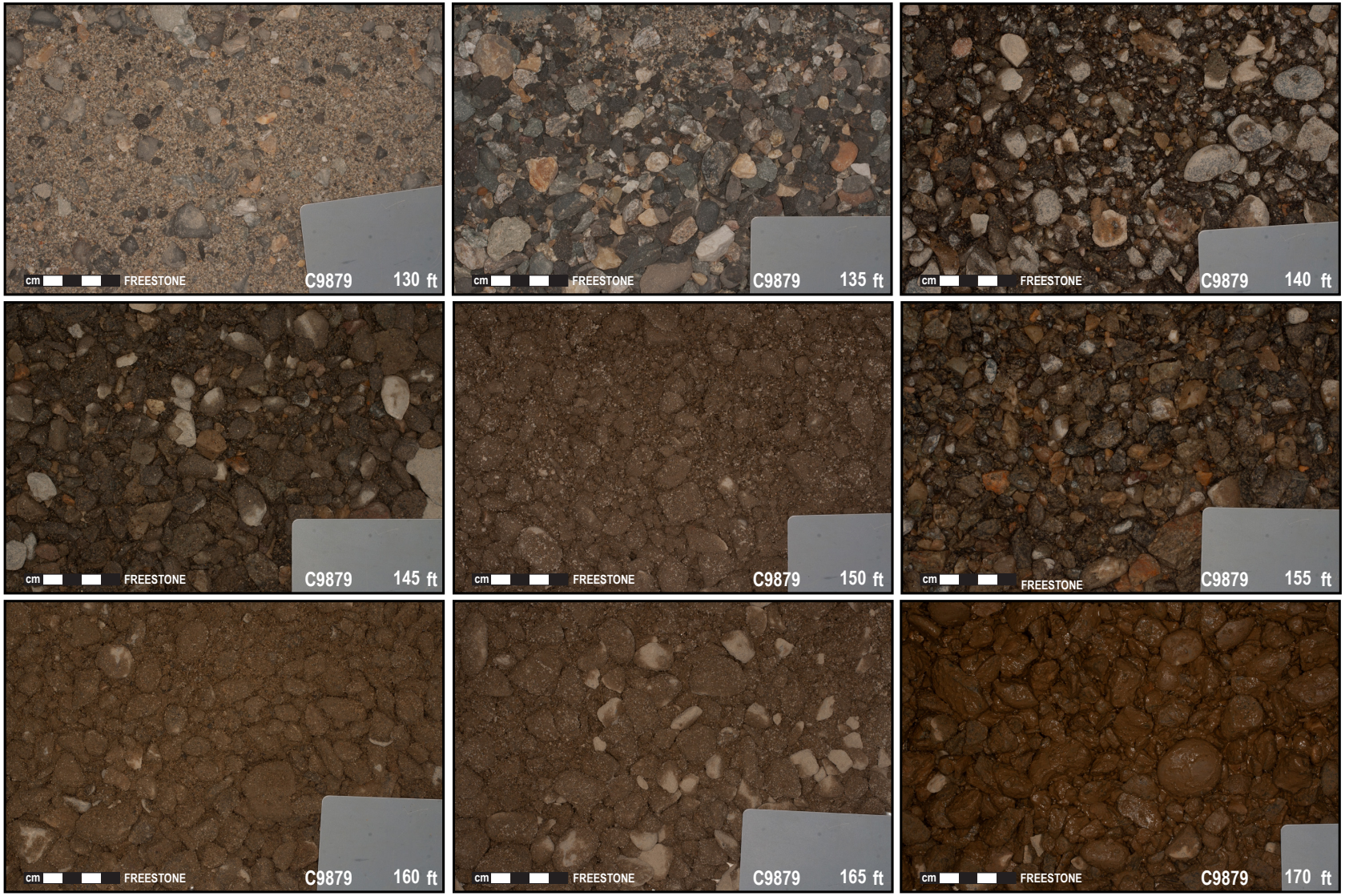
Drill Cutting Photographs for C9879 (699-47-78B)



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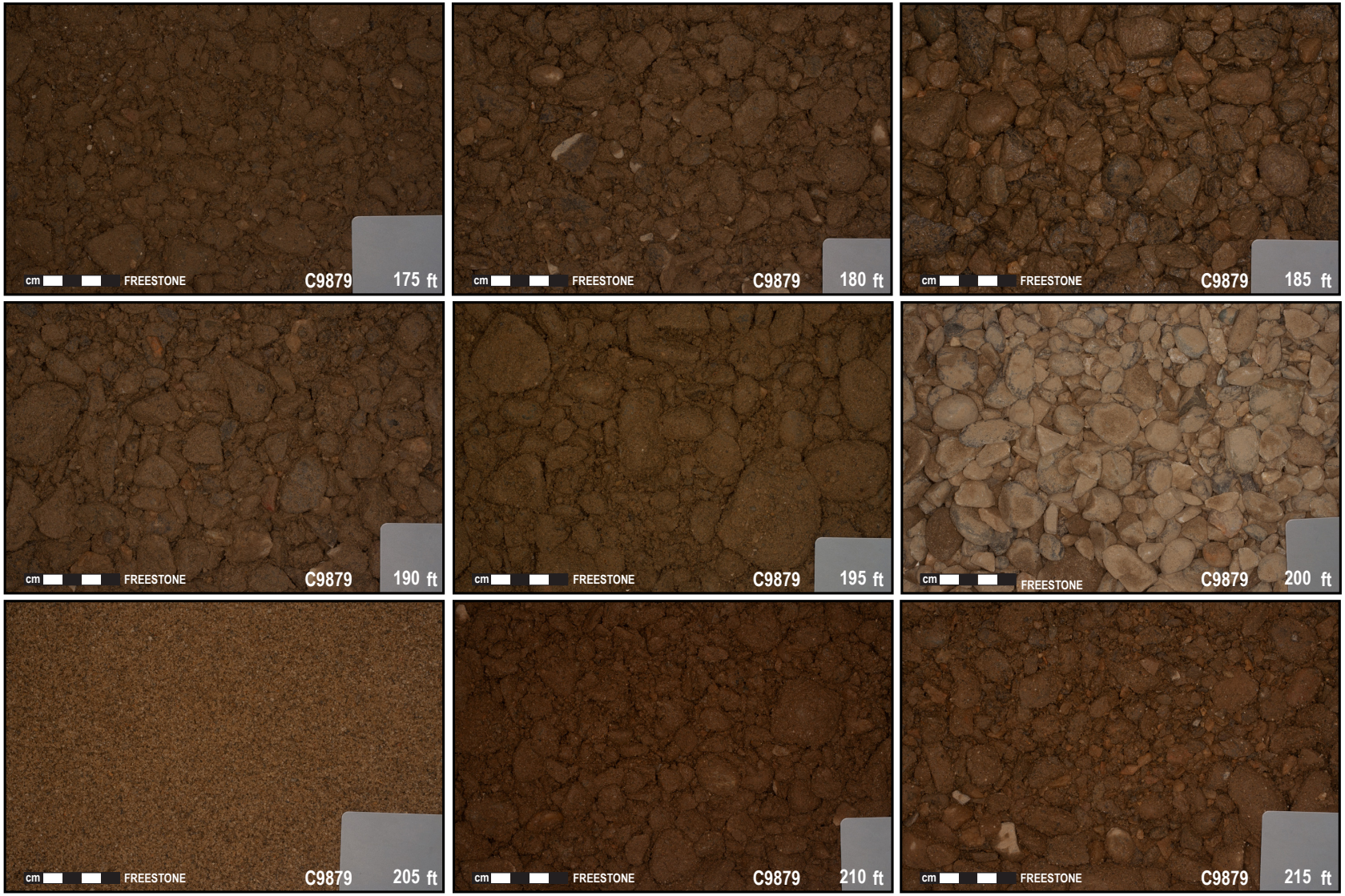

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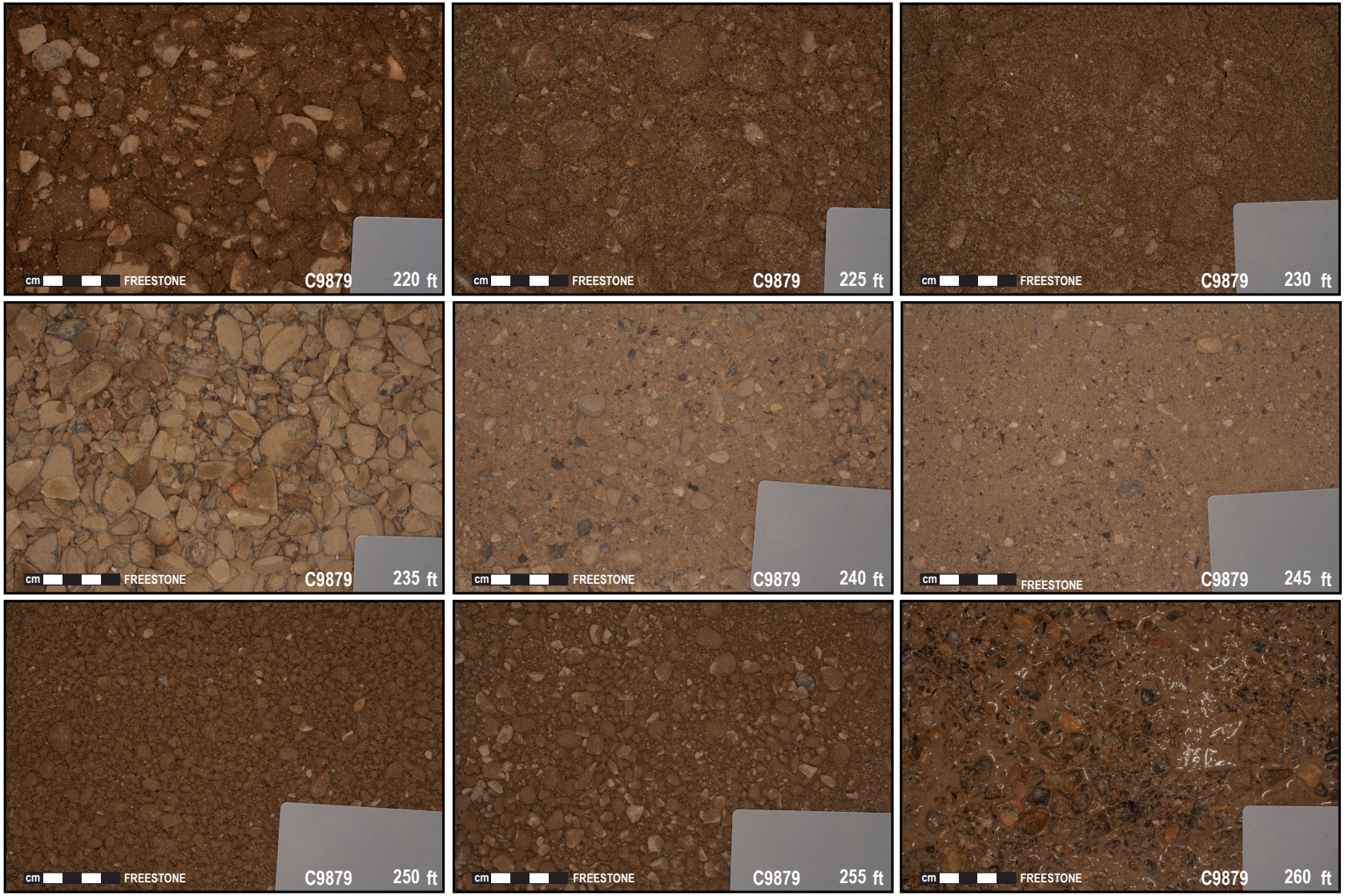
Drill Cutting Photographs for C9879 (699-47-78B)



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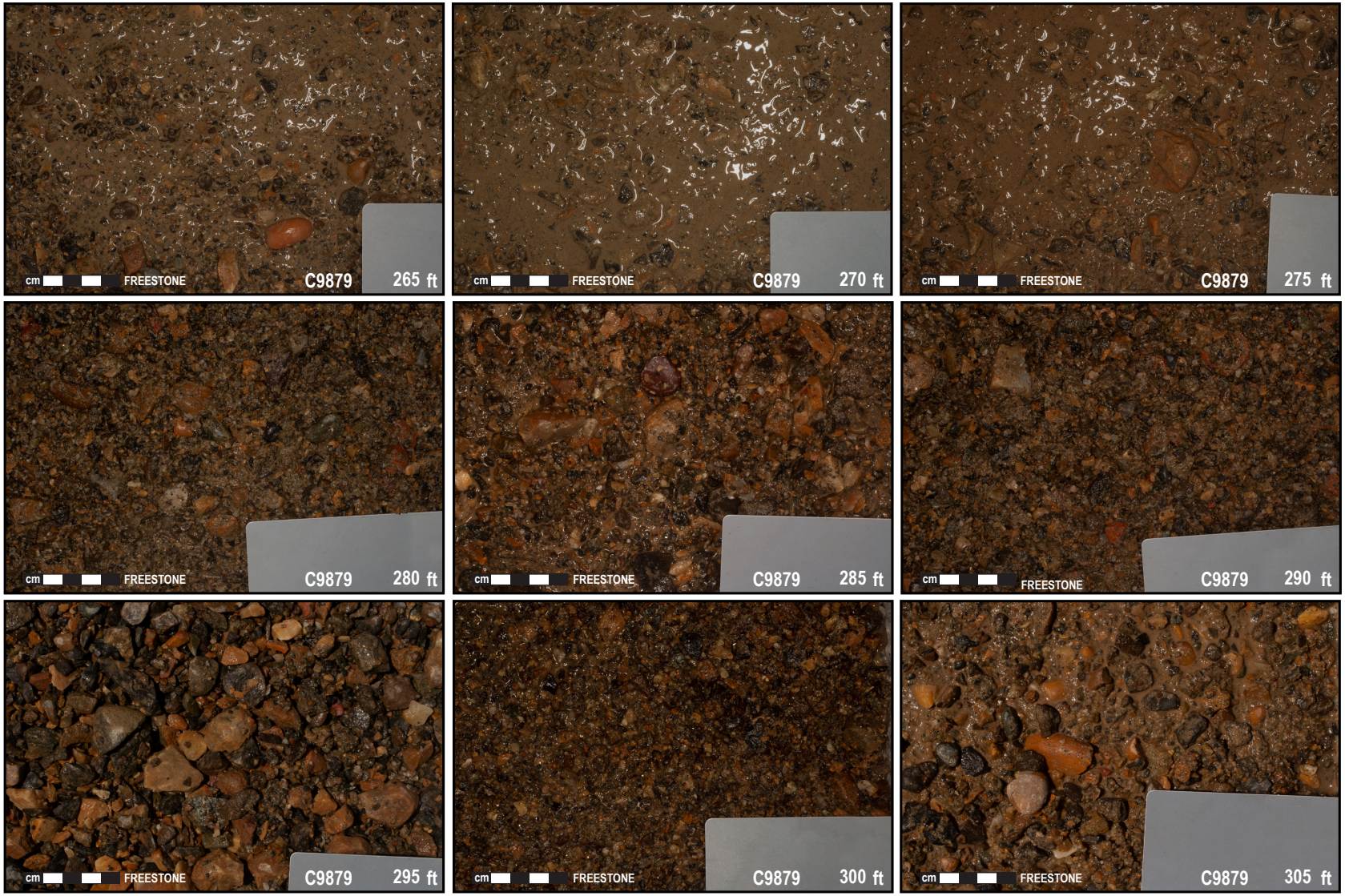

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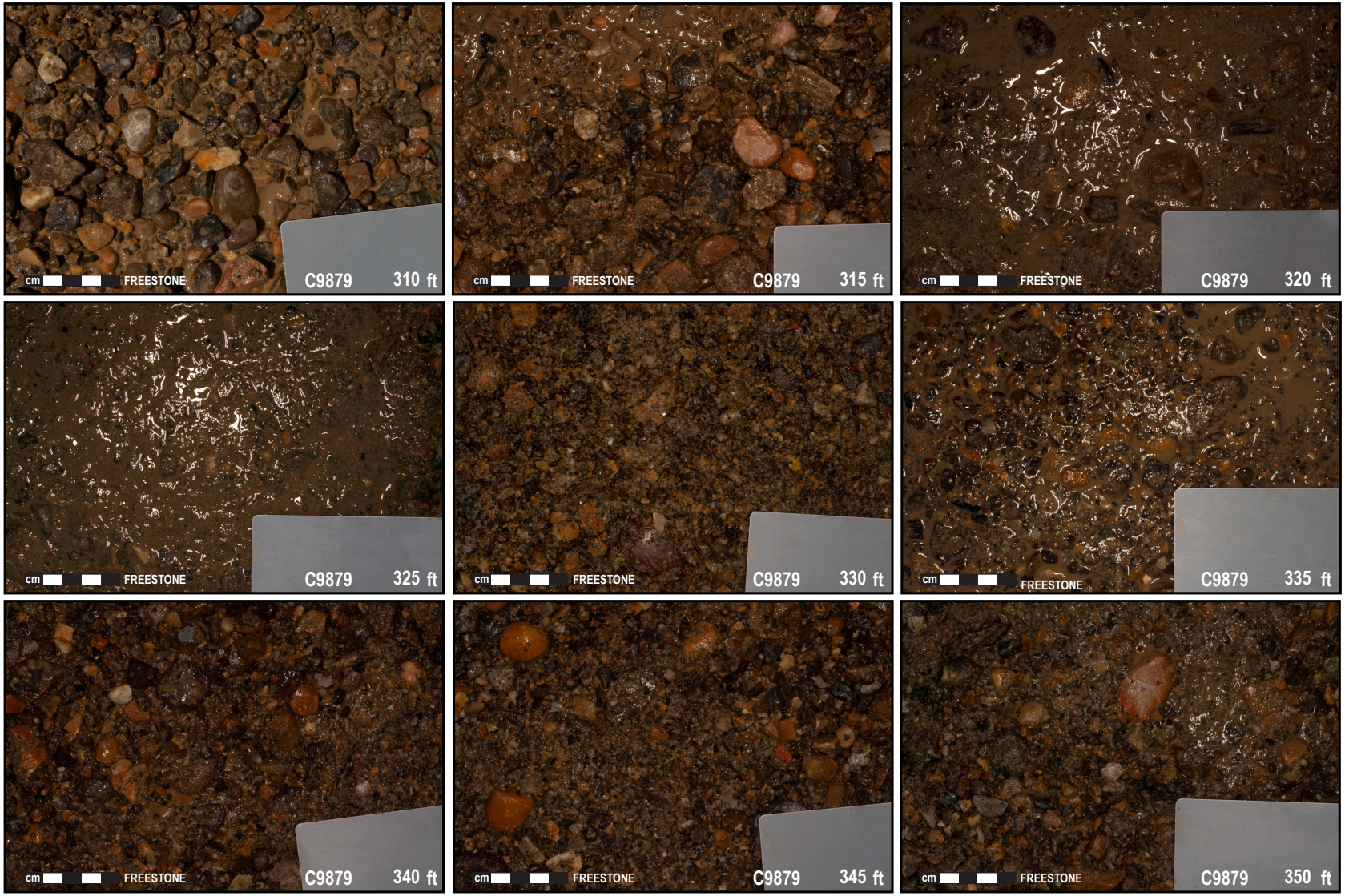
Drill Cutting Photographs for C9879 (699-47-78B)



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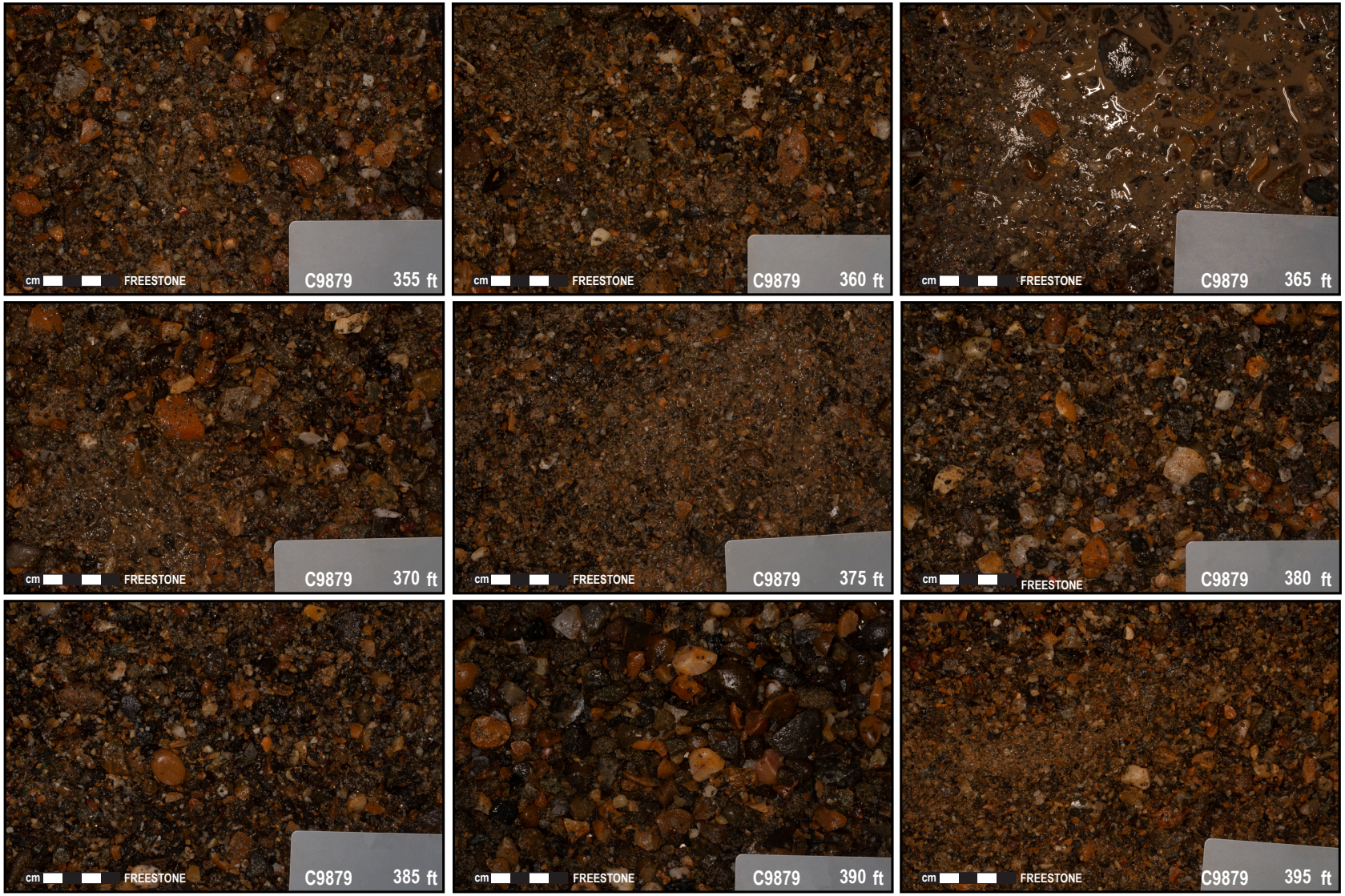

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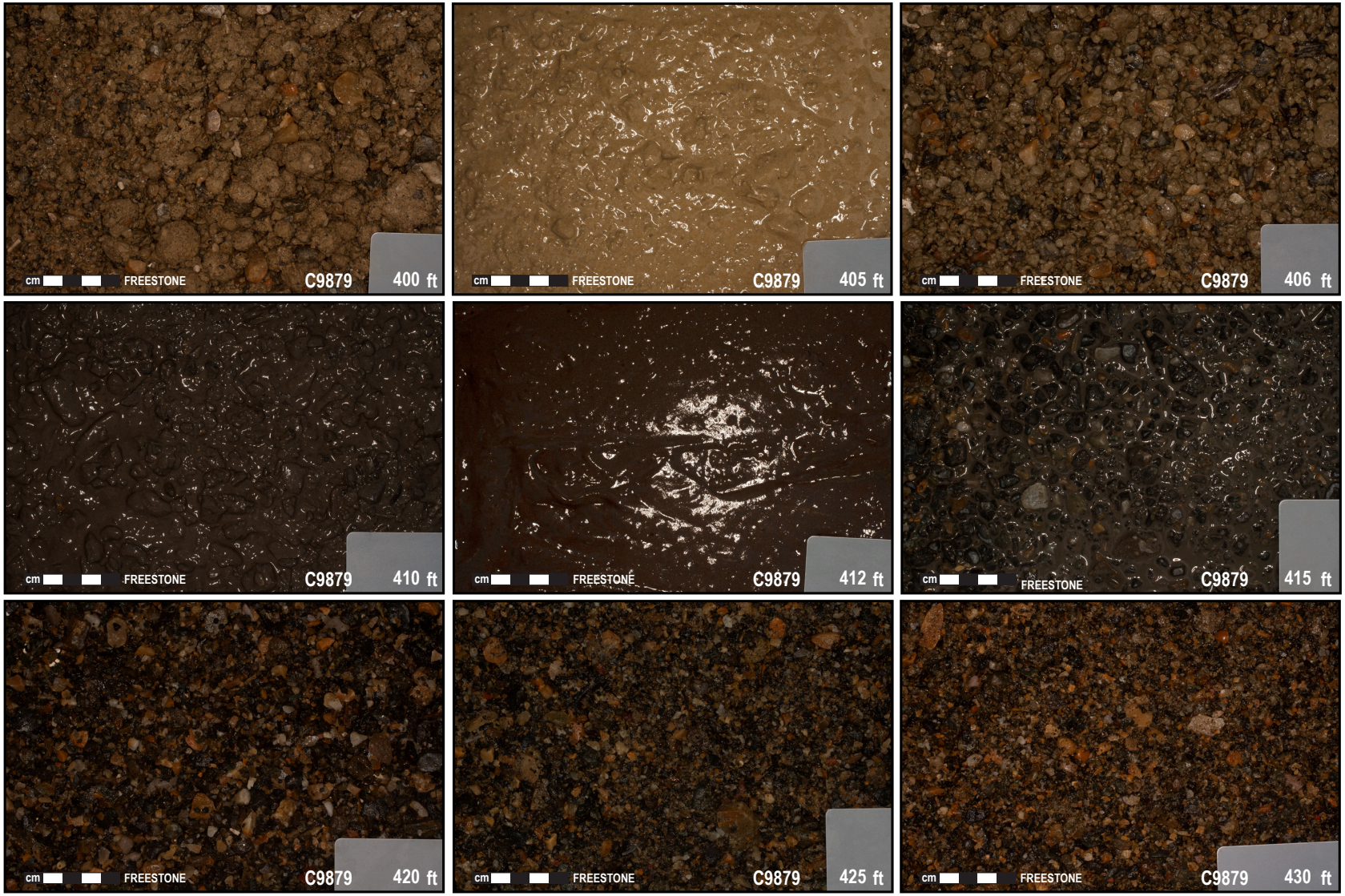

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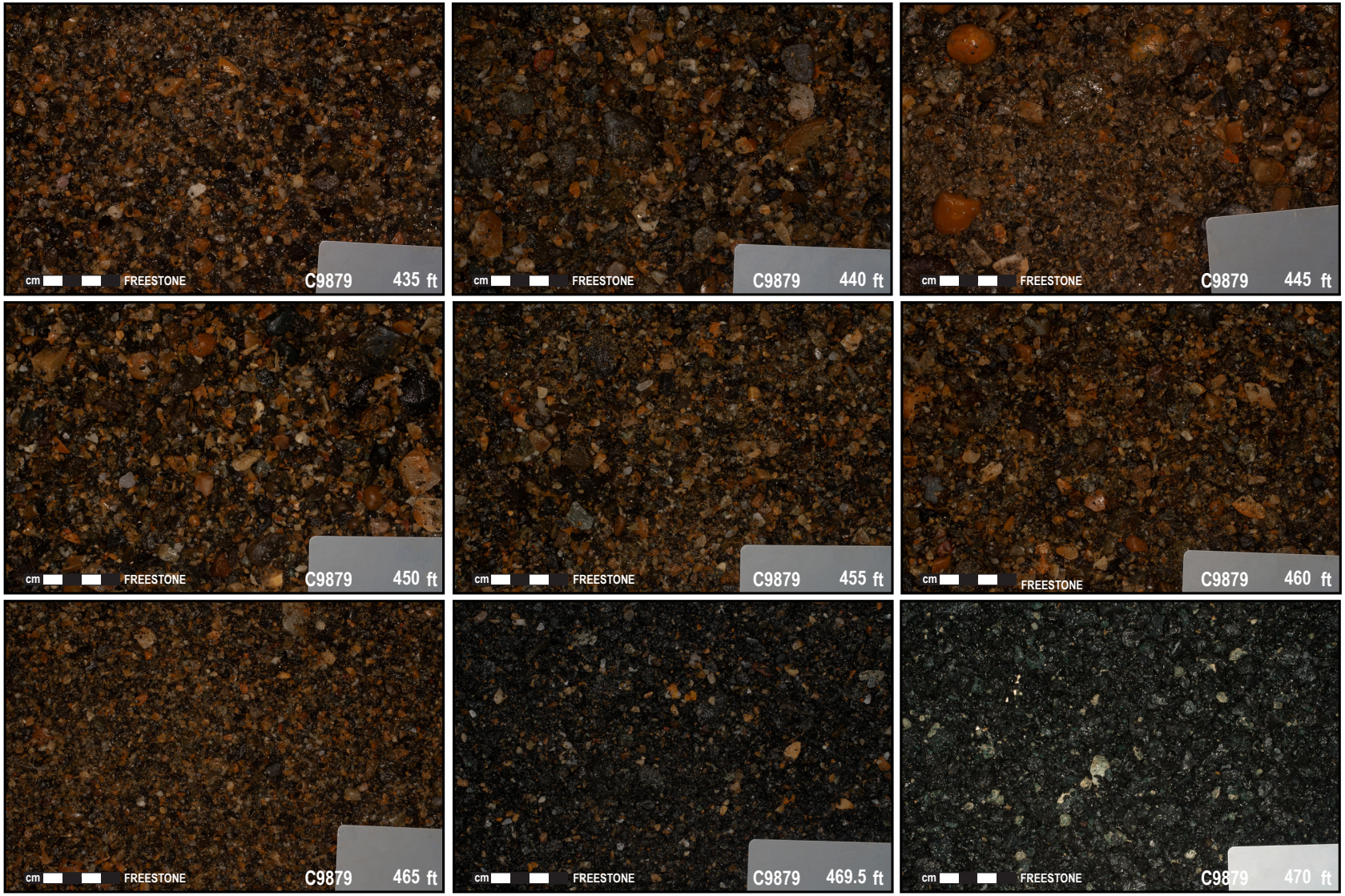

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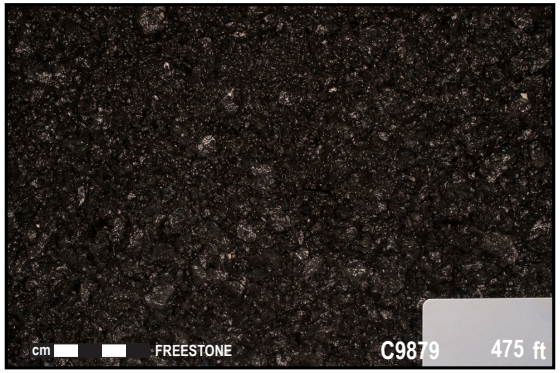
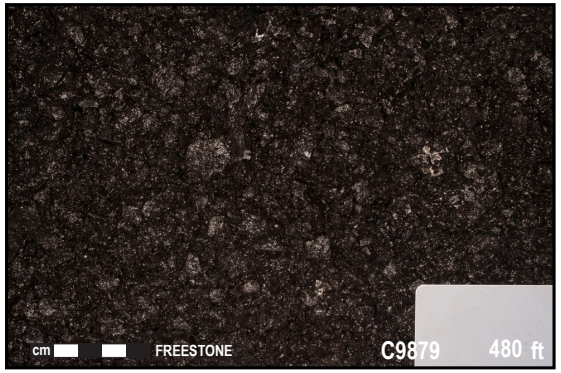
Drill Cutting Photographs for C9879 (699-47-78B)





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Drill Cutting Photographs for C9879 (699-47-78B)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9879	Well Name: 699-47-78B	Date: 11/14/2019
Location: 30m North of 200-W-33		

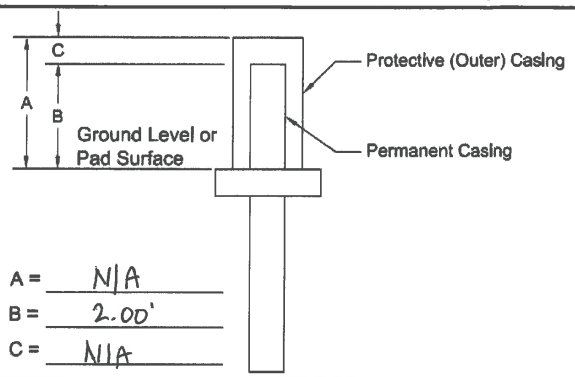
Reference Measuring Point *(unless otherwise noted)*: TOP OF OUTER CASING (TOC)

Has the well been surveyed? ○ Yes ◉ No

Does the well have a cement pad? ○ Yes ◉ No

Initial Conditions

	Start of Job	End of Job
STATIC WATER LEVEL:		
Date: 11-14-2019	239.55'bgs	N/A
Date: 11-19-2019	N/A	239.45'bgs
DEPTH TO BOTTOM:		
Date: 11-14-2019	396.47'bgs	N/A
Date: 11-25-2019	N/A	404.82'bgs



A = N/A
B = 2.00'
C = N/A

	Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbitidy (NTU) Initial	Turbitidy (NTU) Final	Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
11-14-19	389.1	10.98	134.20	34.2	35.7	0825	0921	179	16.30*
	389.1	10.64	134.20	12.7	3.90	0921	1016	120	11.28*
	368.0	10.62	112.61	47.8	3.20	1210	1305	150	14.12*
	346.9	10.50	91.13	40.0	2.92	1359	1452	170	16.19*
11-18-19	325.8	13.24	70.11	115	4.01	1304	1345	135	10.20*
	320.7	11.34	65.46	15.3	2.03	0841	0938	135	11.91*

Total Pumped: 61,871 gallons

Pump Model: GRUNDFOS MS6000QFT40, 40 HP - MODEL C; S/N: 00157724

Troll Serial Number and Pressure Range (PSI and depth): S/N 678611; 210m/692ft

Comments:

Pg. 1/2
*Max DD: Using initial transducer static water level from beginning of day (not E-Tape), due to discrepancy between E-Tape and Transducer reading approx 10' different throughout development.
LOG FILES: C9879_develop_INT#1_11142019; C9879_develop_INT#2_11142019; C9879_develop_INT#3_11142019; C9879_develop_INT#4B_11182019; C9879_develop_INT#4_11182019.

Prepared By:

Print Name	Signature	Date
Lindsey Getchell	Lindsey Getchell	11/18/2019

Reviewed By:

Print Name	Signature	Date
Jennifer Richart	Jennifer Richart	12/30/19

For Office Use Only

OR Doc Type:	WMU Code(s):

Page 1 of 1

A-6005-205 (REV 2)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9879	Well Name: 699-47-78B	Date: 11/14/2019
Location: 30m North of 200-W-33		

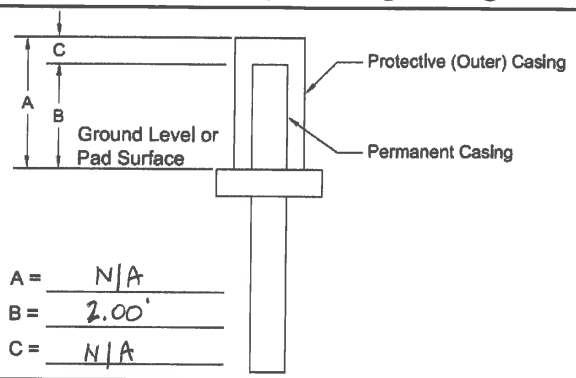
Reference Measuring Point *(unless otherwise noted)*: TOP OF OUTER CASING (TOC)

Has the well been surveyed? ○ Yes ◉ No

Does the well have a cement pad? ○ Yes ◉ No

Initial Conditions

	Start of Job	End of Job
STATIC WATER LEVEL:		
Date: 11-14-2019	239.55'bgs	N/A
Date: 11-19-2019	N/A	239.45'bgs
DEPTH TO BOTTOM:		
Date: 11-14-2019	396.47'bgs	N/A
Date: 11-25-2019	N/A	404.82'bgs



A = N/A
B = 2.00'
C = N/A

Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbitidy (NTU) Initial	Turbitidy (NTU) Final	Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
304.7	11.10	49.22	44.0	1.62	1110	1139	135	12.16*
11-18-19 304.7	9.93	49.22	N/A**	N/A**	1139	1200	302	30.40*
283.6	10.73	27.67	39.2	3.70	1424	1454	150	13.97*
	N/A LG 11-26-19							

Total Pumped: 61,871 gallons

Pump Model: GRUNDFOS MS6000QFT40, 40 HP - MODEL C; S/N: 00157724

Troll Serial Number and Pressure Range (PSI and depth): S/N 678611; 210m/692ft

Comments:

Pg. 2/2
*Max DD: Using initial transducer static water level from beginning of day (not E-Tape), due to discrepancy between E-Tape and Transducer reading approx 10' different throughout development.
**STRESS TEST.
LOG FILES (Cont.): C9879_INT#5_11182019_STRES; C9879_develop_INT#6_11182019.

Prepared By:

Print Name	Signature	Date
Lindsey Getchell	Lindsey Getchell	11/18/2019

Reviewed By:

Print Name	Signature	Date
Jennifer Richart	J. L. Richart	12/30/19

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6005-205 (REV 2)

Bay West
Customer-Focused Environmental & Industrial Solutions

699-47-78B (C9879)
Log Data Report

Borehole Information

Log Date	2019-07-02	Filename	C9879_HG-NM_2019-07-02	Site	200-ZP-1
DTW[1] (ft)	**DTW Date**	**DTW Source**	**Drill Date**	**Total Depth (ft)**	**Depth Datum**
241.65	06/25/19	Freestone	06/26/19	480.7	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Welded Steel	Dual Rotary	TC[2]	16	15.25	3/8	4.28 AGS[3]	237
Welded Steel	Dual Rotary	TC	14	13.26	0.38	1.85 AGS	469.5

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up using a steel tape measure, casing outside diameter using a steel circumference tape, and thickness using a precision wall-thickness gauge. Maximum logging depth achieved was 471 ft, approximately 1.5 ft below the reported casing depth. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 1LD	**Type**	60% Coaxial HPGe (SGLS)[4]
Effective Calibration Date	12/04/2018	**Serial No.**	47-TP-32211A
Calibration Reference	HGLP-CC-175, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 1HD	**Type**	He-3 (CPN 503DR) NMLS[5]
Effective Calibration Date	12/04/2018	**Serial No.**	H310700352
Calibration Reference	HGLP-CC-176, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

Logging System	Gamma 5TB	**Type**	60% Coaxial HPGe (SGLS)
Effective Calibration Date	12/12/2018	**Serial No.**	54-TP13441B
Calibration Reference	HGLP-CC-180, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 5PB	**Type**	He-3 (CPN 503DR) NMLS
Effective Calibration Date	12/12/2018	**Serial No.**	H34055445
Calibration Reference	HGLP-CC-177, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

[1] depth to water inside casing
[2] Temporary casing
[3] Above ground surface
[4] Spectral Gamma Logging System
[5] Neutron Moisture Logging System

SGLS Log Run Information

Log Run	1	2	3	4
HEIS Number	1021118	1021119	1021120	1021121
Date	05/29/19	05/30/19	05/30/19	05/30/19
Logging Engineer	Patterson	Patterson	Patterson	Patterson
Start Depth (ft)	0.01	71.0	78.0	220.0
Finish Depth (ft)	70.0	78.0	220.0	237.0
Count Time (sec)	100	100	100	100
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9879FTB20190 529AV00CAB1	C9879FTB2019053 0AV00CAB1	C9879FTB20190 530BV00CAB1	C9879FTB201905 30BV00CAB1
Start File	AD000001	AD007100	BD007800	CD022000
Finish File	AD007000	AD007800	BD022000	CD023700
Post-Verification	C9879FTB20190 529AV00CAA1	C9879FTB2019053 0CV00CAA1	C9879FTB20190 530CV00CAA1	C9879FTB201905 30CV00CAA1
Depth Return Error (in.)	0.25 high	N/A	N/A	0.75 high
Comments	None	None	None	None

Log Run	5 Repeat	8	9	10 Repeat
HEIS Number	1021122	1021123	1021124	1021125
Date	05/31/19	07/01/19	07/02/19	07/02/19
Logging Engineer	Patterson	Spatz	Spatz	Spatz
Start Depth (ft)	160.0	235.0	400.0	406.0
Finish Depth (ft)	185.03	402.0	471.01	430.0
Count Time (sec)	100	100	100	100
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9879FTB20190 531AV00CAB1	C9879ALD2019070 1AV00CAB1	C9879ALD2019070 2BV00CAB1	C9879ALD2019 0702BV00CAB1
Start File	AD016000	AD023500	BD040000	CD040600
Finish File	AD018503	AD040200	BD047101	CD043000
Post-Verification	C9879FTB20190 530AV00CAA1	C9879ALD2019070 1AV00CAA1	C9879ALD2019070 2CV00CAA1	C9879ALD2019 0702CV00CAA1
Depth Return Error (in.)	0.25 high	0.5 low	N/A	4.0 low
Comments	None	None	None	None

NMLS Log Run Information

Log Run	6	7	11	12 Repeat
HEIS Number	1021126	1021127	1021128	1021129

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Log Run	6	7	11	12 Repeat
Date	05/31/19	05/31/19	07/02/19	07/02/19
Logging Engineer	Meisner	Meisner	Spatz	Spatz
Start Depth (ft)	0.0	212.0	232.0	239.0
Finish Depth (ft)	236.51	236.01	242.5	242.0
Count Time (sec)	15	15	15	15
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	0.25	0.25	0.25	0.25
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9879FPB20190531AV00CAB1	C9879FPB20190531AV00CAB1	C9879AHD20190702AV00CAB1	C9879AHD20190702AV00CAB1
Start File	AD000000	BD021200	AD023200	BD023900
Finish File	AD023651	BD023601	AD024250	BD024200
Post-Verification	C9879FPB20190531BV00CAA1	C9879FPB20190531BV00CAA1	C9879AHD20190702BV00CAA1	C9879AHD20190702BV00CAA1
Depth Return Error (in.)	N/A	1.0 high	N/A	1.0 low
Comments	None	None	None	None

Logging Operation Notes

A centralizer was installed on the sondes. Verification measurements passed the acceptance criteria.

Analysis Notes

Analyst	P.D. Henwood	Date	07/15/19
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

Casing corrections for a 0.375 and 0.38-in. thick casings were applied to the first and second casing, respectively for the SGLS log data.

For the SGLS, a water correction was applied below 241.65 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in EXCEL templates identified as ALD20181204 and FTB20181212 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

NMLS data are reported in counts per second for the entire length of the borehole as the casing diameters exceeded the range of calibration to convert to volumetric moisture.

HGU[6] is an empirical unit of gamma activity proposed as a means to standardize gamma log response across multiple logging systems with different response characteristics. The HGU is defined in terms of measurements in the Hanford Borehole Calibration Facility, and the magnitude is selected such that 1 HGU is approximately equivalent to typical Hanford background activity, based on data from background samples as reported in *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE/RL-96-12).

Results and Interpretations

No manmade radionuclides were detected in this borehole.

Bi-214 energy peaks at 609 and 1764 keV are plotted on the Combination log plots. These energy peaks are used to calculate naturally occurring U-238. Where the concentrations diverge, radon (Rn-222) is indicated that has

[6] Hanford Gamma Unit

disrupted the secular equilibrium (activity of the parent is equal to the activity of its daughters) between the parent U-238 and its daughters below Rn-222 in the uranium decay chain. Radon is apparent in the groundwater. An unusually high concentration of naturally occurring U-238 at approximately 416 ft is enhanced by radon. The existence of the relatively high concentration of U-238 is confirmed by repeat logging and the true concentration is likely between 4 and 6 pCi/g.

The neutron moisture log primarily responds to moisture present in the surrounding formation. In general, an increase in count rate reflects an increase in moisture content. Moisture content generally increases as the sediment becomes more fine-grained. For example, moisture content would be expected to be greater near the top of a fining upward Hanford flood sequence.

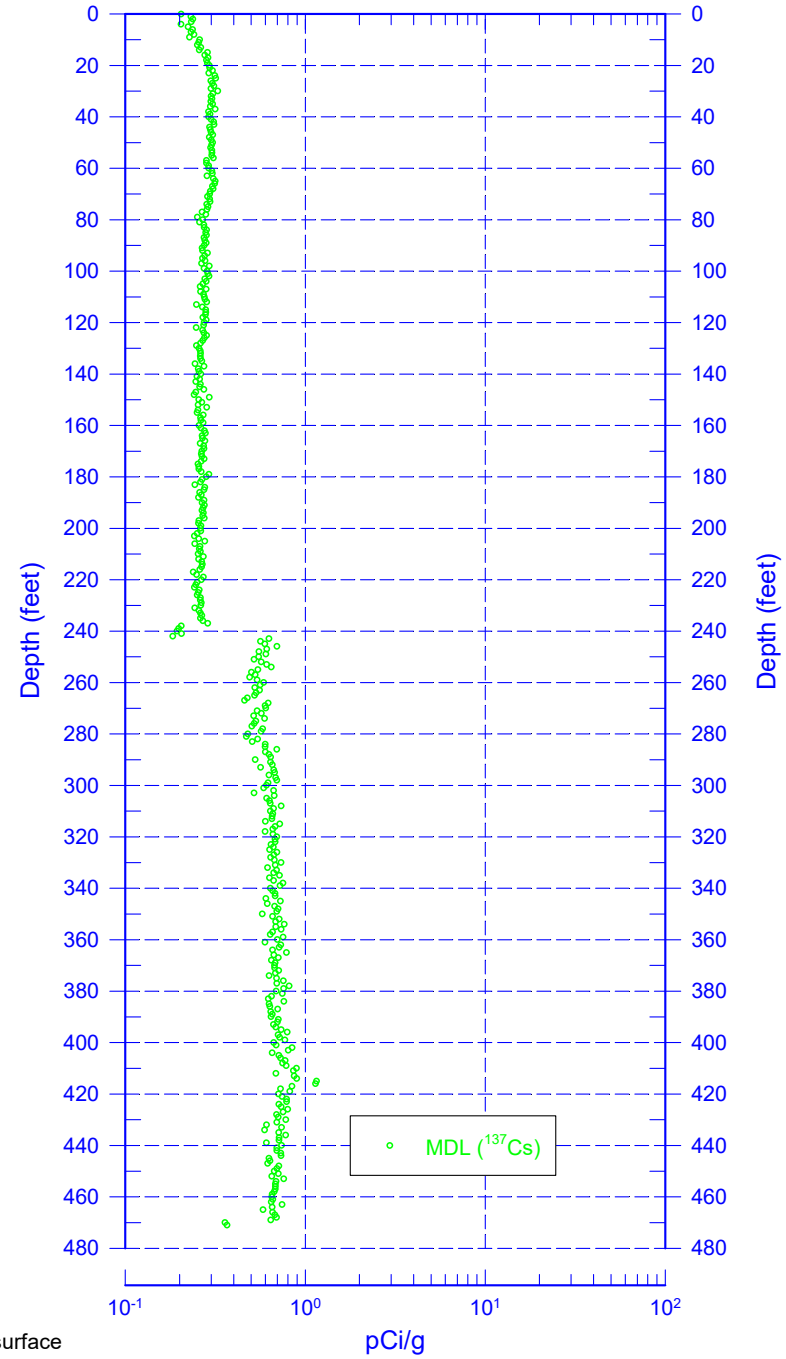
The KUT and moisture repeat plots indicate that the systems were working properly.

List of Log Plots

Depth Reference is ground surface.

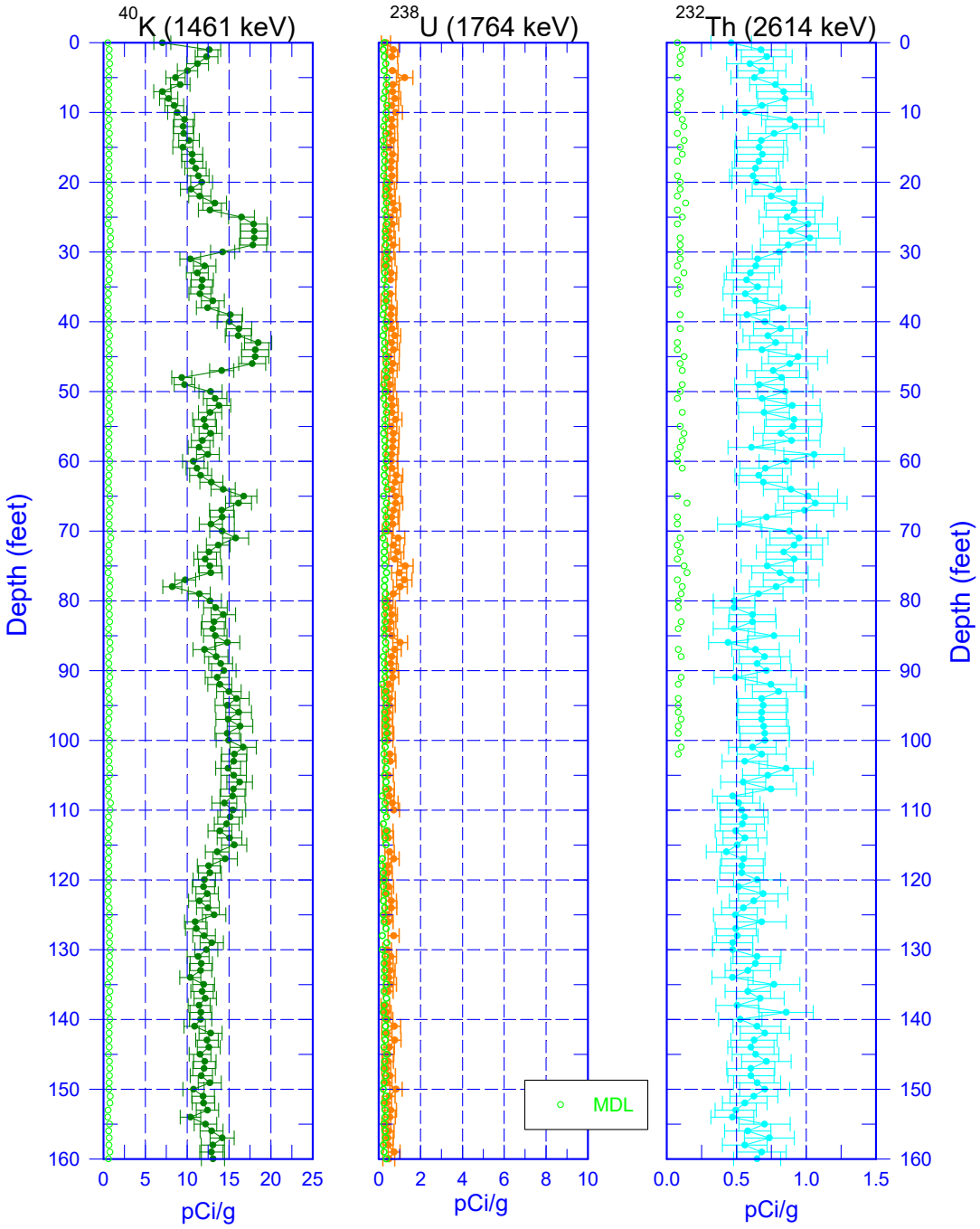
Manmade Radionuclides (0-480 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (160-320 ft)
Natural Gamma Logs (320-480 ft)
Combination Plot (0-120 ft)
Combination Plot (120-240 ft)
Combination Plot (240-360 ft)
Combination Plot (360-480 ft)
Combination Plot (0-480 ft)
Total Gamma & Moisture (0-160 ft)
Total Gamma & Moisture (150-310 ft)
Total Gamma & Hanford Gamma Unit (0-480 ft)
Repeat Section of Natural Gamma Logs (160-185 ft)
Repeat Section of Natural Gamma Logs (406-430 ft)
Moisture Repeat Section (212-236 ft)
Moisture Repeat Section (239-242 ft)

699-47-78B (C9879)
Manmade Radionuclides



Zero Reference - ground surface

699-47-78B (C9879)
Natural Gamma Logs



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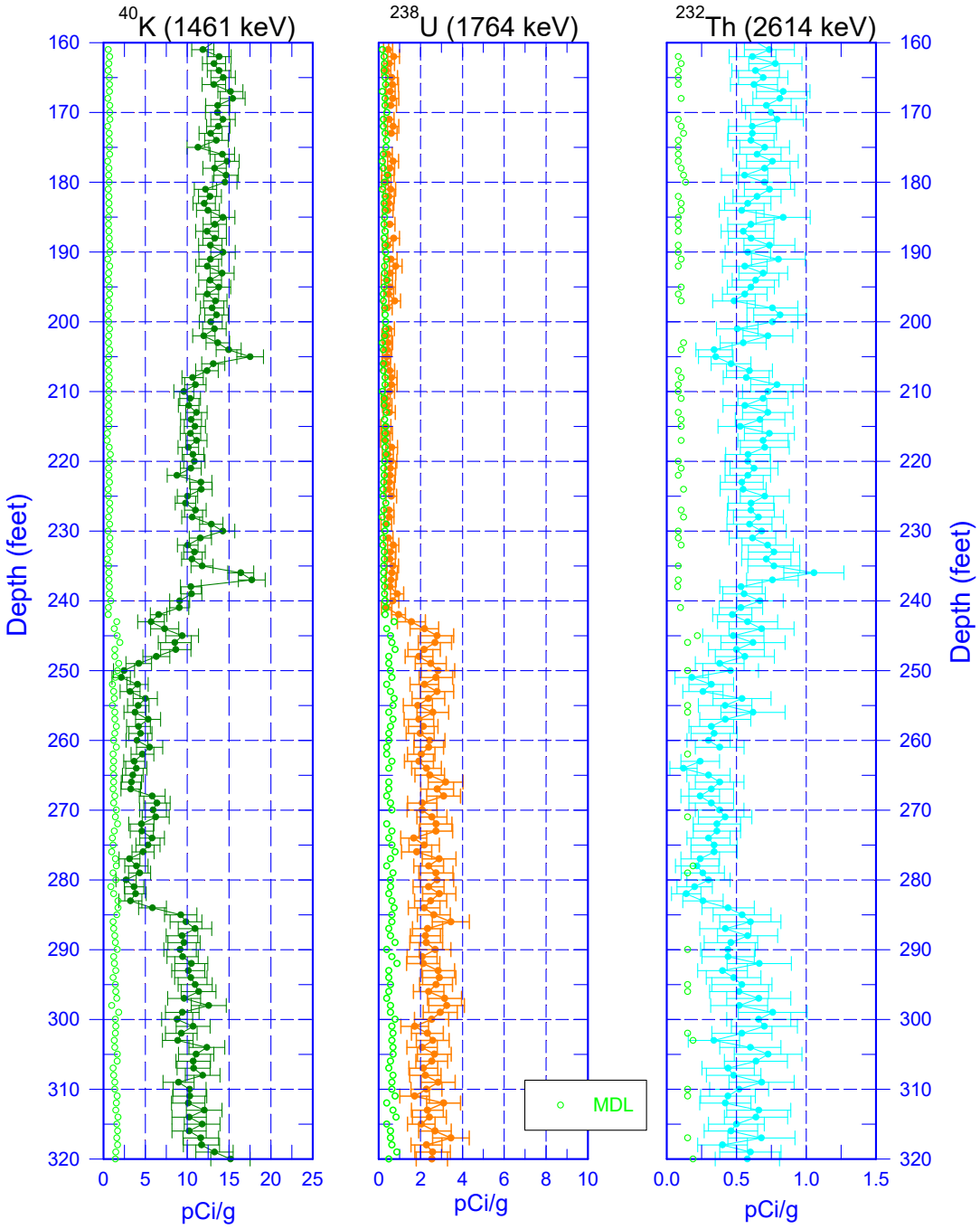
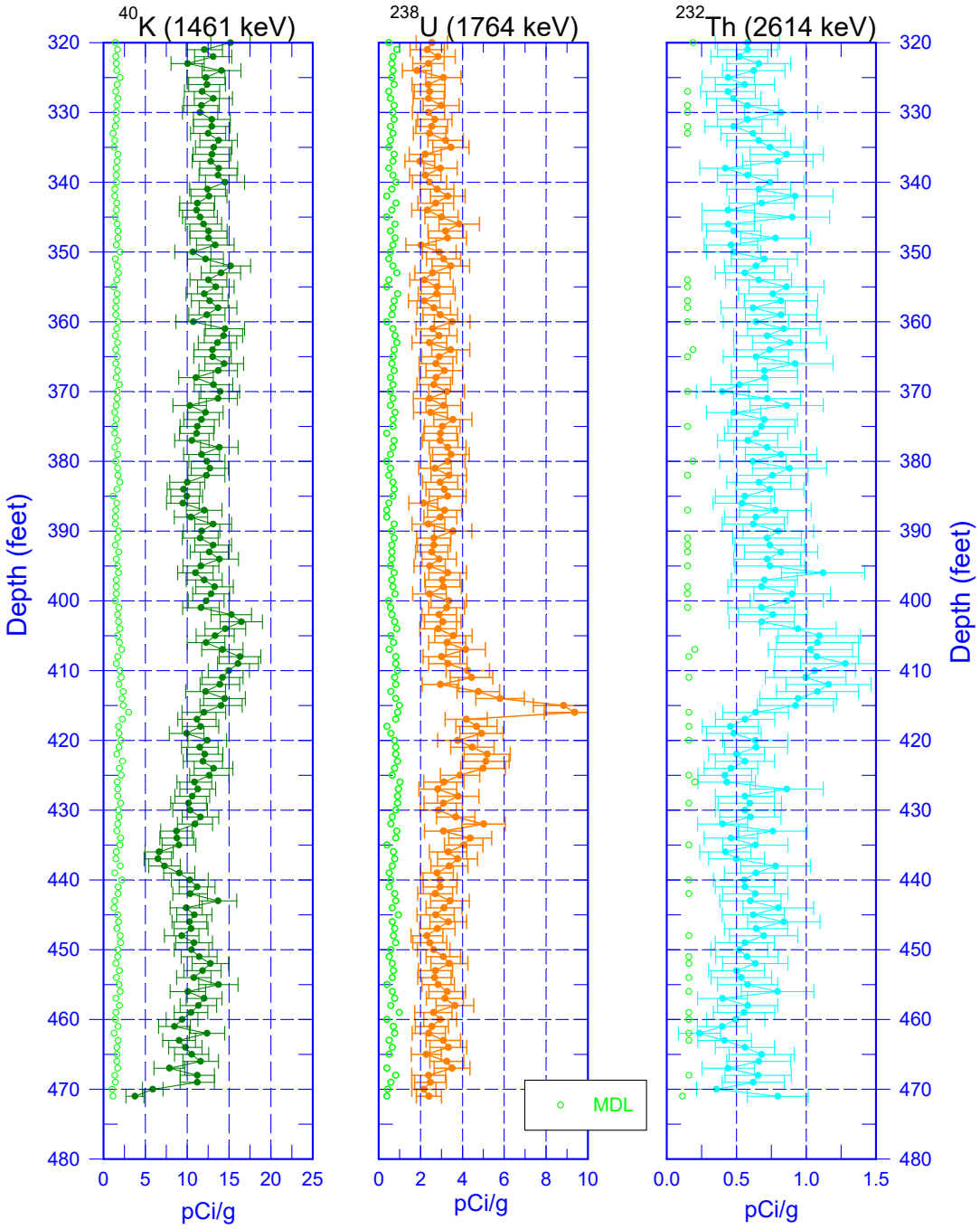
699-47-78B (C9879)
Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

699-47-78B (C9879)
Natural Gamma Logs



Zero Reference - ground surface

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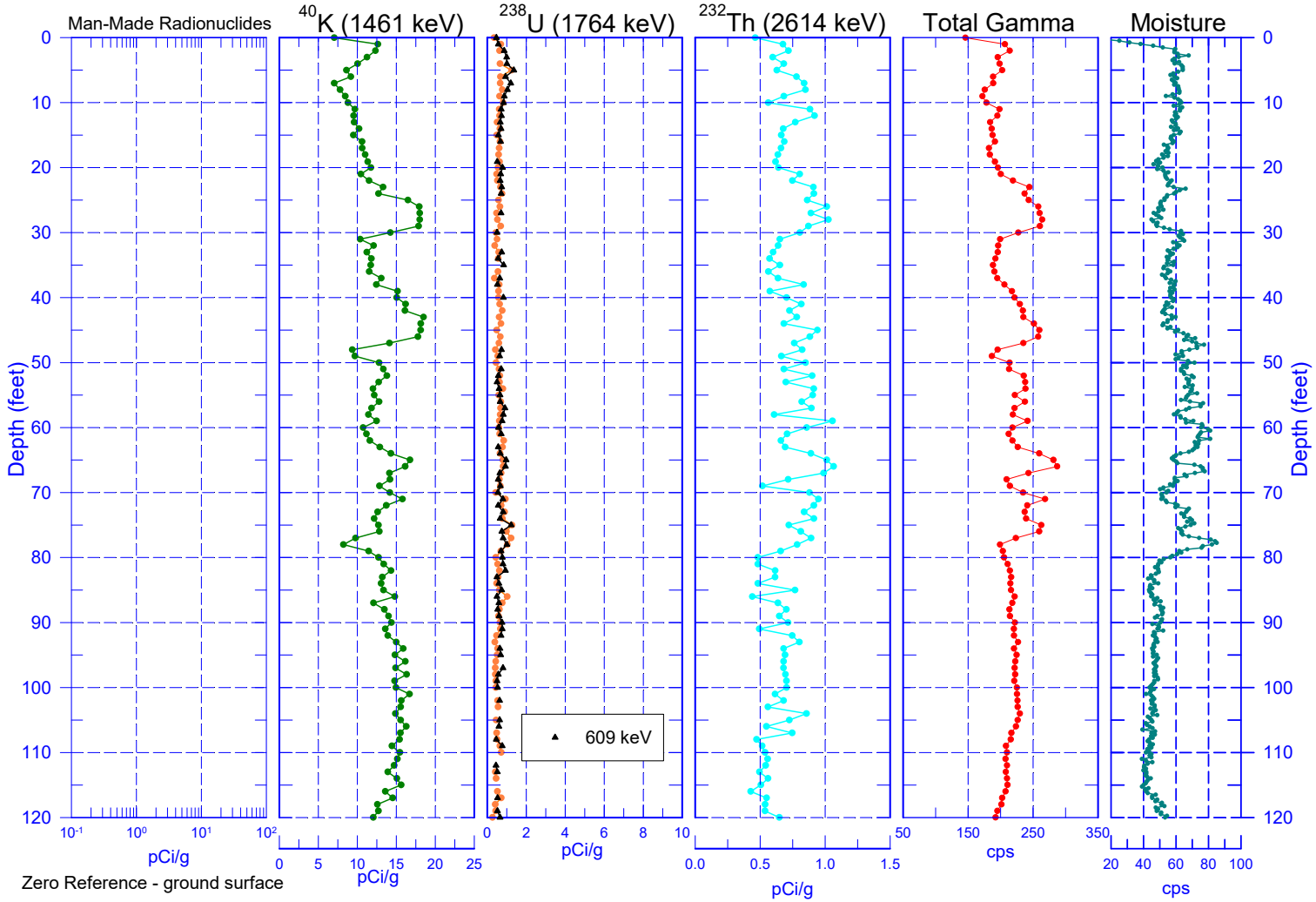
699-47-78B (C9879) Combination Plot



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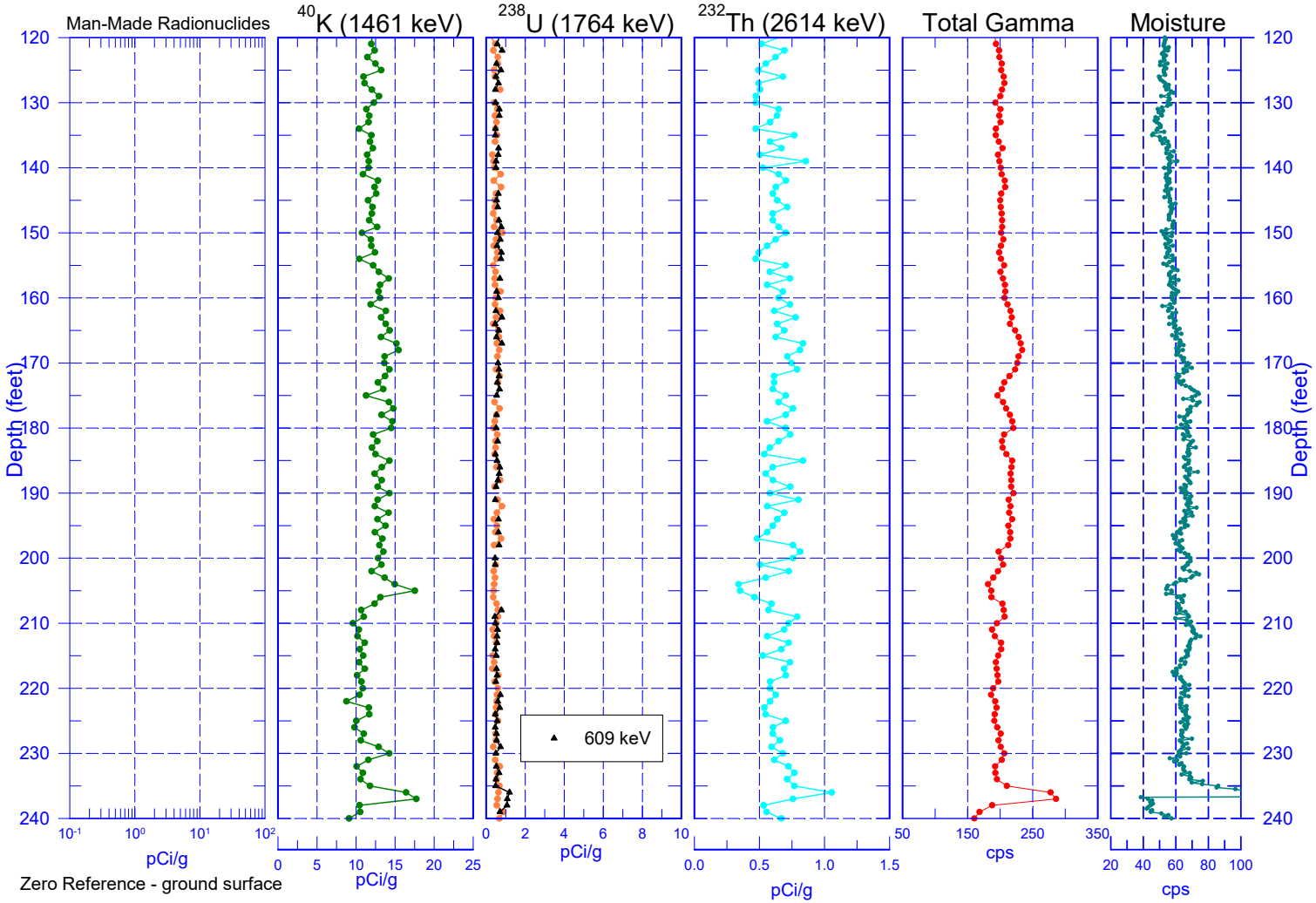
699-47-78B (C9879) Combination Plot



Bay West
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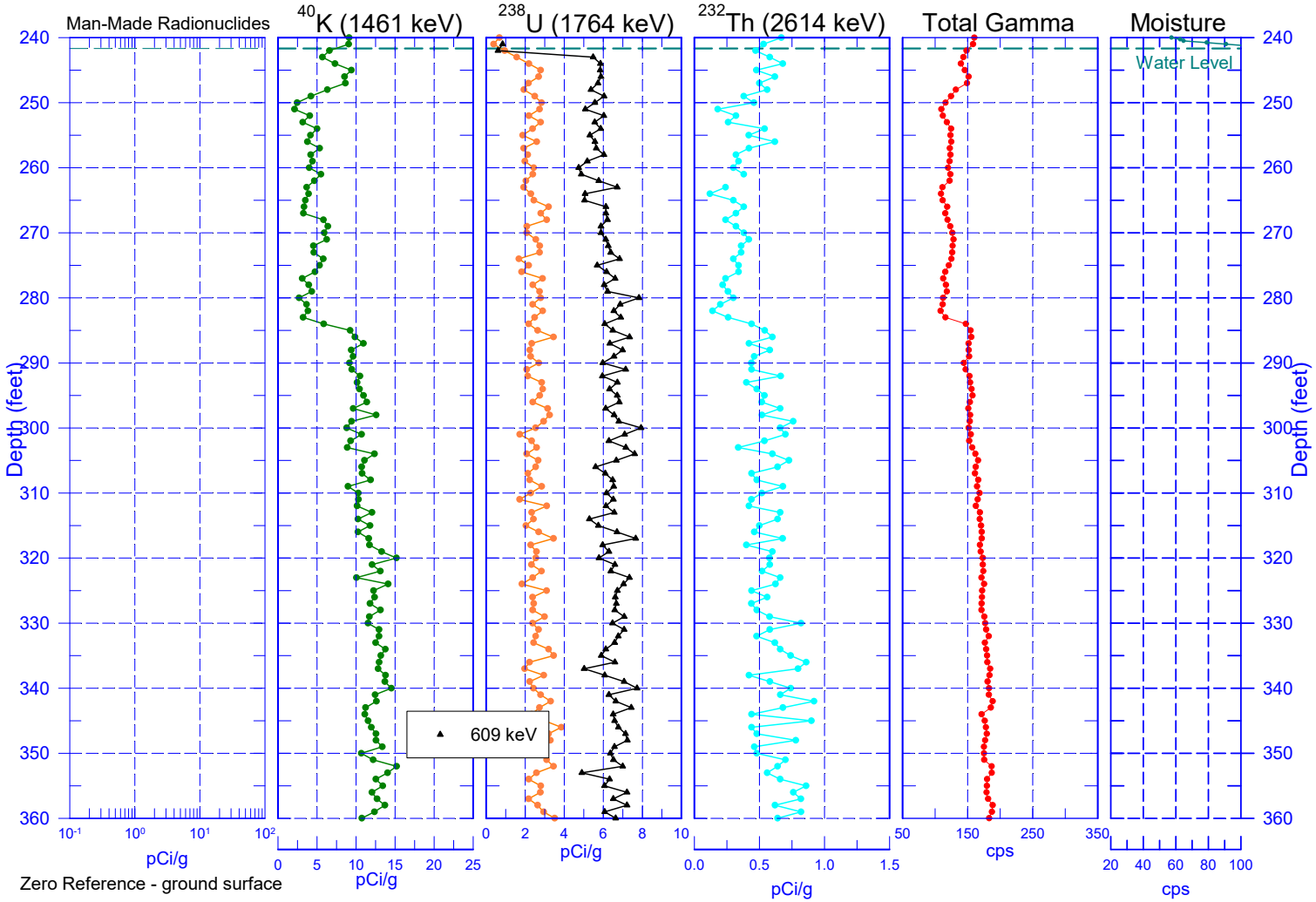
699-47-78B (C9879) Combination Plot



Bay West
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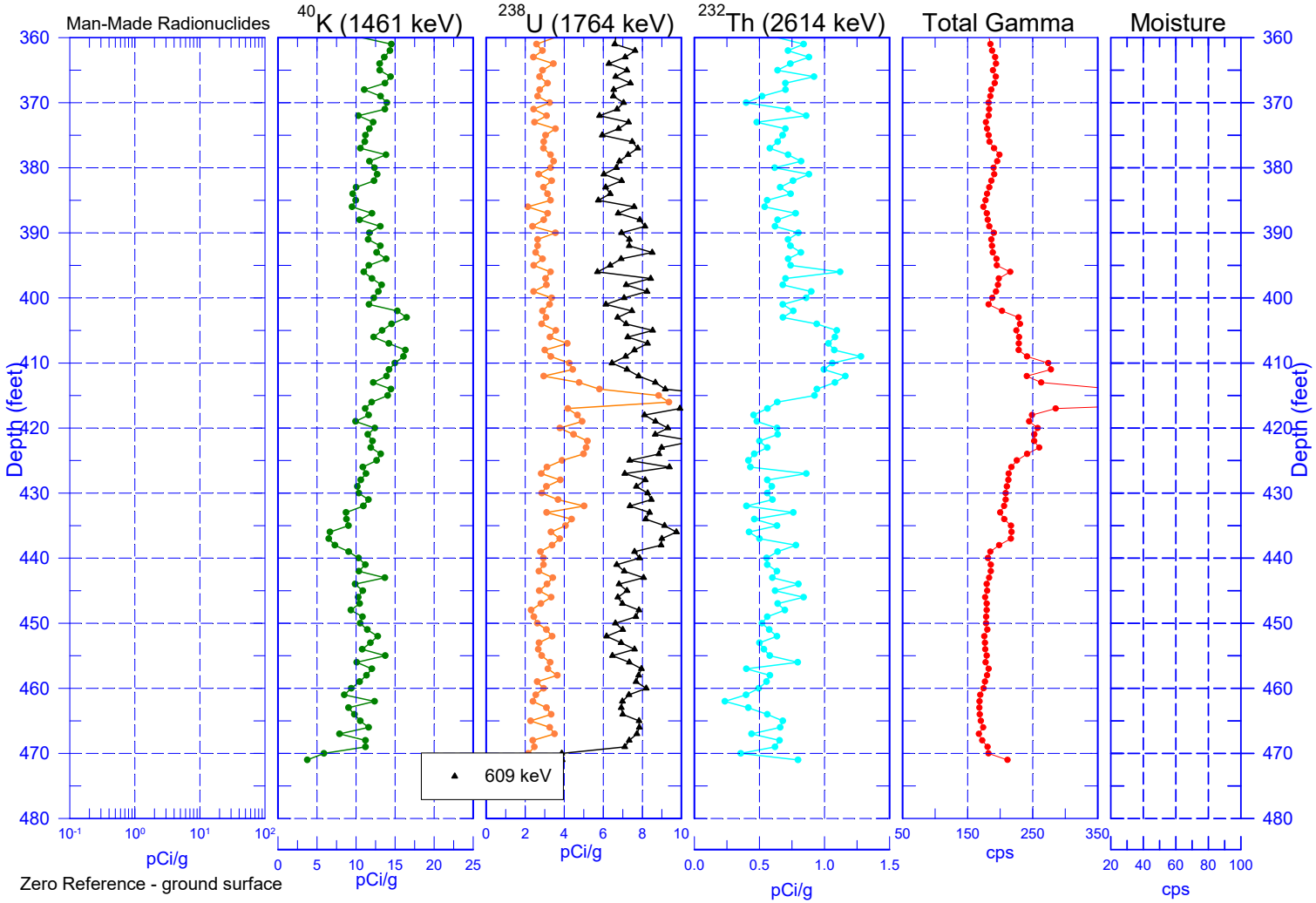
699-47-78B (C9879) Combination Plot



Zero Reference - ground surface

Bay West
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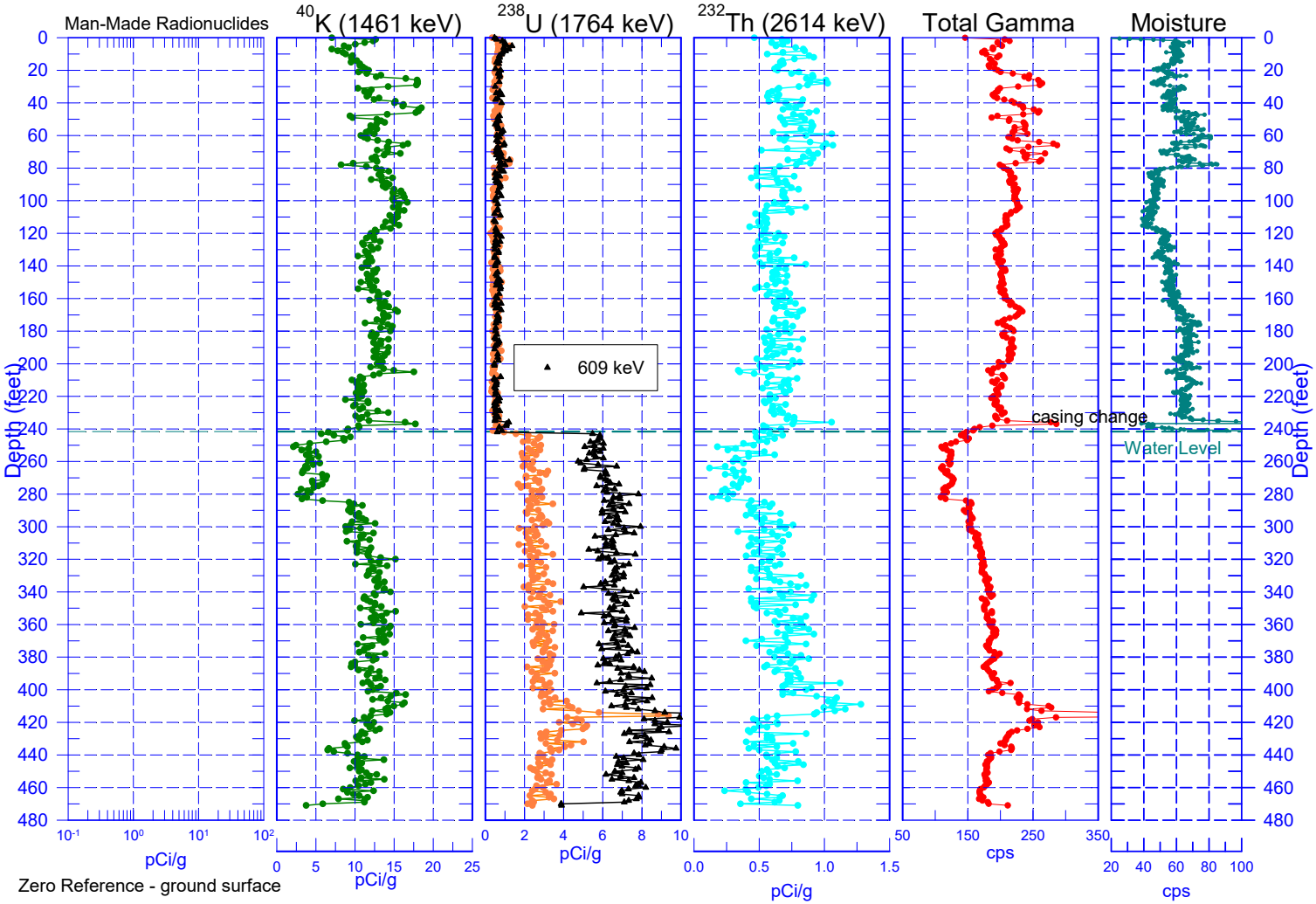
699-47-78B (C9879) Combination Plot



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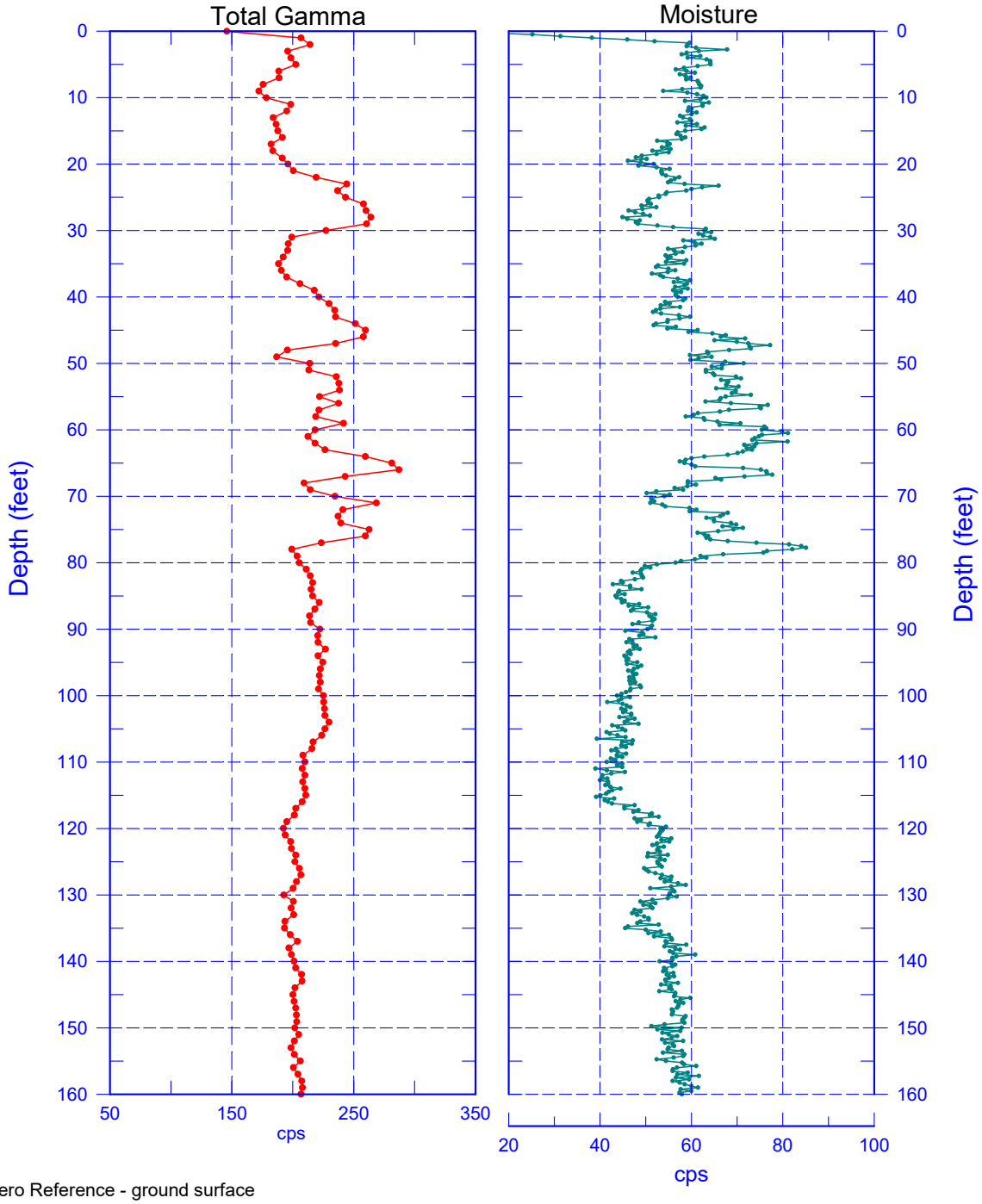
699-47-78B (C9879)
Total Gamma & Moisture



Zero Reference - ground surface

Bay West
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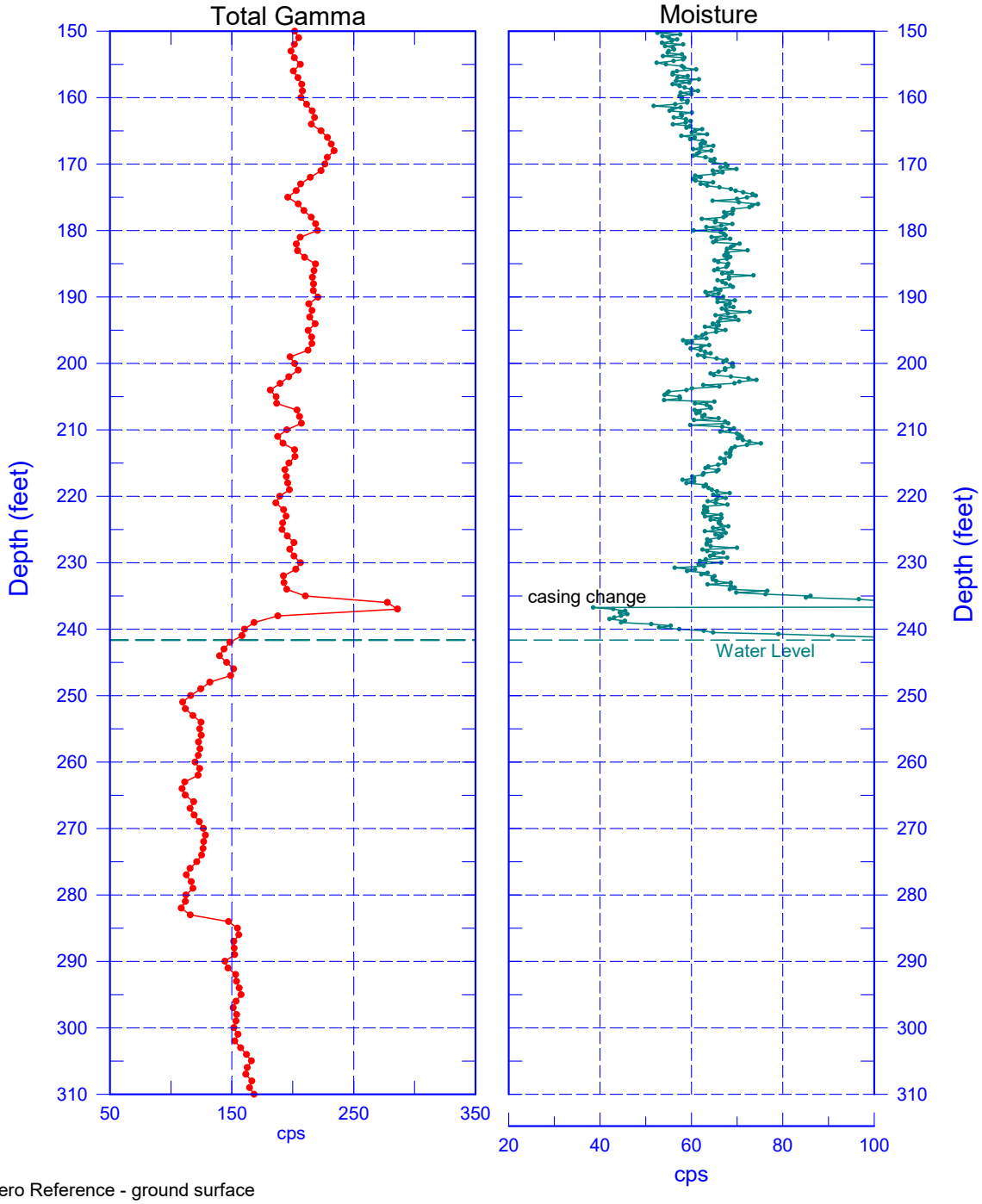
699-47-78B (C9879)
Total Gamma & Moisture



Zero Reference - ground surface

Bay West
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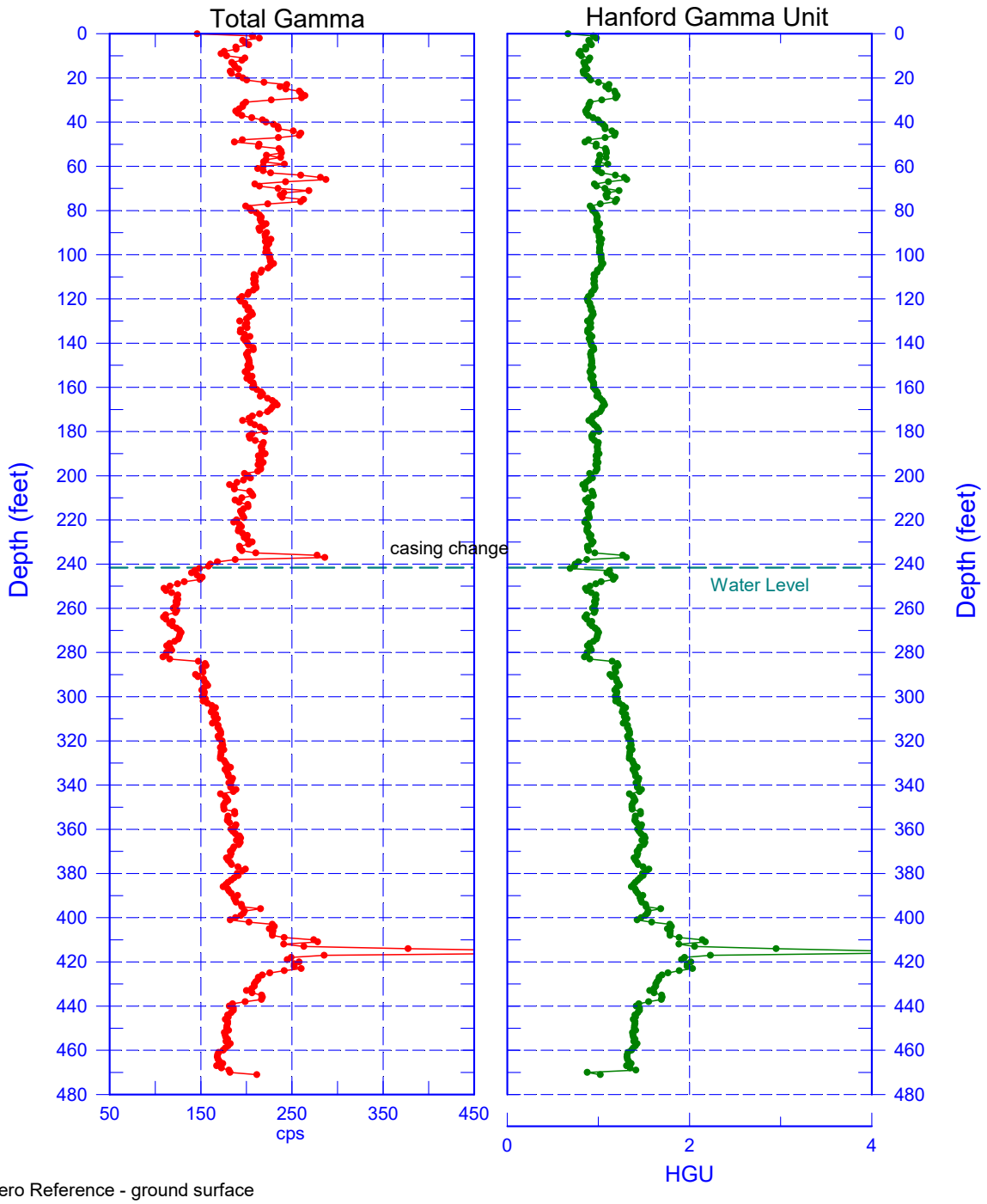
699-47-78B (C9879)
Total Gamma & Hanford Gamma Unit



Zero Reference - ground surface

Bay West
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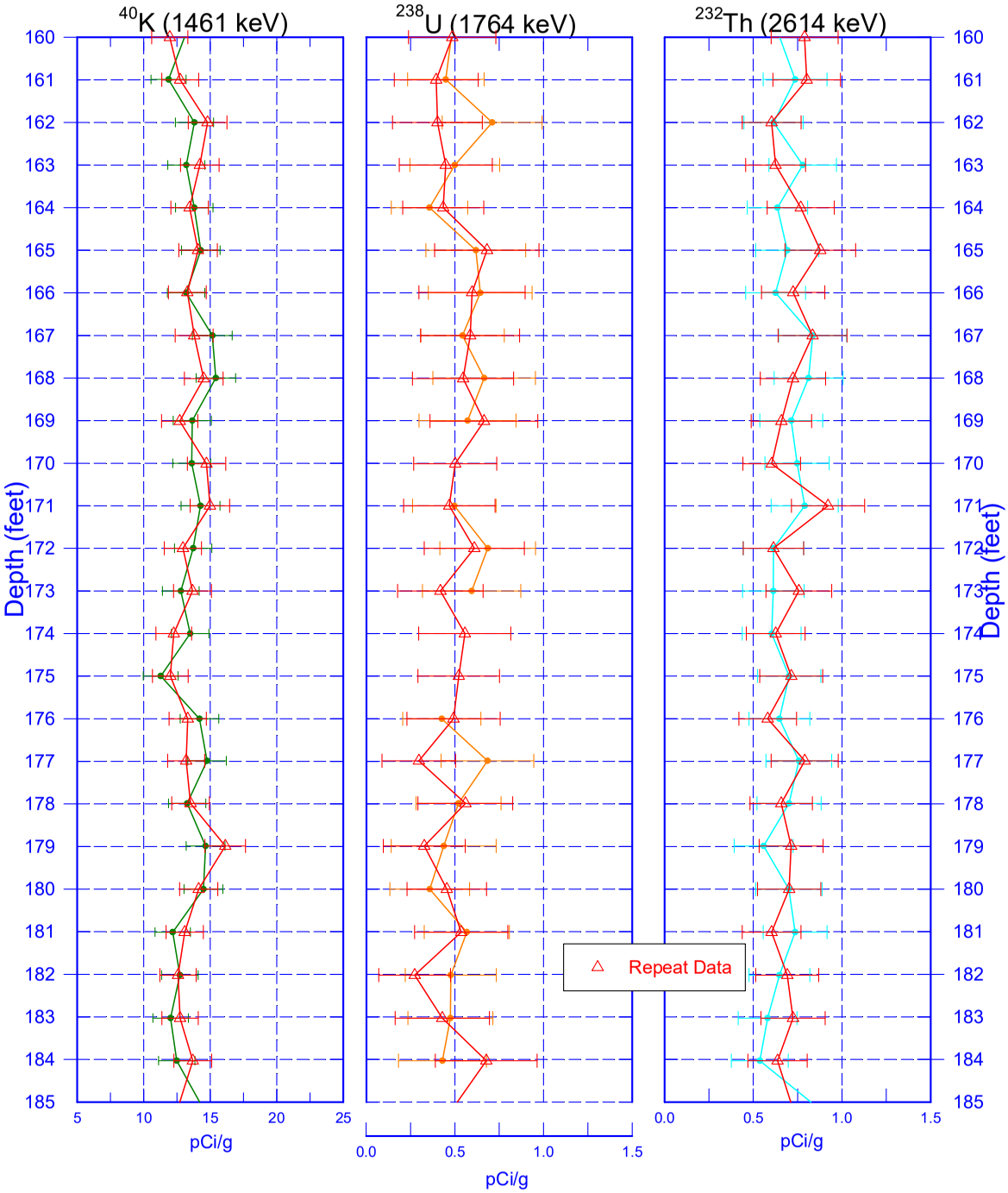
699-47-78B (C9879)
Repeat Section of Natural Gamma Logs

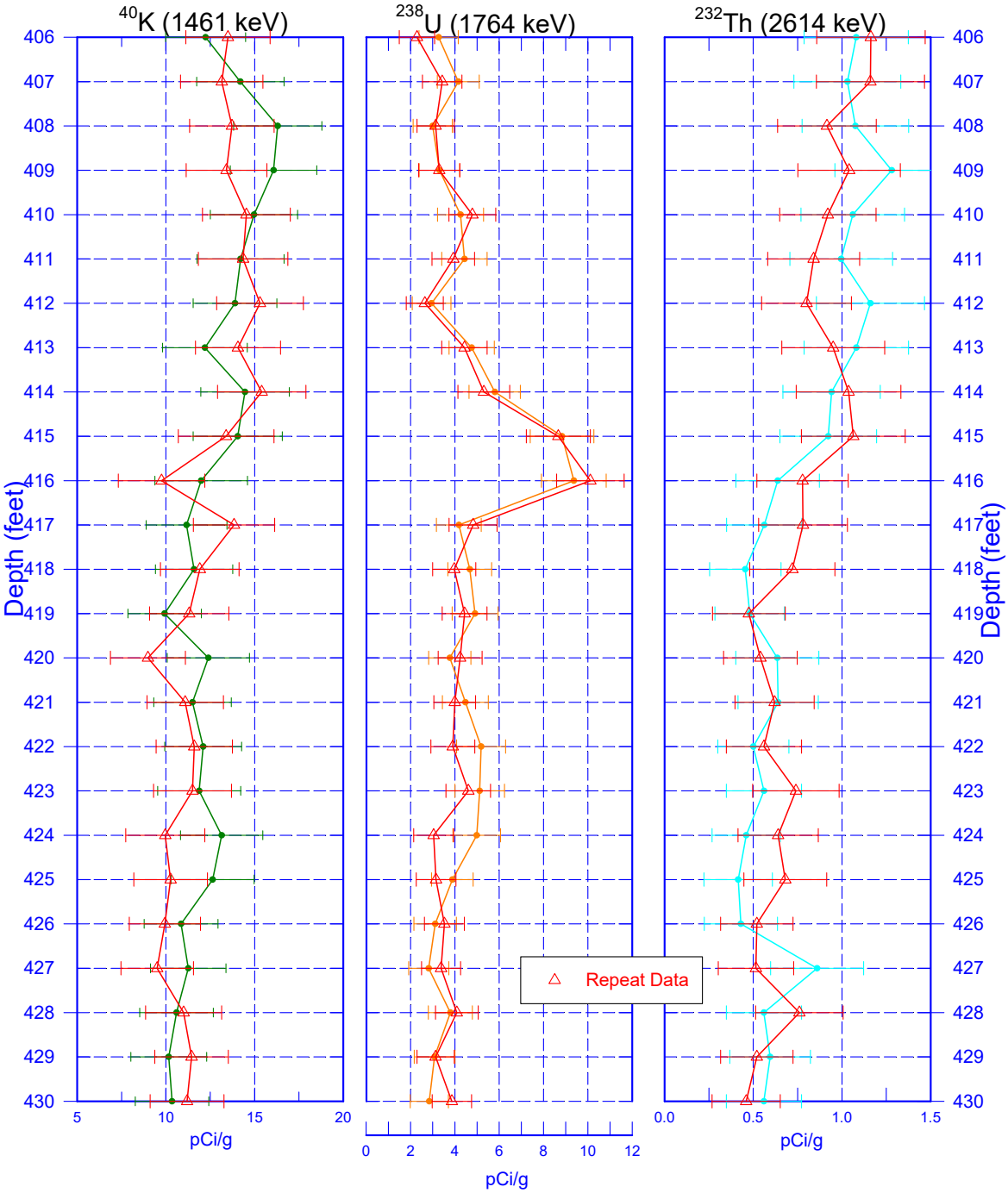


Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

699-47-78B (C9879)

Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

Bay West
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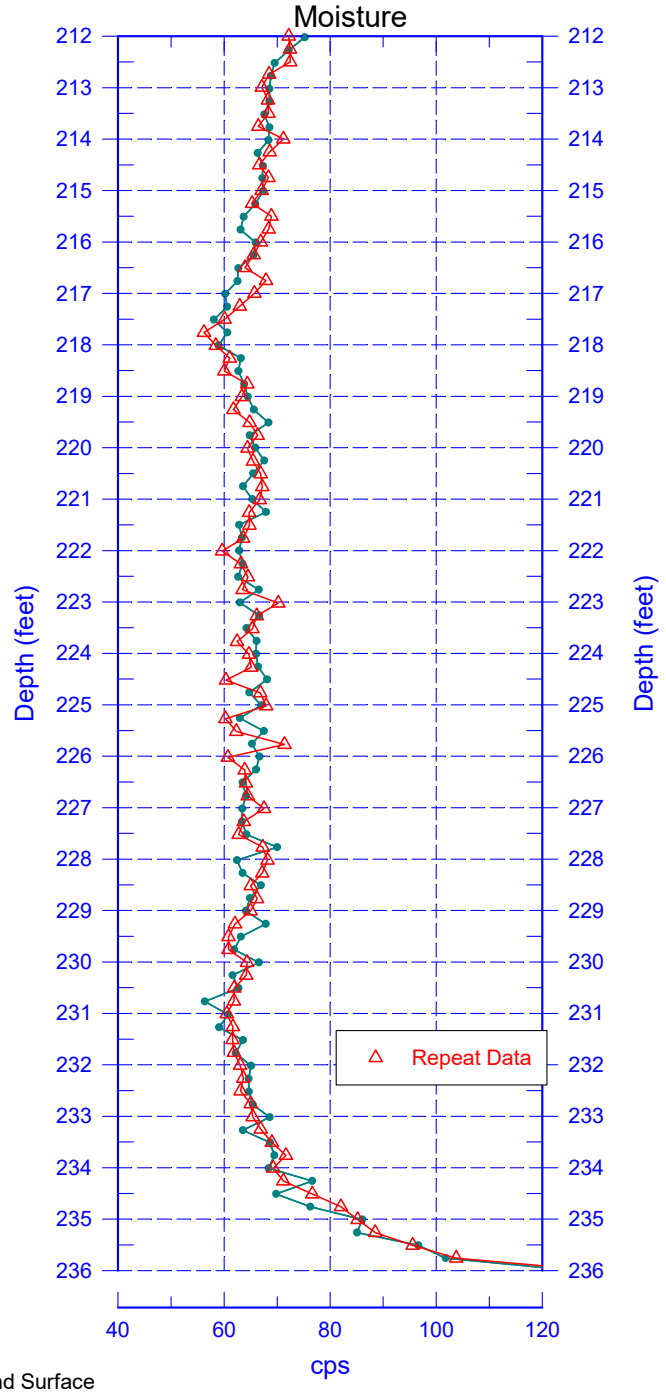
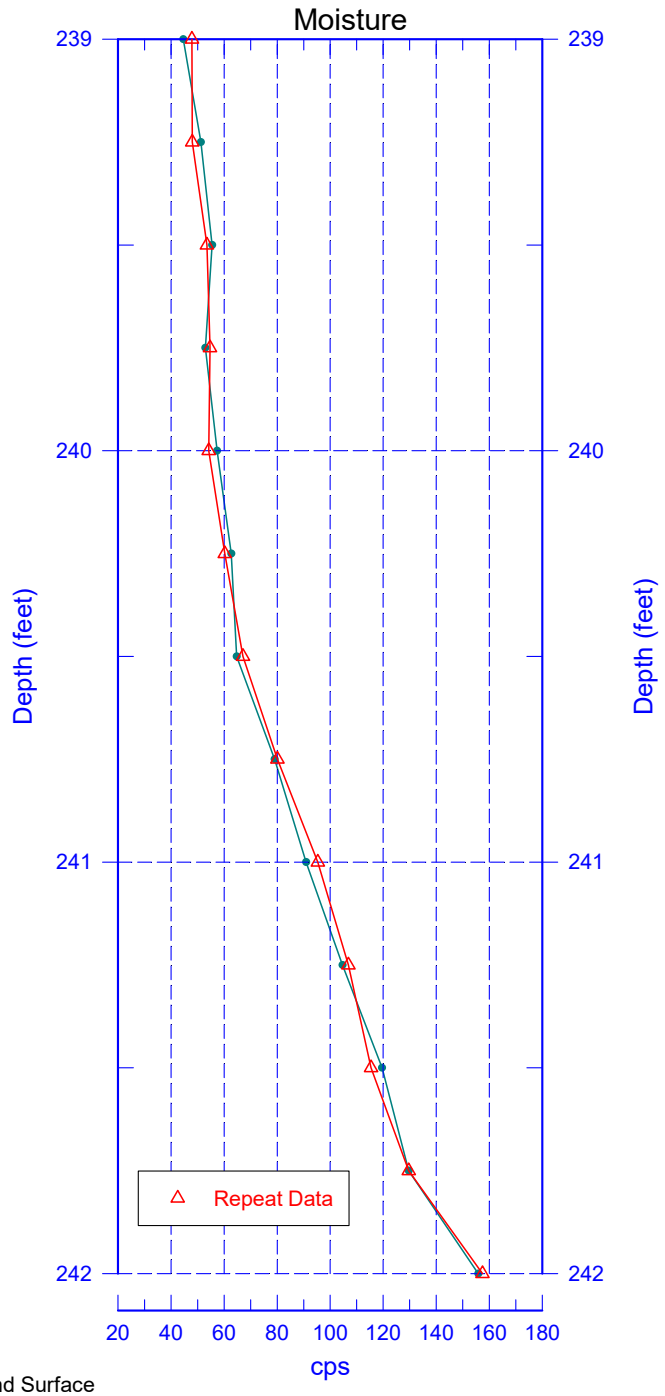
699-47-78B (C9879)
Moisture Repeat Section



Zero Reference - Ground Surface

699-47-78B (C9879)
Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 12/05/19	Requestor: Leonard D. Bultena (CHPRC)
Date of Survey: 12/17/19	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of 200-ZP-1 Well C9879 (699-47-78B) located on west side Dayton Avenue, north of 200W Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 600A

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments: Washington State Reference Network

Vertical Control Monuments: F317 (COE) and 2W-1 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9879	699-47-78B	566046.29	137926.66		Center of Casing
				208.873	Top Outer Casing, N.Edge Stamped "X"
				208.577	Top Inner 8"SS Casing, N.Edge
				208.129	Brass Survey Marker

Notes:

Brass Survey Marker elevation was taken on top domed brass cap in concrete.

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

I, Lawrence B. Munnell, a Professional Land Surveyor registered in the State of Washington (Registration No. 16216), hereby certify this report is based on a field survey performed by me, or under my direct supervision.

A-6003-659 (REV 1)

Appendix B

Well Documentation for C9988 (699-48-70)

Contents

Well Summary Sheet ……..…….…..... B-1
Borehole Log ……....…….…. B-6
Drill Cutting Photographs …….....…….……..... B-17
Well Develepment and Testing Data ……..…….....……...…....… B-26
Log Data Report …….....…..…..……....……...…....… B-27
Well Survey Data Report …….....…..…..……....……...…....… B-46

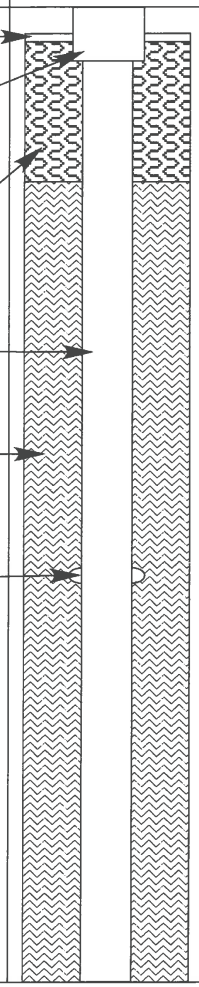
WELL SUMMARY SHEET		Page 1 of 5
Well ID : C9988	Well Name: 699-48-70	Start Date: 4/2/2019
Project: Install 2 Wells in 200-ZP-1 OU	Location: 310m NE of Biosoilds Fac.	Finish Date: 10/2/2019

CONSTRUCTION DATA

Description

- Concrete Pad: 0.5 ft above ground surface (ags)
- 10-in. Protective Casing: 3.03 ft ags - 1.97 ft below ground surface (bgs)
- Type I/II Portland Cement Grout: 0.00 - 10.00 ft bgs
- 8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.02 ft ags - 260.47 ft bgs
- 3/8-in Bentonite Crumbles: 10.00 - 241.15 ft bgs
- Stainless steel centralizer installed above and below screen and every 40 ft

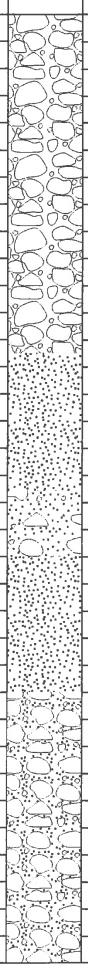
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 10, 20, 30, 40, 50, 60

Graphic Log



Lithologic Description (ft bgs)

- 0.0 - 25.0 Gravel (G)
- 25.0 - 35.0 Sand (S)
- 35.0 - 40.0 Gravelly Sand (gS)
- 40.0 - 50.0 Sand (S)
- 50.0 - 75.0 Sandy Gravel (sG)

Reported By:				
Nicole Combs / Lindsey Getchell	Geologist		10/4/2019	
Print Name	*Title*		*Signature*	*Date*
Reviewed By:				
Jennifer Richart	Well Coordinator		10/8/19	
Print Name	*Title*		*Signature*	*Date*

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET			Page 2 of 5
Well ID: C9988	Well Name: 699-48-70	Project: Install 2 Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
3/8-in Bentonite Crumbles: 10.00 - 241.15 ft bgs		70		50.0 - 75.0 Sandy Gravel (sG)
				75.0 - 80.0 Gravelly Sand (gS)
8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.02 ft ags - 260.47 ft bgs		80		80.0 - 90.0 Sand (S)
		90		90.0 - 130.0 Sandy Gravel (sG)
		100		
		110		
		120		
		130		130.0 - 135.0 Gravelly Sand (gS)
				135.0 - 140.0 Sand (S)
		140		140.0 - 165.0 Sandy Gravel (sG)
		150		
		160		
				165.0 - 170.0 Gravel (G)

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET			Page 3 of 5
Well ID: C9988	Well Name: 699-48-70	Project : Install 2 Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.02 ft ags - 260.47 ft bgs		170		165.0 - 170.0 Gravel (G)
				170.0 - 205.0 Sandy Gravel (sG)
		180		
3/8-in Bentonite Crumbles: 10.00 - 241.15 ft bgs				
		190		
		200		
				205.0 - 220.0 Gravel (G)
		210		
		220		220.0 - 225.0 Sandy Gravel (sG)
				225.0 - 230.0 Gravelly Sand (gS)
		230		230.0 - 255.0 Sandy Gravel (sG)
1/4-in. Non-coated Bentonite Pellet Seal: 241.15 - 246.00 ft bgs		240		
		250		
8-16 mesh Filter Pack Sand: 246.00 - 371.10 ft bgs				255.0 - 265.0 Gravelly Sand (gS)
8-in. I.D. Schedule 10, Type 304/304L, 50-slot (0.050 in.) Stainless Steel Screen: 260.47 - 360.48 ft bgs		260		Water Level: 259.63 ft bgs (9/26/2019)
				265.0 - 275.0 Sandy Gravel (sG)

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9988 | Well Name: 699-48-70 | Project: Install 2 Well in 200-ZP-1 OU

CONSTRUCTION DATA

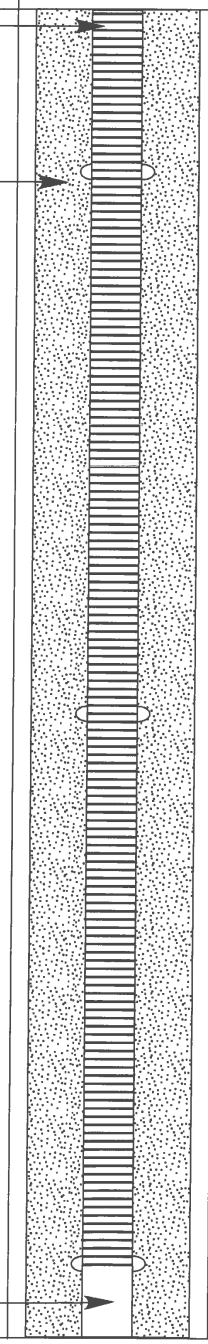
Description:

8-in. I.D. Schedule 10,
Type 304/304L, 50-slot (0.050 in.)
Stainless Steel Screen:
260.47 - 360. ft bgs

8-16 mesh Silica Filter Pack Sand:
246.00 - 371.10 ft bgs

8-in. I.D. Schedule 10, Type 304/304L,
Stainless Steel Sump:
360.48 - 370.48 ft bgs

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 270, 280, 290, 300, 310, 320, 330, 340, 350, 360

Graphic Log

Lithologic Description (ft bgs)

265.0 - 275.0 Sandy Gravel (sG)

275.0 - 295.0 Slightly Silty Sand ((m)S)

295.0 - 300.0 Silty Sandy Gravel (msG)

300.0 - 310.0 Slightly Silty Gravelly Sand ((m)gS)

310.0 - 345.0 Sandy Gravel (sG)

345.0 - 360.0 Gravel (G)

360.0 - 389.0 Sandy Gravel (sG)

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9988 | Well Name: 699-48-70 | Project: Install 2 Well in 200-ZP-1 OU

CONSTRUCTION DATA

Description

8-16 mesh Silica Filter Pack Sand:
246.00 - 371.10 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump:
360.48 - 370.48 ft bgs

3/8-in Bentonite Crumbles:
371.10 - 401.80 ft bgs

Straightness Test: Pass, 07/10/2019

Depths are in ft below ground surface.
Borehole drilled with 16-in. O.D. casing from 0.0 - 214.20 ft bgs

Borehole drilled with 14-in. O.D. casing from 214.20 - 390.69 ft bgs
Borehole drilled with 12 1/2-in. O.D. drill bit from 390.69 - 401.80 ft bgs

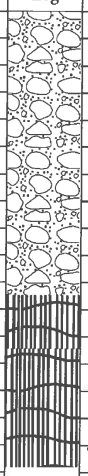
All temporary drill casing was removed from the ground.

Diagram

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 370, 380, 390, 400, 410

Graphic Log



Lithologic Description (ft bgs)

360.0 - 389.0 Sandy Gravel (sG)

389.0 - 401.8 Basalt

Total Depth: 401.8 (5/14/2019)

A-6006-992 (Rev 2)

BOREHOLE LOG

Page 1 of 11

Date: 4-3-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310m NE of Biosolids Facility

Project: Install 2 Wells in 200-ZP-1 OU | Reference Measure Point: Ground Surface

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
0			0-25': Gravel (G) g=95% s=5% m=Trace Gravel: v.fine-coarse peb., 30% vf, 30% f, 30% m, 10% c 2mm avg, 30mm max, mod sort, 20% fel, 80% maf, ang. Sand: c-v.coarse, well sort, 20% fel, 80% maf, ang. Wet, No rxn HCl 2.5Y 5/4 Light Olive Brown	Dual Rotary Drilling with 16"OD/15 1/4"ID temporary casing 0.0'-214.2' bgs. 14"OD/13 3/8"ID temp. casing 214.2'-390.7' bgs. 8 5/8"OD drill rod & 12 1/4"OD tri-cone bit. Grab samples collected every 5' or change in lithology.
5	G			
				NC 5-24-19
10	G		@10': Gravel: max ≈ 20mm, avg ≈ 5mm, 40% fel, 60% maf. Sand: 30% fel, 70% maf. V.weak rxn HCl	0'-~~20'~~ 214.2' drill with 14"OD hammer bit.
15	G			
20	G		@20': Color change 2.5Y 4/2 Dark grayish Brown + No rxn HCl	
25	G		25-35: Sand (S) g=5%, s=95%, m=Trace Gravel: v.coarse pebble, max ≈ avg ~ 35mm, well sort, 95% maf, 5% fel, sub-ang. Sand: m-v.coarse, well sort, 60% fel, 40% maf, sub ang, Moist. No rxn HCl 2.5Y 5/4 Light Olive Brown	
30	G		@30' Gravel: v.fine-v.coarse peb, 95% vf-fine, 5% m-v.coarse, 2mm avg, 35mm max, Well sort, 80% fel, 20% maf. Sand: No change.	

Reported By: Tracy Mallanen (Print Name) | Geologist (Title) | Signature | 5/24/19 (Date)

Reviewed By: Sarah Springer (Print Name) | Sr Geologist (Title) | Signature | 05/29/19 (Date)

For Office Use Only

OR Doc Type: | WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 11

Date: 4-3-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310 m NE of Biosolids Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
35	G		35-40': gravelly Sand (gS) g=10 s=90 m=trace Gravel: fine-v.coarse peb, 95% vf-fine, 5% m-v.c. peb well sort, 80% fel, 20% maf, sub ang. Sand: m ~~v.coarse~~ med-coarse TM 4/30/19 well sort, 60% fel, 40% maf, sub ang, moist, 2.5Y 5/4 Light Olive Brown.	Dual Rotary Drilling with 16" OD / 15 1/4" ID temp casing 0.0' - 214.2' bgs. 14" OD / 13 3/8" ID temp. casing 214.2' - 390.7' bgs. 8 5/8" OD drill rod & 12 1/4" OD tri-cone bit. Grab samples every 5' or change in lithology.
40	G		40-50': Sand (S) g=5%, s=95% m=trace Gravel: vfine-med peb, 2-5mm avg, 10mm max, well sort, 80% fel, 20% maf, sub ang. Sand: vf-med well sort, 80% fel, 20% maf, Moist No rxn HCl 2.5Y 5/4 Light Olive Brown	
45	G		@ 45' Sand: 60% fel, 40% maf	
50	G		50-75': sandy Gravel (sG) g=45% s=50% m=5% Gravel: vf-v.coarse peb, 5mm avg, 30mm max, mod sort, 10% fel, 90% maf, sub ang. Sand: vf-v.coarse, 20% vf-med, 80% c-v.c., well sort, 60% fel, 40% maf, sub ang. Moist, No rxn to HCl 2.5Y 4/3 Olive Brown	
55	G		@ 55' Gravel: 35%, Sand: 60%, M: 5% Gravel: 40% vf-fine peb, 60% med-c. peb. TM 4/30/19 ~~MAG~~ avg ↑ 10mm, 20% fel, 80% maf. Sand: 30% v fine-fine, 20% med, 50% coarse. mod sort, occ. weak rxn HCl	
60	G		@ 60' Gravel: 25% vf-f peb, 70% m-c peb, 5% vc peb max ↑ 40mm, 25% fel, 75% maf. Sand: 10% f-med, 80% c-v. coarse, well sort, 40% fel, 60% maf	
			@ 65' color change 2.5Y 5/2 Gray	
			@ 70'	
65	G		~~@ 65'~~ Gravel: 40% vf-fine peb, 60% med-coarse peb, TM 4/30/19 avg ↑ 15mm, max ↓ 30mm. Sand: 80% vf-fine, 10% med, 10% c-v. coarse, 2.5Y 4/4 Olive Brown	
70	G			

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 5/24/19 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 11

Date: 4-4-19

Well ID: C9988 | Well Name: C699-48-70 | Location: ~310m NE of Biosolids Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
75	G		75'-80': gravelly Sand (gS) g=20% s=80% m=Trace Gravel: vfine-coarse peb., 20% vf, 40% fine, 20% med, 20% c, 5mm avg, 20mm max, mod sort, 25% fel, 75% maf, subang. Sand: vfine-coarse, 20% vfine-fine, 80% m-coarse, well sort, 75% fel, 25% maf. subang. Moist Mod rxn HCl 2.5Y 4/4 Olive Brown.	Dual Rotary Drilling with 16" OD / 15 1/4" ID temp. casing 0.0' - 214.2' bgs. 14" OD / 13 3/8" ID 214.2' - 390.7' bgs. 8 5/8" OD drill rod & 12 1/4" OD tri-cone bit. Grab sample every 5' or change in lithology.
80	G		80'-90': Sand (S) g=5%, s=95%, m=Trace Gravel: vfine-coarse peb., 60% vfine-fine, 30% med, 10% coarse, poor sort, 10% fel, 90% maf, subang. Sand: vfine-v.coarse. 10% vfine-fine, 40% med, 40% coarse, 10% v.coarse, well sort, 50% fel, 50% maf, subang. Dry. No rxn HCl 2.5Y 5/4 Light Olive Brown.	
85	G			
90	G		90'-130': Sandy Gravel (sG) g=70% s=30% m=Trace Gravel: vfine-v.coarse peb., 10% vfine, 20% fine, 30% med, 30% coarse, 10% v.coarse. 15mm avg., 50mm max, poor sort 30% fel, 70% maf, subang-subround. Sand: vfine-v.coarse Trace vfine-fine, 10% med, 90% coarse-v.coarse. well/mod sort, 30% fel, 70% maf, subang. Moist No rxn HCl, 2.5Y 4/3 Olive Brown.	
95	G			
100	G		@100': Gravel=45%, s=50%, m=5% Gravel: 20% vf-fine peb, 60% med, 20% coarse mod sort. 60% fel, 40% maf, ang-subang. Sand: 30% vfine-fine, 30% med, 20% coarse, 20% v.coarse, 60% fel, 40% maf	
105	G		@105': g ↑ to 35%, s ↓ to 60% m=Trace Sand: Trace vfine-fine, 80% coarse, 20% v.coarse, well sort 50% fel, 50% maf.	
110	G		@110': g ↑ to 60%, s ↓ to 40%. Gravel: 60% vfine-fine peb, 30% med, 10% coarse, max 5mm, 40% fel, 60% maf Sand: 30% fel, 70% maf, Color: 2.5Y 6/2 light Brownish Grey	

Reported By:

Tracy Mallgren	Geologist		5/24/19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 4-8-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310m NE of Biosolids Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
115	G		90-130': sandy Gravel (sG) @115' g=40% s=55% m=5% Gravel: vfine-med peb. 60% vf-fine, 40% med, 3mm avg, 15 mm max mod sort, 40% fel, 60% maf, ang-subang. Sand: trace vfine-fine, 100% coarse-v. coarse, well sort, 40% fel, 60% maf, subang. Moist, No rxn HCl, 2.5Y 5/3 Light Olive Brown.	Dual Rotary Drilling with 16" OD/15 1/4" ID temp. casing 0.0'-214.2' bgs. 14" OD/13 3/8" ID 214.2'-390.7' bgs. 8 5/8" OD drill rod & 12 1/4" OD tri-cone. Grab sample every 5' or change in lithology.
120	G		@120' g: 50% vfine-fine peb, 30% med, 20% coarse max ≈ 25mm.	
125	G		TM 4/18/19 @125' ~~g↑ to~~ g↓ to 35%, s↑ to 60%. Color: 2.5Y 4/4 Olive Brown	
130	G		130-135': gravelly Sand (gS) g=15% s=80% m=5% Gravel: vfine-med peb w/ occ coarse peb + ~~small cobble~~ v. coarse peb TM 4/18/19 avg. 10mm max 40mm, mod sort, 40% fel, 60% maf, ang. Sand: trace fines, 30% med, 50% coarse, 10% v. coarse, mod sort, 50% fel, 50% maf, sub ang. Moist. No rxn HCl 2.5Y 4/3 Olive Brown	
135			135-140': Sand (S) g=5% s=95% m=trace Gravel: vfine-fine pebbles, avg & max ≈ 5mm, 30% fel 70% maf, subang. Sand: med with trace fines, well sort, 50/50 fel-maf, subang. Dry. No rxn HCl 2.5Y 4/3 Olive Brown.	
140			140-165': sandy Gravel (sG) g=75% s=25% m=T Gravel: vfine-v. coarse peb. 5mm avg 40mm max, ~~p~~ 30% vf, 20% fine, 20% med, 20% coarse, 10% v. coarse, poor sort 40% fel, 60% maf, ang-subang. Sand: trace fines, 10% med, 70% coarse, 20% v. coarse, well sort, 50/50 fel/maf, ang. Dry No rxn HCl 2.5Y 5/2 Grayish Brown.	
145			@145' Moist 2.5Y 4/4 Olive Brown	
150			@150' gravel 80% fel, 20% maf. Sand: 15% vfine, 30% fine, 40% med, 10% coarse, 5% v. coarse 70% fel, 30% maf, subang. Dry.	

Reported By: Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 5/24/19 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 5 of 11

Date: 4-16-19

Well ID: C9988 | Well Name: C99-48-70 | Location: ~310m NE of Biosolids Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
155	G		140-165': Sandy Gravel (sG)	Dual Rotary Drilling with 16" OD / 15 1/4" ID temp. casing 0.0' - 214.2' bgs. 14" OD / 13 3/8" ID 214.2' - 390.7' bgs. 8 5/8" OD drill rod & 12 1/4" OD tri-cone. Grab sample every 5' or change in lithology.
			@155' g=30%. s=65%. m=5%. Gravel: v.fine peb-vc peb with trace small cobbles. avg 15mm max 70mm, poor sort, 40% fel, 60% maf, round. Sand: vfine-vcoarse, med avg, well sort, 80% fel, 20% maf, ang, Dry	
160	G		Strong rxn HCl 10YR 5/4 Yellowish Brown	
			@160' g↑ to 75%. s↓ 24%. m=1%. Trace Gravel: avg ↑ 50mm, max ~100mm, mod sort, 70% maf Sand: mod sort, 70% fel, sub ang. Moist. No rxn HCl 2.5Y 5/2 Grayish brown	
165	G		165'-170': Gravel (G) g=90%. s=10%. m=Trace Gravel: vfine peb to small cobble. 10% vf-f peb 5% fine, 10% med peb, 15 c. peb, 60% v. coarse peb, 10% sm. cobble. 40mm avg, 65mm max, poor sort, 30% maf, 70% fel, sub round. Sand: vfine-v.coarse, avg med, mod sort, 75% fel 25% maf, sub ang, Dry, No rxn HCl, 10YR 7/2 Light Gray.	
170	G		170'-205': Sandy Gravel (sG) g=40%. s=60%. m=Trace Gravel: vfine-vcoarse peb + trace small cobbles. 20% vf-f 45% med, 30% coarse, 5% v. coarse. 12mm avg, 70mm max, poor sort, 30% fel, 70% maf, sub round. Sand: vfine-vcoarse, 15% vfine, 35% fine, 40% med, 5% coarse, 5% v.coarse, Mod sort, 75% fel, 25% maf, sub ang, Moist. No rxn HCl 2.5Y 6/3 Light Grayish Brown	
175	G		@175' g↓ to 30%, s↑ to 65%. m=5%. Gravel: vfine peb - coarse peb. 35% vf, 25% f, 25% med 10% coarse. max ↓ 20mm. 60% fel, 40% maf. Dry 7.5YR 7/1 Light Gray.	
180	G		@180' g↑ to 75%, s↓ 25%. m=Trace Gravel: vf peb - vcoarse peb, 12mm avg, max ↑ 34mm Sand: 80% fel, 20% maf. Moist. 10YR 6/3 Pale Brown	
185	G		@185': Slight/weak rxn HCl	
190	G			

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 5/24/19 (Date)

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BOREHOLE LOG (Cont.)

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Date: 4-16-19

Well ID: C9988 | Well Name: C99-48-70 | Location: ~310 m NE of Biosolid Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
195			170'-205': Sandy Gravel (sG)	Dual Rotary Drilling with
			@195': g=40% ~~s=40%~~ Jim 4/16/19 s=58% m=2%	16"OD/15 1/4"ID temp. casing.
			Gravel: vfine-coarse peb., 12mm avg, 16mm max, poor	0.0'-214.2' bgs. 14"OD/13 3/8"ID
			sort, 60% fel, 40% maf. subround. Sand: vfine-v. coarse,	214.2'-390.7' bgs. 8 5/8"OD
			10% vf, 30% f, 40% med, 10% coarse, 10% vc., mod sort, 60% fel,	drill rod & 12 1/4"OD tri-cone.
200			40% maf, ang-subang, Moist: No rxn HCl, 10YR 5/4 Yellowish	Grab sample every 5' or
			Brown.	change in lithology.
			@200' g=50%, s=50%. Gravel: vfine peb-small	
			cobble. 15mm avg 45% max, Sand: 70% fel, 30% maf	
			7.5YR 4/3 Brown.	
205			205-220': Gravel (G) g=80% s=20%	
			Gravel: vfine-v. coarse peb. 15mm avg, 40mm max,	
			poor sort, 60% fel, 40% maf, subround. Sand: vf-v coarse,	
			15% vf, 30% fine, 40% med, 10% coarse 5% v. coarse, poor sort,	
			70% fel, 30% maf, subang, Dry No rxn HCl, 10YR 5/4	
210			Yellowish Brown.	
			@210': Color: 10YR 7/2 Light Gray	
				214.2'-401.8' drill with
215			@215': g↑85% s↓ to 15% Color: 10YR 5/4 Yellowish	tri-cone bit, 12 1/4"OD
			Brown.	
			220'-225': Sandy Gravel (sG) g=55%, s=35%, m=10%	
220			Gravel: v. fine-coarse peb, 10% vf, 15% fine, 45% med, 30%	
			coarse, 10mm avg, 20mm max, mod sort, 70% fel, 30% maf,	
			subang. Sand: vfine-coarse, 25% vfine, 40% fine, 20% med,	
			15% coarse, mod sort, 70% fel, 30% maf, subang. Wet	
			No rxn HCl 2.5Y 4/4 Olive Brown	
225				
			225-230: gravelly Sand (gS) g=20% s=75% m=5%	
			Gravel: vfine-coarse peb. 5mm avg 20mm max, mod sort,	
			70% fel, 30% maf, subang. Sand: 70% vfine-fine, 30% med	
			well sort, 70% fel, 30% maf, subang. Moist No rxn HCl	
230			2.5Y 4/4 Olive Brown.	
			230-255: Sandy Gravel (sG) g=45% s=50% m=5%	
			Gravel: vf-c. peb. 5mm avg. 25mm max	
			- Description continued on page 7 -	

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 5/24/19 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 4-30-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310m NE of Biosolid Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
235	G		230-255: sandy Gravel (sG) g=45% s=50% m=5% Gravel: vfine - c. peb. 5mm avg 25mm max, mod sort, 70% fel, 30% maf, subang. Sand: vfine - coarse, well sort, 70% fel, 30% maf, subang, MOIST. MOD rxn HCl 2.5Y 4/4 Olive Brown.	Dual Rotary Drilling with 16" OD / 15 1/4" ID temp. casing 0.0' - 214.2' bgs. 14" OD / 13 3/8" ID 214.2' - 390.7' bgs. 8 5/8" drill rod & 12 1/4" OD tri-cone bit. Grab sample every 5' or change in lithology.
240	G		@ 240' Max g ≥ 20mm, sand: vf - v coarse No rxn HCl	
245	G		@ 245' g ≥ 55% s=40% m=5% g: vfine - trace v. coarse peb.	
250	G		@ 250': Dry	
255	G		255-265: gravelly Sand (gS) g=20%, s=75% m=5% Gravel: vfine - med peb. 5mm avg, 15mm max, mod sort, 60% fel, 40% maf, ang. Sand: vfine - v. coarse, 15% vf, 25% fine, 40% med, 15% c, 5% v.c, mod sort, 65% fel, 35% maf, ang. Dry No rxn HCl 2.5Y 4/4 Olive Brown	Water table: 259.6' bgs (5-14-19)
260	G		@ 260': g ≥ 15%, s ≥ 80%, m=5% g = vfine - med max ≥ 10mm fel 50%, maf 50% Strong rxn HCl	
265	G		265-275: sandy Gravel (sG) g=65% s=35% m=Trace Gravel: vfine - v coarse peb. 5mm avg, 35mm max, mod sort, 70% fel, 30% maf, subang. Sand: vfine - v. coarse 20% vf, 20% fine, 40% med, 15% coarse, 5% v. coarse, mod sort, 70% fel, 30% maf, subang, MOIST, No rxn HCl 2.5Y 4/4 Olive Brown	
270	G		@ 270': g=60% s=40% m=Trace	

Reported By:

Tracy Mallgren (Print Name) — Geologist (Title) — Signature — 5/24/19 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5-8-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310m NE Biosolids Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
275	G WS		275'-295': slightly silty sand ((m) S) g=Ts=80% m=20%. ~~Gravel~~ NC 5-8-19 Sand: VF-coarse, mod. sort, 60% fel., 40% maf., ang., avg=fine, wet, no rxn. HCl, 2.5Y 5/4 light olive brown, non-plastic	Dual Rotary Drilling with 16"OD/15 1/4"ID temp. casing 0.0'-214.2' bgs. 14"OD/13 5/8"ID 214.2'-390.7' bgs. 8 5/8" drill rod & 12 1/4"OD tri-cone bit. Grab sample every 5' or change in lithology.
280	G		@280': Gravel: VF-coarse, avg. 5mm, max 9mm, 50% fel. 50% maf. Sand: ~~70% coarse~~ NC 5-8-19 VF-VC, 70% coarse	Water sample: I-001 @ 275.4' bgs.
285	G		@285': Gravel: fine-med. Sand: moist.	
290	G		@290': Gravel: N/A. Sand: wet	
295	G WS		295'-300': silty sandy gravel (ms G) g=65% s=20% m=15%. Gravel: VF-VC, avg. 10mm, max. 55mm, poor sort, 60% fel. 40% maf., ang.-round. Sand: VF-VC, trace VF, avg. VC, mod sort, 40% fel 60% maf, ang.-subang., wet, no rxn HCl, 2.5Y 4/3 olive brown	Water sample: I-002 @ 295.2' bgs.
300	G		300'-310': slightly silty gravelly sand ((m) gS) g=15% s=70% m=15%. Gravel: VF-coarse, avg. fine, avg. 4mm, max. 20mm, mod sort, 60% fel. 40% maf., ang.-subrnd. Sand: VF-VC, avg. coarse, v. occ. coarse, well sort, 40% fel. 60% maf, ang.-subang., wet, no rxn HCl, 2.5Y 5/3 light olive brown.	
305	G		@305': Gravel: VF-VC, avg. med. peb., avg ↑ 8mm, max ↑ 60mm, ~~poor~~ NC 5-8-19 sort, ang-rnd.	
310	G		310'-345': sandy gravel (s G) g=60% s=30% m=10% Gravel: VF-VC peb, 70% med. peb, avg. 5mm, max. 35mm, mod sort, 60% fel. 40% maf, ang-rnd. Sand: fine-VC, 50% fine-med., 30% coarse, 20% VC, well sort, 40% fel. 60% maf ang-subang., wet, strong rxn HCl, 2.5Y 5/3 light olive brown	

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist		5-24-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5-8-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310m NE Biosolids Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
315	G WS		310'-345': sandy gravel (sG)	Dual Rotary Drilling with 16"OD/15 1/4"ID temp. casing 0.0'-214.2' bgs. 14"OD/13 3/8"ID 214.2'-390.7' bgs. 8 5/8"OD drill rod & 12 1/4"OD tri-cone. Grab sample every 5' or change in lithology.
			@315': g=75% s=15% m=10%. Gravel: VF-VC, ↓40% med. peb, avg ↑15mm, max ↑40mm, mod sort, ↑70% fel ↓30% maf, ang-rnd. Sand: fine-VC, ↓40% fine-med, ↑60% coarse-VC, well sort, 40% fel. 60% maf., ang., moist, no rxn HCl, 2.5Y 5/3 light olive brown.	
320	G		@320': Gravel: fine-VC, avg ↓ 5mm, max ~~↓~~ NC 5-9-19 ↑ 55mm	Water sample: I-003@ 315.4' bgs.
325	G		@325': g=75% s↑20% m↓5%. Gravel: VF-coarse, avg ↑6mm, max ↓30mm, ↓50% fel. ↑50% maf, Sand: ↓10% fine, ↑80% med-coarse, ↓10% vc, subang., 2.5Y 4/4 olive brown	
330	G		@330': Gravel: ↑70% fine peb, max ↓25mm, ang-subrnd, 5% subrnd. Sand: strong rxn HCl	
335	G WS		@335': Gravel: 40% VF-fine, 50% med., 10% coarse, avg ↓5mm, max ↑30mm. Sand: weak rxn HCl	Water sample: I-004@ 335.4' bgs.
340	G		@340': wet, ~~weak~~ NC 5-9-19 mod. rxn HCl	
345	G		345'-360': gravel (G) g=80% s=10% m=10%. Gravel: VF-coarse, avg. 4mm, max. 20mm, mod sort, 50% fel. 50% maf., ang.-subang., 5% subang. Sand: fine-VC, 50% fine-med, 50% coarse-VC, well sort, 40% fel 60% maf, ang.-subang., wet, weak rxn HCl, 2.5Y 4/4 olive brown	
350	G		@350': g↑90% s↓to 5% m↓5%. Gravel: VF-VC, 20% VF-fine, 70% med-coarse, 10% VC, poor sort, ang.-rnd. Sand: mod sort, ↑50% fel ↓50% maf, moist, no rxn HCl	

Reported By:

Nicole Combs	Geologist	[signature]	5-24-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5-13-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310m NE Biosolids Facility

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
355	G WS		345'-360': gravel (G)	Dual Rotary Drilling with 16" OD / 15 1/4" ID temp. casing 0.0'-214.2' bgs. 14" OD / 13 3/8" ID 214.2'-390.7' bgs. 8 5/8" OD drill rod & 12 1/4" OD tri-cone. Grab sample every 5' or change in lithology.
			@355': g=90% s↑10% m↓T. Gravel: VF-VC, 80% VF-fine, 10% med, 5% coarse, 5% vc. avg↑5mm, max↑38mm well sort, 50% fel 50% maf, ang-rnd. Sand: fine-vc, 90% coarse-vc, well sort, 50% fel 50% maf, ang-subang, wet, no rxn HCl, 2.5Y 4/4 olive brown.	
360	G		360'-389': sandy gravel (sG) g=75% s=15% m=10% Gravel: VF-VC, 10% coarse-vc, avg 5mm, max 30mm, poor sort, 50% fel. 50% maf., ang.-rnd. Sand: fine-vc, 90% coarse-vc, well sort, 50% fel. 50% maf, ang-subang., wet, no reaction HCl, 2.5Y 5/2 grayish brown.	Water sample: I-005 @ 355.5' bgs.
365	G		@365': gravel: VF-coarse, max↓25mm, mod sort. Sand: 50% fine-med, 50% coarse-vc, mod sort, 2.5Y 4/4 olive brown.	
370	G		@370': g↓70% s↑25% m↓5%. Gravel: VF-VC, 80% med, max↑45mm, well sort, ↑60% fel. ↓40% maf, ang.-subrnd. Sand: ↑70% fine-med, ↓30% coarse-vc, ↑60% fel ↓40% maf, cemented gravels	
375	G WS		@375': g↑80% s↓20% m↓T. Gravel: 80% fine-VF, 10% med, 10% coarse, T. vc, max↓35mm, poor sort, ↓fel. 40%, ↑maf 60%, ang-rnd. Sand: ↓50% fine-med, ↑50% coarse-vc, mod sort, cemented gravels.	Water sample: Contingency 1 @ 375.6' bgs.
380	G		@380': Gravel: VF-coarse, ↑20% med, ↓T. coarse, max↓29mm, med sort, ↓30% fel., ↑70% maf. Sand: VF-VC, ↑70% coarse-vc, ↓50% fel., ↑50% maf	
385	G		@385': Gravel: VF-med. peb., 50% VF-fine, 50% med, max↓15mm. Sand: moist	
390	G G		389'-401.8': Basalt Angular-subang., 3mm-25mm, avg. 4mm, vesicular, blue/gray weathering inside vesicles, light green & white weathering on basalt w/o vesicles, iron staining/oxidation, wet, 2.5Y 2.5/1 black	

Reported By:

Nicole Combs	Geologist		5-24-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5-14-19

Well ID: C9988 | Well Name: 699-48-70 | Location: ~310m NE Biosolids Facility

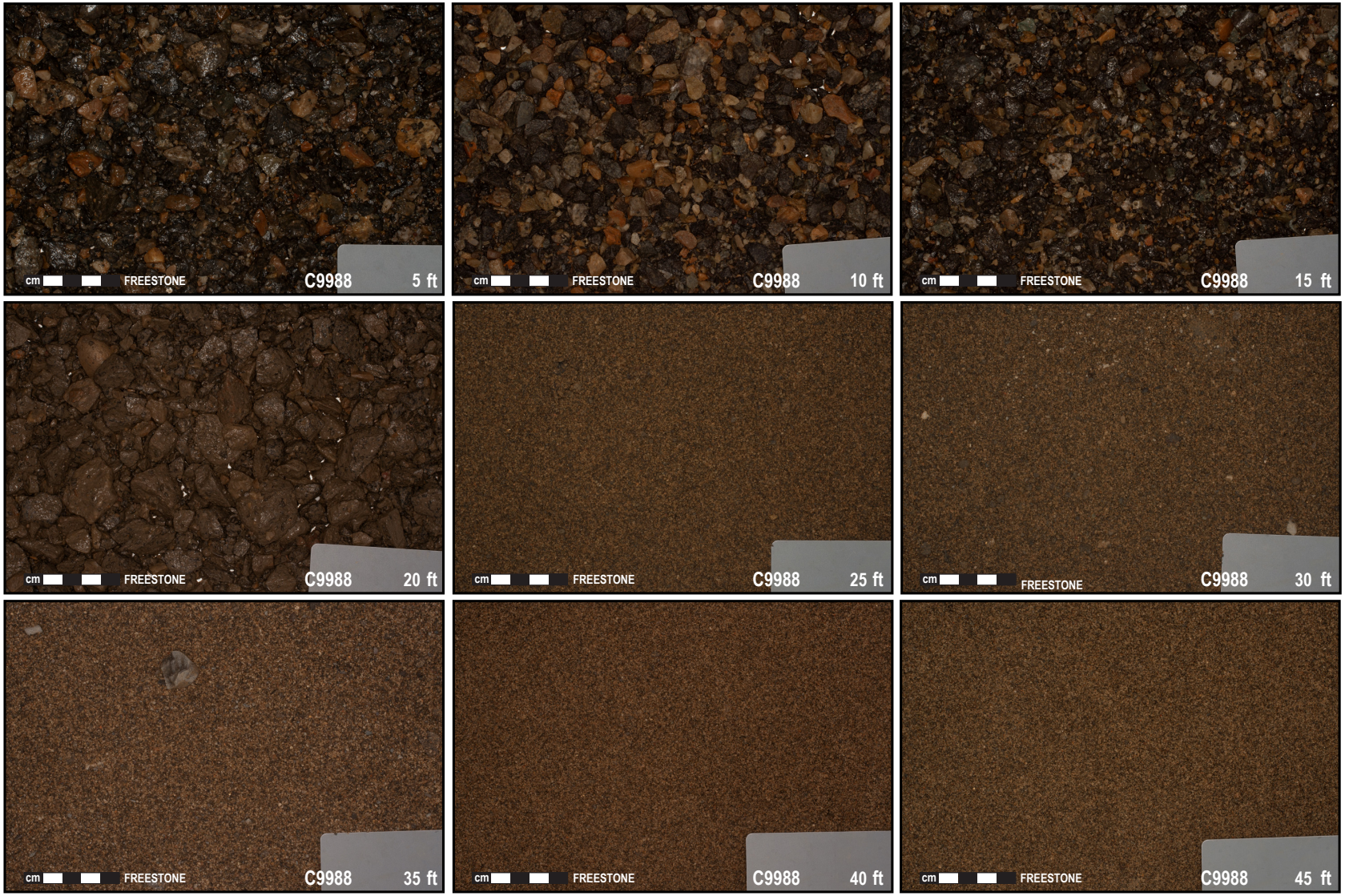
Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
395	G		389' - 401.8' : Basalt	Dual Rotary Drilling with
			Ang. - Subang., 3mm - 25mm, avg. 4mm, vesicular,	16"OD/15 1/4"ID temp. casing
			blue & gray weathering inside vesicles, light	0.0' - 241.2' bgs. 14"OD/13 3/8"ID
			green/white circular weathering outside vesicles,	214.2' - 390.7' bgs. 8 5/8"OD
			iron staining/oxidation, wet, 2.5Y 2.5/1 black	drill rod & 12 1/4"OD tri-cone.
400	G		@395': loss of iron staining/oxidation	Grab sample every 5' or
			presence not found	change in lithology.
				TD: 401.8' (5.14.19)
				Depth to water:
				259.6' bgs (5.14.19)

NOT USED
NC 5.24.19

Reported By:

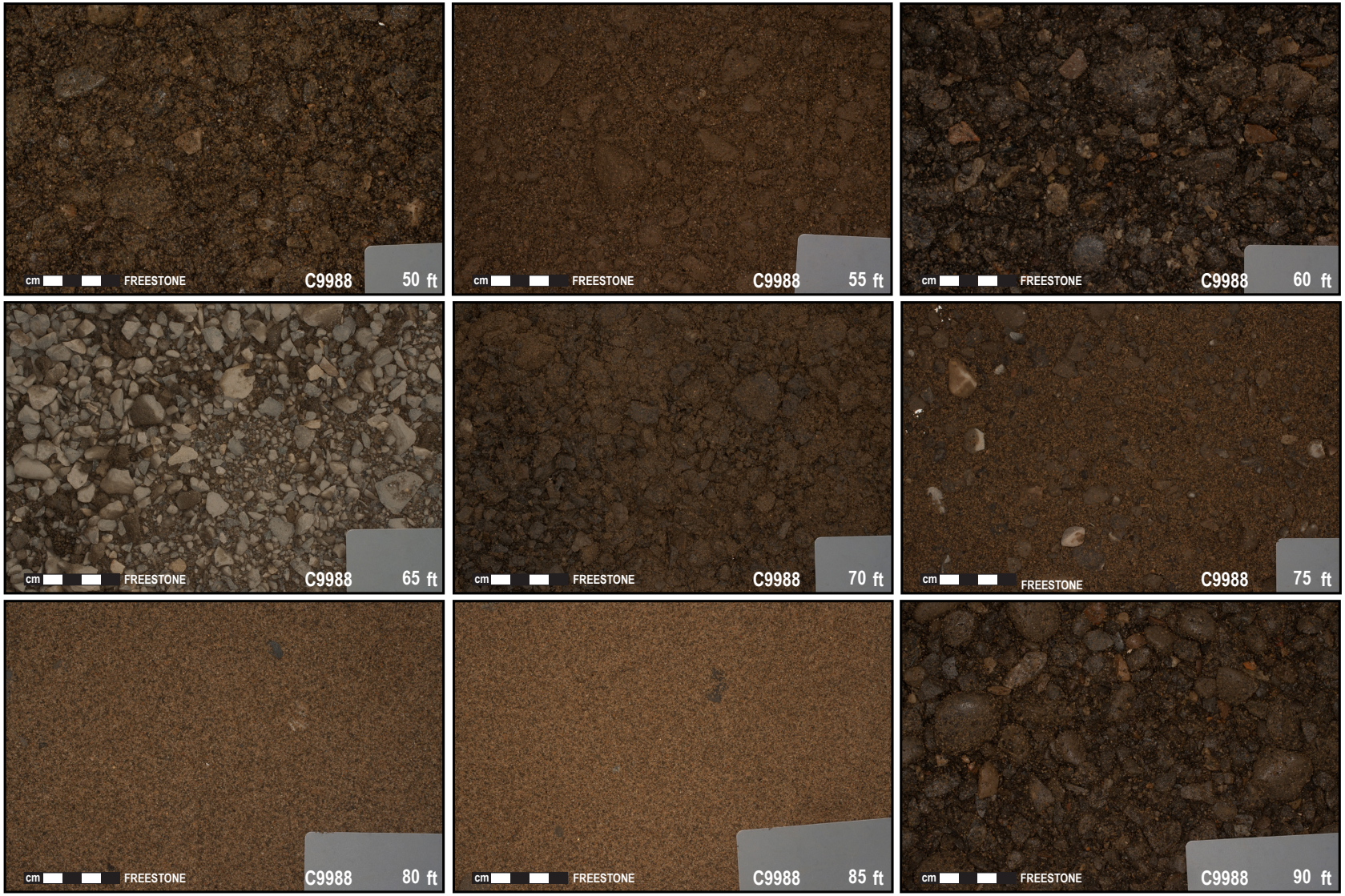
Print Name	Title	Signature	Date
Nicole Combs	Geologist		5-24-19

A-6006-993 (REV 0)



FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9988 (699-48-70)



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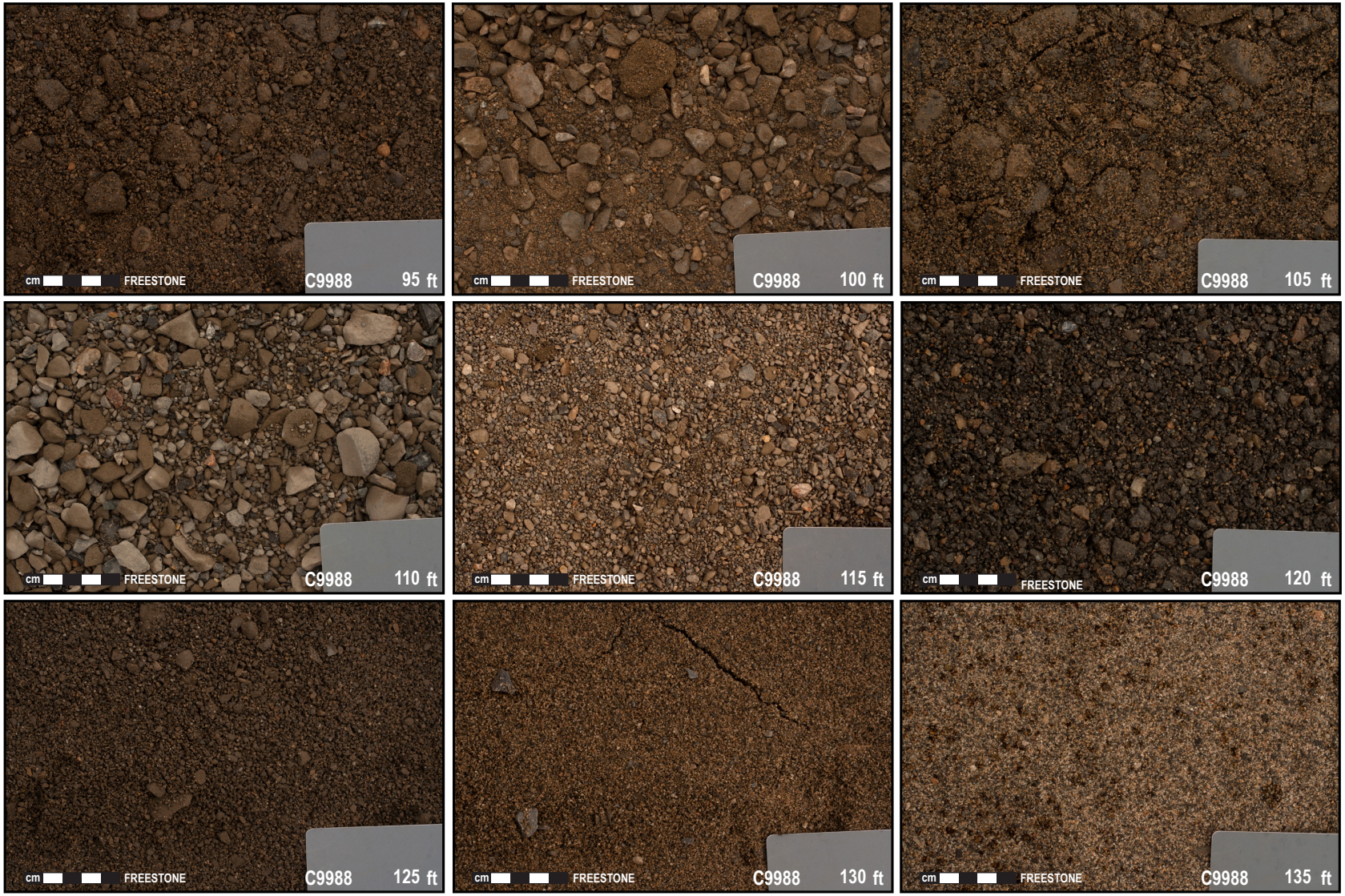
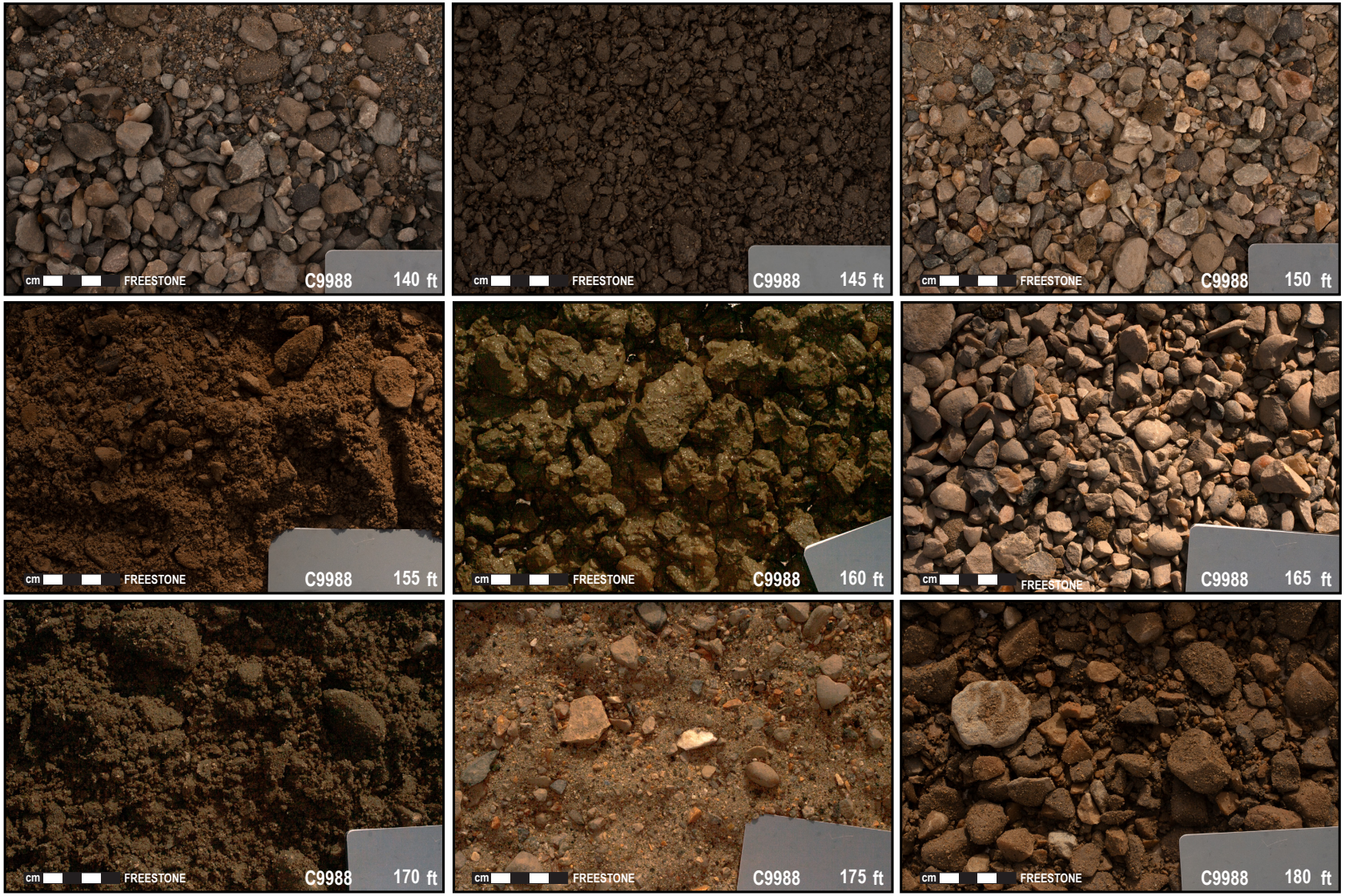
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9988 (699-48-70)



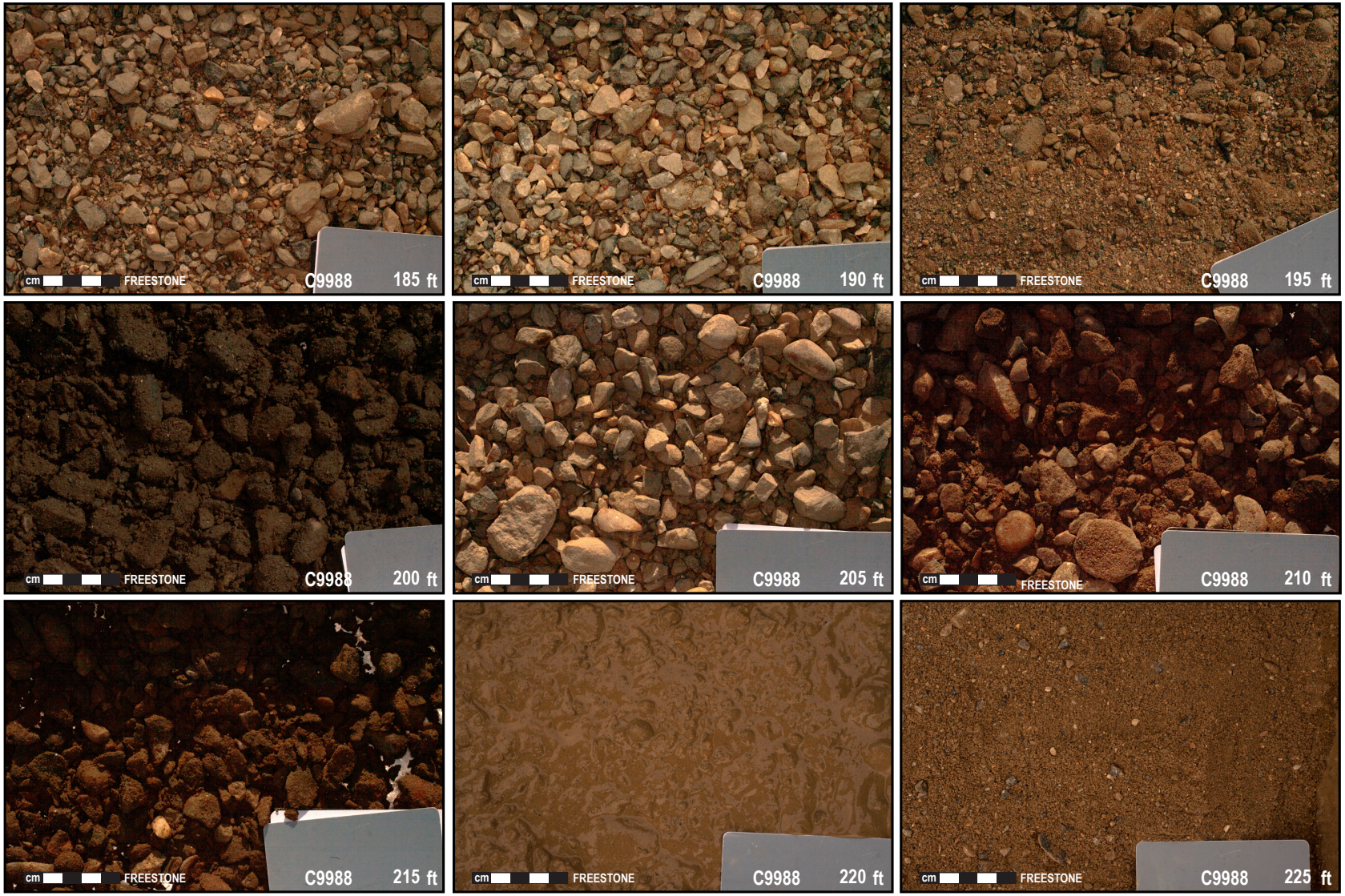
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9988 (699-48-70)



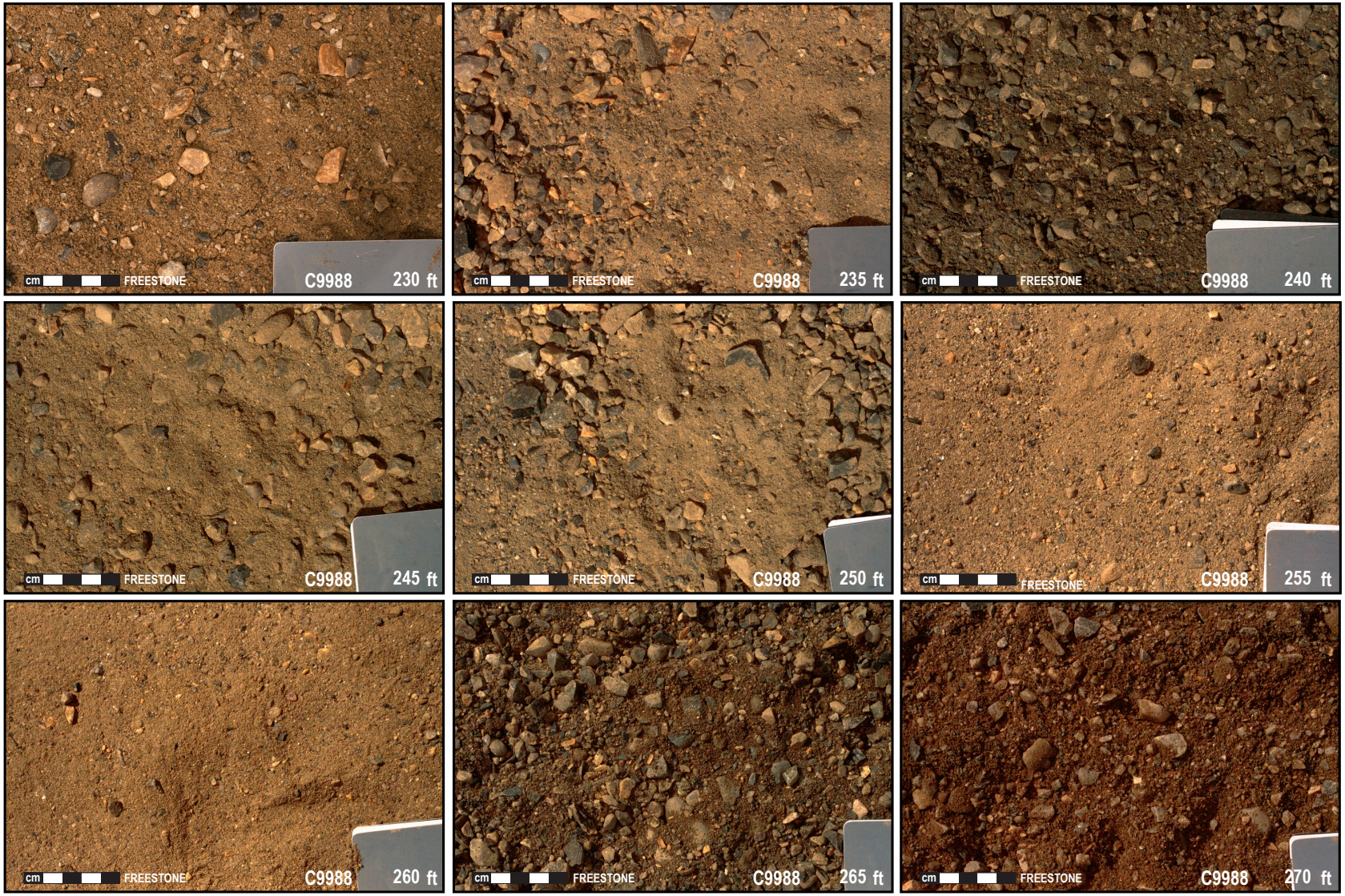
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9988 (699-48-70)



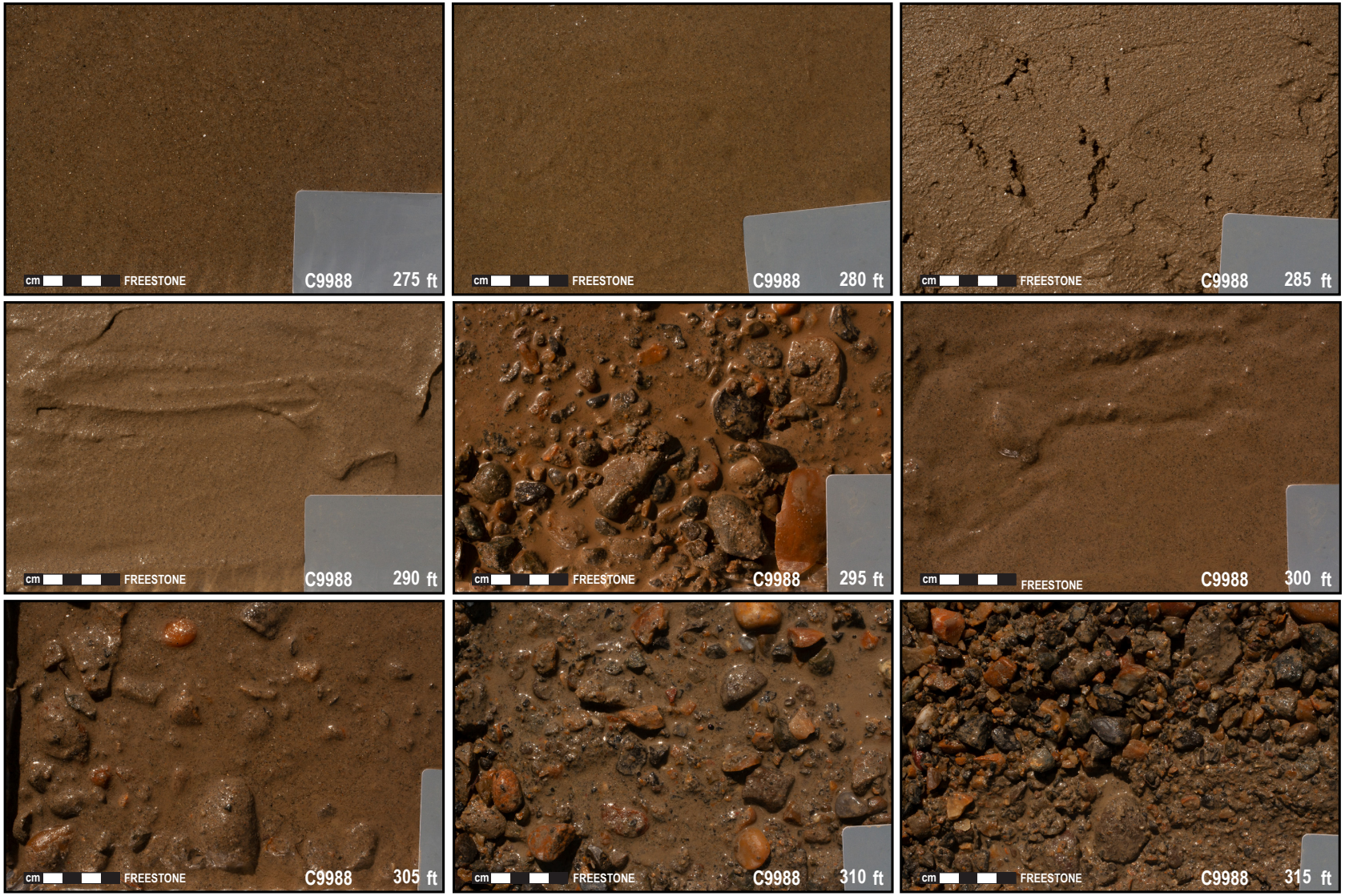
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9988 (699-48-70)



FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9988 (699-48-70)



FREESTONE
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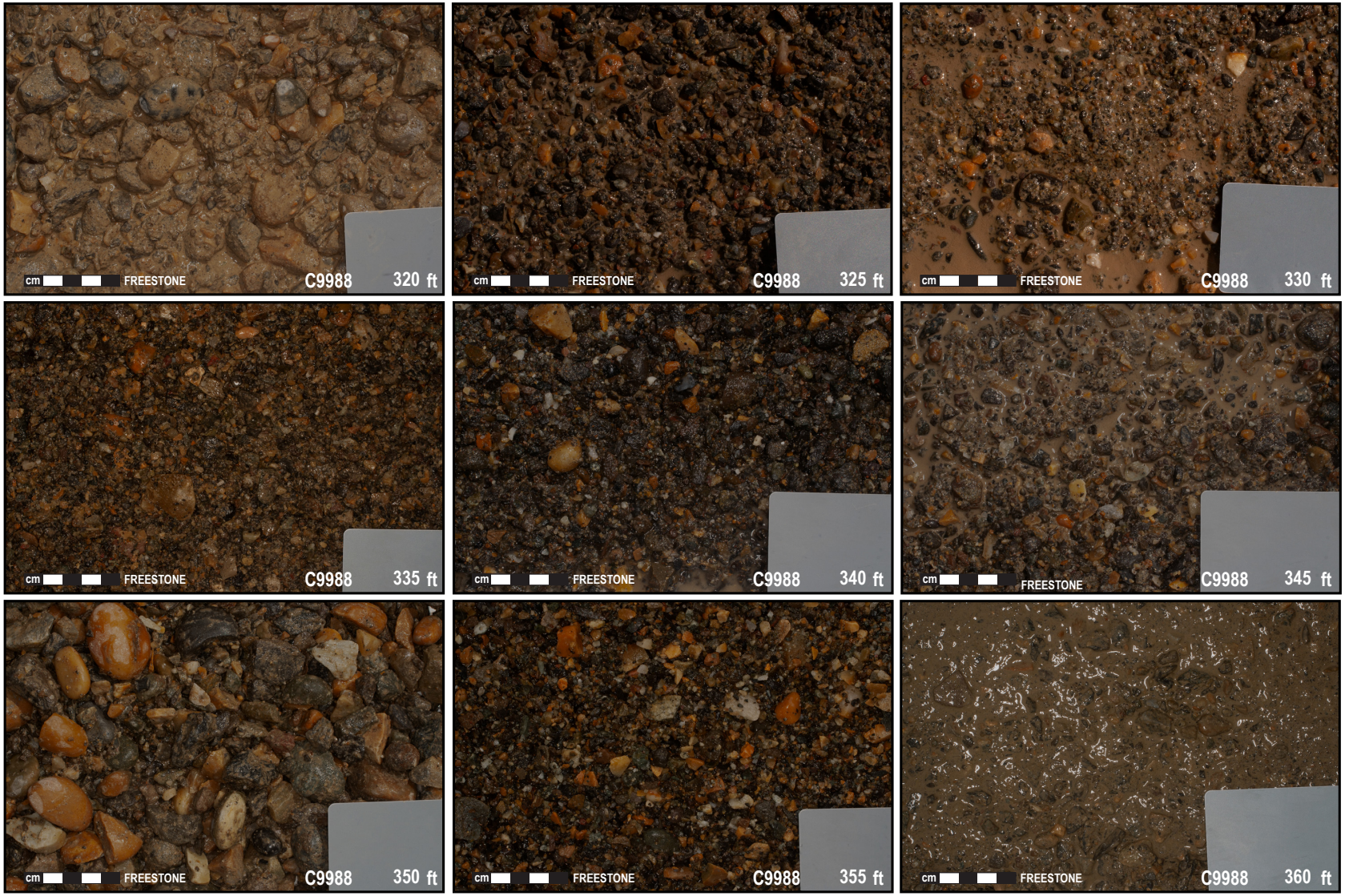
Drill Cutting Photographs for C9988 (699-48-70)



FREESTONE
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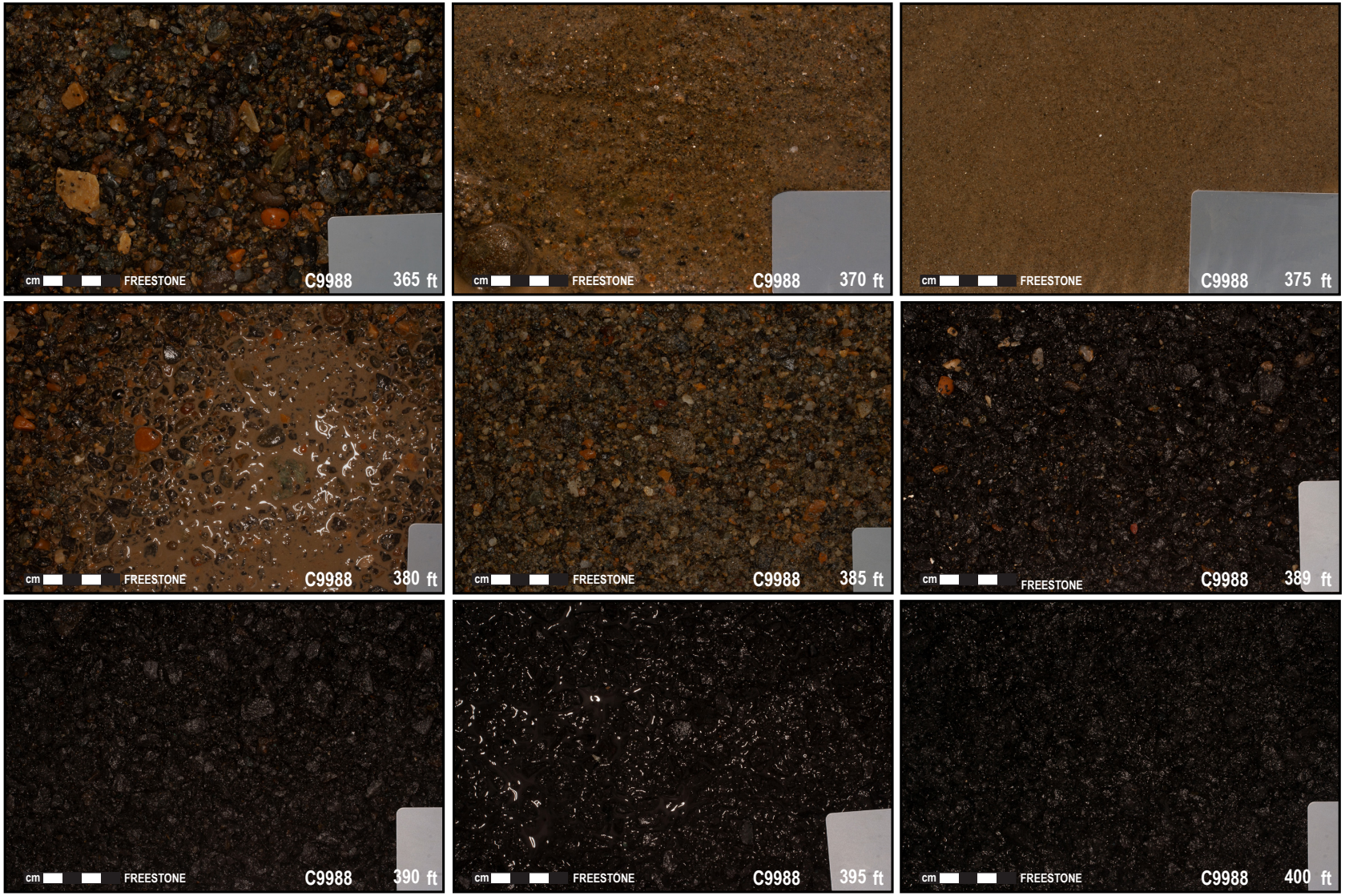
Drill Cutting Photographs for C9988 (699-48-70)



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Drill Cutting Photographs for C9988 (699-48-70)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9988	Well Name: 699-48-70	Date: 8/6/2019

Location: 310m NE of Biosolids Facility

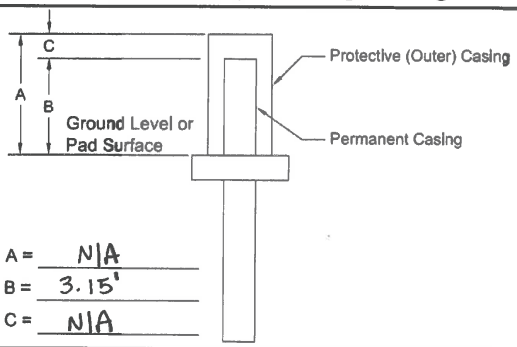
Reference Measuring Point *(unless otherwise noted)*: TOP OF OUTER CASING (TOC)

Has the well been surveyed? ○ Yes ◉ No

Does the well have a cement pad? ○ Yes ◉ No

Initial Conditions

	Start of Job	End of Job
STATIC WATER LEVEL:		
Date: 8-6-19	259.17 bgs	260.14 bgs
Date: 8-7-19	259.27 bgs	260.77 bgs
DEPTH TO BOTTOM:		
Date: 8-1-19	360.50 bgs	N/A
Date: 10-2-19	N/A	370.50 bgs



A = N/A
B = 3.15'
C = N/A

	Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbitidy (NTU) Initial	Turbitidy (NTU) Final	Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
8/6/19	341.10	9.07	77.43	528	24.2	1330	1419	180.00	19.84
	341.10	10.43	77.43	38.3	24.8	1536	1614	100.00	9.59
8/7/19	341.10	10.26	77.33	3.48	3.86	0751	0944	128.57	12.53
	320.00	9.61	55.57	5.41	1.71	1234	1315	180.00	18.74
	298.90	10.22	34.10	4.53	1.75	1352	1417	180.00	17.61
	277.80	10.05	13.02	5.38	0.98	1455	1520	135.00*	13.43

Total Pumped: 52,298.41 gallons

Pump Model: GRUNDFOS; Model C/SN MS6000QFT40 40HP.

Troll Serial Number and Pressure Range (PSI and depth): S/N 553248 - 70m/231ft

Comments:

* Pump rate @ 140 gpm for 5 min & 135 gpm for 18 min; max drawdown during 140gpm rate.
**Stress test: 1054-1128, intake: 320.00' bgs, troll: 55.74' bwt, spec gravity: 9.03 gpm/ft, pump rate: 290 gpm, max drawdown: 32.11 ft. LOG FILES: C9988_develop_Int#1_08062019; C9988_develop_Int#1B_08062019; C9988_develop_Int#1_08072019; C9988_develop_Int#2_08072019; C9988_develop_Int#2B_08072019; C9988_develop_Int#3_08072019; C9988_develop_Int#4_08072019

Prepared By:

Print Name	Signature	Date
Lindsey Getchell	Lindsey Getchell	8/7/2019

Reviewed By:

Print Name	Signature	Date
Jennifer Richart	J. Richart	10/8/19

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6005-205 (REV 2)

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699-48-70 (C9988)
Log Data Report

Borehole Information

Log Date	2019-05-21	Filename	C9988_HG-NM_2019-05-21	Site	200-ZP-1
DTW[1] (ft)	**DTW Date**	**DTW Source**	**Drill Date**	**Total Depth (ft)**	**Depth Datum**
259.68	05/21/19	Bay West	05/14/19	401.8	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Welded Steel	Dual Rotary	TC[2]	16.0	15.26	0.37	5.75 AGS[3]	214.2
Welded Steel	Dual Rotary	TC	14.0	13.30	0.33	1.67 AGS	390.7

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up using a steel tape measure, casing outside diameter using a steel circumference tape, and thickness using a precision wall-thickness gauge. Maximum logging depth achieved was 392 ft, approximately 1.3 ft below the reported casing depth. The geologist reports drillers encountering basalt at approximately 389 ft. The remainder of the borehole was drilled without casing which was not logged. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 5TB	Type	60% Coaxial HPGe (SGLS) [4]
Effective Calibration Date	12/12/2018	Serial No.	54-TP13441B
Calibration Reference	HGLP-CC-180, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 1LD	Type	60% Coaxial HPGe (SGLS)
Effective Calibration Date	12/04/2018	Serial No.	47-TP-32211A
Calibration Reference	HGLP-CC-175, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 1HD	Type	He-3 (CPN 503DR) NMLS [5]
Effective Calibration Date	12/04/2018	Serial No.	H310700352
Calibration Reference	HGLP-CC-176, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

Logging System	Gamma 5PB	Type	He-3 (CPN 503DR) NMLS
Effective Calibration Date	12/12/2018	Serial No.	H34055445

[1] depth to water inside casing
[2] Temporary casing
[3] Above ground surface
[4] Spectral Gamma Logging System
[5] Neutron Moisture Logging System

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Calibration Reference	HGLP-CC-177, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

SGLS Log Run Information

Log Run	1	2 Repeat	5	6 Repeat
HEIS Number	1021080	1021081	1021082	1021083
Date	04/11/19	04/11/19	05/20/19	05/20/19
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	0.0	140.0	212.0	251.0
Finish Depth (ft)	213.01	161.01	392.01	270.0
Count Time (sec)	100	100	100	100
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9988FTB20190411AV00CAB1	C9988FTB20190411AV00CAB1	C9988ALD20190520AV00CAB1	C9988ALD20190520AV00CAB1
Start File	AD000000	BD014000	AD021200	BD025100
Finish File	AD021301	BD016101	AD039201	BD027000
Post-Verification	C9988FTB20190411BV00CAA1	C9988FTB20190411BV00CAA1	C9988ALD20190520BV00CAA1	C9988ALD20190520BV00CAA1
Depth Return Error (in.)	N/A	2.5 high	N/A	0.0
Comments	None	None	None	None

NMLS Log Run Information

Log Run	3	4 Repeat	7	8 Repeat
HEIS Number	1021084	1021085	1021086	1021087
Date	04/12/19	04/12/19	05/21/19	05/21/19
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	0.0	145.0	213.0	254.0
Finish Depth (ft)	214.51	166.01	260.01	259.0
Count Time (sec)	15	15	15	15
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	0.25	0.25	0.25	0.25
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9988FPB20190412AV00CAB1	C9988FPB20190412AV00CAB1	C9988AHD20190521AV00CAB1	C9988AHD20190521AV00CAB1
Start File	AD000000	BD014500	AD021300	BD025400
Finish File	AD021451	BD016601	AD026001	BD025900
Post-Verification	C9988FPB20190412BV00CAA1	C9988FPB20190412BV00CAA1	C9988AHD20190521BV00CAA1	C9988AHD20190521BV00CAA1
Depth Return Error (in.)	N/A	1.0 high	N/A	1.0 high
Comments	None	None	None	None

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Logging Operation Notes

A centralizer was installed on the sondes. Verification measurements passed the acceptance criteria.

Analysis Notes

Analyst	P.D. Henwood	**Date**	06/10/19
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

Casing corrections for a 0.37 and 0.35-in. thick casings were applied to the SGLS log data.

For the SGLS, a water correction was applied below 259.68 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in EXCEL templates identified as FTB20181218 and ALD20181204 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

NMLS data are reported in counts per second for the entire length of the borehole as there is no calibration available to convert to volume percent moisture for 16-in. and 14-in. casing.

HGU[6] is an empirical unit of gamma activity proposed as a means to standardize gamma log response across multiple logging systems with different response characteristics. The HGU is defined in terms of measurements in the Hanford Borehole Calibration Facility, and the magnitude is selected such that 1 HGU is approximately equivalent to typical Hanford background activity, based on data from background samples as reported in *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE/RL-96-12).

Results and Interpretations

No manmade radionuclides were detected in this borehole.

Bi-214 energy peaks at 609 and 1764 keV are plotted on the Combination log plots. These energy peaks are used to calculate naturally occurring U-238. Where the concentrations diverge, radon (Rn-222) is indicated that has disrupted the secular equilibrium (activity of the parent is equal to the activity of its daughters) between the parent U-238 and its daughters below Rn-222 in the uranium decay chain. Rn-222 appears to have been building in during logging of the first casing from approximately 90 to 214 ft. It is also in the groundwater.

The K-40 concentration spike at 260 ft is a result of an over correction for water and not representative of a sediment change.

The neutron moisture log primarily responds to moisture present in the surrounding formation. In general, an increase in count rate reflects an increase in moisture content. Moisture content generally increases as the sediment becomes more fine-grained. For example, moisture content would be expected to be greater near the top of a fining upward Hanford flood sequence.

The KUT and moisture repeat plots indicate that the systems were working properly.

List of Log Plots

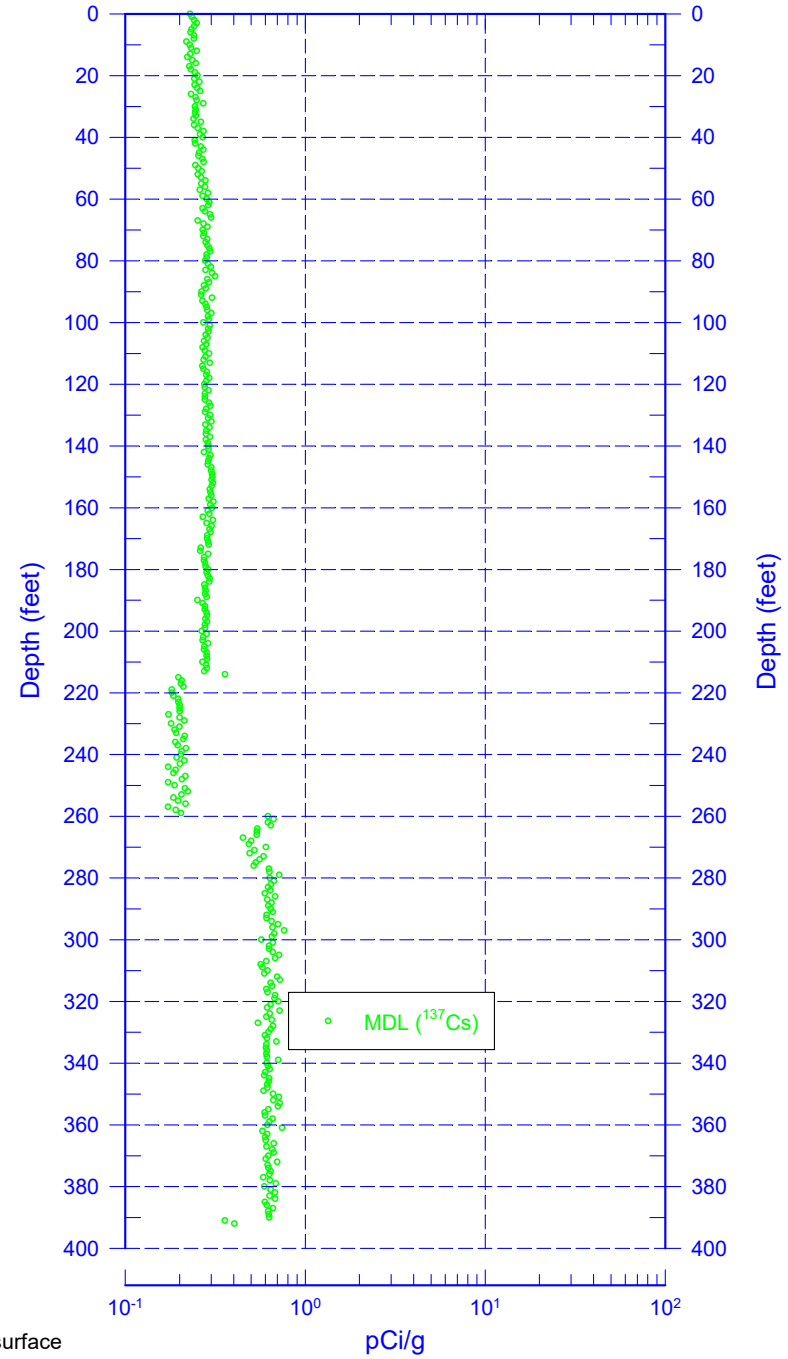
Depth Reference is ground surface.

Manmade Radionuclides (0-400 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (150-310 ft)
Natural Gamma Logs (300-460 ft)
Combination Plot (0-120 ft)
Combination Plot (110-230 ft)

[6] Hanford Gamma Unit

Combination Plot (220-340 ft)
Combination Plot (330-450 ft)
Combination Plot (0-420 ft)
Total Gamma & Moisture (0-260 ft)
Total Gamma & Hanford Gamma Unit (0-420 ft)
Repeat Section of Natural Gamma Logs (140-161 ft)
Repeat Section of Natural Gamma Logs (250-270 ft)
Moisture Repeat Section (145-166 ft)
Moisture Repeat Section (254-259 ft)

699-48-70 (C9988)
Manmade Radionuclides



Zero Reference - ground surface

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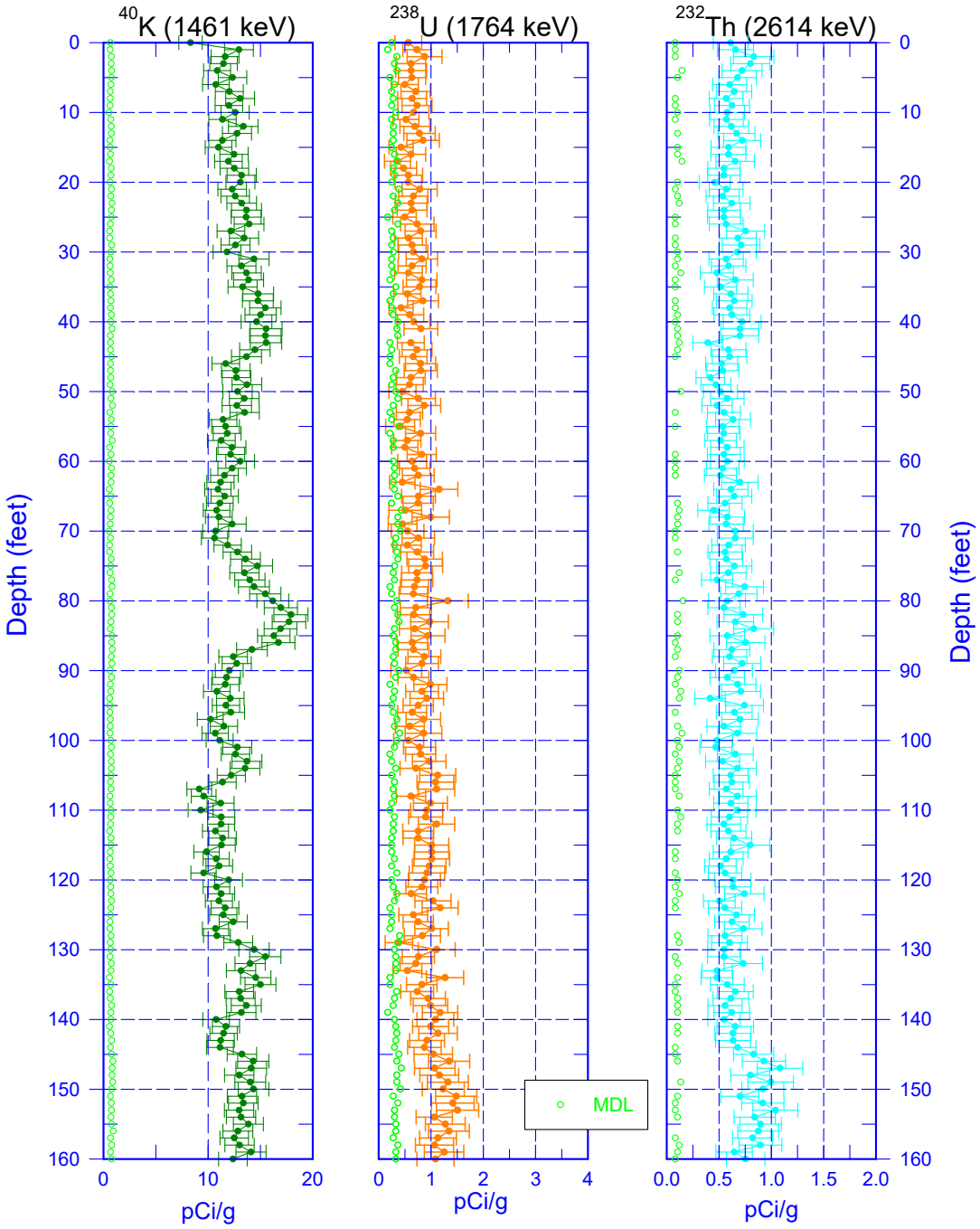
699-48-70 (C9988)
Natural Gamma Logs



Zero Reference - ground surface

Bay West
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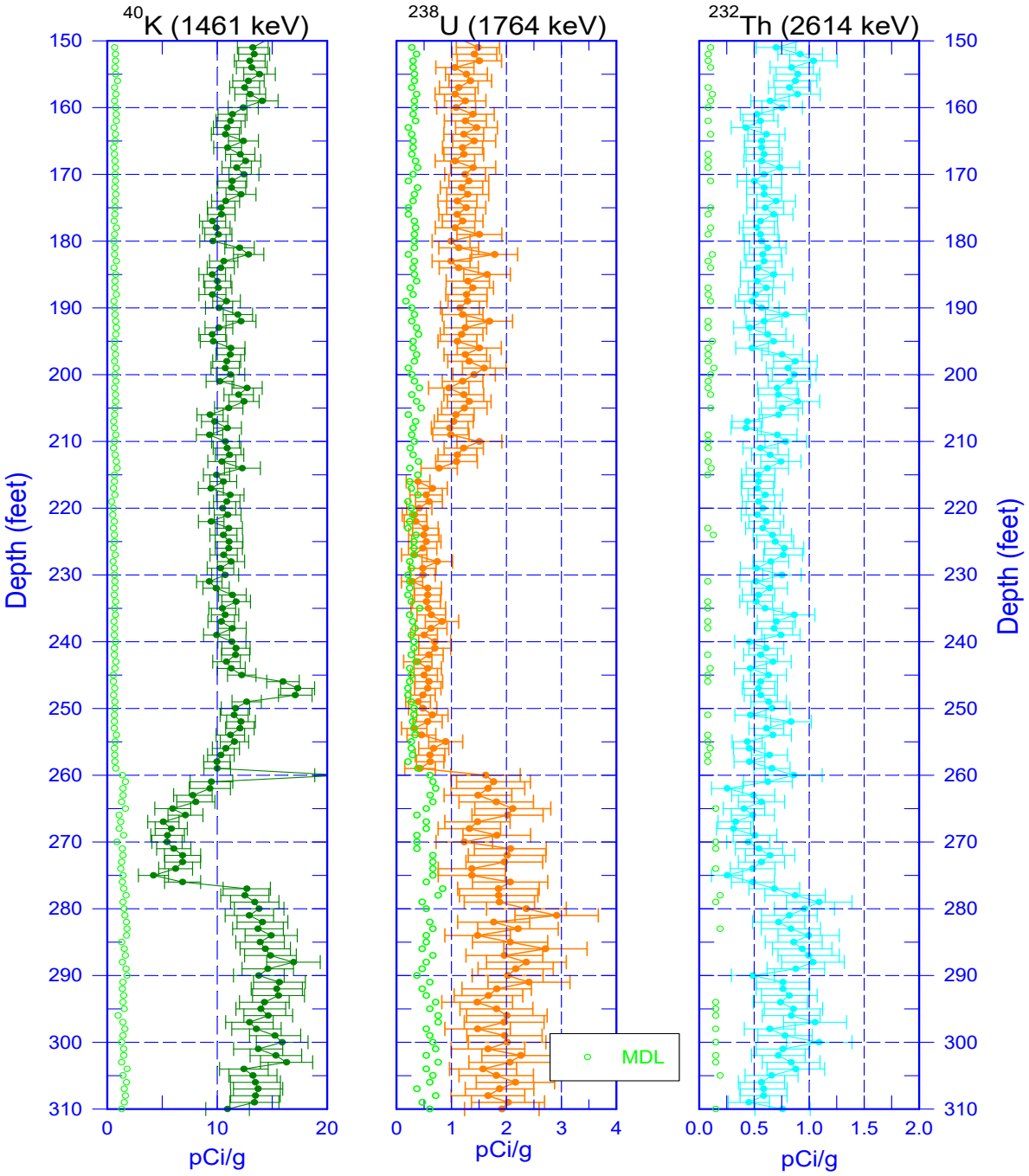
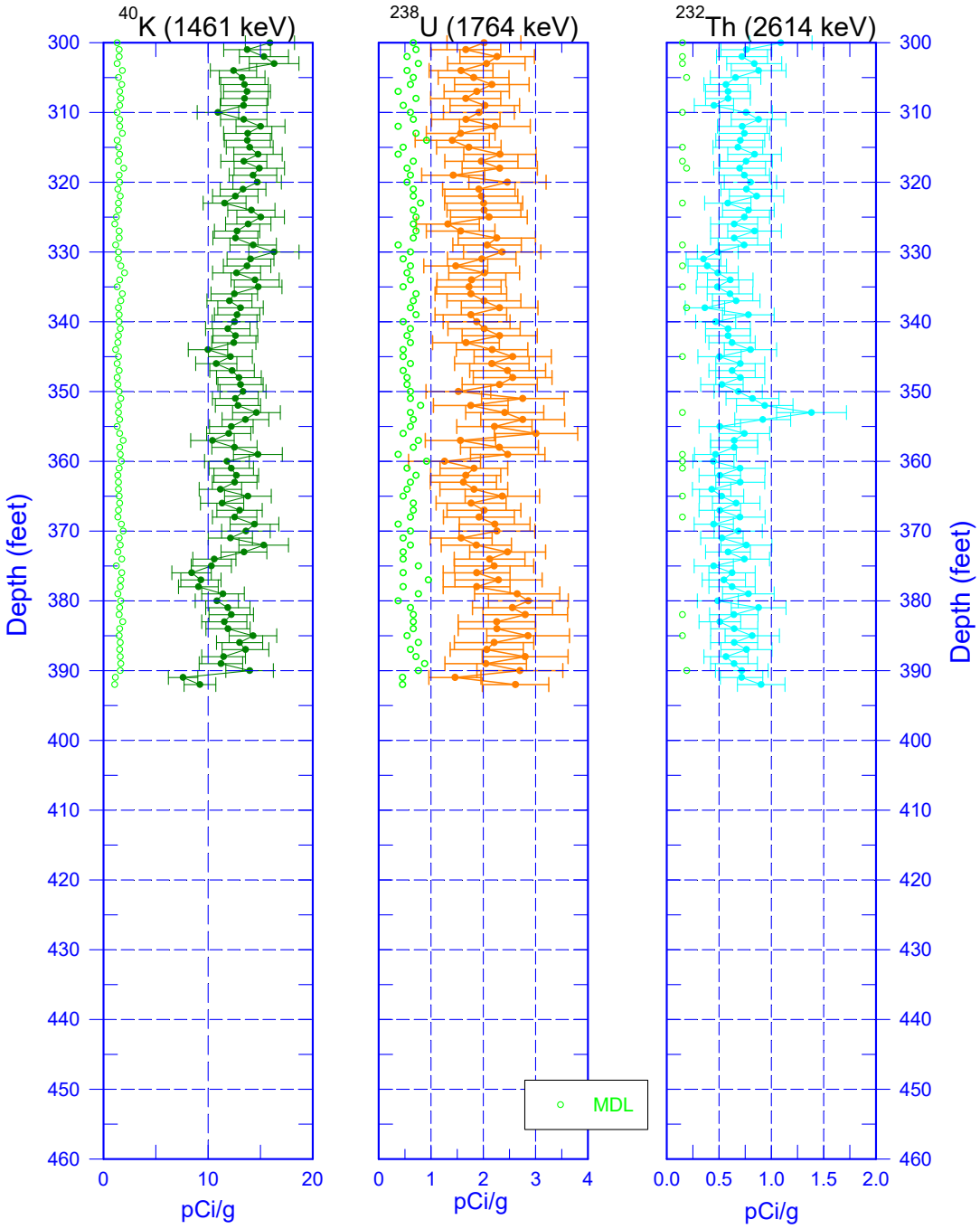
699-48-70 (C9988)
Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

699-48-70 (C9988)
Natural Gamma Logs



Zero Reference - ground surface

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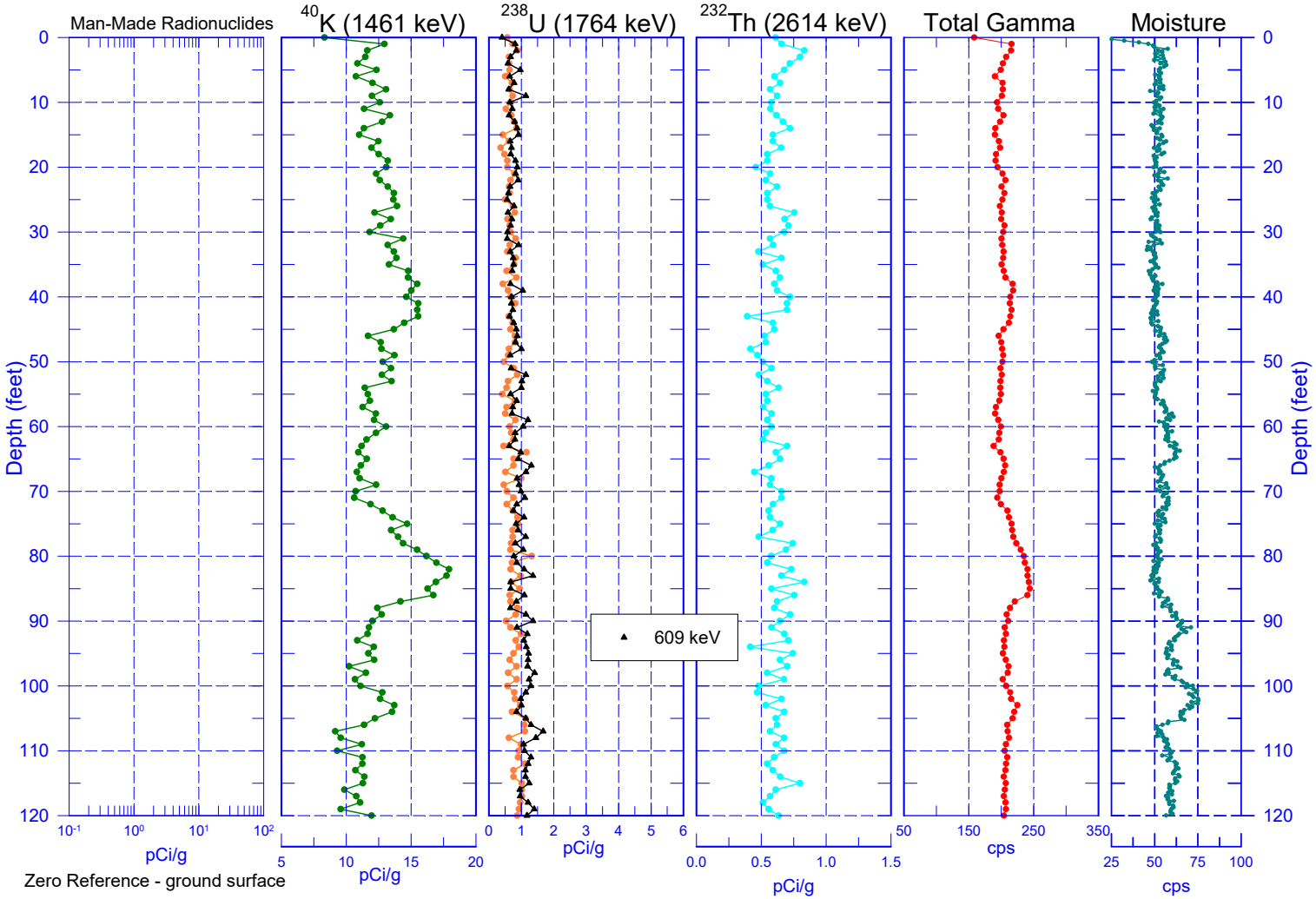
699-48-70 (C9988) Combination Plot



Bay West
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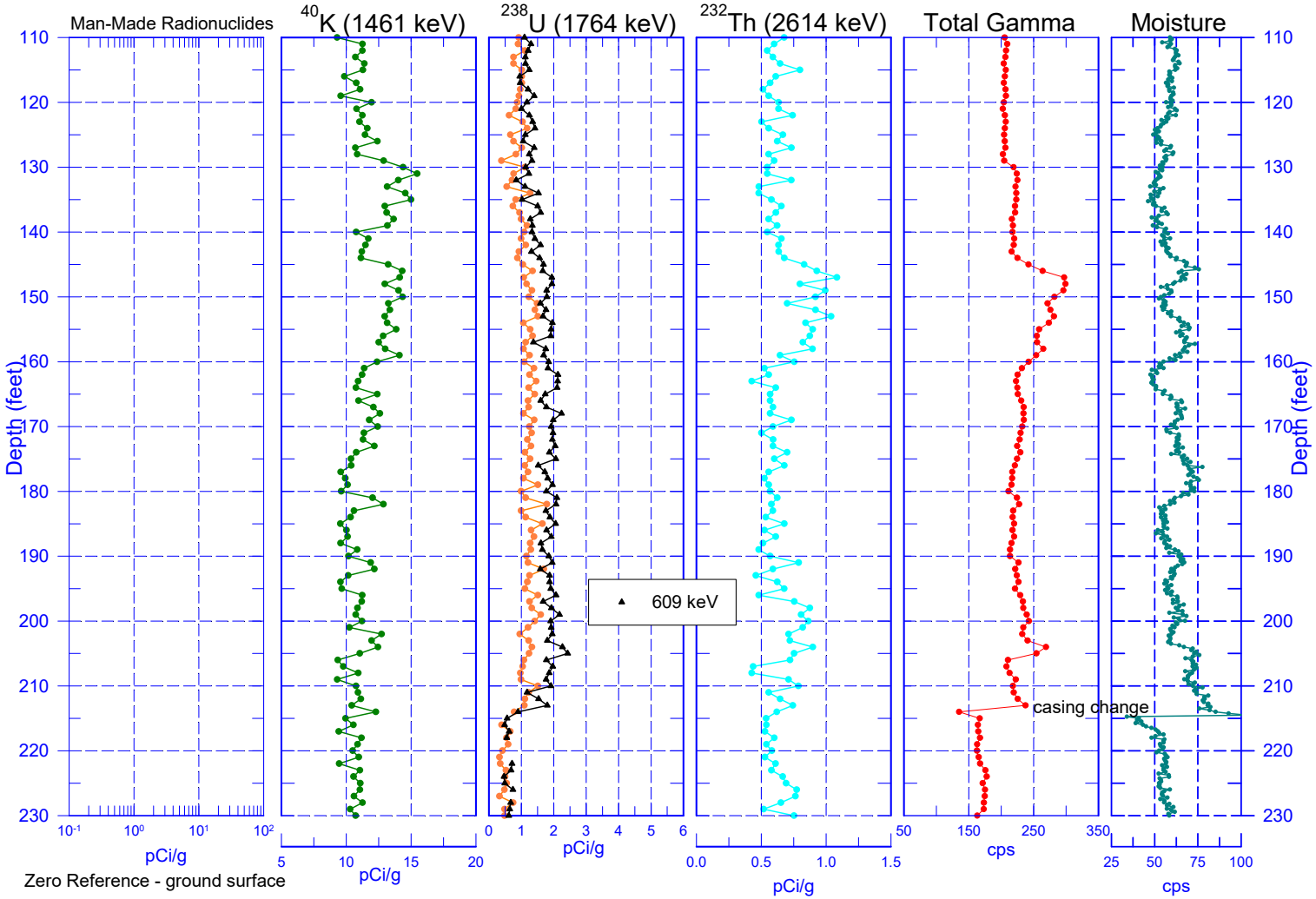
699-48-70 (C9988) Combination Plot



Bay West
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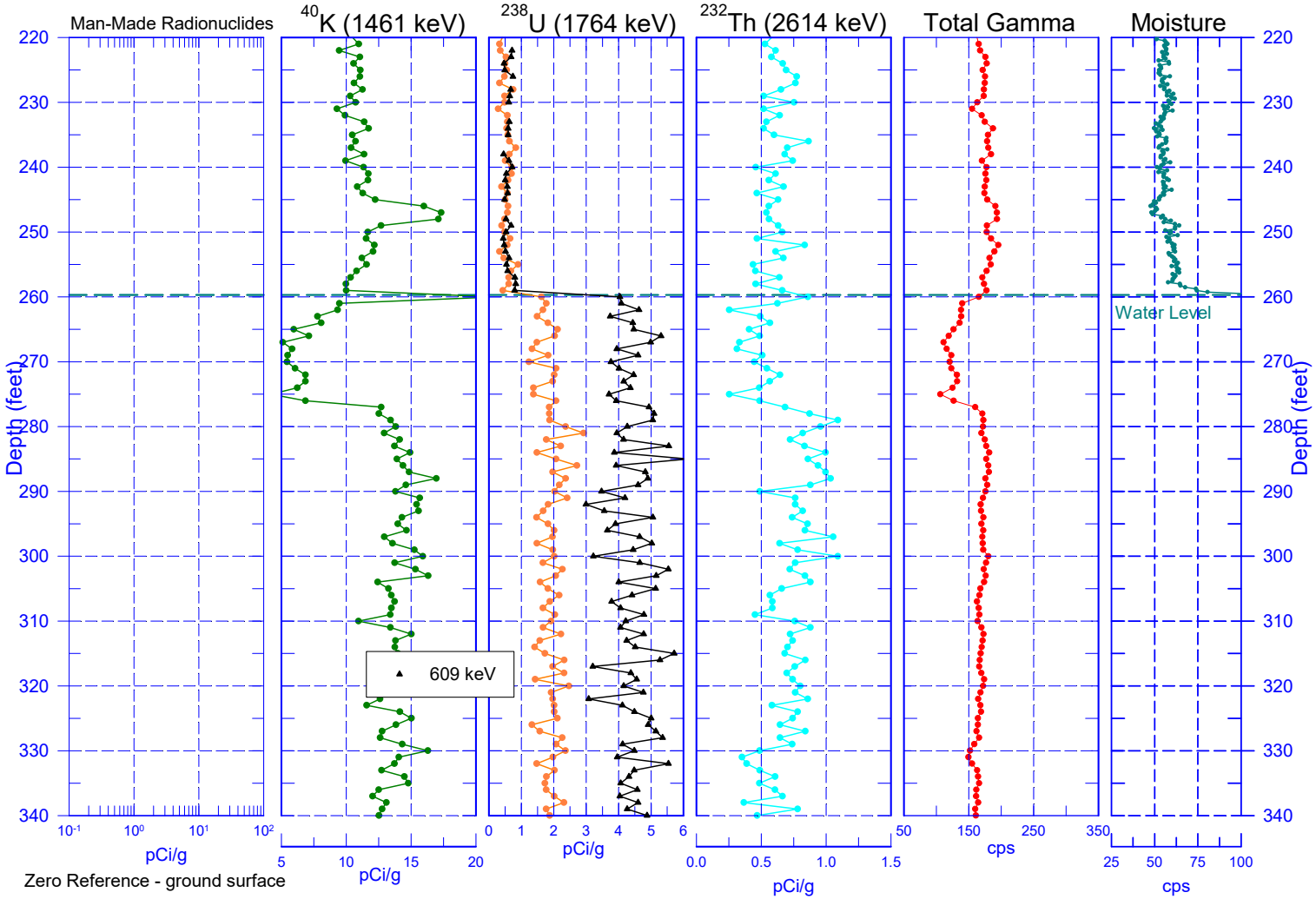
699-48-70 (C9988) Combination Plot



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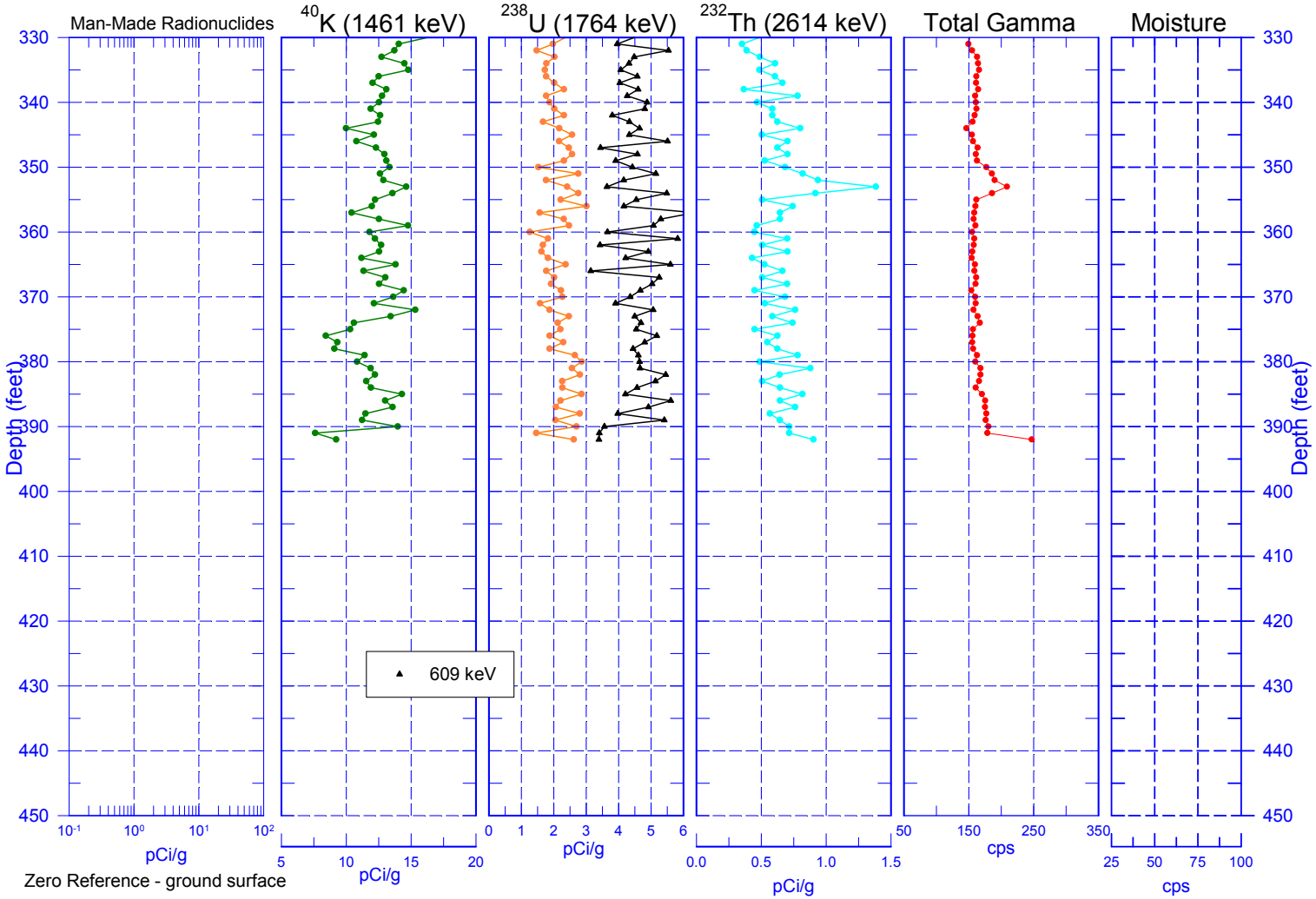
699-48-70 (C9988) Combination Plot



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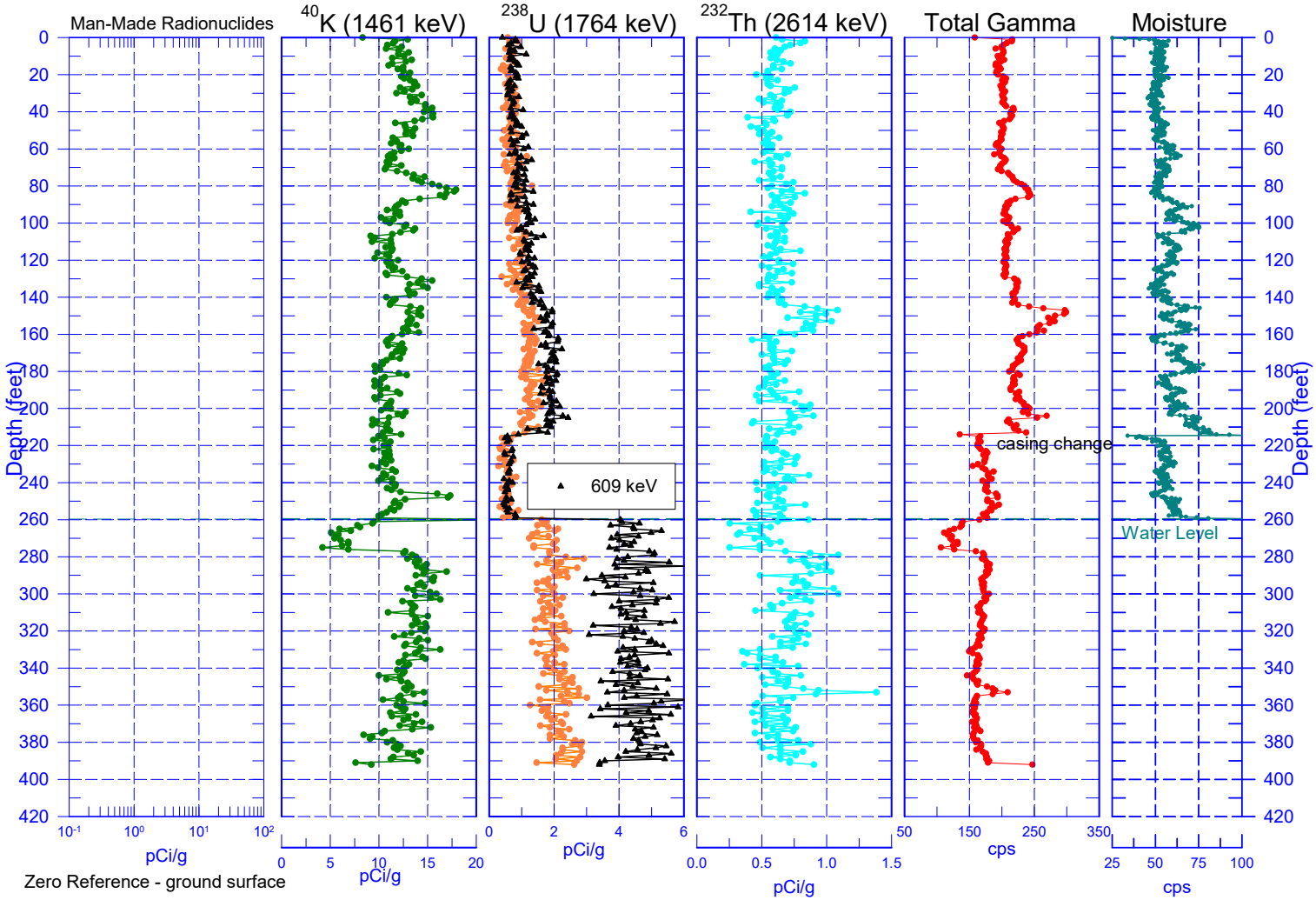
699-48-70 (C9988) Combination Plot



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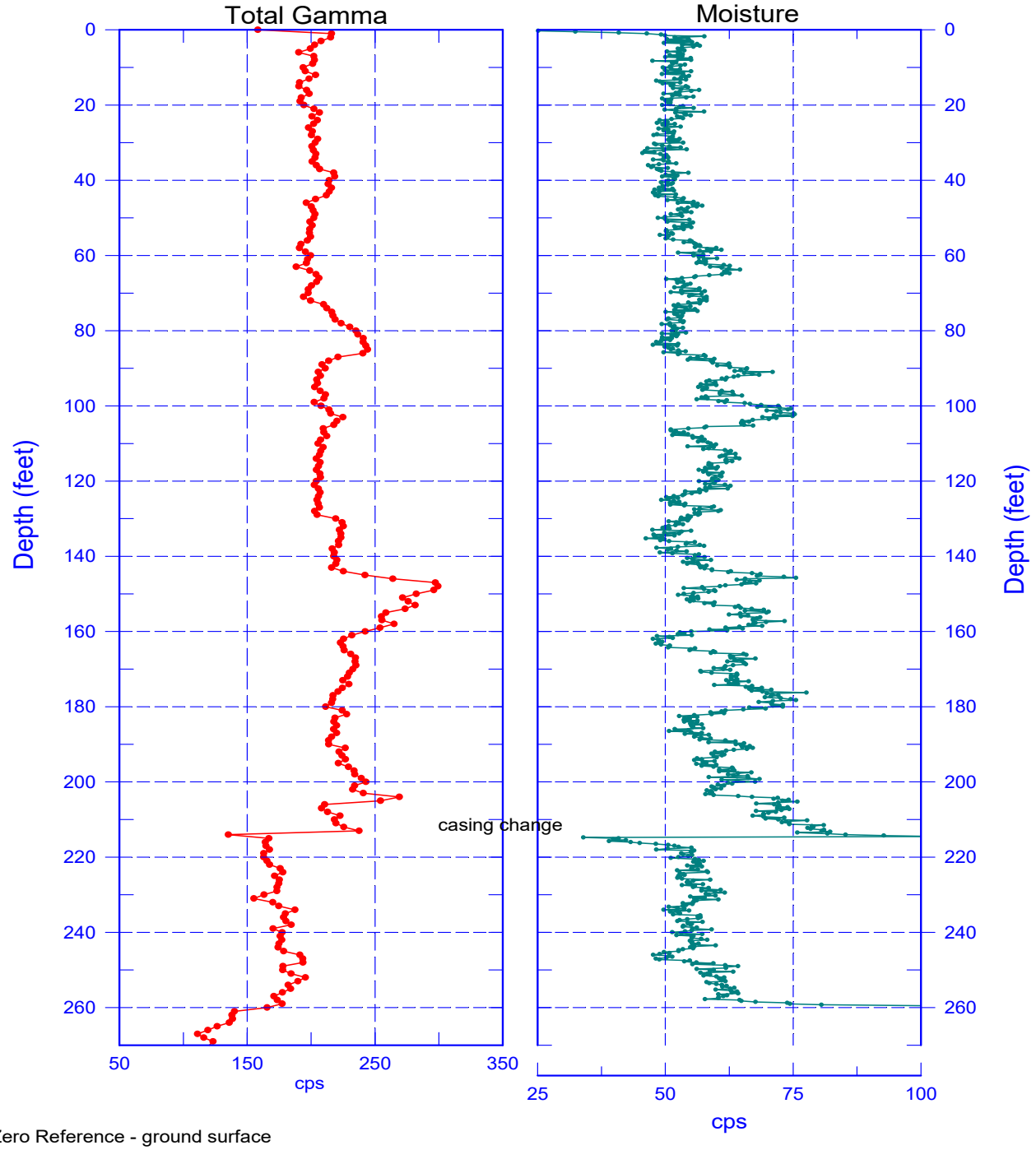
699-48-70 (C9988)
Total Gamma & Moisture



Zero Reference - ground surface

Water Level

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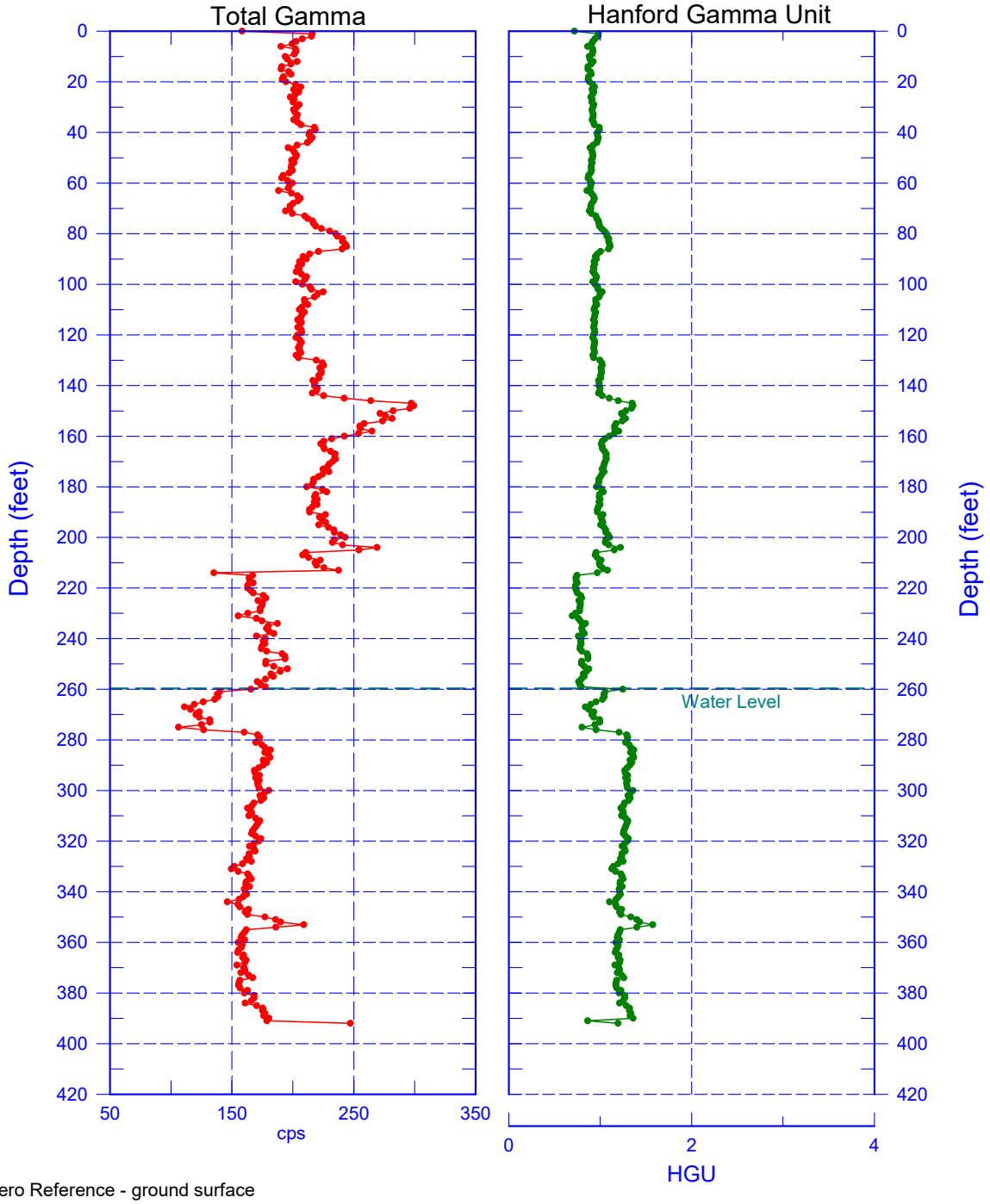
699-48-70 (C9988)
Total Gamma & Hanford Gamma Unit



Zero Reference - ground surface

Bay West
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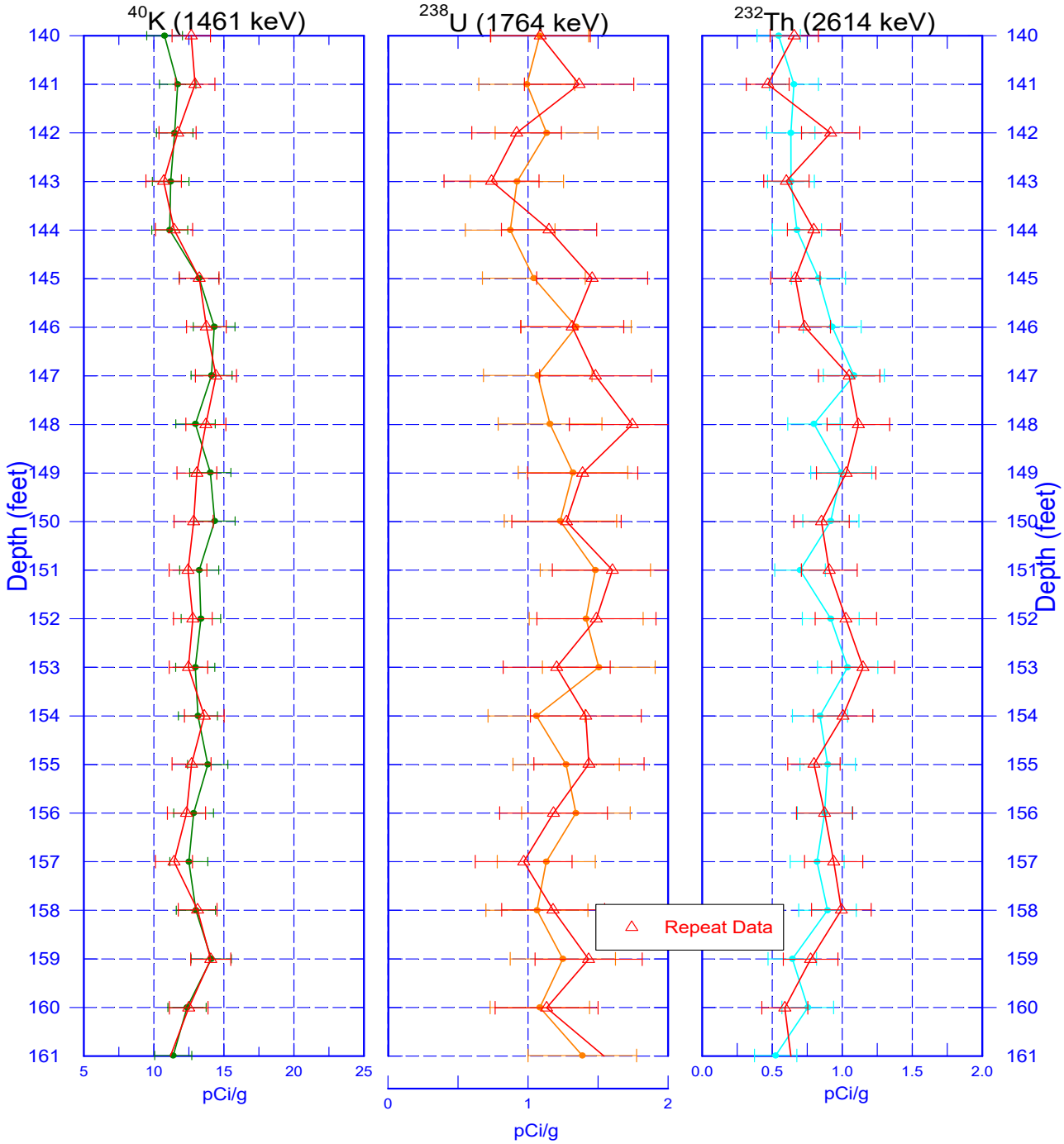
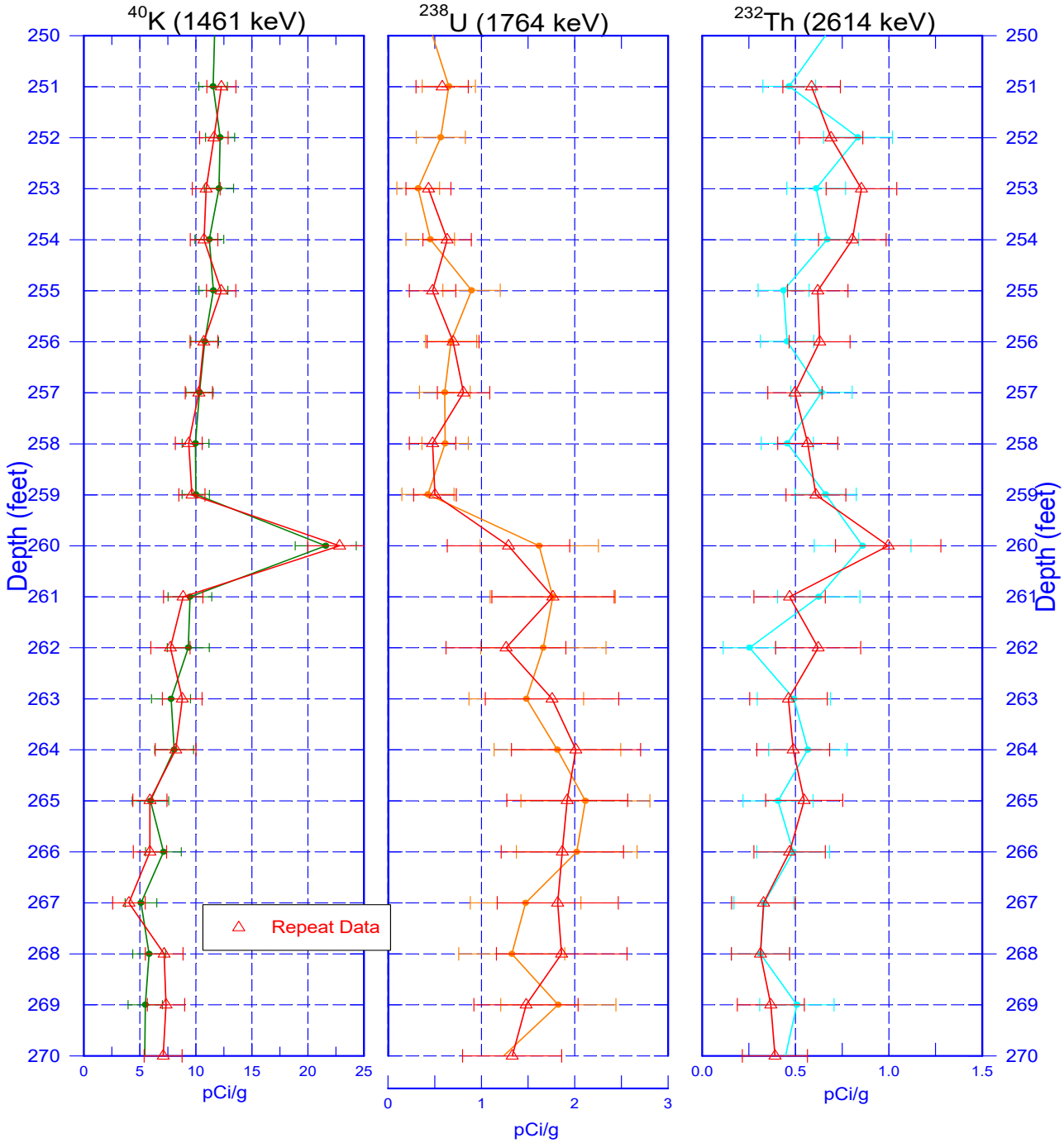
699-48-70 (C9988)
Repeat Section of Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

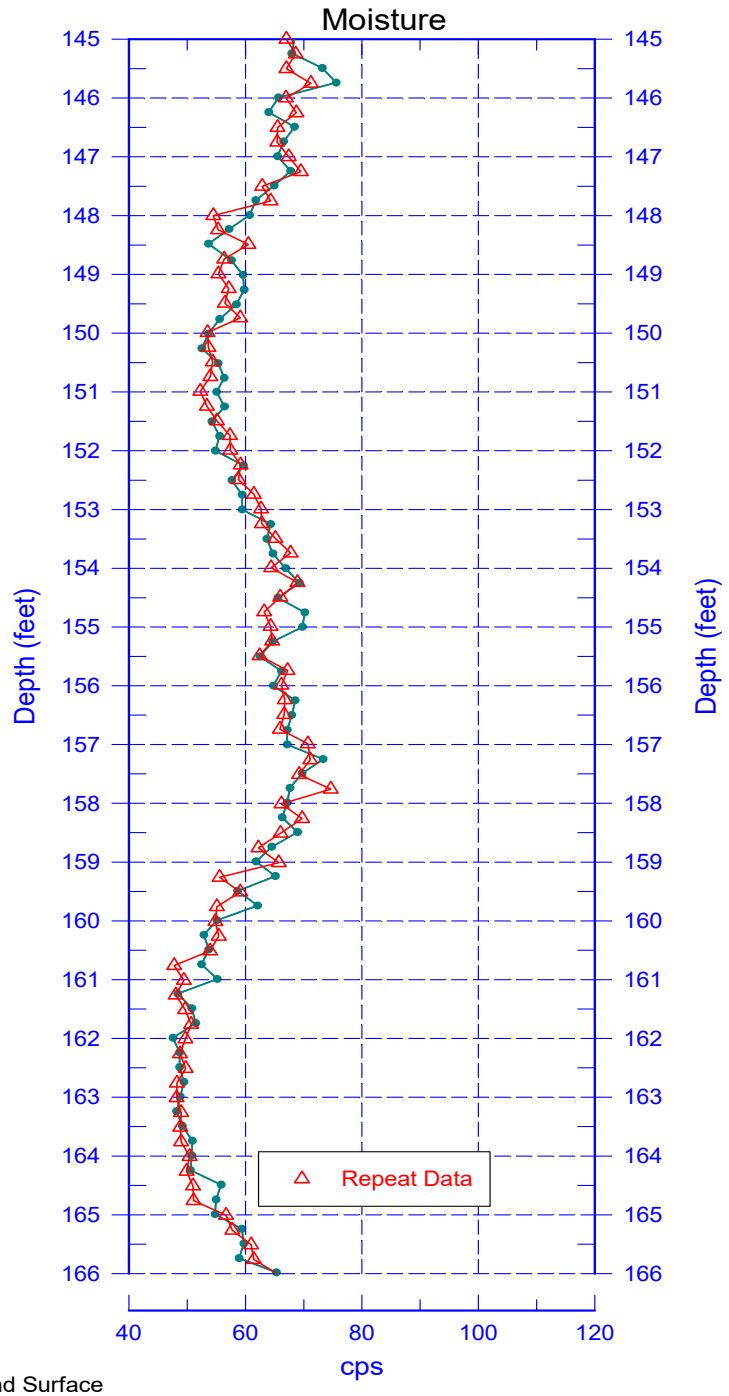
699-48-70 (C9988)
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

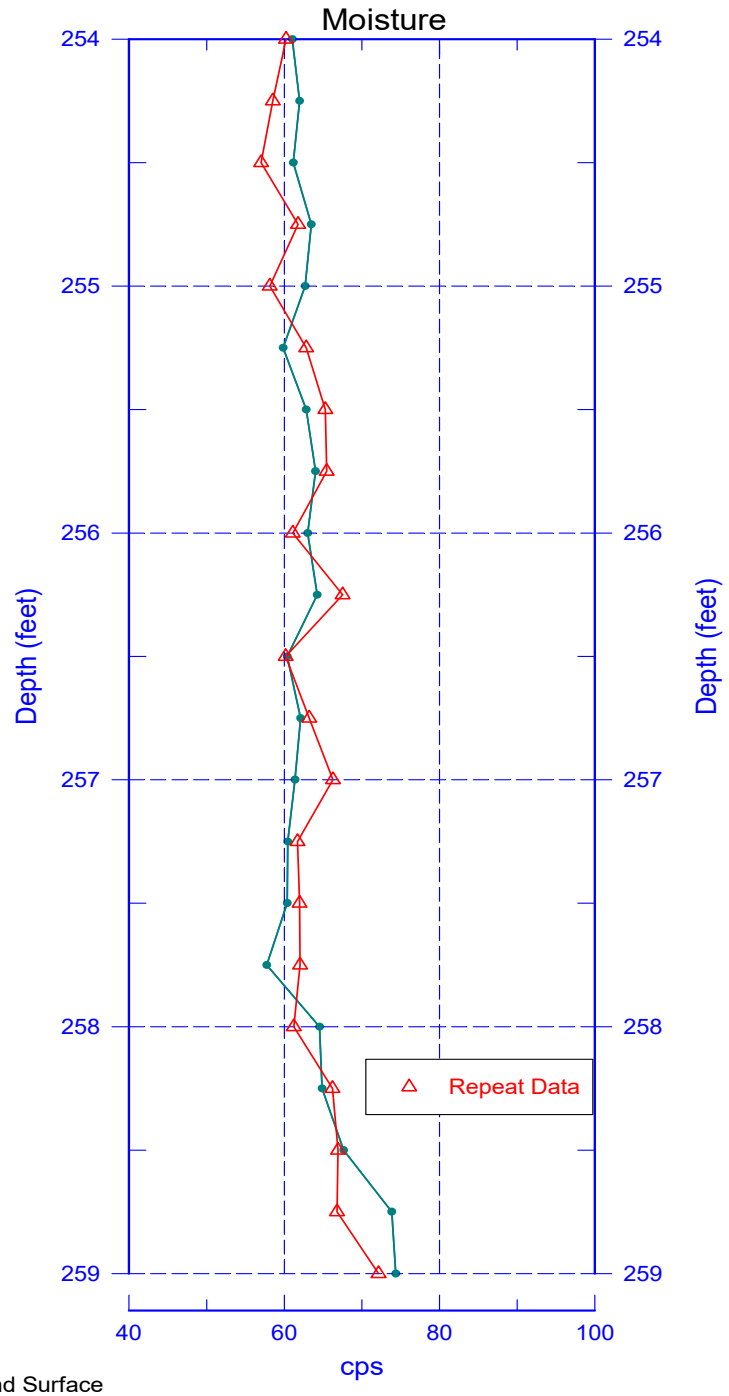
Bay West
Customer-Focused Environmental & Industrial Solutions

699-48-70 (C9988)
Moisture Repeat Section



Zero Reference - Ground Surface

699-48-70 (C9988)
Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 10/02/19	Requestor: Leonard D. Bultena (CHPRC)
Date of Survey: 11/11/19	Surveyor / Company: Lawrence B. Munnell / CHPRC
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of ZP-1 Well C9988 (699-48-70) located northeast of 200W Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 600A

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
W56 (COE) and R3-3 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9988	699-48-70	568501.64	138200.91		Center of Casing
				209.026	Top Landing Plate, N.Edge
				208.997	Top Outer 10" Casing, N.Edge
				208.248	Brass Survey Marker

Notes:

Brass Survey Marker elevation was taken on top of domed brass cap in concrete.

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

I, Lawrence B. Munnell, a Professional Land Surveyor registered in the State of Washington (Registration No. 16216), hereby certify this report is based on a field survey performed by me, or under my direct supervision.

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
11-11-19

Page 1 of 1

A-6003-659 (REV 1)

Appendix C

Well Construction Variance: Greater than Five Feet of Filter Pack above the Screen

VARIANCE TO CONSTRUCT NEW 200-ZP-1 PUMP AND TREAT WELLS WITH GREATER THAN 5 FEET OF SAND ABOVE THE SCREEN
November 6, 2018

Name, address, and telephone number of the person requesting the variance:
J.P. Hanson, Department of Energy-Richland Operations, Federal Building, Richland, WA 99352, (509) 376-0057
[Provided by J.L. Richart, CHPRC, Soil & Groundwater Remediation Project, Well Coordinator, (509) 942-3946]

Address of the well sites:
Hanford Site, Richland, WA 99352

WELL NAME	WELL ID	Well Purpose	Operable Unit	Easting	Northing
699-47-78B	C9879	Injection	200-ZP-1	566046.13	137926.7
699-48-70	C9988	Extraction	200-ZP-1	568500	138200

The specific regulation(s) that cannot be followed; comparable alternative specification; and justification for the request:
A variance is requested for constructing two (2) 200-ZP-1 Operable Unit (OU) groundwater treatment wells listed above to have more than five (5) feet of sand filter pack installed and extending above the screened interval. WAC 173-160-450 "What are the sealing requirements?" states, "The filter pack shall be no less than one foot or greater than five feet above the screened interval."

The listed wells will function as injection or extraction wells (see Well Purpose in table above) supporting the 200 West Groundwater Pump-and-Treat System. The U.S. Department of Energy is requesting the sand filter pack extend from 10 to 15 ft above the top of the screened interval to ensure the longevity and functionality of these wells is maintained over long-term pump and treat operations. Figures 1 illustrates the locations of the new 200-ZP-1 wells.

Figure 2 illustrates the conceptual well design for the injection and extraction wells planned for the 200-ZP-1 OU. The extended filter packs are requested to account for potential settling of the filter pack sand in these wells over their duration of use. Although the wells will be developed to the extent possible, long-term withdrawal of groundwater or injection of treated groundwater may induce additional settling of the filter pack sand in these wells. This settling could lead to annular seal bentonite and/or formation silts and sands inflowing into the well screens. Therefore it is prudent to extend the sand filter packs to accommodate the potential for future filter pack settling.

The extent of filter pack sand above the screened interval will be determined as part of the well design process. It is expected that not more than 10 ft of filter pack sand will extend beyond the top of the screened interval for any of the wells listed in this variance request. Depths from the surface to groundwater range from 240 – 260 feet in the vicinity of the proposed 200-ZP-1 wells, so the additional filter pack will not significantly reduce the overall length of the cement grout seal in the annulus of the well. All other aspects of the completion for these wells will be in accordance with WAC requirements.

The completed well design does not interconnect separate aquifers, will not impose a hazard to the environment, and is protective of groundwater.

VARIANCE TO CONSTRUCT NEW 200-ZP-1 PUMP AND TREAT WELLS WITH GREATER THAN 5 FEET OF SAND ABOVE THE SCREEN
November 6, 2018

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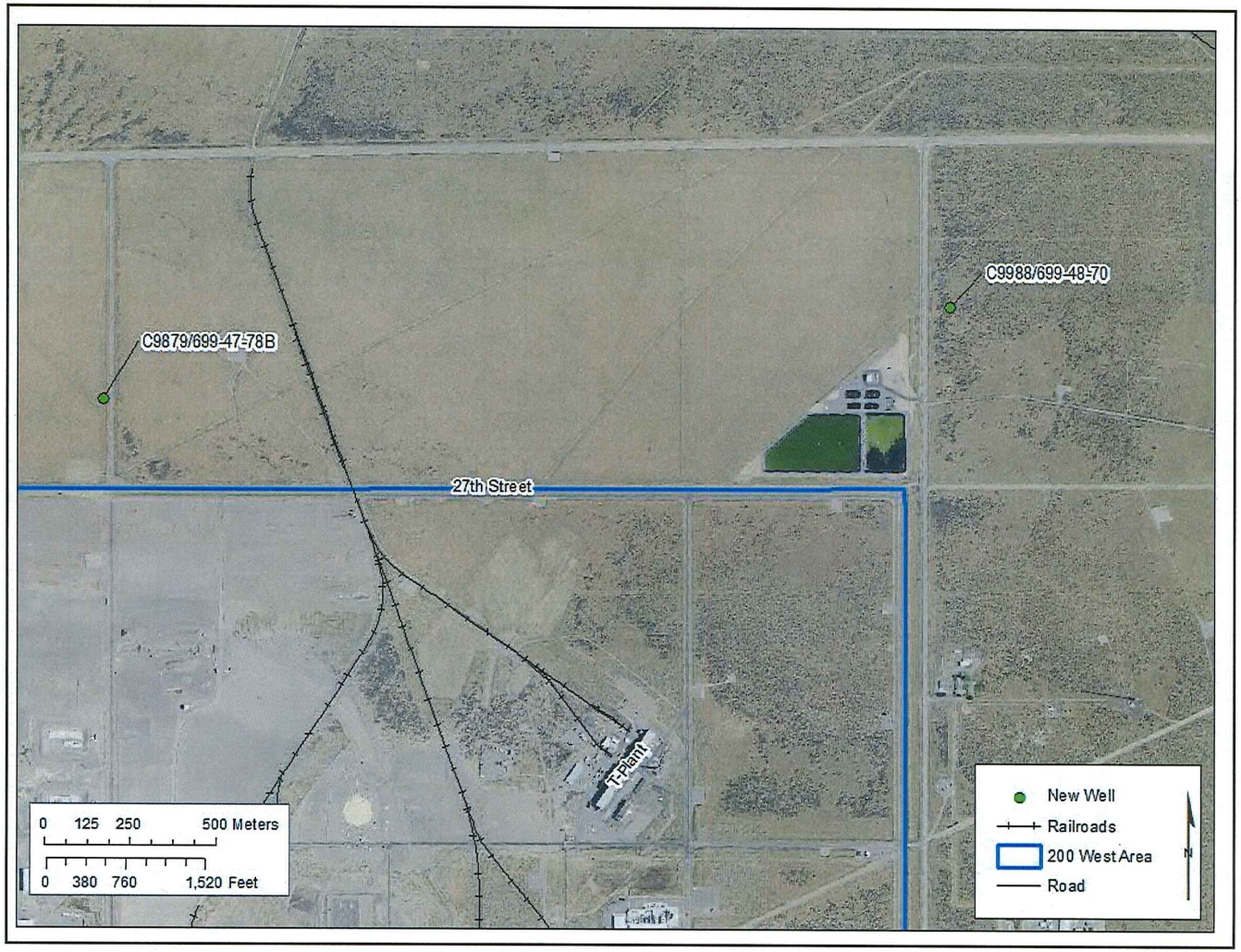

Figure 1. Map of 200-ZP-1 Well Locations.

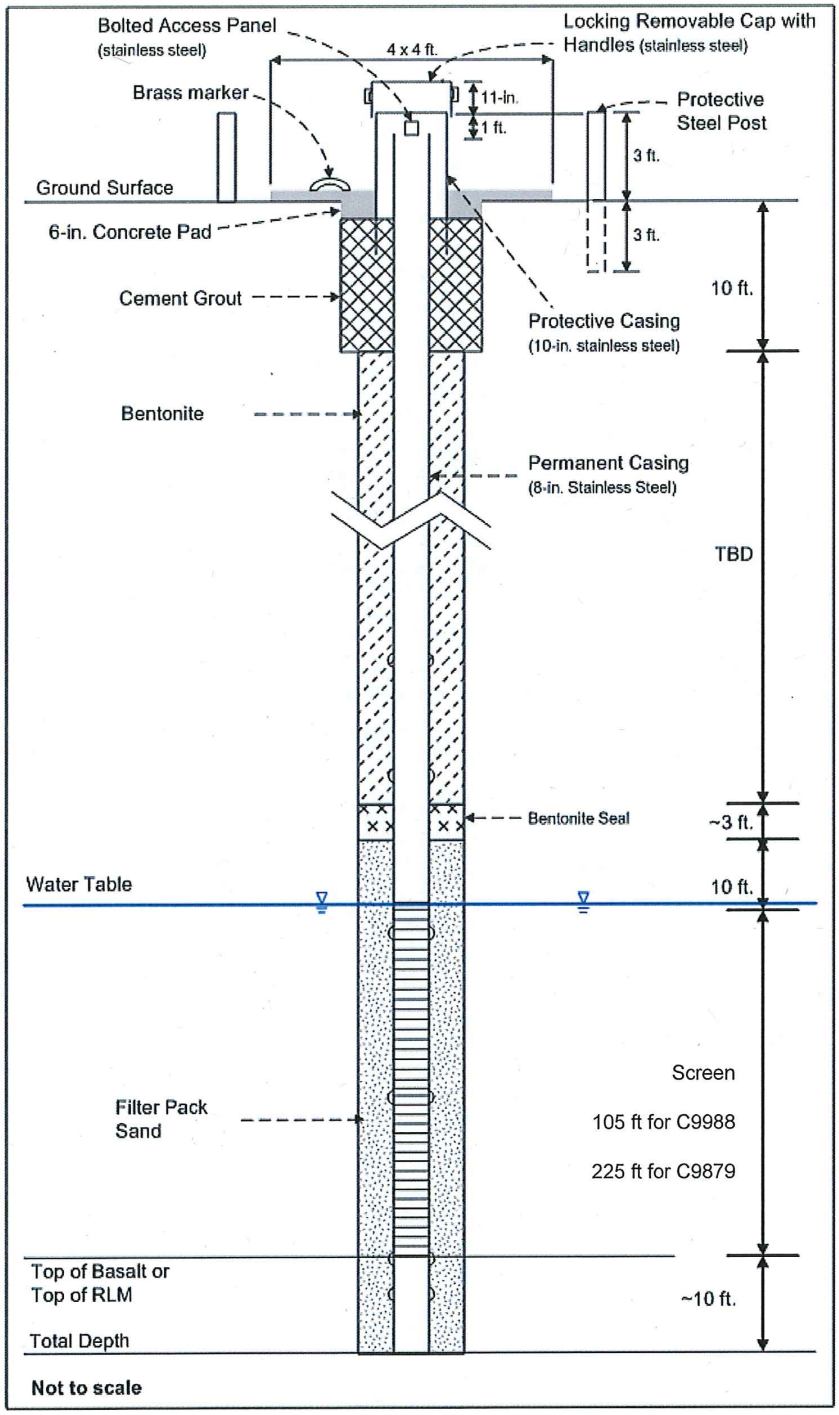

Figure 2. Conceptual Well Design for 200-ZP-1 Extraction and Injection Wells.

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