SGW-62791
Revision 0

Borehole Summary Report for the Installation of Wells 699-47-78 (C9878) and 699-47-78C (C9880) in the 200-ZP-1 OU, FY2018

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;
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Freestone Environmental, Inc.

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Terms

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
gpm	gallons per minute
HCl	hydrochloric acid
HEIS	Hanford Environmental Information System
HII	Huntington Ingalls Industries
ID	identification
hp	horsepower
m	meters
NMLS	Neutron Moisture Logging System
NTU	Nephelemetric Turbidity Units
OU	operable unit
P&T	Pump and treat
PFP	Plutonium Finishing Plant
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
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 two injection wells in the 200-ZP-1 groundwater Operable Unit (OU). As an ongoing effort under the remedial design/remedial action work plan, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Work Plan* (DOE/RL-2008-78), the two new injection wells expand the existing well network for the 200-ZP-1 OU pump and treat (P&T) system. Field activities carried out during the installation of the two new injection wells 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 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 April 10, 2018 to September 6, 2018 and was performed by Yellow Jacket Drilling Services (Yellow Jacket) and its' subcontractor Carpenter Drilling (Carpenter) under the direction of CH2M HILL Plateau Remediation Company (CHPRC). Well development occurred from August 14, 2018 to August 29, 2018 and was performed by Yellow Jacket at C9880 and Carpenter at C9878. Freestone Environmental Services Inc., provided well site geology and well construction documentation services. Technical Solutions, a division of Huntington Ingalls Industries (HII) provided geophysical logging services.

1.1 Purpose and Scope

This document summarizes the observations and measurements made during the drilling and installation of two injection wells in the 200-ZP-1 OU. This summary report includes copies of the field notes and forms prepared during the drilling, sampling, construction, and drilling 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-61325, *Description of Work for the Installation of Two Injection Wells in the 200-ZP-1 Groundwater Operable Unit, FY2018 (C9878 and C9880)*. 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 (C9878) and B (C9880) 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 two injection wells will hereafter be referred to in the text by the borehole identification number (e.g. C9878).

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
C9878	699-47-78	BKG 077	137800.71	566045.53	209.005	June 13, 2018	September 6, 2018
C9880	699-47-78C	BKG 079	138045.76	566046.21	207.904	April 10, 2018	August 24, 2018[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.

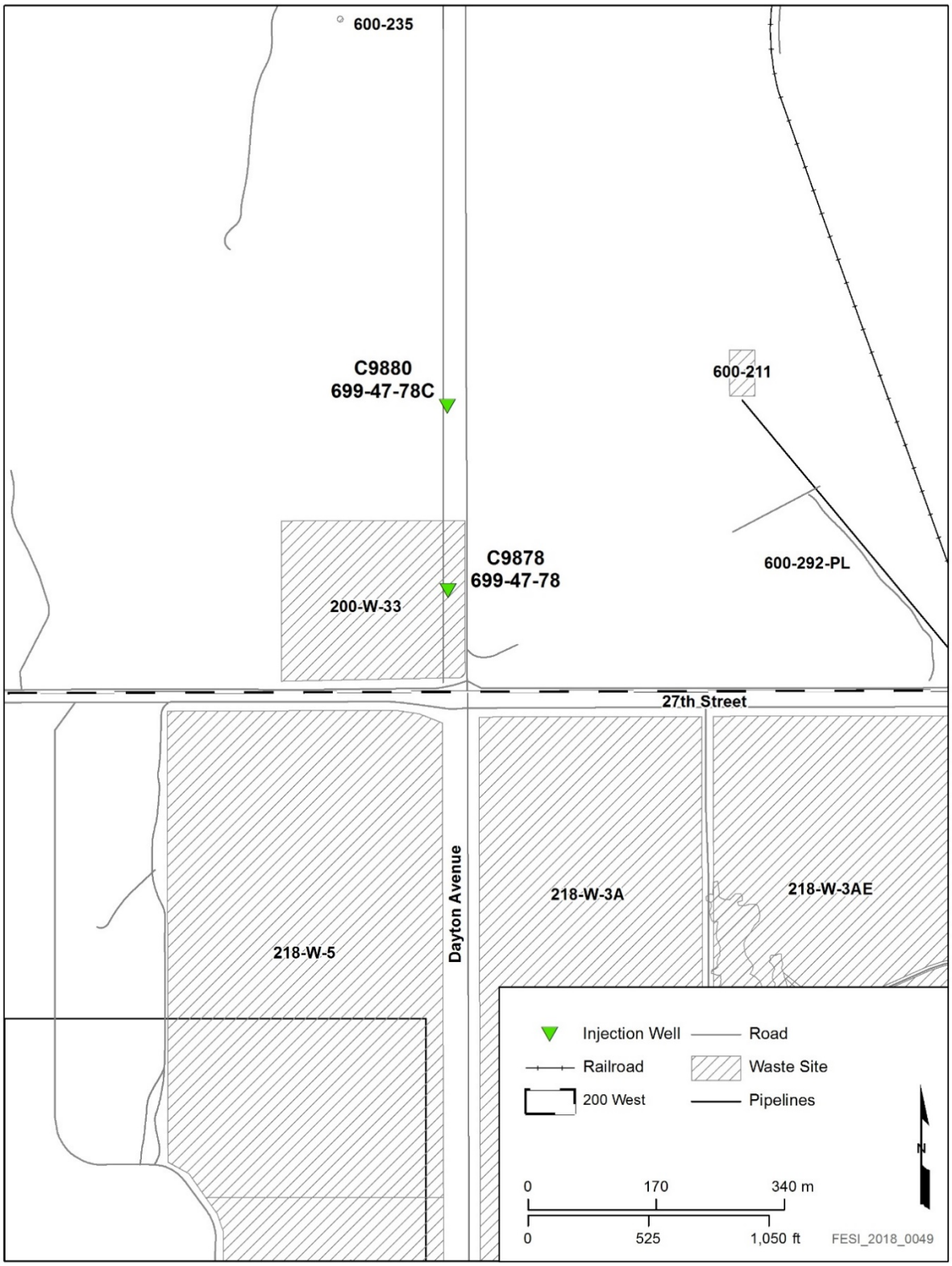

Figure 1-1. New Well Locations in the 200-ZP-1 Operable Unit

2 Drilling, Sampling, and Well Construction Activities

This section summarizes field activities associated with two injection wells. 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 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

The boreholes were advanced to depths between 457.1 and 475.6 feet below ground surface (ft bgs), extending between 216.4 and 237.4 ft below the static water level. Boreholes were drilled using a DR-24HD Dual Rotary drill rig (Figure 2-1). Two strings of temporary welded carbon steel casing with outer diameters of 16-in. and 14-in. were used to ensure the annulus has a "minimum of four inches greater in dimeter than the nominal size of the permanent casing", in accordance with WAC 173-160.

Figure 2-1. Yellow Jacket DR-24HD Dual Rotary Drill Rig.

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.

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.

Sediment samples were collected using split-spoon sampler at each of the boreholes to characterize the geochemistry of the sediments and associated pore water. Split spoon samples were collected from the aquifer at approximately 240, 340, 410, 430, 450, and 470 ft bgs. Split spoon samples were collected by driving a decontaminated 4-in. diameter split-spoon sampler with four separate polycarbonate liners, 2.5 ft through the sampling interval or until refusal. Split spoon sample depths and associated Hanford Environmental Information System (HEIS) numbers are included in Section 2.2.

During drilling, depth-discrete groundwater samples were collected using a plastic bailer or a 3-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 were also collected at the end of well development for laboratory analysis. All groundwater sample depths and associated HEIS numbers are included in Section 2.2.

Each borehole was logged using HII'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 HII, 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 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. No measurements above background levels were reported during drilling activities.

2.1.3 Well Construction and Development

The wells were constructed using 8-in. nominal diameter, Schedule 10S, Type 304/304L stainless steel casing, 75-slot (0.075-in.) screen with an additional 10.0 ft of 70-slot (0.070-in.) screen in C9878, and sump with end cap. The primary filter pack consists of 6-9 mesh silica sand extending from below the well sump to between 9.5 and 10.0 ft above the top of the screen. A variance was issued on March 7, 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 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 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 an electronic depth sounder and 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)							
C9878	457.1	8	0.070	+1.90 – 240.09	240.09 – 250.09	430.12 – 440.12	0.0 – 9.9	9.9 – 226.0	226.0 – 230.6	230.6 – 443.1	6 - 9
			0.075		250.09 – 430.12			443.1 – 457.1			
C9880	475.6	8	0.075	+1.97 – 240.08	240.08 – 460.08	460.08 – 470.09	0.0 – 10.3	10.3 – 225.7	225.7 – 230.1	230.1 – 475.6	6 - 9

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)
C9878	240.7	08/28/2018	381.6	55	70	2.90	5.37	3,850	13.0
	240.4	08/29/2018	339.5	37	80	2.35	5.14	2,960	15.6
			297.3	39	80	1.83	4.99	3,120	16.0
			255.1	31	80	2.02	4.90	2,480	16.3
			276.2[b]	33	237	-	19.96	7,821	11.9
C9880	238.7	08/14/2018	424.5	104	125	4.62	4.83	13,000	16.6
			124.8	63	120	4.28	4.09	7,560	29.3
			103.9	41	125	2.69	3.97	5,125	31.5
	238.2	08/15/2018	276.5	101	125	3.46	4.58	12,625	27.2

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 699-47-78 (C9878)

Borehole C9878 was drilled from June 13, 2018 through July 23, 2018 to a TD of 457.1 ft bgs. The borehole was drilled using 16-in. diameter welded carbon steel casing to a depth of 235.4 ft bgs and 14-in. diameter welded carbon steel casing to a depth of 447.2 ft bgs. To prevent interconnection between the unconfined and confined aquifer the 14-in. temporary casing was backpulled to 441.0 ft bgs and the borehole was sealed with 10.7 ft of 3/8-in. bentonite chips. Drilling continued with the inner drill rods with a 12 3/8-in. bit to a TD of 457.1 ft bgs. Approximately 186 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.

Four split spoon soil samples were collected in the aquifer and are detailed in Table 2-3. Eight groundwater samples were collected and are summarized in Table 2-4. On June 27, 2018 a maintenance issue occurred with a valve on the pump line requiring the first groundwater sample to be collected with a bailer. The last groundwater sample was collected during the final interval of well development.

Following placement of the 16-in. temporary casing, the borehole was logged by HII using SGLS and NMLS. SGLS logging occurred on June 21, 2018 from ground surface to 234.0 ft bgs, and NMLS logging occurred on June 22, 2018 from ground surface to 235.0 ft bgs. Following placement of the 14-in. temporary casing, the borehole was logged using SGLS on July 18, 2018 from 233.0 to 466.0 ft bgs and NMLS on July 18, 2018 from 234.0 to 243.5.0 ft bgs.

A borehole straightness test was successfully performed on July 31, 2018. Well construction took place from July 24, 2018 through September 6, 2018. The well was constructed as an 8-in. nominal diameter well with 241.99 ft of stainless steel blank casing, 10.00 ft of 70-slot (0.070-in.) screen, 180.03 ft of 75-slot (0.075-in.) screen, and a 10.00 ft sump with end cap. The well was placed at 440.12 ft bgs, extending 1.90 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 14.0-ft interval of medium bentonite chips, 212.5-ft interval of 6-9 mesh sand, 4.6-ft interval of 1/4-in. bentonite pellets, 216.1-ft interval of 3/8-in. medium bentonite chips, and 9.9-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on September 6, 2018. Well construction information is summarized in Table 2-1 and documentation is provided in Appendix A.

Table 2-3. C9878 Split Spoon Samples

Date	Sample Interval	Sample Depth Interval (ft bgs)	Sample Method	Media	Recovery %	HEIS Number
06/27/2018	I-005	246.0 – 248.5	Split spoon	Soil	100	B3JHN3
07/01/2018	I-008	336.4 – 338.9			100	B3JHN4
07/10/2018	I-010	417.1 – 419.6			100	B3JHN5
07/13/2018	I-012	436.0 – 438.5			100	B3JHN6

ft bgs = feet below ground surface.

HEIS = *Hanford Environmental Information System*.

Well development occurred from August 28, 2018 through August 29, 2018 using a 40-hp Grundfos submersible pump. Static water level was measured before well development at 240.7 ft bgs on August 28, 2018. Well development is summarized in Table 2-2.

Table 2-4. C9878 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
06/27/2018	I-004	242.5	Bailer	N/A	N/A	279	7.38	B3JHP0, B3JHP1, B3JHP2, B3JHP3, B3JHP4, B3JHP5, B3JK50
06/28/2018	260 Water	254.8	Submersible Pump	5	365	19.4	6.20	B3JVJ4, B3JVJ5, B3JVJ6, B3JVJ7, B3JVJ8, B3JVJ9
06/29/2018	I-006	294.9		18	1,512	8.32	6.59	B3JHR4, B3JHR5, B3JHR6, B3JHR7, B3JHR8, B3JHR9
07/02/2018	I-007	336.1		16	2,112	6.88	5.49	B3JHT1, B3JHT2, B3JHT3, B3JHT4, B3JHT5, B3JHT6, B3JK52
07/10/2018	I-009	415.9		10	2,272	22.3	4.24	B3JHT8, B3JHT9, B3JHV0, B3JHV1, B3JHV2, B3JHV3, B3JK77
07/12/2018	I-011	435.8		15	2,386	24.9	2.54	B3JHW4, B3JHW5, B3JHW6, B3JHW7, B3JHW8, B3JHW9

Table 2-4. C9878 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
07/23/2018	I-015	457.0		15	1,997	42.1	2.66	B3JHY0, B3JHY1, B3JHY2, B3JHY3, B3JHY4, B3JHY5
07/29/2018	Post Development	255.1[b]		80	3,200	3.0	6.09	B3JJ04, B3JJ05, B3JJ06, B3JJ07, B3JJ08

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

b. Sample collected during last well development interval.

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 699-47-78C (C9880)

Borehole C9880 was drilled from April 10, 2018 through June 6, 2018 to a TD of 475.6 ft bgs. The borehole was drilled using 16-in. diameter welded carbon steel casing to a depth of 222.3 ft bgs and 14-in. diameter welded carbon steel casing to a depth of 463.7 ft bgs and inner drill rods with a 12 3/8-in. bit to a TD of 475.6 ft bgs. Approximately 1,561 gallons of water was added to the borehole during drilling operations in the vadose zone to aid in the advancement of the borehole and provide dust suppression.

Five split spoon soil samples were collected in the aquifer and are detailed in Table 2-5. Eight groundwater samples were collected and are summarized in Table 2-6. The last groundwater sample was collected during the final interval of well development.

Following placement of the 16-in. temporary casing, the borehole was logged by HII using SGLS and NMLS. SGLS logging occurred on April 27, 2018 from ground surface to 221 ft bgs, and NMLS logging occurred on April 26, 2018 and April 27, 2018 from ground surface to 222.0 ft bgs. Following placement of the 14-in. temporary casing, the borehole was logged using SGLS on June 13, 2018 and June 14, 2018 from 220 to 466 ft bgs. NMLS logging occurred on June 14, 2018 from 221.0 to 239.0 ft bgs.

A borehole straightness test was successfully performed on July 12, 2018. Well construction took place from July 13, 2018 through August 24, 2018. The well was constructed as an 8-in. nominal diameter well with 242.05 ft of stainless steel blank casing, 220.00 ft of 75-slot (0.075-in.) screen, and a 10.01 ft sump with end cap. The well was placed at 470.09 ft bgs, extending 1.97 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 245.5-ft interval of 6-9 mesh sand, 4.4-ft interval of 1/4-in. bentonite pellets, 215.4-ft interval of 3/8-in. medium bentonite chips, and 10.3-ft interval of cement grout. All temporary casing was removed during well construction. From approximately 460.4 ft to 470.4 ft bgs, 10 ft of 1-in. galvanized steel tremie remains in the borehole. The protective casing was installed on August 24, 2018. Well construction information is summarized in Table 2-1 and documentation is provided in Appendix B.

Well development occurred from August 14, 2018 through August 15, 2018 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 238.7 ft bgs on August 14, 2018.

Table 2-5. C9880 Split Spoon Samples

Date	Sample Interval	Sample Depth Interval (ft bgs)	Sample Method	Media	Recovery %	HEIS Number
05/07/2018	I-005	255.2 – 257.2	Split spoon	Soil	100	B3JJ16
05/16/2018	I-008	344.6 – 335.1			75	B3JJ17
05/22/2018	I-010	415.3 – 417.6			100	B3JJ18
05/29/2018	I-012	437.1 – 439.6			100	B3JJ19
05/31/2018	I-014	456.5 – 459.0			100	B3JJ20

ft bgs = feet below ground surface.

HEIS = *Hanford Environmental Information System.*

Table 2-6. C9880 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
05/08/2018	I-004	255.3	Submersible Pump	3	988	32.3	7.09	B3JJ35, B3JHV4, B3JJ23, B3JJ24, B3JJ25, B3JJ26, B3JK79, B3JJ27, B3JJ29, B3JJ30, B3JJ31, B3JJ32, B3JJ33, B3JJ34, B3JK80
05/09/2018	Optional Water	274.8		10	940	8.41	8.49	B3JJ87, B3JJ88, B3JJ89, B3JJ90, B3JJ91, B3JJ92
05/10/2018	I-006	295.3		10	1,040	6.27	8.90	B3JJ36, B3JJ37, B3JJ38, B3JJ39, B3JJ40, B3JJ41
05/16/2018	I-007	335.3		13.6	1,169	3.51	8.09	B3JJ43, B3JJ44, B3JJ45, B3JJ46, B3JJ47
05/23/2018	I-009	415.3		13.6	3,019	6.85	6.95	B3JJ49, B3JJ50, B3JJ51, B3JJ52, B3JJ53, B3JJ54, B3JK82
05/30/2018	I-011	435.6		13.3	2,314	8.30	6.85	B3JJ64, B3JJ65, B3JJ66, B3JJ67, B3JJ68, B3JJ69, B3JJ70, B3JJ71

Table 2-6. C9880 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
06/04/2018	I-013	455.3		13.6	2,298	6.47	6.23	B3JJ72, B3JJ73, B3JJ74, B3JJ75, B3JJ76, B3JJ77, B3JJ79
08/15/2018	Post Development	276.5[b]		125	12,625	4.56	9.00	B3JJ94, B3JJ95, B3JJ96, B3JJ97, B3JJ98

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

b. Sample collected during last well development interval.

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.

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 was only encountered at C9878. 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, 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 Air 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 C9878 (699-47-78)

Stratigraphic units encountered during drilling of C9878 were the Hanford formation, Rwie, RLM, and the Rwia. Recovered sediments from C9878 are primarily gravelly sand, sandy gravel, sand, gravel, and silt.

The sediments encountered from ground surface to 30.0 ft bgs consist of Hanford formation gravelly sand, gravel, and sandy gravel. Gravelly sand is present from ground surface to 20.0 ft bgs with gravel present from 20.0 to 45.0 ft bgs. The gravelly sand is composed of 20% gravel, 75% sand and 5% silt. The gravel fraction is moderately sorted, angular clasts ranging from medium to very fine pebbles that are 80% mafic in composition. The sand within the sandy gravel is moderately sorted, coarse to very fine grained, and is 85% mafic in composition. Gravel present from 20.0 to 25.0 ft bgs contains 5% sand and trace silt. The gravel is made up of moderately sorted, subangular to angular clasts ranging from coarse to very fine pebbles that are 80% mafic in composition. Sand content in the sediment increases at 25.0 ft bgs and sandy gravel is present until 30.0 ft bgs. The sandy gravel consists of 55% gravel, 45% sand, and trace silt. Within the sandy gravel, the gravel fraction is composed of subround to angular clasts ranging from coarse to very fine pebbles. The gravels consist of 60% mafic minerals. The sand fraction is very coarse to medium grained consisting of 70% mafic grains. The Hanford formation sediments have no reaction to HCl and are olive brown (2.5Y 4/3) in color.

The Hanford formation to CCU contact is interpreted to be at 30.0 ft bgs where there is an increase of silt and carbonate cementation. The CCU extends to 107.0 ft bgs and consists of silty gravel, silty sandy gravel, gravelly sandy silt, gravel, slightly silty gravelly sand, sandy gravel, slightly silty sandy gravel, slightly silty sand, sandy silt, and sand. The sediments in the CCU displayed a weak to strong reaction to HCl and are predominately light olive brown (2.5Y 5/4) to olive brown (2.5Y 4/4) in color

The silty gravel that ranges from 30.0 to 45.0 ft bgs is composed of 50% gravel, 10% sand, and 40% silt. The gravel fraction consists of poorly sorted, subround, coarse to very fine pebbles that are 35% mafic in composition. The sand fraction ranges from fine to very fine grains and is well sorted. The silt within the silty gravel has a medium plasticity and the sediments have a strong reaction to HCl. From 45.0 to 52.0 ft bgs silty sandy gravel is encountered and consists of 60% gravel, 20% sand, and 20% silt. Within the silty sandy gravel, the max gravel clast size increases to range from very coarse to very fine pebbles, and the mafic content increases to 70%. The sand grain size increases in the silty sand gravel to include very coarse to very fine grains with a 60% mafic composition. From 52.0 to 54.0 ft bgs the silt content increases to 60% and gravelly sand silt is present consisting of 10% gravel, and 30% sand. The gravel clast size decreases within the gravelly sandy silt, and predominately very fine pebbles with a 95% mafic composition are encountered. At 54.0 ft bgs the silt content in the sediment decreases to trace amounts and gravel is present extending to 57.0 ft bgs. The gravel consists of subround to subangular clasts ranging in size from medium to very fine pebbles. Very coarse, angular, well sorted sand comprises 10% of the gravel and has an 80% mafic composition. From 57.0 to 75.0 ft bgs alternating layers of slightly silty gravelly sand and sandy gravel are encountered. The slightly silty gravelly sand occurs from 57.0 to 60.0 ft bgs and 67.0 to 70.0 ft bgs, and consists of 10% gravel, 70 to 75% sand, and 15 to 20% silt.

The sandy gravel occurs from 60.0 to 67.0 ft bgs and 70.0 to 75.0 ft bgs, and consists of 40% gravel, 50% sand, and 10% silt. The gravel content in the sediment decreases to 5% at 75.0 ft bgs where slightly silty sand is encountered and is composed of 75% sand, and 20% silt. At 77.0 ft bgs the gravel content increases and sediments reaction to HCl changes from strong to moderate. From 77.0 to 82.0 ft bgs sandy gravel is present and is composed of 65% gravel, 30% sand, and 5% silt. At 82.0 ft bgs sandy silt is encountered and extends to 87.0 ft bgs. The sandy silt is composed of 40% sand, 60% silt, and trace gravels. The sand fraction is well sorted, medium to very fine grained sand. Sand with 10% silt begins at 87.0 ft and continues to 125.0 ft bgs. The sand increases to 100% at 97.0 ft bgs and the reaction to HCl changes from a moderate to a weak reaction. The sand is well sorted medium sand that is 25% mafic in composition.

The CCU to Rwie contact is interpreted to be at 107.0 ft bgs where there is no longer carbonate cementation and the sediments have no reaction to HCl. The sand continues in the Rwie to 125 ft bgs where sandy gravel is encountered. Alternating layers of sandy gravel and gravel continue until 230.0 ft bgs with a layer of silty sandy gravel present from 200.0 to 205.0 ft bgs. The sandy gravel is present from 125.0 to 135.0 ft bgs, 140.0 to 145.0 ft bgs, 155.0 to 200.0 ft bgs, and 205.0 to 215.0 ft bgs. The gravel is present from 135.0 to 140.0 ft bgs, 145.0 to 155.0 ft bgs, and 215.0 to 230.0 ft bgs. Within the sandy gravel the gravel ranges from 40 to 75% and sand ranges from 25 to 60%. The silt within the sandy gravel ranges from 5 to 10% at 205.0 to 210.0 ft interval and is trace elsewhere in the sandy gravel. The gravel fraction consists of poorly sorted, subangular clasts ranging in size from very coarse to very fine pebbles. The sand fraction consists of moderately sorted sand that ranges in size from very coarse to very fine grained with an average coarse to medium grain size. Within the gravel intervals the gravel is composed of 80 to 98% gravel, 2 to 20% sand, and trace silt. The gravel fraction consists of poorly sorted, subangular clasts that range from very coarse to very fine pebbles in size. The sand fraction consists of very coarse to medium grained sand with trace fines. The sandy gravel and gravel intervals are predominately olive brown in color (2.5Y 4/4) with a light olive brown (2.5Y 5/4) color from 189.0 to 200.0 ft bgs. The silty sandy gravel that is present from 200.0 to 205.0 ft bgs is dark yellowish brown (10YR 4/4) in color and consists of 55% gravel, 30% sand, and 15% silt. The gravels in the Rwie from 107.0 to 230.0 ft bgs decrease in mafic composition from 80% to 35%, and the mafics in the sands decrease from 65 to 25%. The gravels at 215.0 ft bgs have a weak reaction to HCl which becomes a strong reaction at 220.0 ft bgs. At 225.0 ft bgs the gravels have no reaction to HCl.

From 230.0 to 360.0 ft bgs alternating layers of silty sandy gravel and sandy gravel are present with one layer of gravelly silty sand encountered from 255.0 to 260.0 ft bgs. The silty sandy gravel is present from 230.0 to 240.0 ft bgs, and 250.0 to 255.0 ft bgs. The sandy gravel is encountered at 240.0 to 250.0 ft bgs, and 260.0 to 360.0 ft bgs. The silty sandy gravel is composed of 30 to 40% gravel, 30 to 55% sand, and 15 to 25% silt. The gravel fraction consists of well sorted, subangular to angular clasts ranging from fine to very fine pebbles that have a 20 to 30% mafic composition. The sand fraction is coarse to very fine grained with a fine average grain size. The sand is moderately sorted with a 25% mafic composition. The silt is nonplastic and the silty sandy gravel is light olive brown (2.5Y 5/4) in color from 230.0 to 240.0 ft bgs and olive brown (2.5Y 4/4) in color from 250.0 to 255.0 ft bgs. The sandy gravel interval from 240.0 to 250.0 ft bgs is composed of 35%gravel, 65% sand, and trace silt. The sandy gravel in this interval is light olive brown (2.5Y 5/4) in color and has a moderate reaction to HCl. The gravelly silty sand interval is composed of 10% gravel, 30% sand, and 25% silt. The gravel fraction consists of well sorted, angular clasts ranging in size from fine to very fine pebbles that have a 30% mafic composition. The sand fraction consists of very fine, well sorted sand with 20% mafic grains. The gravelly silty sand has a strong reaction to HCl and is olive brown (2.5Y 4/4) in color. The sandy gravel encountered at 260.0 ft bgs is composed of 75% gravel, 20%sand, and 5% silt. The sandy gravel in this interval is olive brown (2.5Y 4/4) in color and has a moderate reaction to HCl until 280.0 ft bgs where the

sandy gravel has no reaction to HCl. The gravel fraction within the sandy gravel decreases with depth from 75 to 30%. The gravels consist of round to subrounded clasts that range in size from very coarse to very fine pebbles with occasional small cobbles present at 350.0 ft bgs. The mafic composition of the gravel fraction varies from 30 to 60%. The sand fraction within the sandy gravel increases with depth from 20 to 65% and consists of predominately medium grained sand that can vary in size from very coarse to very fine grained. The mafic composition of the sand fraction varies from 15 to 50%. The color of the sandy gravel changes to light olive brown (2.5Y 5/4) at 320.0 ft bgs and to dark yellowish brown (10YR 4/6) at 355.0 ft bgs.

From 360.0 to 440.0 ft bgs alternating layers of gravelly sand and sandy gravel are present. The gravelly sand occurs from 360.0to 365.0 ft bgs, 410.0 to 415.0 ft bgs, and 420.0 to 425.0 ft bgs. The sandy gravel occurs from 365.0 to 410.0 ft bgs, 415.0 to 420.0 ft bgs, and 425.0 to 440.0 ft bgs. In the gravelly sand intervals, the gravel fraction ranges from 20 to 25%, the sand ranges from 70 to 75%, and the silt content ranges from trace to 10%. In the sandy gravel intervals, the gravel fraction ranges from 40 to 70%, the sand ranges from 25 to 60%, and the silt content ranges from trace to 5%. Overall the gravels from 360.0 to 440.0 ft bgs consist of poorly to moderately sorted, round to subangular clasts that range in size from very coarse to very fine pebbles. The gravels are medium to fine pebbles on average and have a mafic composition ranging from 30 to 65%. The sand fraction consists of predominately moderately sorted, very coarse to very fine grained sand. The average grain size of the sand changes from medium to very coarse with depth and the mafic composition varies from 15 to 40%. The color of the sediment from 360.0 to 440.0 ft bgs is light olive brown (2.5Y 5/6) with a yellowish brown (10YR 5/6) color from 400.0 to 405.0 ft bgs.

At 440.0 ft bgs the silt content in the sediment increases and silty gravel is encountered. The silty gravel is composed of 30% gravel, 30% sand, and 40% silt. The gravel fraction consists of moderately sorted, subangular to angular clasts ranging in size from coarse to very fine pebbles. The sand fraction consists of predominately very fine grained sand. Clay nodules are present in the silty sand and range in size from 10 to 40 mm nodules and have a medium dry strength. The silty gravel extends to 445.0 ft bgs and is interpreted as the transition zone from the Rwie to the RLM. The contact between the Rwie and RLM was encountered at 445.0 ft bgs where silt is present until 447.0 ft bgs. The silt is composed of 5% medium to very fine pebbles, 15% fine to very fine sand, and 80% silt. The clay nodules that range in size up to 40 mm continue through the silt until 447.0 ft bgs. The sediments encountered from 440.0 to 447.0 ft bgs are light olive brown (2.5Y 5/6) in color and have a weak reaction to HCl.

The transition from the RLM to the Rwia is interpreted to start at 447.0 ft bgs where silty sandy gravel is encountered. The silty sandy gravel is composed of 50% gravel, 30% sand, and 20% silt. The gravel fraction consists of moderately sorted, coarse to very fine pebbles, that are 40% mafic in composition. The sand fraction consists of medium to very fine sand that is 20% mafic in composition. The sediments are light olive brown (2.5Y 3/6) in color and have occasional weak reactions to HCl. Drilling continued in the silty sandy gravel until TD was reached at 457.1 ft bgs.

3.2.2 Borehole Geology for C9880 (699-47-78C)

Stratigraphic units encountered during drilling of C9880 were the Hanford formation, Rwie, Rwia, and the Columbia River Basalt. Recovered sediments from C9880 are primarily gravelly sand, sandy gravel, sand, gravel, and basalt.

The sediments encountered from ground surface to 50.0 ft bgs consist of Hanford formation gravelly sand and sandy gravel. Gravelly sand is present from ground surface to 20.0 ft bgs with sandy gravel present from 20.0 to 40.0 ft bgs. Within the gravelly sand interval, the gravel fraction varies from 10 to 20% and is poorly sorted, subangular to angular clasts ranging from medium pebbles to very fine pebbles. Gravels

within the gravelly sand consist of 75% mafic minerals and the very coarse to very fine grained sand consists of 75% mafic grains. The sandy gravel present from 20.0 to 40.0 ft bgs and consists of 42 to 55% gravel, 35 to 50% sand, and 5 to 10% silt. Within the sandy gravel, the gravel fraction is composed of angular clasts ranging from coarse pebbles to very fine pebbles. The gravels consist of 85 to 90% mafic minerals. The sand fraction is very coarse to very fine grained consisting of 75% mafic grains. The Hanford formation sediments had no reaction to HCl and were predominately olive brown (2.5Y 4/3) in color.

The Hanford formation to CCU contact is interpreted to be at 40.0 ft bgs where there is an increase of silt and carbonate cementation. The CCU extends to 120.0 ft bgs and consists of slightly silty gravelly sand to 50.0 ft bgs, gravelly silty sand from 50.0 to 76.0 ft bgs, slightly silty sand from 76.0 to 85.0 ft bgs, gravelly sand from 85.0 to 100.0 ft bgs, sand from 100.0 to 105.0 ft bgs, and sandy gravel from 105 to 120 ft bgs. The sediments in the CCU displayed a weak to moderate reaction to HCl and are predominately light olive brown in color (2.5Y 5/4).

The slightly silty gravelly sand that ranges from 40.0 to 50.0 ft bgs is composed of 15% gravel, 70% sand, and 15% silt. The gravel fraction consists of well sorted, subrounded to angular, very fine pebbles. The sand fraction ranges from coarse to very fine grains consisting of 65% mafic grains. At 50.0 ft, silt content increases and gravelly silty sand is present until 76.0 ft bgs. The gravelly silty sand is composed of 15% gravel, 55% sand, and 30% silt. The gravel fraction is primarily made of moderately sorted, subround to angular fine to very fine pebbles that are 60% mafic in composition. The sand fraction is moderately sorted, primarily medium sand that is 65% mafic in composition. The silt is nonplastic. The slightly silty sand present from 76 to 85 ft bgs is composed of 85% sand,15% silt, and trace fine to very fine pebbles. The sand fraction is well sorted predominately medium grained sand that is 50% mafic in composition. The silt is nonplastic. At 85.0 ft bgs there is an increase in gravels and a decrease in silt where gravelly sand is present until 100.0 ft bgs. The gravelly sand is composed of 10% gravel, 80% sand, and 10% silt. The gravel fraction is moderately sorted, subangular, coarse to very fine pebbles that are 80% mafic in composition. The sand fraction is predominately well sorted, very coarse to coarse grained sand that is 60% mafic in composition. As the silt decreases at 105.0 ft, sandy gravel is present until 120.0 ft bgs. At 115.0 ft bgs the color changes to dark olive brown (2.5Y 3/8). Within the sandy gravel interval, the gravel fraction varies from 35 to 55% and is moderately sorted, subrounded to angular clasts ranging from coarse to medium pebbles. The pebbles consist of 80% mafic minerals. The sand within the sandy gravel varies from 40 to 60% and is moderately sorted predominately coarse grained sand that is 70% mafic in composition. From 120.0 to 125.0 ft bgs sand is encountered and is composed of 95% sand, 5% silt, and trace very fine pebbles. The sand ranges from very fine to coarse grained but is predominately medium grained with a 70% mafic composition. The sand has no reaction to HCl.

The CCU to Rwie contact is interpreted to be at 125.0 ft bgs where gravel increases to 55% and sandy gravel, olive brown (2.5Y 4/4) in color, is present. The sandy gravel extends to 140.0 ft bgs. The gravel fraction of the sandy gravel varies from 35 to 55% and is primarily made up of subround to subangular medium to very fine pebbles that are 50 to 60% mafic in composition. The sand fraction ranges from 40 to 60% and is moderately sorted predominately medium grained sand that is 50 to 55% mafic in composition. Silt comprises 5% of the sandy gravel and is nonplastic. From 140.0 to 145.0 ft bgs the gravel content decreases to 5% in the sediment and sand is encountered. The very coarse to very fine grained sand is predominately medium to coarse grained and is subangular with a 50% mafic composition.

Gravel increases to 10% at 145.0 ft bgs and dark grayish brown (2.5Y 4/2) gravelly sand is present until 155.0 ft bgs. Gravel content continues to increase to 40% and sandy gravel present until 170.0 ft bgs. The gravelly sand present from 145.0 to 155.0 ft bgs is composed of 10% gravel, 85% sand, and 5% silt. The

gravel fraction consists of moderately sorted, subangular to angular, medium to very fine pebbles that are 60% mafic in composition. The moderately sorted sand fraction ranges from very coarse to very fine grains consisting of 50% mafic grains. The sandy gravel present from 155.0 to 170.0 ft bgs is composed of 40% to 55% gravel, 45 to 55% sand, and up to 5% silt. The poorly sorted gravel of the sandy gravel is made up of coarse to very fine pebbles that are subangular to angular and are 40% mafic in composition. The sand fraction consists of moderately sorted very coarse to very fine sand that is predominately medium grained and is 30% mafic in composition. The sandy gravel is light olive brown (2.5Y 5/3) in color. At 170.0 ft bgs gravelly sand is encountered and is very dark grayish brown in color (2.5Y 3/2) until 175 ft bgs where the color changes to olive brown (2.5Y 4/4). The gravelly sand is composed of 20% gravel, 75% sand, and 5% silt. The gravel fraction consists of subround to angular, medium to very fine pebbles that are 60% mafic in composition. The sand fraction is made up of primarily medium grained sand that varies from very coarse to very fine and is 60% mafic in composition. As the silt content increases to 15% with depth and the color changes to light olive brown (2.5Y 5/4), slightly silty gravelly sand is present from 180.0 to 185.0 ft bgs and silty sandy gravel is present until 200.0 ft bgs. The slightly silty sandy gravel is composed of 10% gravel, 75% sand, and 15% silt. The gravel fraction is poorly sorted, subround to subangular, coarse to very fine pebbles that are 40% mafic in composition. The sand fraction is fine grained, well sorted, with a 30% mafic composition. The silty sandy gravel present from 185.0 to 200.0 ft bgs consists of 45 to 55% gravel, 30 to 40% sand, and 15% silt. Within the silty sandy gravel, the gravel fraction is composed of subangular to angular clasts ranging from very coarse pebbles to very fine pebbles. The gravels consist of 35% mafic minerals. The sand fraction is medium to very fine grained consisting of 30% mafic grains.

From 200.0 to 255.0 ft bgs alternating layers of sand and sandy gravel are present with one layer of gravelly sand. The sand is encountered from 200.0 to 205.0 and 210.0 to 215.0 ft bgs and is very coarse to very fine grained containing 2 to 5% medium to very fine pebbles. The sand from 200.0 to 205.0 ft bgs is light yellowish brown (2.5Y 6/4) in color. The color changes to light olive brown (2.5Y 5/4) at 205 ft bgs where sandy gravel is present. Sandy gravel encountered from 205.0 to210.0 and 225.0 to 255.0 ft bgs is composed of 55 to 70% gravel, 25 to 45% sand, and up to 5% silt. The gravel fraction, within the sandy gravel, is poorly sorted, subround to angular, medium to very fine pebbles that are 30 to 40% mafic in composition. The sand fraction is predominately medium to fine grained, moderately sorted, with a 15% mafic composition. The layer of gravelly sand encountered from 215.0 to 225.0 ft bgs is composed of 20% gravel, 75% sand, and 5% silt. The sediment had a moderate reaction to HCl at 250.0 ft bgs. At 255.0 ft bgs gravel is encountered and continues to 265.0 ft bgs. The gravel consists of round to angular, very coarse to very fine pebbles that are poorly sorted and 40% mafic in composition. The gravel contains 15% angular, coarse grained sand that is 30% mafic in composition and trace silt. The gravel displayed no reaction to HCl.

From 265.0 to 315.0 ft bgs sandy gravel is present with a layer of silty sandy gravel from 290 to 295 ft bgs. Within the sandy gravel interval, the gravel fraction decreases from 75 to 30%, with depth, and is poorly sorted, consisting of round to angular clasts ranging from very coarse to very fine pebbles that are 40 to 65% mafic minerals. The sand fraction of the sandy gravel is composed of coarse to very fine grained sand that is moderately sorted and has a 30 to 60% mafic composition. The silty sandy gravel encountered from 290.0 to 295.0 ft bgs consists of 55% gravel, 30% sand, and 15% nonplastic silt. At 315.0 ft to 335.0 ft bgs gravelly sand is present and consists of 15% gravel, 80% sand, and 5% silt. Within the gravelly sand interval, the gravel fraction is composed of moderately sorted, round to subround, coarse to medium pebbles that are 25% mafic in composition. The sand fraction is medium to very fined grained, well sorted, sand that is 90% mafic.

At 335.0 ft bgs the gravel content in the sediment increases and an olive brown (2.5Y 5/6) sandy gravel is encountered. The sandy gravel continues to 464.0 ft bgs with a layer of gravelly sand encountered from

385.0 to 390.0 ft bgs. The contact between the Rwie and the Rwia is interpreted to be at 390.0 ft bgs where there is an increase in quartz-feldspar-lithic gravels and a decrease in drilling rate. Prior to 390.0 ft bgs the drilling rate was approximately 30 minutes per 5 feet of drilling. At 390.0 ft bgs the drilling rate decreased to approximately 60 to 90 minutes per 5 feet of drilling. The gravelly sand interval is composed of 15% gravel, 80% sand, and 5% silt and is light olive brown in color (2.5Y 5/4). The sandy gravel interval has localized strong reactions to HCl at 335.0 ft bgs and a weak reaction to HCl from 335.0 ft to 345.0 ft bgs. The gravel fraction within the sandy gravel varies from 35 to 65% and is made up of poorly sorted, round, small cobbles to very fine pebbles. The sand fraction varies from 30 to 55% and is predominately medium grained, well sorted sand. The basalt content in the sediment increases with depth and the mafic content of the gravel fraction increases from 35 to 85%, and the mafic content in the sand fraction increases from 45 to 85% with depth. With the increase in mafic content the color of the sediment changes with depth. Light olive brown (2.5Y 5/4) color is present from 385.0 to 447.0 ft bgs, dark gray (2.5Y 4/1) is present from 447.0 to 450.0 ft bgs, and grayish brown (2.5Y 5/2) is present from 450.0 to 464.0 ft bgs.

The contact between the Rwia and the Basalt was encountered at 464.0 ft bgs. The basalt is black (10YR 2/1) in color and shows no apparent weathering. The basalt was broken from drilling into angular, 2 to 30 mm sized cuttings. Drilling in the basalt continued until TD was reached at 475.6 ft bgs.

4 Waste Management

Waste generated during the activities described in this document were 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 Industrial Hygiene 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 industrial hygiene 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 C9880 on August 29, 2018 and C9878 on September 10, 2018. 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 C9878 (699-47-78)

Contents

Well Summary Sheet ……..……..…..... A-1
Borehole Log ……...…….…. A-6
Drill Cutting Photographs …….....…….……..... A-18
Well Develepment and Testing Data ……..……....……...…...… A-29
Log Data Report …….....…..…..……....……...…...… A-30
Well Survey Data Report …….....…..…..……....……...…...… A-50

WELL SUMMARY SHEET

Well ID : C9878	Well Name: 699-47-78	Start Date: 6-13-2018
Project: 2 Injection Wells in the 200-ZP-1 OU	Location: East Boundary of 200-W-33	Finish Date: 9-06-2018

CONSTRUCTION DATA

Description

Concrete Pad: 0.50 ft above ground surface (ags)

10-in. Protective Casing: 2.90 ft ags - 2.10 ft below ground surface (bgs)

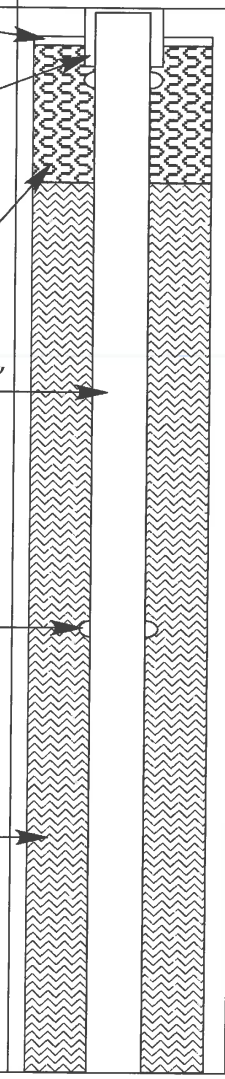
Type I/II Portland Cement Grout: 0.0 - 9.9 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.90 ft ags - 240.09 ft bgs

Stainless steel centralizer installed above and below screen and every 40 ft

Medium Bentonite Chips: 9.9 - 226.0 ft bgs

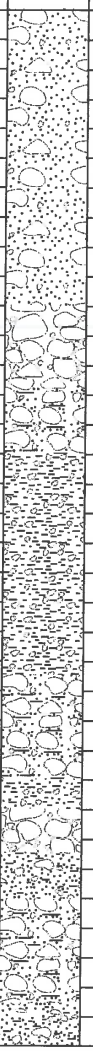
Diagram



GEOLOGIC/HYDROLOGIC DATA

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

Graphic Log



Lithologic Description (ft bgs)

- 0.0 - 20.0 Gravelly Sand (gS)
- 20.0 - 25.0 Gravel (G)
- 25.0 - 30.0 Sandy Gravel (sG)
- 30.0 - 45.0 Silty Gravel (mG)
- 45.0 - 52.0 Silty Sandy Gravel (msG)
- 52.0 - 54.0 Gravelly Sandy Silt (gsM)
- 54.0 - 57.0 Gravel (G)
- 57.0 - 60.0 Slightly Silty Gravelly Sandy ((m)gS)
- 60.0 - 67.0 Sandy Gravel (sG)
- 67.0 - 70.0 Slightly Silty Gravelly Sandy ((m)gS)

Reported By:

Tracy Mallgren	Geologist		9-10-2018
Print Name	*Title*	*Signature*	*Date*

Reviewed By:

Jennifer Richart	Well Coordinator	J. Richart	9/17/18
Print Name	*Title*	*Signature*	*Date*

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OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9878	Well Name: 699-47-78	Project	2 Injection Wells in the 200-ZP-1 OU

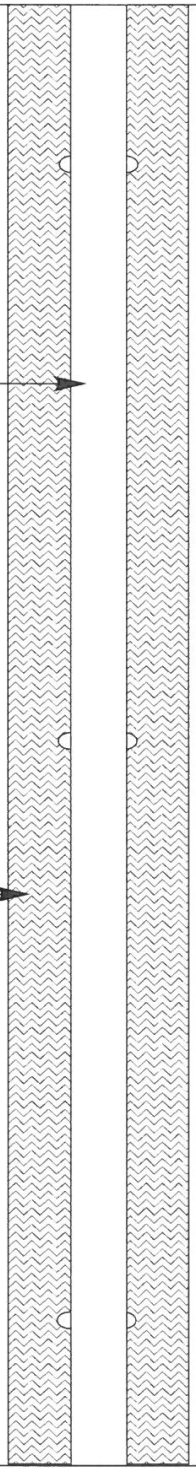
CONSTRUCTION DATA

Description

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.90 ft ags - 240.09 ft bgs

Medium Bentonite Chips: 9.9 - 226.0 ft bgs

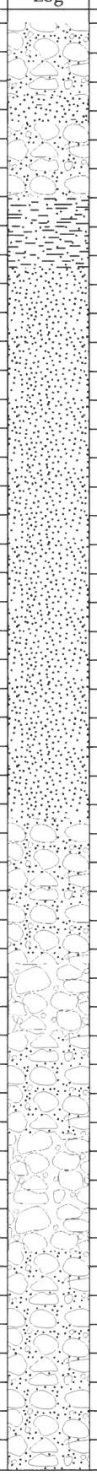
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 70, 80, 90, 100, 110, 120, 130, 140, 150, 160

Graphic Log



Lithologic Description (ft bgs)

70.0 - 75.0 Sandy Gravel (sG)

75.0 - 77.0 Slightly Silty Sand ((m)S)

77.0 - 82.0 Sandy Gravel (sG)

82.0 - 87.0 Sandy Silt (sM)

87.0 - 125.0 Sand (S)

125.0 - 135.0 Sandy Gravel (sG)

135.0 - 140.0 Gravel (G)

140.0 - 145.0 Sandy Gravel (sG)

145.0 - 155.0 Gravel (G)

155.0 - 215.0 Sandy Gravel (sG)

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET

Page 3 of 5

Well ID: C9878 | Well Name: 699-47-78 | Project: 2 Injection Wells in the 200-ZP-1 OU

CONSTRUCTION DATA

Description

Medium Bentonite Chips: 9.9 - 226.0 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.90 ft ags - 240.09 ft bgs

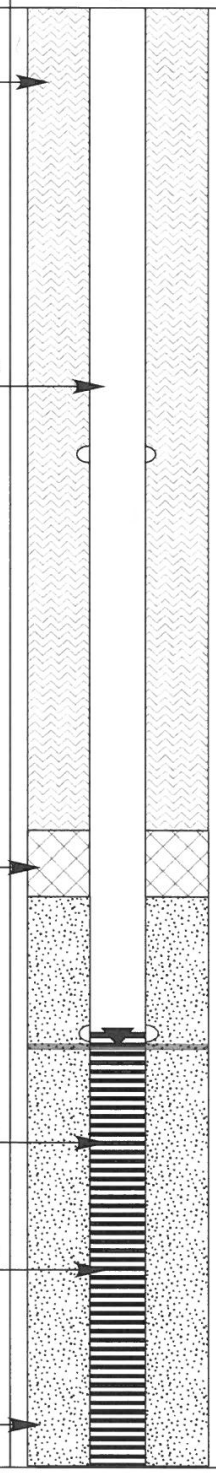
1/4-in. Coated Bentonite Pellet Seal: 226.0 - 230.6 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, 70-slot (0.070 in.) Stainless Steel Screen: 240.09 - 250.09 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 250.09 - 430.12 ft bgs

6-9 mesh Premier Silica Filter Pack Sand: 230.6 - 443.1 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)

155.0 - 215.0 Sandy Gravel (sG)

215.0 - 230.0 Gravel (G)

230.0 - 240.0 Silty Sandy Gravel (msG)

240.0 - 250.0 Sandy Gravel (sG)

Depth to Water: 240.7 ft bgs (08-28-2018)

250.0 - 255.0 Silty Sandy Gravel (msG)

255.0 - 260.0 Gravelly Silty Sand (gmS)

260.0 - 360.0 Sandy Gravel (sG)

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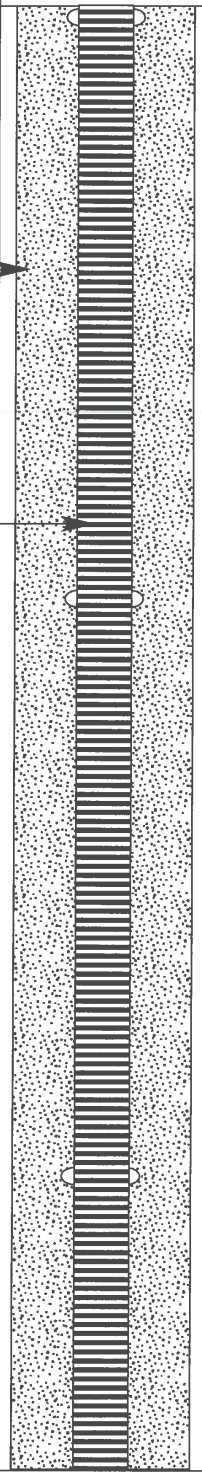
WELL SUMMARY CONTINUATION SHEET

Well ID: C9878 | Well Name: 699-47-~~7C~~ 79 JCR 9/17/18 | Project: 2 Injection Wells in the 200-ZP-1 OU

CONSTRUCTION DATA

Description	Diagram
6-9 mesh Premier Silica Filter Pack Sand: 230.6 - 443.1 ft bgs	
8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 250.09 - 430.12 ft bgs	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
270		260.0 - 360.0 Sandy Gravel (sG)
280		
290		
300		
310		
320		
330		
340		
350		
360		360.0 - 365.0 Gravelly Sand (gS)
		365.0 - 410.0 Sandy Gravel (sG)

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9878 | Well Name: 699-47-78 | Project: 2 Injection Wells in the 200-ZP-1 OU

CONSTRUCTION DATA

Description

6-9 mesh Premier Silica Filter Pack Sand: 230.6 - 443.1 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 250.09 - 430.12 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 430.12 - 440.12 ft bgs

Medium Bentonite Chips: 443.1 - 457.1 ft bgs

Straightness Test: Pass, 07-31-2018

Depths are in ft below ground surface.

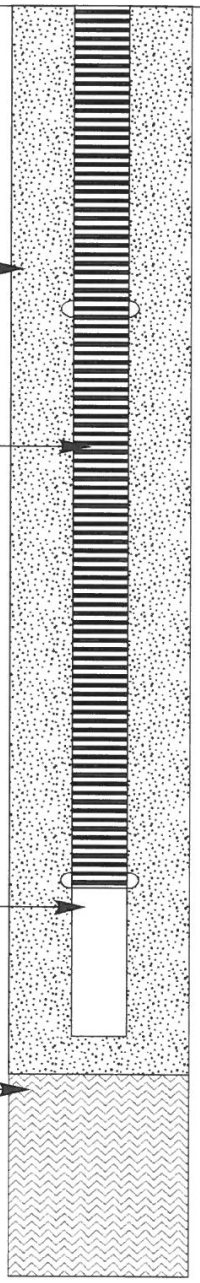
Borehole drilled with 16-1/2-in. O.D. casing from 0.00 - 235.4 ft bgs

Borehole drilled with 14-in. O.D. casing from 235.4 - 447.2 ft bgs

Borehole drilled with 12-3/8-in. O.D. drill bit from 447.2 - 457.1 ft bgs

All temporary drill casing was removed from the ground.

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
370		365.0 - 410.0 Sandy Gravel (sG)
380		
390		
400		
410		410.0 - 415.0 Gravelly Sand (gS)
		415.0 - 420.0 Sandy Gravel (sG)
420		420.0 - 425.0 Gravelly Sandy (gS)
		425.0 - 440.0 Sandy Gravel (sG)
430		
440		440.0 - 445.0 Silty Gravel (mG)
		445.0 - 447.0 Silt (M)
450		447.0 - 457.1 Silty Sandy Gravel (msG)
460		Total Depth: 457.1 ft bgs (07-23-2018)

A-6006-992 (Rev 2)

BOREHOLE LOG

Page 1 of 12
Date: 6-14-18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary of 200-W-33
Project: Install 2 Injection Wells in 200-ZP-1 GW 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	~~G~~		0-20': gravelly Sand (gS)	Air Rotary Drilling with
			g=20%, s=75%, m=5%.	16" OD/15½" ID temporary
			Gravel: v. fine to med. pebble, vfine	casing 0.0-235.4' bgs
			peb. =50% f.peb=40% med peb.=10%, 2-3mm avg. 2- to 14" OD/13¾" ID temp. casing	
			Mod. sorted, 20% fel, 80% maf. ang.	235.4-447.2' bgs. Grab
5	G		Sand: v. fine-coarse. 20% vfine, 30% fine,	samples collected every 5'
			30% med, 20% coarse. mod sorted. 15% fel,	or change in lithology.
			85% maf. ang. Wet. No rxn HCl 2.5Y	447.2-457.0' drilled 9 7/8" drill bit
			4/3 Olive Brown.	0-38ft: ~30 gal H_2O added
10	G			
15	G		Loss of fines	
			20'-25': Gravel (G) g=95% s=5% m=Trace	
			Gravel: v. fine to coarse pebble, 15% vfine,	
			40% fine, 40% med, 5% coarse. avg. 10mm,	
20	G		20mm max, mod. sorted. 20% fel, 80% maf, ang-	
			sub ang. Sand: med-v. coarse, 10% med,	
			70% coarse, 20% v. coarse. Well sort, 35% fel,	
			65% maf. ang. Moist. No rxn HCl 2.5Y 4/3	
			Olive Brown.	
25	G		25-30': sandy Gravel (sG) g=55%, s=45% m=T	
			Gravel: vfine to ~~med~~ coarse peb., 15% v fine,	
			40% fine, 40% med, 5% coarse peb. 10mm avg.	
			30mm max, 40% fel, 60% maf, ang - sub round.	
			Sand: med - v ~~fine~~ coarse, 10% med, 70% coarse, 20%	
30	G		v. coarse. Well sort, 30% fel, 70% maf, ang. Wet	
			No rxn HCl 2.5Y 4/3 Olive Brown.	
			fines RETURN	
			30'-45': silty Gravel (mG)	
			g=50% s=10% m=40%	
			-Descriptions on page 2-	

Reported By: Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 8/20/18 (Date)

Reviewed By: Sarah Springer (Print Name) | Sr. Geologist (Title) | Signature | 08-08-18 (Date)

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OR Doc Type: | WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 12

Date: 6-15-18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary 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		30-45': silty Gravel (m(G)) g=50% s=10% m=40% Gravel: v.fine to coarse pebble, 20% v fine, 20% fine, 30% med, 30% coarse peb., max 30mm, poor sort, 65% fel, 35% mof. sub round, Sand: v.fine-fine, well sort, Moist. Strong rxn HCl. Silt med plastic 2.5Y 5/6 Light Olive Brown.	Air Rotary Drilling with 16"/15 1/8" temp casing O.D. 235.4' bgs & 14"/13 1/4" temp casing 235.4-447.2' bgs. Grab samples collected every 5' or change in lithology.
40	G		@40' g=35% s=10% m=55% max 5mm. 10YR 7/4 Very Pale Brown	
			45-52': silty sandy Gravel (msG) g=60% s=20% m=20% Gravel: v fine-v.coarse, 5% v fine, 20% fine, 65% med, 5% coarse 5% vc avg ~15mm, 40mm max, Mod sort, 70% mof, 30% fel, sub rnd-sub.rnd	39-42': ~4 gal H_2O added
45	G		Sand: v.fine-v.coarse, 20% v fine, 15% fine, 30% med, 5% coarse, 30% vc poor sort, 60% mof, 40% fel, ang, Moist. Strong rxn HCl. 2.5Y 4/4 Olive Brown, Silt med plastic.	
			52-54': gravelly sandy silt (gsM) g=10% s=30% m=60% Gravel: v fine pebble, med pebble. 95% v fine 5% med, 2mm avg 20mm max, 95% mof, 5% fel, sub ang. Sand: v.fine-fine, Well sort, Wet, Strong rxn HCl, Silt med plastic, 2.5Y 4/4 Olive Brown	50-52': ~4 gal H_2O added
50	G		54-57': Gravel (G) g=90% s=10% m=T Gravel: v. fine to med. pebble, avg 5mm, max 10mm, 40% vf-50% f, 10% med peb. sub ang/sub rnd. Sand: v. coarse, well sort 20% fel, 80% mof, ang. Moist. Strong rxn HCl, 2.5Y 5/4 light Olive Brown	
	G			
	G			
55			57-60': slightly silty gravelly Sand (lmgS) g=10% s=75% m=15% Gravel: v fine-fine peb, 5mm avg/max, well sort, 90% mof, sub ang-ang Sand: v fine to v. coarse: 25% vf, 40% fine, 20% m, 10% coarse, 5% vc mod sort, 60% fel, 40% mof, ang Wet strong rxn HCl	56-60': ~9 gal H_2O added
	G			
60	G		60-67': sandy Gravel (sG) g=40% s=50% m=10% Gravel: v fine-fine 5mm avg, well sort, 90% mof, ang-sub ang Sand: v fine-coarse, mod sort, ang, 40% fel, 60% mof, ang. Wet Strong rxn HCl 2.5Y 5/3	
			@65 gravel max ≈ 30mm 80% mof-20% fel Sand: fine/v.fine	
65	G		67-70': slightly silty gravelly Sand (lmgS) g=10% s=70% m=20% Gravel: v.fine-med peb. 90% v fine-fine 10% med. mod sort, 20% fel ang/sub ang. Sand: v fine-fine, well sort, Wet Strong rxn HCl	65-67': ~2 gal H_2O added
	G			
			70-75': sandy Gravel (sG) g=40% s=50% m=10% Gravel: v fine-coarse peb. max 30mm avg 5mm, mod sort, 40% fel, 60% mof, sub ang-sub rnd. Sand: v fine-v.coarse 50% vf-med, 20% coarse, 30% v. coarse. 30% fel, 70% mof. Moist, Strong rxn HCl Silt low plastic. 2.5Y 5/3	68-75': ~9 gal H_2O added
70	G			

Reported By:

Tracy Mallgan (Print Name) | Geologist (Title) | Signature | 8/20/18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 12

Date: 6·15·18

Well ID: C9876 | Well Name: 699-47-78 | Location: East Boundary of 700-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		75-77': slightly silty Sand (sm) S) g=5% s=75% m=20%	Air Rotary Drilling with
			Gravel: v fine pebble, 2-3mm, well sort, 60% mat, subang-ang	11 a/15 1/2" temporary casing
	G		Sand: v fine-fine, well sort, ~~angular~~ rel. moist WET, Strong rxn HCl. 2.5Y 5/3	0.0-235.4 bgs and 14/13 1/4"
			77-82': sandy Gravel (sG) g=65% s=30% m=5% Gravel: 5%	Temp. casing 235.4-447.2'
			fine-med. occ coarse, 40% v. fine, 40% fine, 15 med, 5% coarse	bgs. Geolo samples collected
80	G TMB05		max 20mm, avg 10mm, mod sort, 40% fel, subang-ang. Sand:	every 5' or change in lithology.
			v. fine-v. coarse, 30% vf, 20% f, 30% med, 10% coarse, 10% v. coarse,	447.2-457.0' bgs drilled
	G		mod sort, 60% fel, 40% mat, subang, Moist. Mod rxn HCl	with 8 5/8" inner rod & 9 7/8"
			2.5Y 5/3	drill bit.
			82-87': sandy Silt (sM) g=Trace s=40% m=60%	
85			Sand: v fine-med & trace coarse. Well sort Moist. Silt	
			is nonplastic. Mod rxn HCl 2.5Y 5/4 (light Olive Brown	
	G		87-125': Sand (S) g=Trace s=90% m=10%	
			Sand: v fine-med & trace coarse. 10% v fine, 10% fine	
			80% med, 75% fel, 25% mat, subang. Moist mod rxn HCl	
90			2.5Y 5/4	
	G			
95			@ 97' s=100% trace gravel & silt 80% fel, 20% mat	
	G		5% v fine, 5% fine, 80% med, 5% coarse, 5% v. coarse	
			Dry Weak rxn HCl	
100			@ 102' very occasional weak rxn HCl	
	G			
105				
	G		@ 107' no rxn HCl	
110				
	G			

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 8/20/18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 12

Date: 6·18·18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary 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
115			37-125': Sand (S) 2.5Y 5/4	Air Rotary Drilling with
			@ 117': g=5% s=95% m=Trace Gravel: v fine-fine pebble,	K-15 12" temporary casing
	G		avg. 4mm max 8mm, mod sort, 98% maf basalt, sub eng	O.D. 235.4' bgs and 14"/13 3/4"
			Sand: v. fine - v. coarse 5% v fine, 5% fine, 80% med, 5% coarse, 5% v.c.	casing 235.4-447.2' bgs
			well sort, 75% fel 25% maf, sub eng. Wet No rxn HCl.	and 9 7/8" drill bit & 5 5/8"
120			@ 122' g to Trace s to 100%	inner rods 447.2-457.0' bgs
	G			
125	G		125-135': sandy Gravel (sG) g=40% s=60% m=Trace	
			Gravel: v. fine - coarse peb, 10% vf, 30% fine, 30% med, 20% coarse	
			20mm max, 10-15mm avg, mod sort, 20% fel, 80% maf, eng. Sand:	
			v. fine - v. coarse 80% mod well sort, Wet, No rxn HCl 2.5Y 5/4	
130	G		@130': g 55% s 45% Gravel: 20mm avg 30mm max	
			40% fel, 60% maf, sub eng. Sand: 70% med, 5% vf, 10% fine,	130-135': ~14 gal H_2O added
			10% coarse, 5% v.c. mod sort, 80% fel.	
135	G		135-140': Gravel (G) g=98% s=2% Gravel: v. fine - v. coarse	
			pebble, 15-20mm avg, 40mm max poorly sort, 65% maf, 35%	
			fel, eng/sub eng. Sand: coarse - v. coarse, mod sort, 65% maf, eng	135-144: ~22 gal H_2O added
			Wet. No rxn HCl 2.5Y 4/3 Olive Brown	
140	G		140'-145': sandy Gravel (sG) g=75% s=25% Gravel: v. fine-	
			v. coarse peb 15-20mm avg. 40mm max, poor sort, 65% maf, eng	
			sub eng. Sand: med - v. coarse 30% med 30% coarse, 40% v.c.	
			mod sort. 65% maf, eng. Wet. No rxn HCl 2.5Y 4/3 Olive Brown	
145	G		145-155': Gravel (G): g=85% s=15% m=Trace Gravel:	145-154': ~31 gal H_2O added
			v fine - v. coarse peb. 15-20mm avg. 40mm max, poor sort, 65%	
			maf, sub eng. Sand: med - v. coarse, mod sort, 30% med, 30% c, 40% v.c.	
			65% maf, wet, no rxn HCl. 2.5Y 4/3 Olive Brown.	
150	G			

Reported By:

Tracy Mallgren — Print Name | Geologist — Title | Signature | 8/20/18 — Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 6.19.18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary 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		155-215': sandy Gravel (sG) g=75% s=25% m=trace Gravel: vfine - coarse pebble, 5mm avg 70mm max, 30% vf, 40% fine, 20% med, 10% coarse, med sort, 30% fel, 70% maf, ang Sand: vfine-v.coarse, 10% fine-v.fine, 30% med, 30% c, 30% v.c 50/50 fel-Maf. med sort, ang/subang, Moist. No rxn HCl 2.5Y 4/4 Olive Brown	Air Rotary drilling with 16"/15"/12" Temporary casing 0.0-235.4' bgs, 14"/13"/11" 235.4-447.2' bgs and 8 5/8" drill rod & 9 7/8" bit 447.2-457.0' bgs. Grab samples collected every 5' or change in lithology.
160	G		@160': gravel 40mm max, poor sort, 40% fel, subround Wet.	
				155-160': ~6 gal H_2O added
165	G			160-165': ~7 gal H_2O added
				165-170': ~7 gal H_2O added
170	G		@170': gravel avg & 10mm, 50/50 maf. fel Sand: 70% fel. 30% maf. Moist	170-175': ~10 gal H_2O added
175	G		@175': Wet	
180	G		@179': g & 40% s & 60% gravel avg 2-10mm, 30mm max. Sand: 10% vf, 20% fine, 30% med, 30% coarse, 10% v.c Poor sort, sub ang, Moist	179-184': ~12 gal H_2O added
185	G		@184': g & 60% s & 40%	184-189': ~4 gal H_2O added
190	G		@189': g & 75% s & 25% gravel: 20% vf, 30% fine, 30% med, 10% coarse, 10% v.coarse. 10mm avg. 50mm max Sand: Trace fine + v.fine, 30% med, 40% coarse, 30% v.coarse 70% fel, 30% maf, sub ang. Wet. 2.5Y 5/4 light Olive Brown	
194	G			194-200': ~12 gal H_2O added

Reported By:

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A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 6 of 12

Date: 6.20.18

Well ID: C9878 | Well Name: C99-47-78 | Location: East Boundary 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			155-215: sandy Gravel (sG)	Air Rotary Drilling with
			@195': g=75%, s=25%. trace silt. Gravel: v fine to v.	16/15 1/16" temporary casing
			coarse pebble. 20% vf, 30% fine, 30% med, 10% coarse, 10% v. coarse	0.0-235.4' bgs, 14"/13 1/4"
			avg 10mm, 50mm max, mod sort, 50/50 fel-mef, sub-rnd-sub-ang	235.4-447.2' bgs, 8 5/8"
			Sand: trace v. fine - fine, 30% med, 40% coarse, 30% v. coarse	drill rod to 9 7/8" bit 447.2-
200	G		mod sort, 70% fel, 30% mef, sub ang, moist	457.0' bgs. Grab samples
			@200' g≈55% s≈30% m≈15%. Gravel: v. fine to	collected every 5' or change
			coarse pebble, 20% vf, 30% fine, 40% med, 10% coarse peb, 10-15	in lithology.
			mm avg, 30mm max, poor sort, 65% fel, 35% mef, sub ang-sub rnd	
			Sand: v fine-v coarse, 30% vf, 30% fine, 20% med, 10% coarse, 10% vc	
205	G		mod sort, 75% fel, sub ang. wet. 10YR 4/4 Dark Yellowish	
			brown. Silt nonplastic. No rxn HCl	
			@205' g≈60%, s≈35%, m≈5%	
210	G		@210': g≈50% s≈40% m≈10%	
				215-220': ~8 gal H_2O added
215	G		215'-230': gravel (G) g=30% s=20% m-trace	
			Gravel: v fine-v. coarse pebble, 10% vf, 20% fine, 30% med,	
			35% coarse, 5% v. coarse avg 20mm, max 50mm, poor sort,	
			65% fel, 35% mef, sub ang. Sand: med-v. coarse. mod sort,	
			75% fel, 25% mef, sub ang. Wet, Weak rxn HCl 2.5Y 4/4	
220	G		Olive Brown.	
			@220' Moist. Strong rxn HCl	220-225': ~7 gal H_2O added
225	G		@225': No rxn HCl	
				225-230': ~18 gal H_2O added
			230-240': silty Sandy Gravel (msG) g=30 s=55 m=15%	
230	G		Gravel: v fine-fine pebble, 5mm max, well sort, 30% fel	
			sub ang. Sand: v fine-coarse, trace v. coarse, 35% v. fine,	
			40% fine, 20% med, 5% coarse, mod sort, 75% fel, 25% mef, sub ang.	
			Wet. 2.5Y 5/4 light Olive Brown - silt. nonplastic	

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | (Signature) | 8/20/15 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG

Page 7 of 12
Date: 6-28-18

Well ID: C9878 | Well Name: C699-47-78 | Location: East Boundary of 200W-33
Project: | 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
235	G		230-240': silty sandy Gravel (msG) g=30% s=55% m=15%.	Air Rotary Drilling with
			@235' Gravel: v fine to v. coarse pebble, 40mm max,	16"/15½" temporary casing,
			mod sorted, 80% fel, subang. Sand: v. fine-coarse, 35%	0.0-235.4' bgs, 14"/13¾"
			v. fine, 40% fine, 20% med, 5% coarse, mod sort, 75% fel, 25% maf	235.4-447.4 447.2' bgs,
			subang, Wet 2.5Y 5/4 Light Olive Brown Silt non plastic	8⅝" drill rod & 9⅞" bit
240	G		240-250': sandy Gravel (sG) g=35%, s=65% m=trace	447.2-457.0' bgs Grab
			Gravel: v fine-fine pebble, well sort, 75% fel, 25% maf, ang.	samples collected every 5'
			Sand: v fine-v. coarse, 5% v fine, 15% fine, 20% med, 30% coarse,	or change in lithology.
			30% v. coarse, poor sort, 75% fel, 25% maf, ang, Dry, mod	
			rxn HCl. 2.5Y 5/4 Light Olive Brown	Water level: 238.96' bgs (7/2/18)
245	G			246-248.5: split spoon
	WS			246.2': Water Sample
	SS			
250	G		250-255': silty sandy Gravel (msG) g=40% s=30% m=25%	
			Gravel: v fine - coarse pebble, 30% vf, 30% fine, 25% med, 15% coarse	
			avg: 2mm max 30mm, poor sort, 70% fel, 30% maf, ang-sub	
			Sand: v fine-coarse, 30% vf, 30% fine, 25% med, 15% coarse, mod	
			sort, 80% fel, 20% maf, ang. Wet 2.5Y 4/4 Olive Brown	254.8: Water sample
255	G WS		Strong rxn HCl	
			255-260': gravelly silty Sand (gmS) g=10%, s=60%, m=30%	
			Gravel: v fine-fine pebble, trace med peb., 95% v. fine,	
			well sort, 70% fel, 30% maf, ang. Sand: v fine, well sort,	
			Wet 2.5Y 4/4 Olive Brown Strong rxn HCl	
260	G			
			260-360': sandy Gravel (sG) g=75 s=20% m=5%	
			Gravel: v fine - v. coarse pebble, 10% vf, 30% fine, 30% med, 20% coarse,	
			10% v. coarse pebble, 15mm avg, 60mm max, poor sort, 70% fel,	
			30% maf, ang-round. Sand: v fine-med, trace coarse & v.c.	
265	G		10% v fine, 20% fine, 70% med, well sort, 80% fel, 20% maf, subang.	
			Wet. 2.5Y 4/4 Olive Brown Mod rxn HCl	

Reported By:

Print Name	Title	Signature	Date
Tracy Mallory	Geologist	Tracy Mallory	8/20/18

Reviewed By:

Print Name	Title	Signature	Date
Sarah Springer	Sr. Geologist	Sarah Springer	08-08-18

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OR Doc Type:	WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

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Date: 7·1·18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary 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
270	G		260-360: sandy Gravel (SG)	Air Rotary Drilling with
			@270' g=60% s=35% m=5% Gravel: v fine - v. coarse	16" /15 1/2" Temp Casing 0.0
			pebble, 30% v fine, 20% fine, 20% med, 20% coarse, 10% v. coarse	235.4' bgs, 14" / 13 1/4" 235.4-
			20mm avg, 40mm max, poor sort, 65% fel, 35% mof, ang -	447.2' bgs, 8 5/8" drill rod &
			round. Sand: v fine - v. coarse, 30% vf, 30% fine, 20% med, 15%	9 7/8" bit 447.2-457.0' bgs.
275	G		coarse, 5% v.c., poor sort, 70% fel, 30% mof, subang, Wet.	Grab samples collected
			2.5Y 4/4 Olive Brown. Mod rxn HCl	every 5' or change in lithology.
280	G		@280': g=40% s=55% m=5%	
			Gravel: v fine - coarse pebble, 15% vf, 30% fine, 40% med,	
			15% coarse, 10mm avg, 30mm max, mod sort, 60% fel,	
			40% mof, ang. Sand: v fine - coarse, 35% v fine, 30% fine, 30%	
			med, 5% coarse, 65% fel, 35% mof 2.5Y 5/6 light	
285	G		Olive Brown. No rxn HCl	
			@285': max gravel ≈ 35mm	
290	G		~~@290~~ 290': cementation noticed on occasional	
			gravels	
				294.9': Water Sample
295	G WS		@295' g=55% s=40% m=5%	
300	G		@300': max g 40mm, 40% v fine, 30% fine, 20% med,	
			10% coarse, Trace v. coarse pebbles, 50/50 fel/mof	
			ang. - subround. Sand: 20% v fine, 30% fine, 20% med, 30%	
			coarse, 60% fel, 40% mof, ang. No rxn HCl	
305	G		@305' weak rxn HCl	

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 8/20/18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 9 of 12

Date: 7.3.18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Bandary 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
310	G		260-360': Sandy Gravel (SG)	Air Rotary Drilling with
			@310' g=50 s=45% m=Trace. Gravel: vfine-v.coarse	16"/15½" temp casing from
			pebble. 25% vf, 30% fine, 30% med, 15% coarse, Trace v.coarse,	0.0-235.4' bgs, 14"/13¼"
			avg: 10mm max 40mm, poor sort, 50 fel, 50% maf, ang-	235.4-447.2' bgs, 8⅝" drill
			sub rand. Sand: v.fine-v.coarse, 20% vf, 30% fine, 25% med,	rod to 9⅞" bit 447.2-457.0' bgs
315	G		15% coarse, 10% v.coarse, poor sort, 50/50 maf-fel, ang. Wet	Grab samples collected every
			2.5Y 5/6 Olive Brown	5' or change in lithology.
			@315' g=55% s=45% m=5% (Gravel): 20% vfine, 20%	
			fine, 30% med, 20% coarse, 10% v.coarse pebble. Sand: fel	
			↑ 75%, 25% maf.	
320	G		@320': 2.5Y 5/4 Light Olive Brown. max ↑ 60mm	
325	G			
330	G		@330': g=35% s=60% m=5% Gravel: 5% vfine, 10%	
			fine, 30% med, 30% coarse, 15% v.coarse pebble. Sand: 20%	
			v.fine, 30% fine, 40% med, 10% coarse, Trace v.coarse. Mod	
			sorting, subang.	
335	G			336.1': Water Sample
				336.4-338.5': split spoon
	SS			
340	G		@340': g=60% s=40% m=Trace Gravel: 20% v.fine,	
			20% fine, 30% med, 20% coarse, 15% v.coarse. avg 10mm	
			max=40mm, 40% fel, 60% maf, ang-subround. Sand:	
			15% v.fine, 20% fine, 50% med, 10% coarse, 5% v.coarse. 75% fel	
345	G		25% maf. cog. Wet. 2.5Y 5/4 Light Olive Brown.	
			@345': g=60% s=35% m=5%	

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 8/20/18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 7.3.18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary 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
350	G		2160-3160: sandy Gravel (sG)	Air Rotary Drilling with
			@350' g=30% s=65% m=5%. Gravel: v fine to	16"/15 1/2" temp. casing.
			v. coarse pebble + occ. cobble (small) 15% v fine,	0.0-235.4' bgs, 14"/13 1/4"
			15% fine, 20% med, 30% coarse, 20% v. coarse pebble.	235.4-447.2, 8 5/8" drill
			30mm avg, 80mm max, poor sort, 60% fel, 40% mef,	rod + 9 7/8" bit 447.2-457.0
355	G		subround-round. Sand: v. fine-med, trace coarse +	Grab samples collected
			v. coarse, 10% v fine, 20% fine, 70% med. Well sorted,	every 5' or change in
			85% ~~mef~~ fel, 15% mef, sub ang, Wet. 2.5Y 5/4 Light	lithology
			Olive Brown. No rxn HCl.	
			@355': max g 30mm 10YR 4/6 Dark yellowish	
360	G		Brown.	
			360-365: gravelly Sand (gS): g=25% s=70% m=5%.	
			Gravel: v fine-coarse pebble. 20% v fine, 20% fine, 40%	
			med, 20% coarse, 10mm avg, 45mm max, mod sort	
			60% fel, 40% mef, sub-round. Sand: v. fine-med, trace	
365	G		coarse + v. coarse. 30% fine, 10% v fine, 70% med. well	
			sort, 55% fel, sub ang. Wet. No rxn HCl 2.5Y 5/6	
			Light Olive Brown.	
			365-410': sandy Gravel (sG) g=45% s=50% m=5%.	
			Gravel: v. fine-coarse pebble, 20% v fine, 20% fine, 40%	
370	G		med, 20% coarse, 10mm avg. 45mm max, mod sorted,	
			60% fel, 40% mef, subround. Sand: v fine-v. coarse,	
			5% v fine, 10% fine, 25% med, 30% coarse, 30% v. coarse,	
			poor sort, 60% fel, 40% mef, ang, Wet. No rxn HCl.	
			2.5Y 5/6 Light Olive Brown.	
375	G		@370' g=60%, s=35%, m=5%.	
380	G		@380': g=55% s=40% m=5%.	
385	G			

Reported By:

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A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 7.11.18

Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary 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
390	G		365-410': sandy Gravel (sG)	Air Rotary Drilling with
			@ 390' g=60% s=35% m=5% Gravel: v.fine-v.coarse pebble, 10mm avg, 45mm max, 20% v fine,	16"/15½" temporary casing
			20% fine, 30% med, 20% coarse, 10% v.coarse. poor sorted,	0.0-235.4' bgs, 14/13¾"
			35% fel, 65% mof, ang-round Sand: fine-v.coarse,	235.4-447.2' bgs, 8⅝" drill
395	G		Trace fine, 20% med, 30% coarse, 50% v.coarse, Mod sort,	rod 9⅞" bit 447.2-457.0'
			45% fel, 55% mof, ang, Wet, No rxn HCl, 2.5Y 5/6 Light	Grab samples collected
			Olive Brown.	at every 5' or change in
			@ 395': g avg 20mm, 40% fel, 60% mof. Sand: 5% fine,	lithology.
			50% med, 30% coarse, 15% v.coarse	
400	G		@ 400': g=40% s=50% m=10% Gravel: 50/50 fel-mof	
			Sand: 10% v.fine, 20% fine, 30% med, 30% coarse, 10% v.coarse	
			60% fel, 10 YR 5/6 Yellowish Brown	
405	G		@ 405': g=60% s=45% m=5% Gravel: 20% v fine, 30%	
			fine, 30% med, 20% coarse, 30mm max, poor sort, 70% fel	
			30% mof. Sand: 10% v fine, 15% fine, 30% med, 30% coarse, 15% v.	
			coarse. 80% fel, 20% mof. 2.5Y 5/6 Light Olive Brown	
410	G		410-415': gravelly Sand (gS) g=20% s=70% m=10%	
			Gravel: v.fine-coarse pebble, 30% v.fine, 40% fine, 20%	
			med, 10% coarse. 4mm avg, 30mm max, Mod sorted,	
			60% fel, 40% mof, ang. Sand: v fine-coarse, 20% v fine, 20%	
			fine, 40% med, 20% coarse, Mod, 75% fel, 25% mof, ang,	
415	G		Wet, 2.5Y 5/6 Light Olive Brown	415.9': water sample
			415-420 (Sampling): sandy Gravel (sG) g=70% s=25% m=5%	
	WS		Gravel: v fine-v.coarse pebble, 20% v.fine, 20% fine, 30%	
	SS		med, 20% coarse, 10% v.coarse, 10mm avg, 50mm max, poor	417.1-419.6: split spoon
			sorted, 50/50 fel-mof, ang-subround, Sand: v fine-v.coarse,	
420	G		10% v.fine, 20% fine, 20% med, 30% coarse, 20% v.coarse, poor	
			sorted, 65% fel, 35% mof, ang-subang. Wet. 2.5Y 5/6	
			Light Olive Brown.	
			420-425': gravelly Sand (gS) g=25% s=75% m=Trace	
			Gravel: v fine-v.coarse pebble. 40% vf, 40% fine, 10% med, 10% coarse	
425	G		2mm avg. 30mm max, Mod sort, 70% fel, 30% mof, ang. Sand:	
			v fine-v.coarse, 10% vf, 15% fine, 20% med, 25% coarse, 30% v.coarse,	
			poor sort, 65% fel, 35% mof, ang. Wet No rxn HCl, 2.5Y	
			5/6 Light Olive Brown.	
			425-440': sandy Gravel (sG) g=40% s=60% m=Trace	

Reported By:

Tracy Mellgren — Print Name | Geologist — Title | Signature | 8/20/18 — Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 12 of 12

Date: 7.23.18

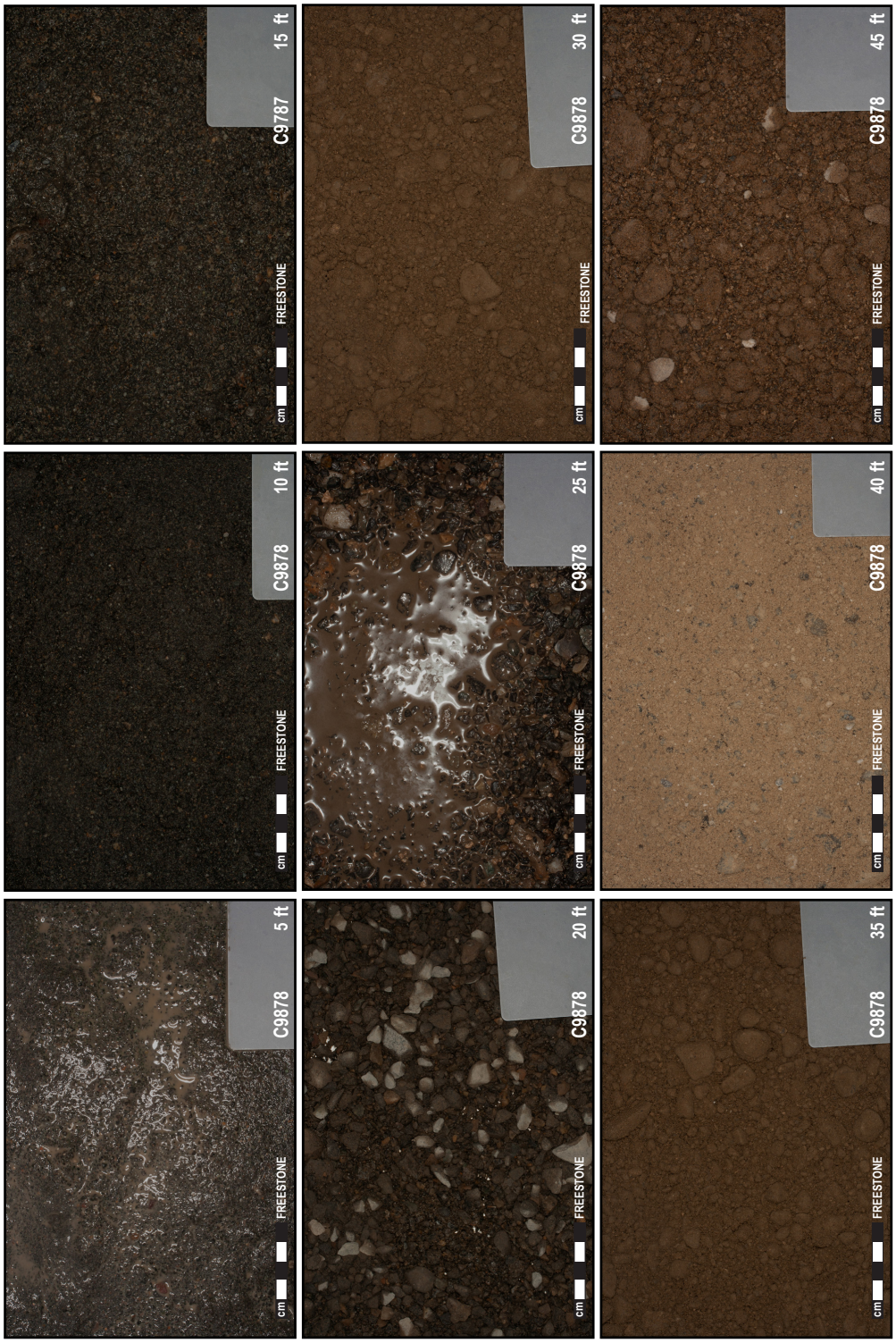
Well ID: C9878 | Well Name: 699-47-78 | Location: East Boundary of 200W-33

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
430	G		425-440': sandy Gravel (sG) g=40 s=60 m=Trace. Gravel: v. fine - v. coarse pebble, 15% v.fine, 30% fine, 30% med, 20% coarse, 5% v.coarse, 4mm avg, 40mm max poor sort, 60% fel, 40% maf, ang to round. Sand: v.fine - v.coarse, trace v.fine, 20% fine, 30% med, 30% coarse, 40% v. coarse, poor sort, 65% fel, 35% maf, sub ang, Wet, No rxn HCl, 2.5Y 5/6 Light Olive Brown.	Air Rotary Drilling with 16" / 15 1/2" Temporary casing 0.0-235.4' bgs, 14" / 13 3/4" 235.4-447.2' bgs, 8 5/8" shell and 9 7/8" bit 447.2-457.0' bgs Grab samples every 5' or change in lithology.
435	G WS 1 SS 1		@430' max gt 30mm 70% fel	
			@435' max gt 25mm avg 10mm	
				435.8': water sample
440			440-445': silty Gravel (mG) g=30 s=30 m=40%. Gravel: v. fine - coarse pebble, max 20mm avg 4mm ang, sub ang. Mod sort. Sand: v. fine - v. coarse. 60% v. fine 30% fine, 10% med, Trace coarse v. coarse. Wet. 2.5Y 5/6 Light Olive Brown v. weak rxn HCl	436-438.5': split spoon
445			Up to 40mm clay, Med dry strength	
			445-447: Silt (M) g=5% s=15% m=80% Gravel: v. fine to med. pebbles. Max 8mm. Sand: v fine - fine. Clay avg. 10mm nodules, max 40mm ang. with med dry strength. Weak rxn HCl 2.5Y 5/6 Light Olive Brown	
450			447-457.0' silty sandy Gravel (msG) g=50% s=30% m=20% Gravel: v fine - coarse pebble 8mm avg 20mm max, mod sort. 60% fel, ~~30~~ 40% maf, sub ang. Sand: v fine - med. 80% v fine - fine. 30% fel, 70% maf. Wet 2.5Y 5/6 Light Olive Brown. Weak rxn. rxn HCl	
455				
460				
465				

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | (Signature) | 8/20/15 (Date)

A-6006-993 (REV 0)



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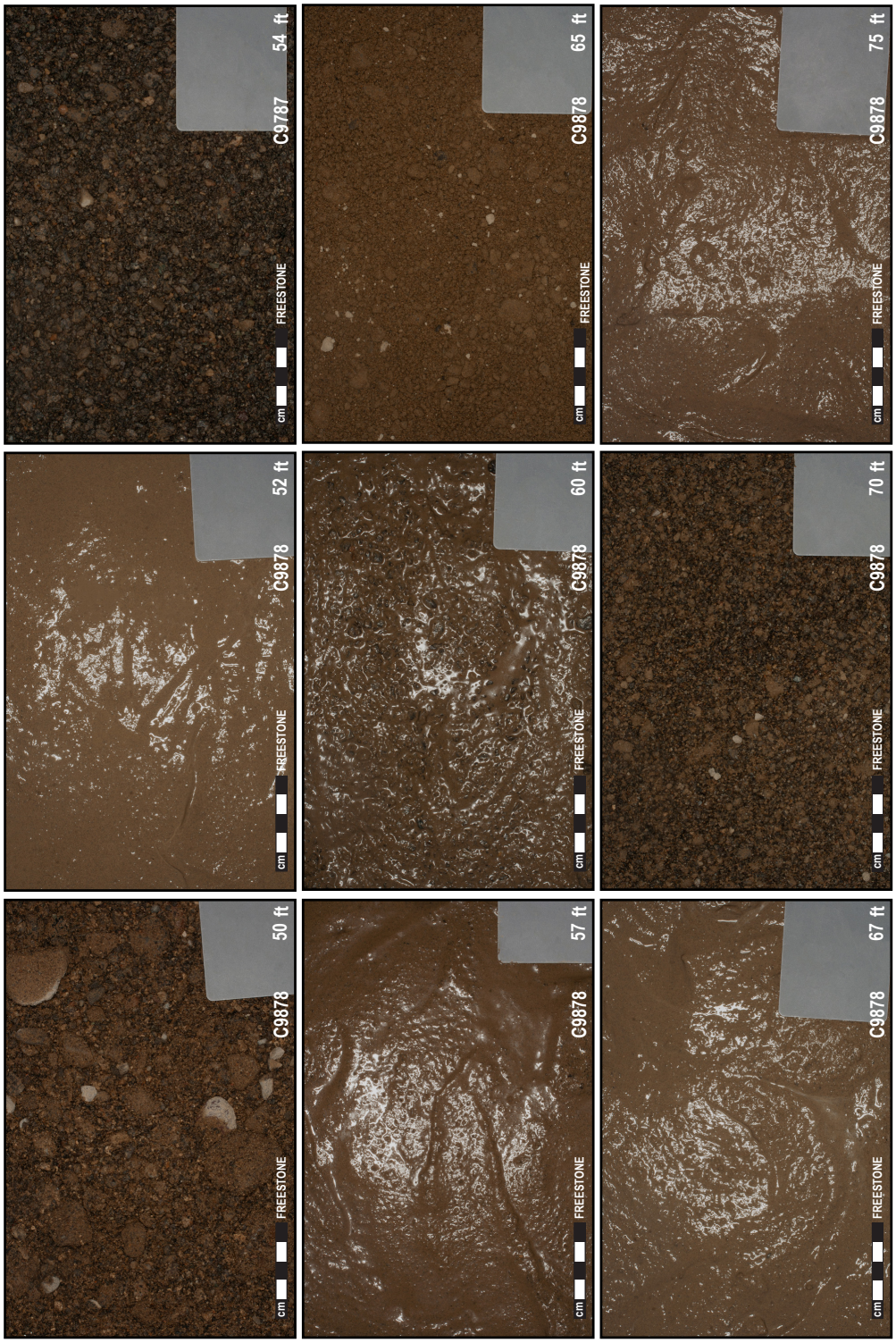
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9878 (699-47-78)



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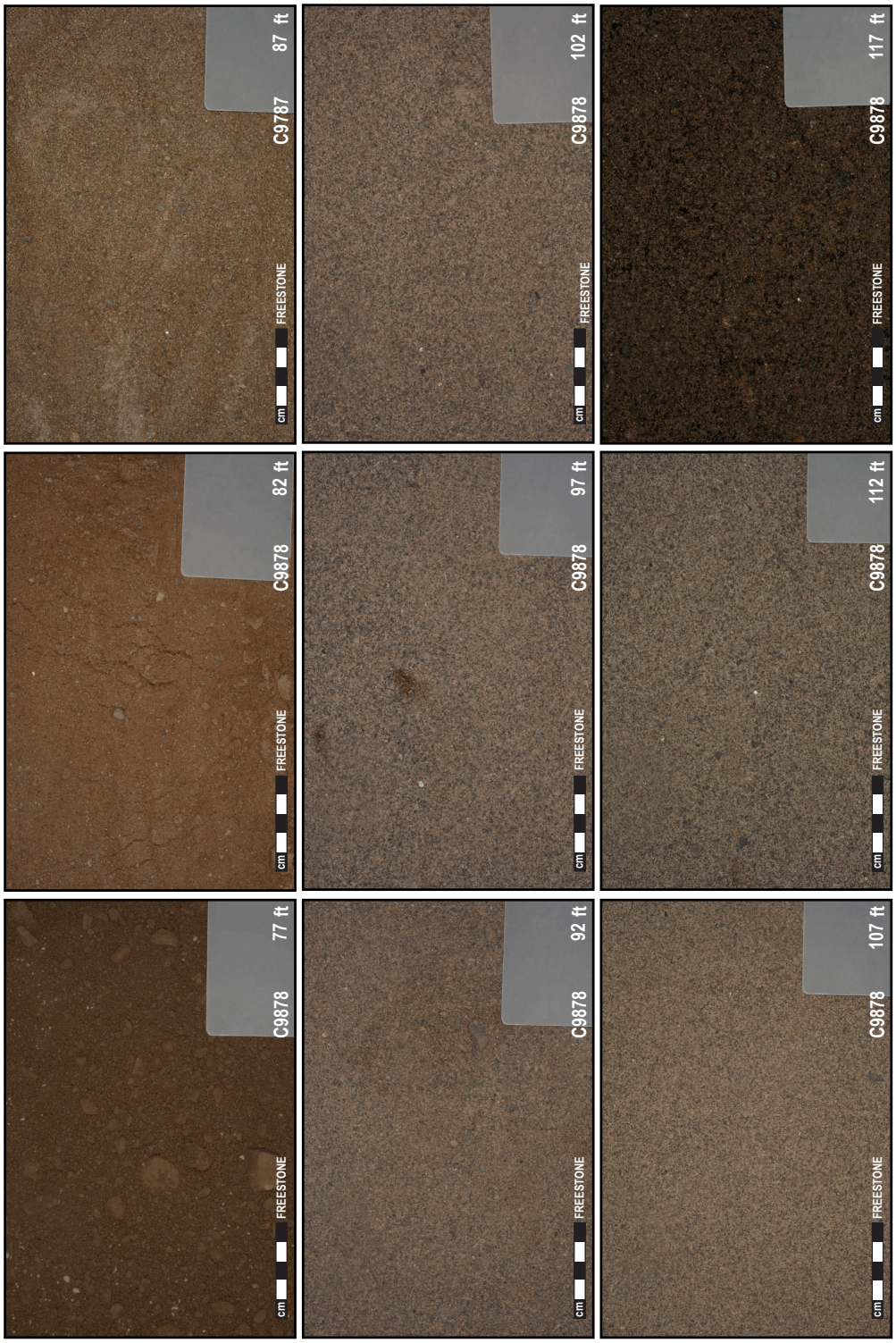

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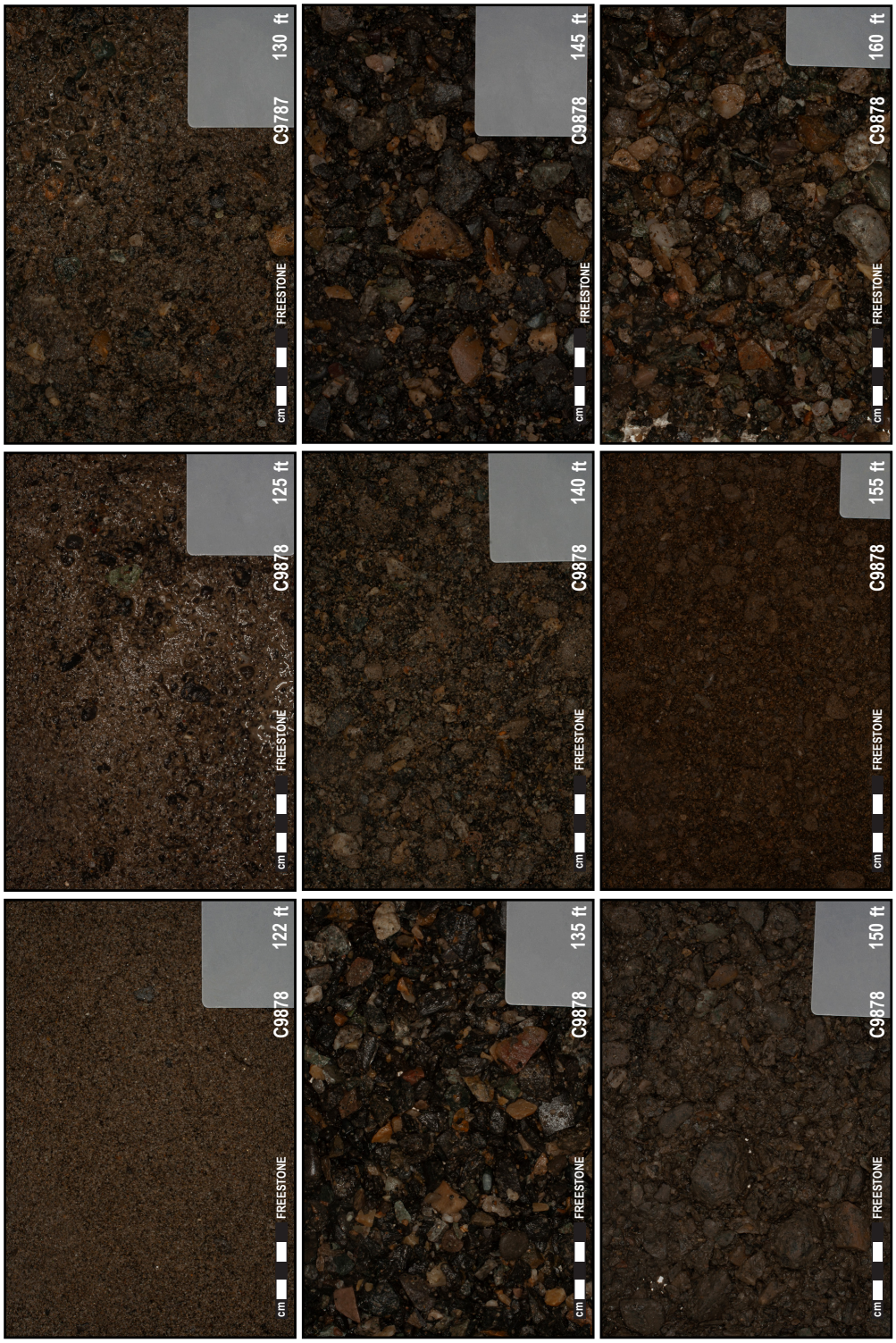

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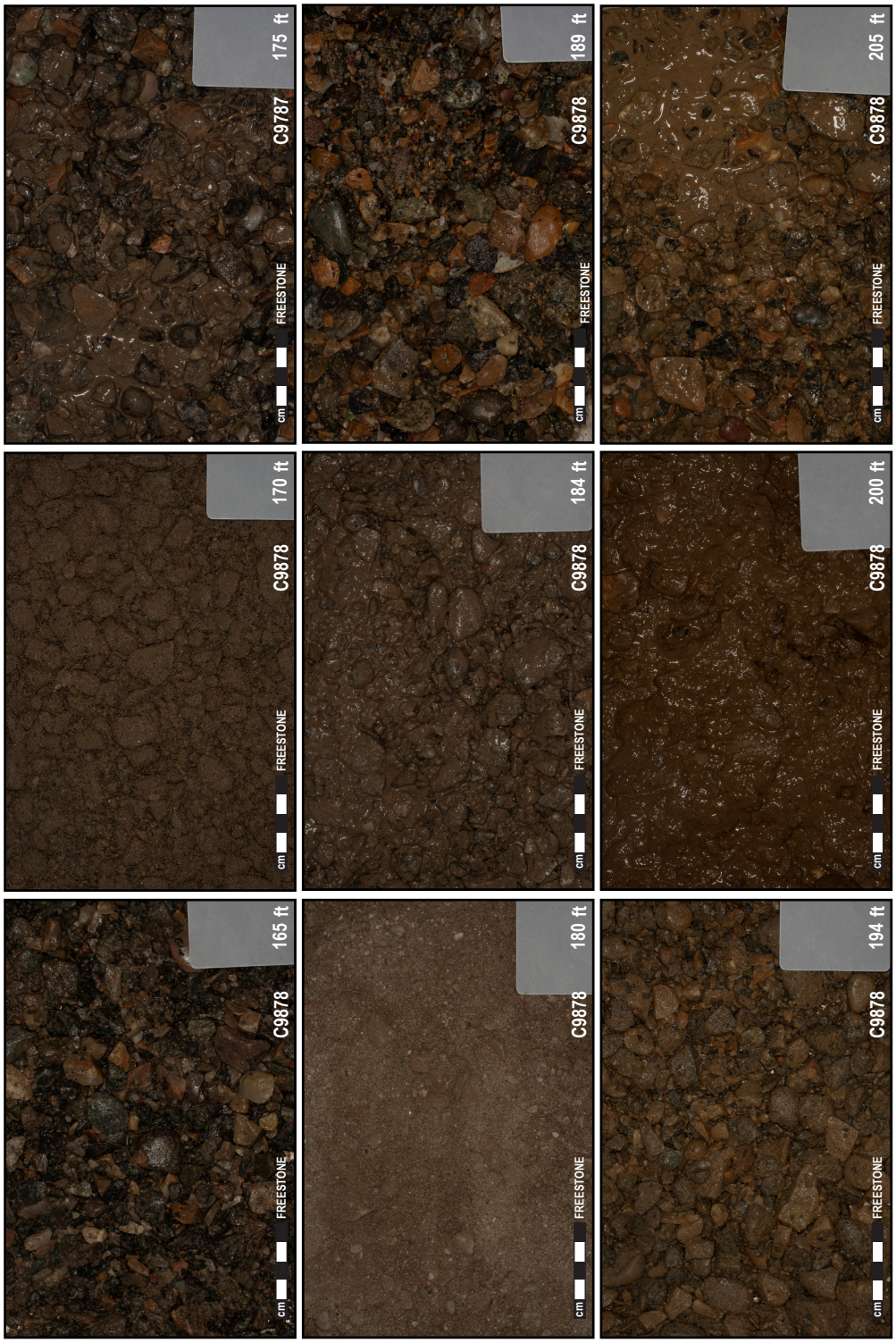
Drill Cutting Photographs for C9878 (699-47-78)



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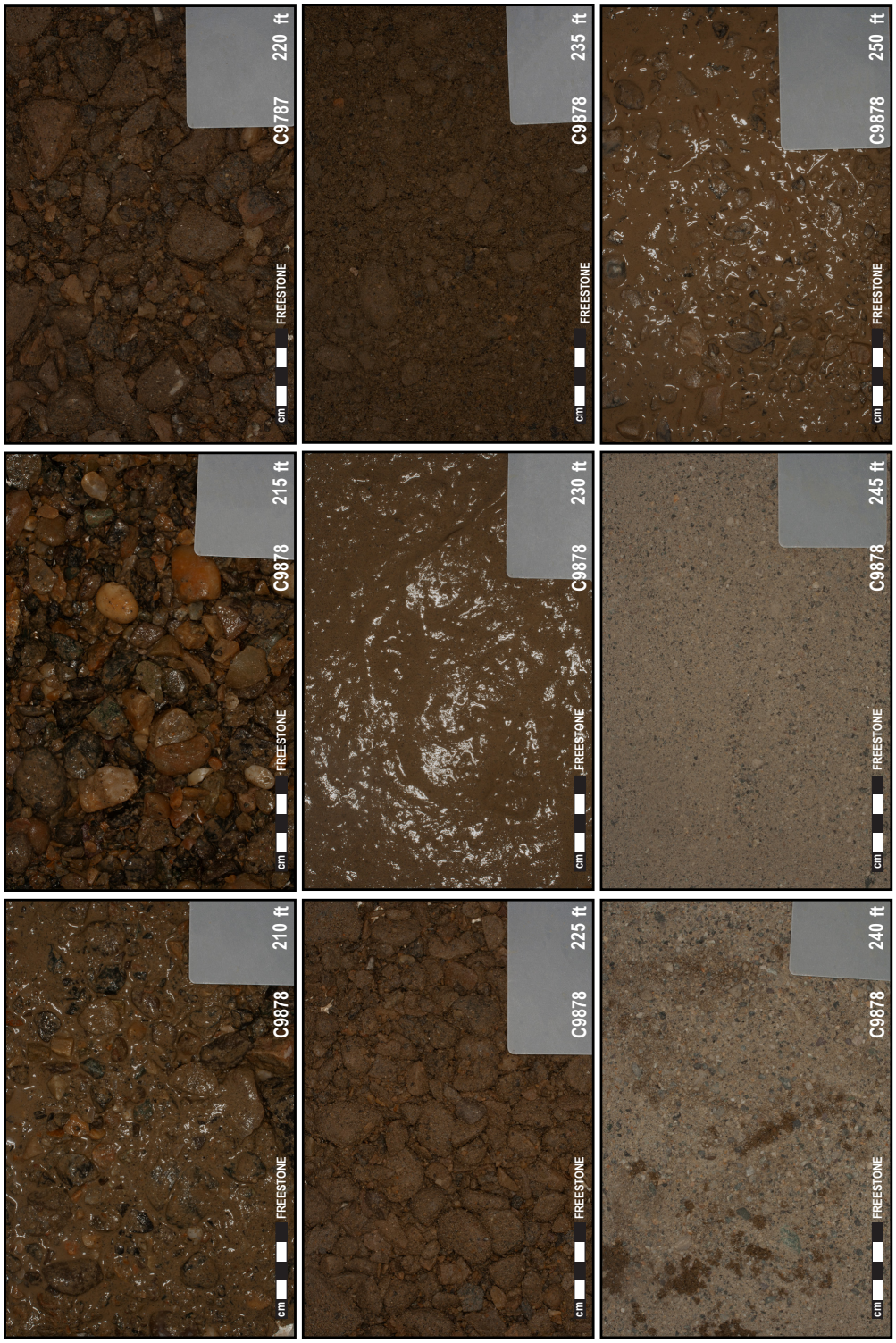

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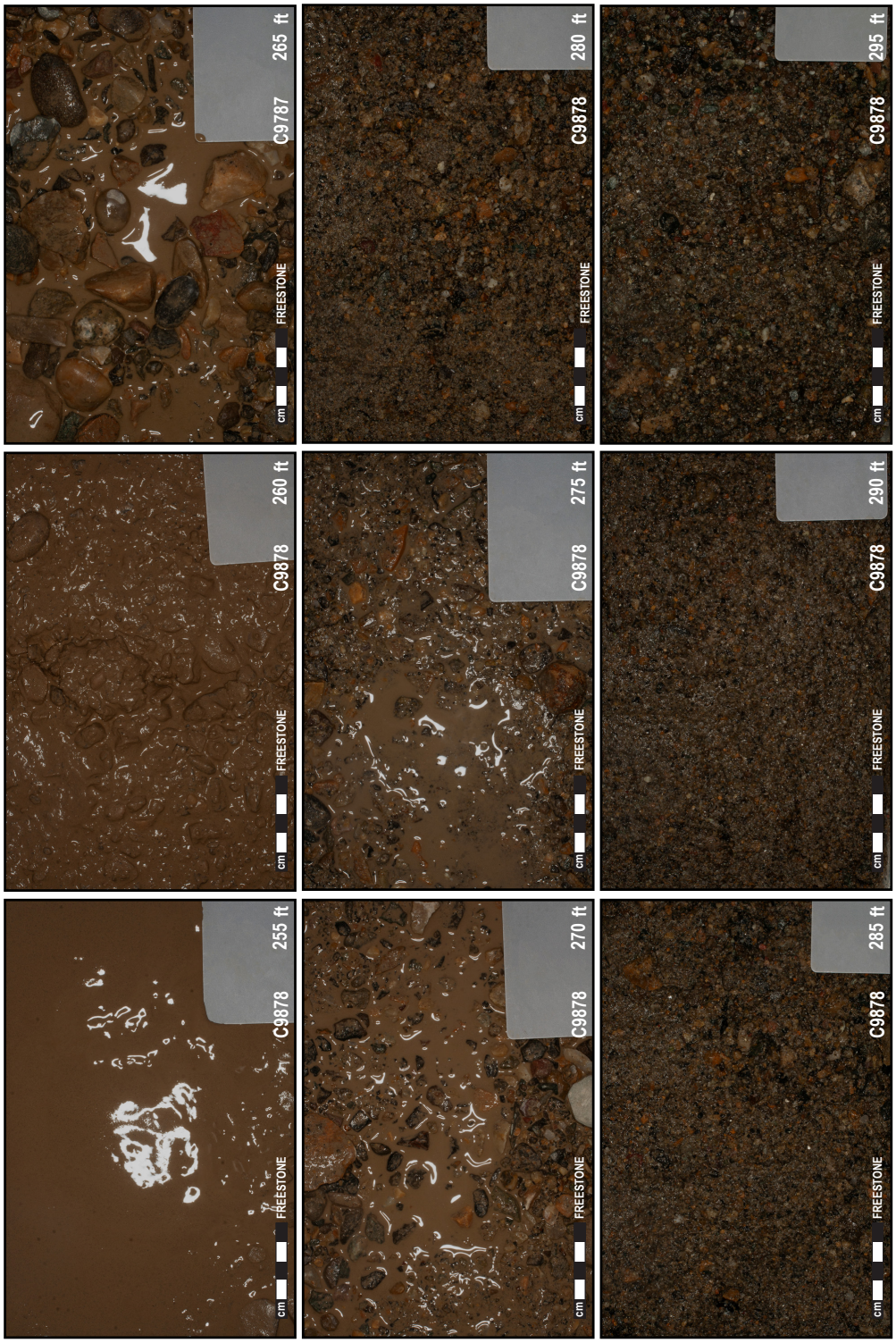

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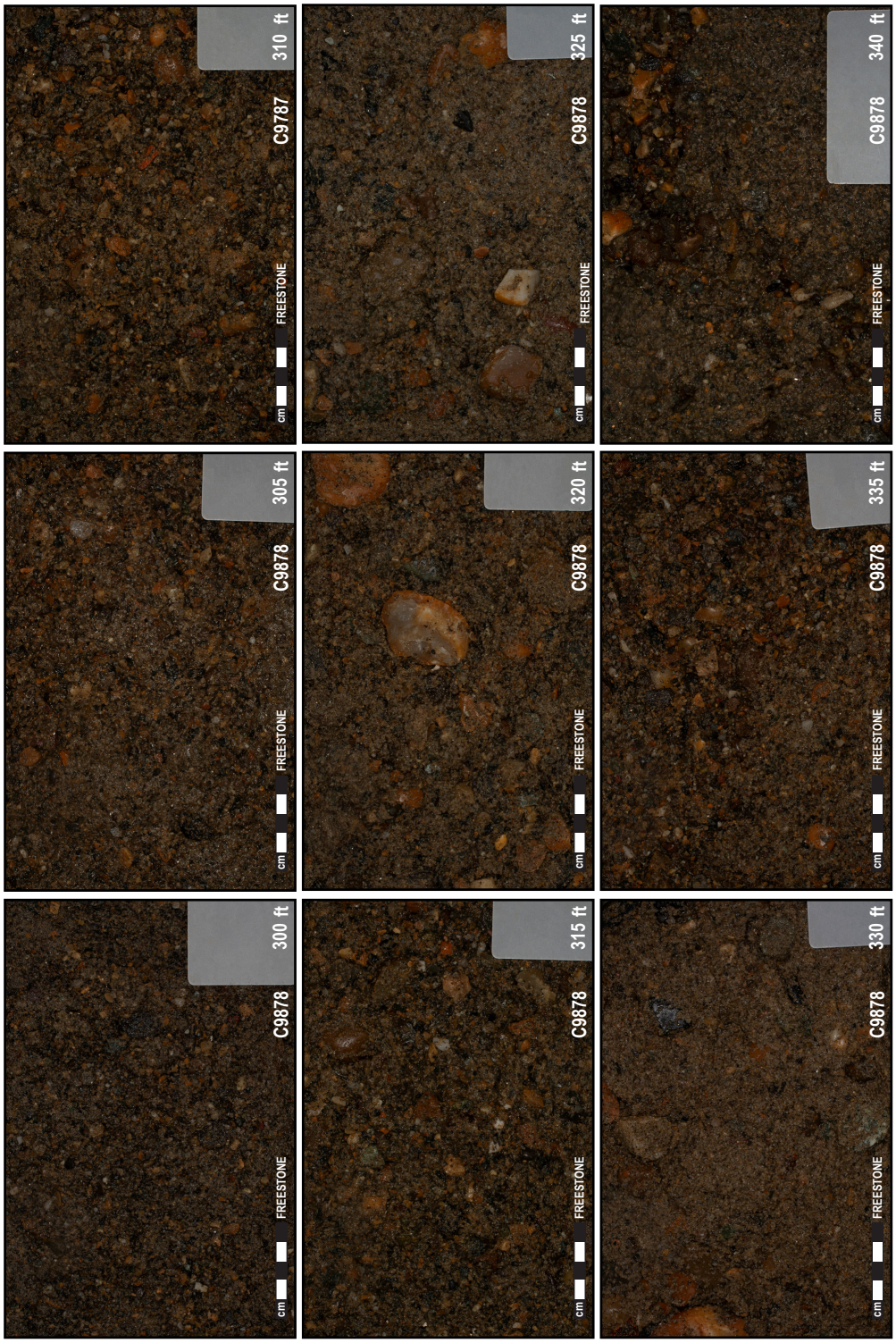

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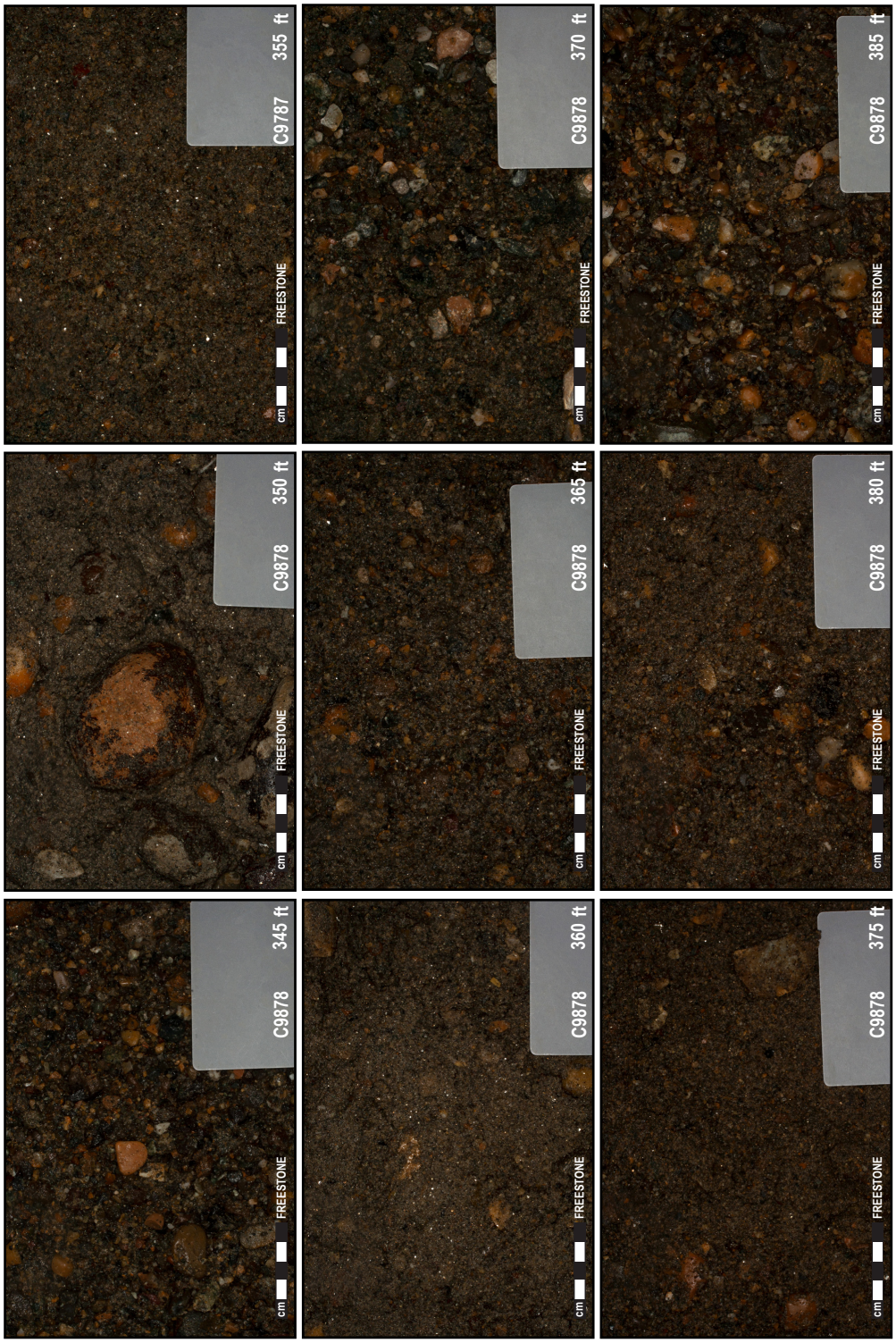

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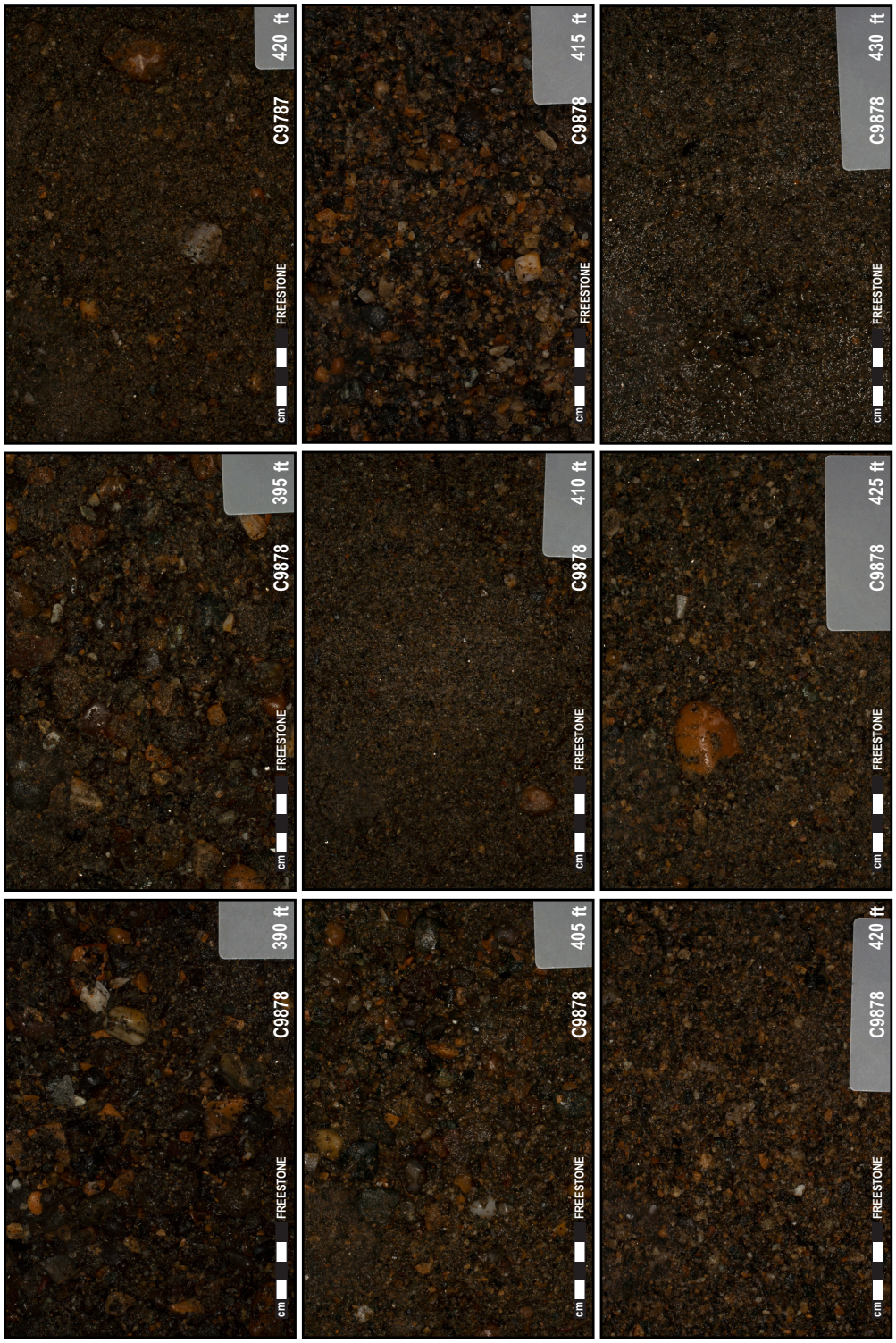

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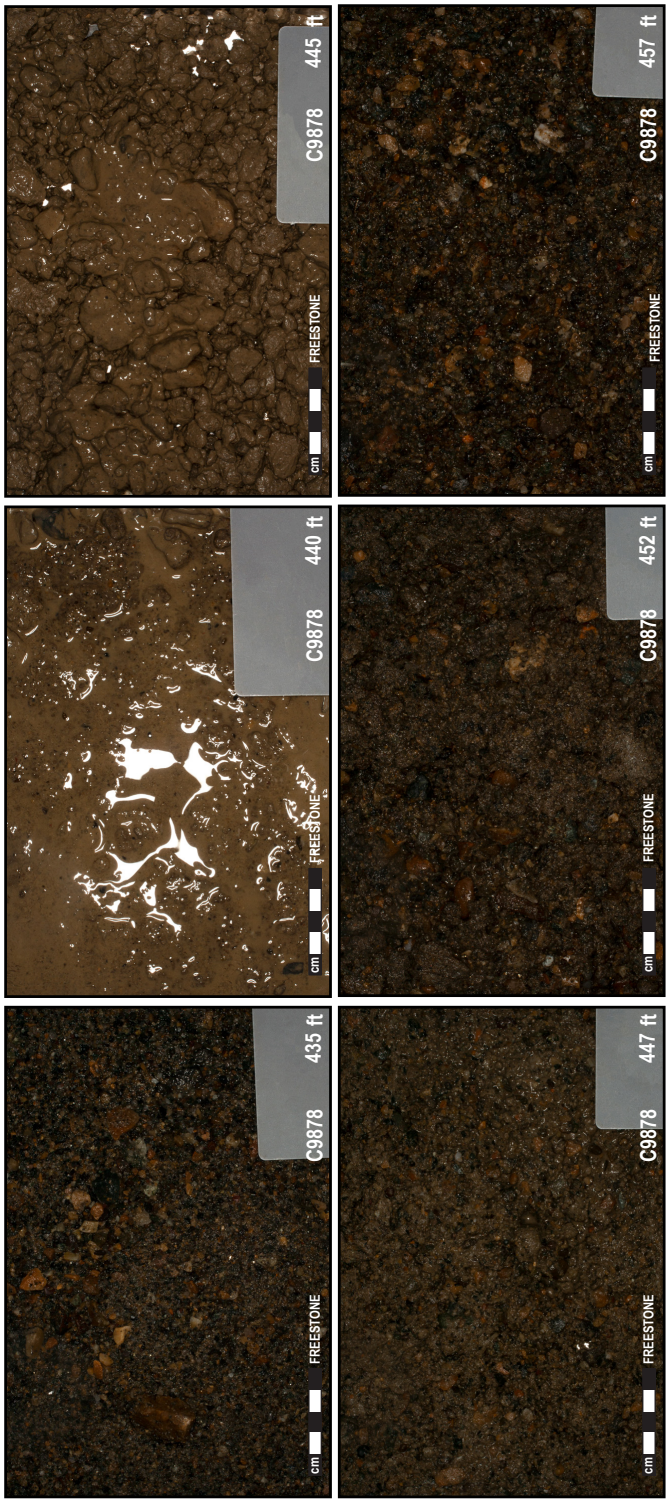
Drill Cutting Photographs for C9878 (699-47-78)



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Drill Cutting Photographs for C9878 (699-47-78)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9878 | Well Name: C99-47-78 | Date: 8.28.18

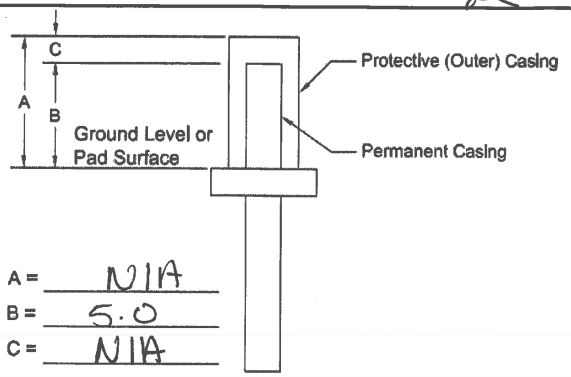
Location: East Boundary of 200-W-33

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: 8.28.18	240.7'bgs	240.6'bgs
Date: 8.29.18	240.4'bgs	240.9'bgs
DEPTH TO BOTTOM:		
Date: 8.28.18	440.0'bgs	439.9'bgs
Date: 8.29.18	439.9'bgs	439.9'bgs



A = N/A
B = 5.0
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)
381.64	13.0	376.6	333	2.90	1415	1510	70	5.37
339.54	15.6	334.5	21.0	2.35	0656	0733	80	5.14
297.34	16.0	292.3	17.3	1.83	0810	0849	80	4.99
255.14	16.3	250.1	18.5	2.02	0926	0957	80	4.9
255.14	N/A	250.1	8.0	3.0	1031	1111	80	N/A
276.24	11.9	271.2	N/A	N/A	1145	1212	~~27~~ 237	19.96
Total Pumped: 23,431 gal				and-b	1247 - 1253		237	19.96

Pump Model: Grundfos OF2305400-11

Troll Serial Number and Pressure Range (PSI and depth): 546780 210m/692ft Vented

Comments:
C9878_develop-int#1_8-28-18
C9878_develop_int#2_8-29-18
C9878_develop_int#3_8-29-18
C9878_develop_int#4_8-29-18
C9878 Stresstest_8-29-18
C9878_Stresstest2_8-29-18

Prepared By:
Tracy Mallgren (Print Name) — Signature — 8.29.18 (Date)

Reviewed By:
Jennifer Richart (Print Name) — Signature — 9/17/18 (Date)

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6005-205 (REV 2)

Huntington Ingalls Industries

Technical Solutions

699-47-78 (C9878)
Log Data Report

Borehole Information

Log Date	2018-07-18	Filename	C9878_HG-NM_2018-07-18	Site	200-ZP-1

DTW[1] (ft)	DTW Date	DTW Source	Drill Date	Total Depth (ft)	Depth Datum
242.6	07/18/18	HII	07/18/18	447.15	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	1.2	16	15.26	0.370	-1.2	235.4
Welded Steel	Dual Rotary	5.3	14	13.26	0.370	-5.3	448.96

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up and casing diameters. The maximum logging depth achieved was 446 ft. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 5TB	**Type**	60% Coaxial HPGe (SGLS)
Effective Calibration Date	11/28/2017	**Serial No.**	54-TP-13441B
Calibration Reference	HGLP-CC-167, 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	11/14/2017	**Serial No.**	H34055445
Calibration Reference	HGLP-CC-164, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

Logging System	Gamma 1LD	**Type**	60% Coaxial HPGe (SGLS)
Effective Calibration Date	10/19/2017	**Serial No.**	47-TP-32211A
Calibration Reference	HGLP-CC-166, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 1HD	**Type**	He-3 (CPN 503DR) NMLS
Effective Calibration Date	10/16/2017	**Serial No.**	H310700352
Calibration Reference	HGLP-CC-161, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

[1] depth to water inside casing

Huntington Ingalls Industries

Technical Solutions

SGLS Log Run Information

Log Run	1	2 Repeat	5	6 Repeat	
HEIS Number	1020213	1020214	1020215	1020216	
Date	06/21/18	06/21/18	07/18/18	07/18/18	
Logging Engineer	Spatz/McClellan	Spatz	Spatz	Spatz	
Start Depth (ft)	0.0	27.0	233.0	424.0	
Finish Depth (ft)	234.01	50.0	446.01	446.01	
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	C9878FTB20180621AV00CAB1	C9878FTB20180621AV00CAB1	C9878ALD20180718AV00CAB1	C9878ALD20180718AV00CAB1	
Start File	AD000000	BD002700	AD023300	BD042400	
Finish File	AD023401	BD005000	AD044601	BD044601	
Post-Verification	C9878FTB20180621BV00CAA1	C9878FTB20180621BV00CAA1	C9878ALD20180718BV00CAA1	C9878ALD20180718BV00CAA1	
Depth Return Error (in.)	N/A	1.0 high	N/A	2.0 low	
Comments	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	

NMLS Log Run Information

Log Run	3	4 Repeat	7	8 Repeat	
HEIS Number	1020217	1020218	1020219	1020220	
Date	06/22/18	06/22/18	07/18/18	07/18/18	
Logging Engineer	Felt	Felt	Spatz	Spatz	
Start Depth (ft)	0.0	190.0	234.0	238.0	
Finish Depth (ft)	235.02	213.0	243.5	243.0	
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	C9878FPB20180622AV00CAB1	C9878FPB20180622AV00CAB1	C9878AHD20180718AV00CAB1	C9878AHD20180718AV00CAB1	
Start File	AD000000	BD019000	AD023400	BD023800	
Finish File	AD023502	BD021300	AD024350	BD024300	
Post-Verification	C9878FPB20180622BV00CAA1	C9878FPB20180622BV00CAA1	C9878AHD20180718BV00CAA1	C9878AHD20180718BV00CAA1	
Depth Return Error (in.)	N/A	3.0 high	N/A	1.0 low	
Comments	None	None	None	None	

Logging Operation Notes

A centralizer was not installed on the sondes for the first casing to 235 ft. A centralizer was installed for the remainder of the borehole.

Analysis Notes

Analyst	P.D. Henwood	**Date**	07/25/18
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

Casing corrections for a 0.370-in. thick casing were applied to the SGLS log data for the entire borehole.

A water correction was applied below 242.6 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 FTB20171128 and ALD20171019 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

An interpreted data set was created for this borehole. Depth overlaps from consecutive log runs were removed from 233 and 234 ft. This results in a data set where only one data point is presented for each depth.

Neutron moisture data are reported in counts per second (cps) as there is no calibration available to convert to volumetric moisture for the large diameter casings.

HGU[2] 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 generally detected in this borehole. Cs-137 was detected at the ground surface at 0.8 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 may increase in sediments of relatively high silt or clay content.

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

List of Log Plots

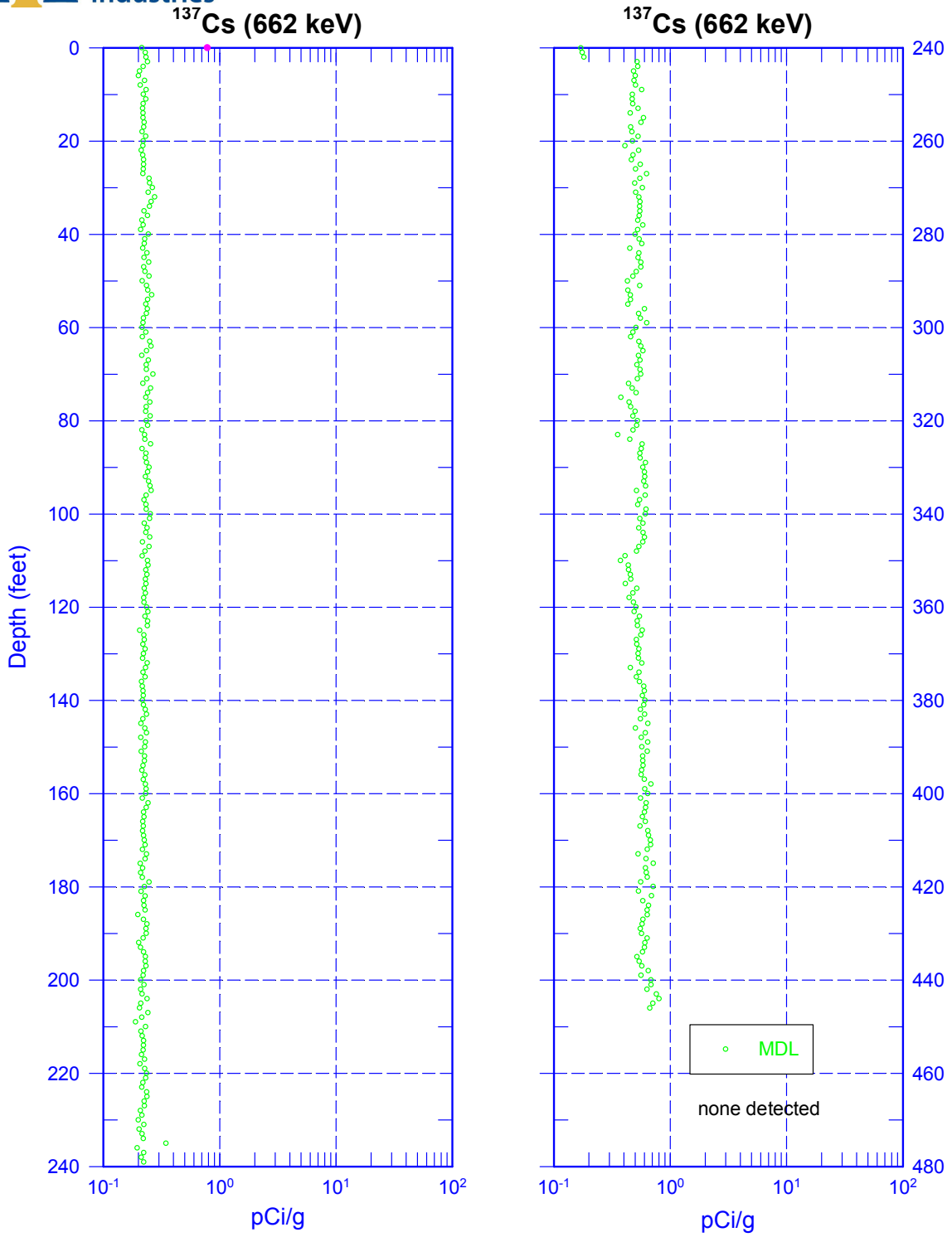
Depth Reference is ground surface.

Manmade Radionuclides (0-480 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (150-310 ft)
Natural Gamma Logs (310-470 ft)
Combination Plot (0-120 ft)
Combination Plot (110-230 ft)
Combination Plot (230-350 ft)
Combination Plot (350-470 ft)
Combination Plot (0-460 ft)
Total Gamma & Moisture (0-160 ft)

[2] Hanford Gamma Unit

Total Gamma & Moisture (150-310 ft)
Total Gamma & Hanford Gamma Unit (0-480 ft)
Repeat Section of Natural Gamma Logs (27-50 ft)
Repeat Section of Natural Gamma Logs (424-446 ft)
Moisture Repeat Section (190-213 ft)
Moisture Repeat Section (238-243 ft)

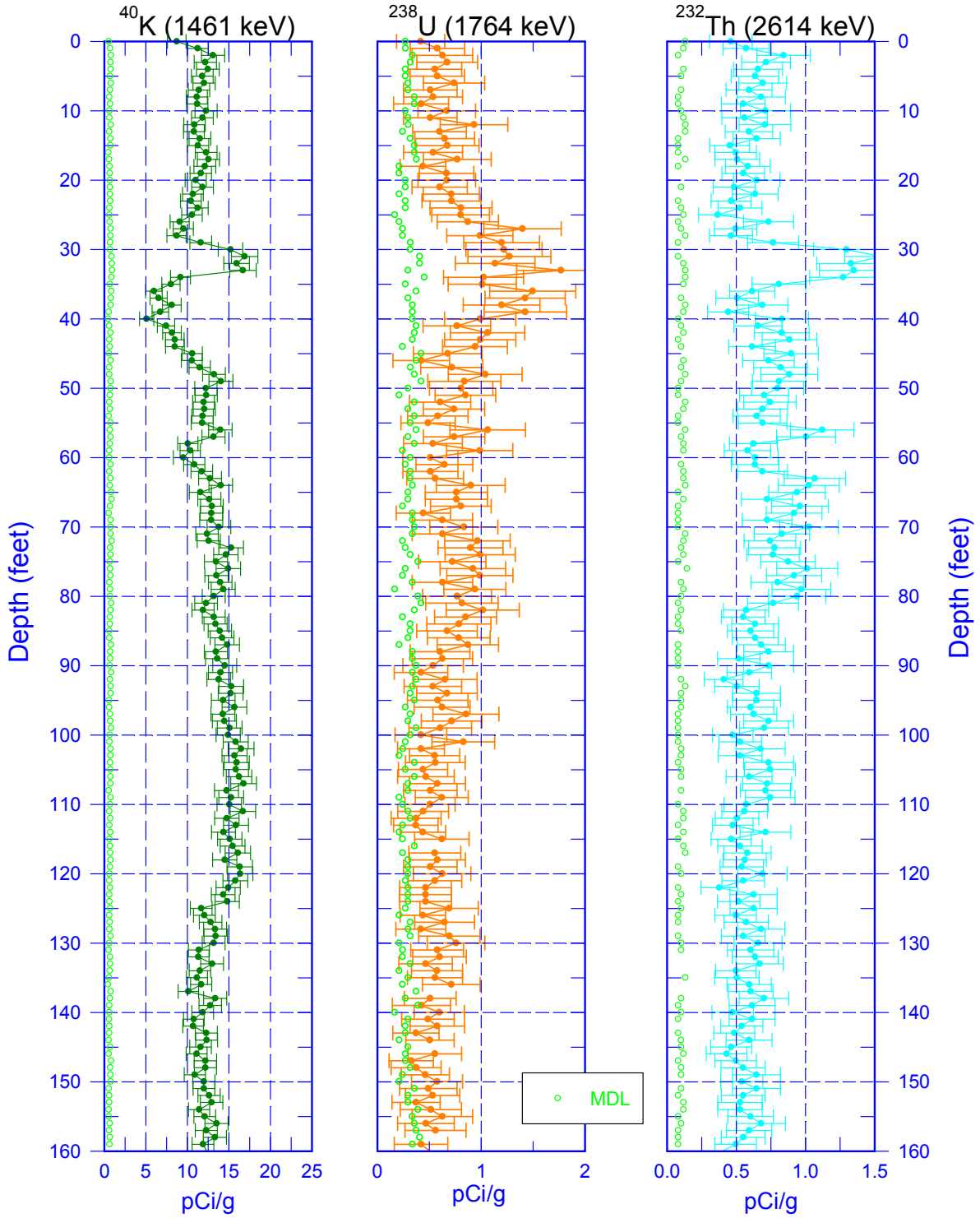
699-47-78 (C9878)
Manmade Radionuclides



Zero Reference - Ground Surface

Huntington Ingalls Industries

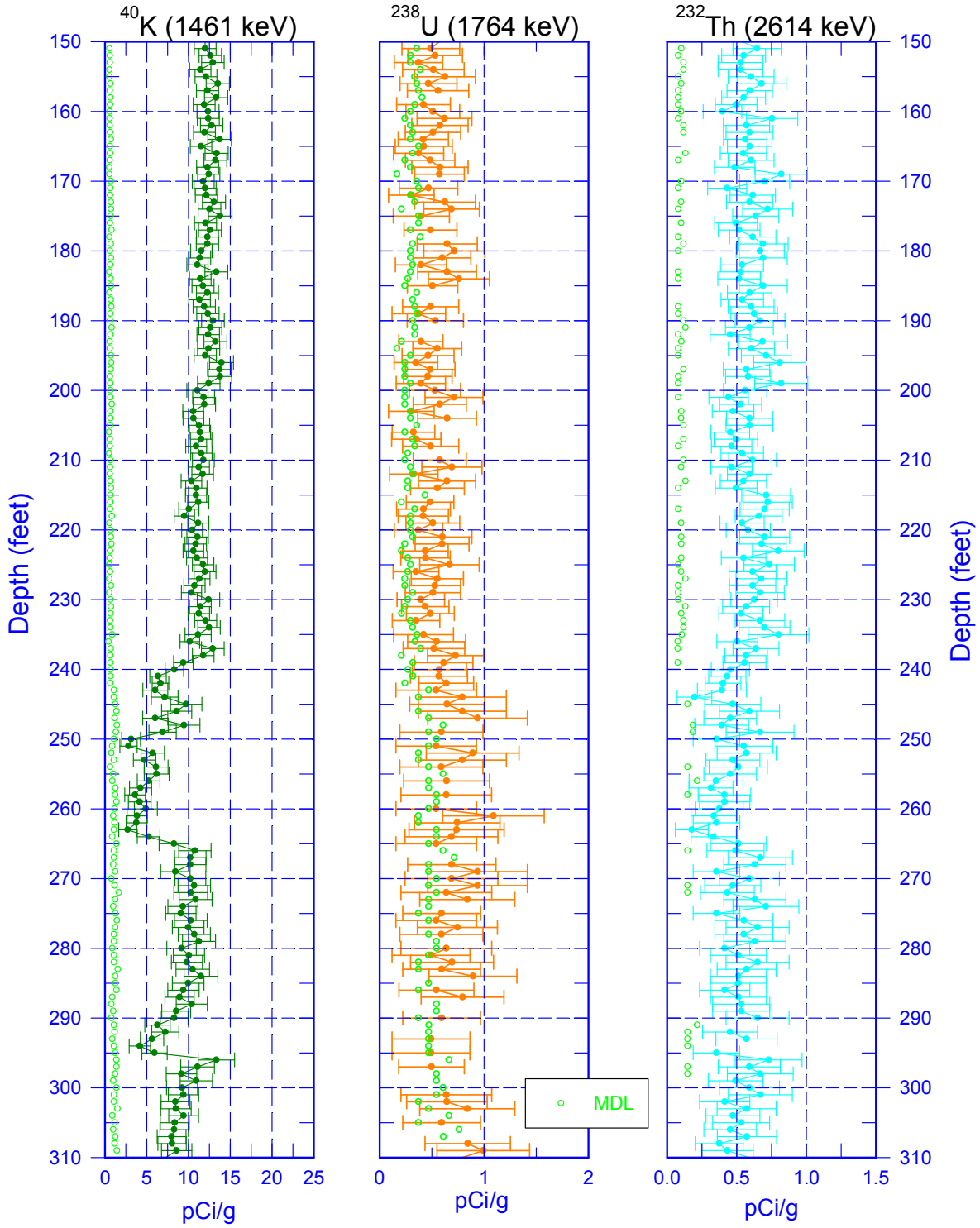
699-47-78 (C9878)
Natural Gamma Logs



Zero Reference - Ground Surface

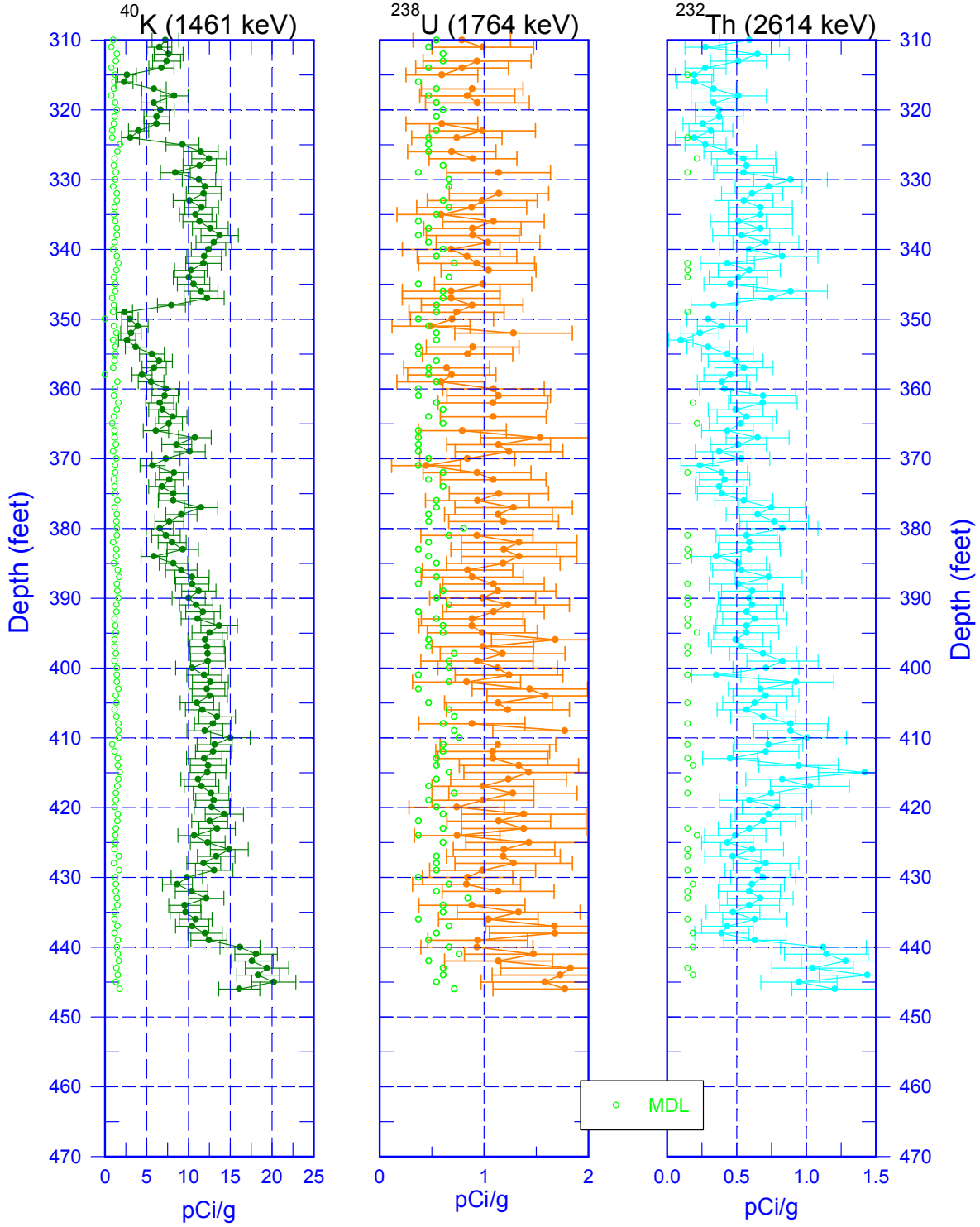
Huntington Ingalls Industries

699-47-78 (C9878)
Natural Gamma Logs

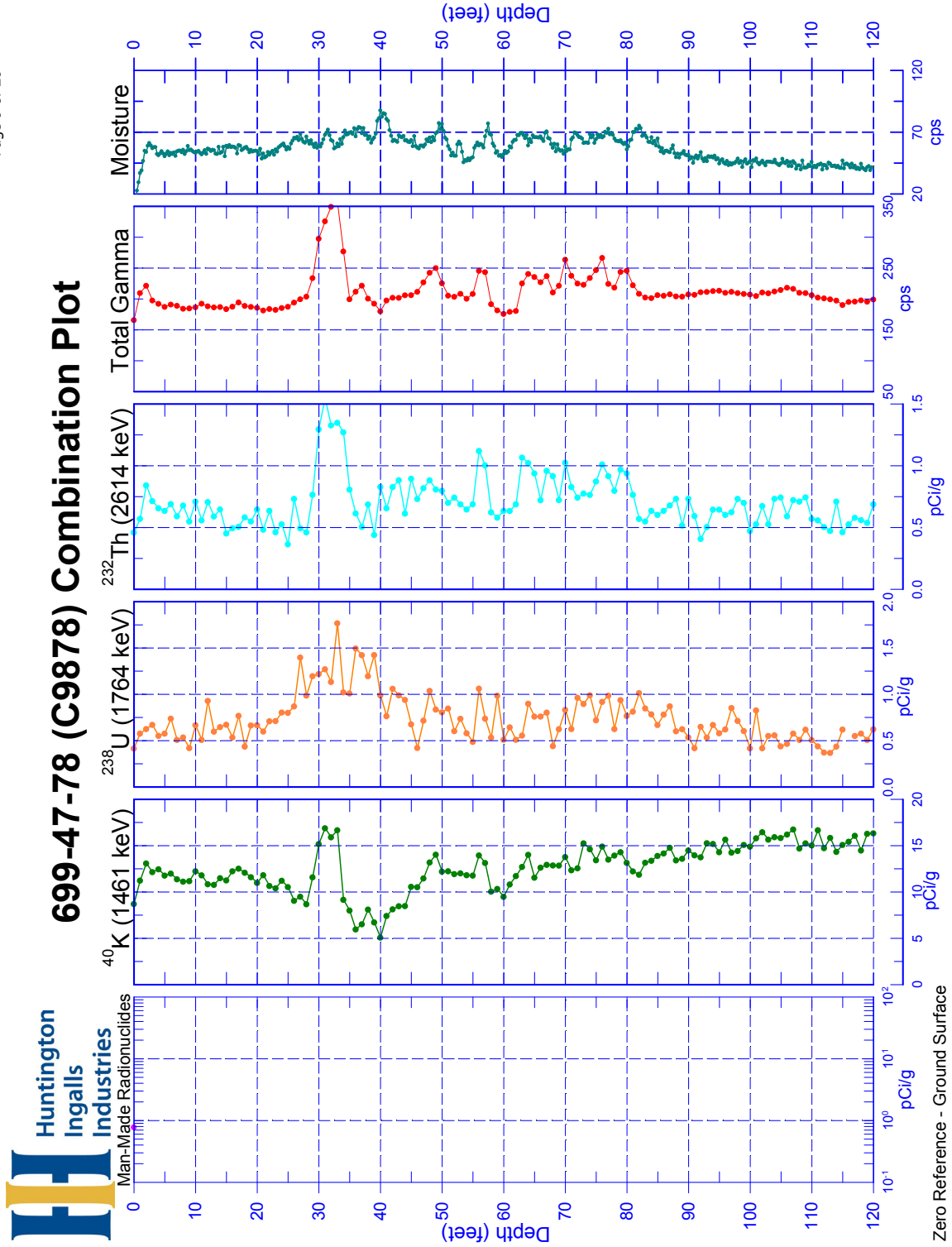


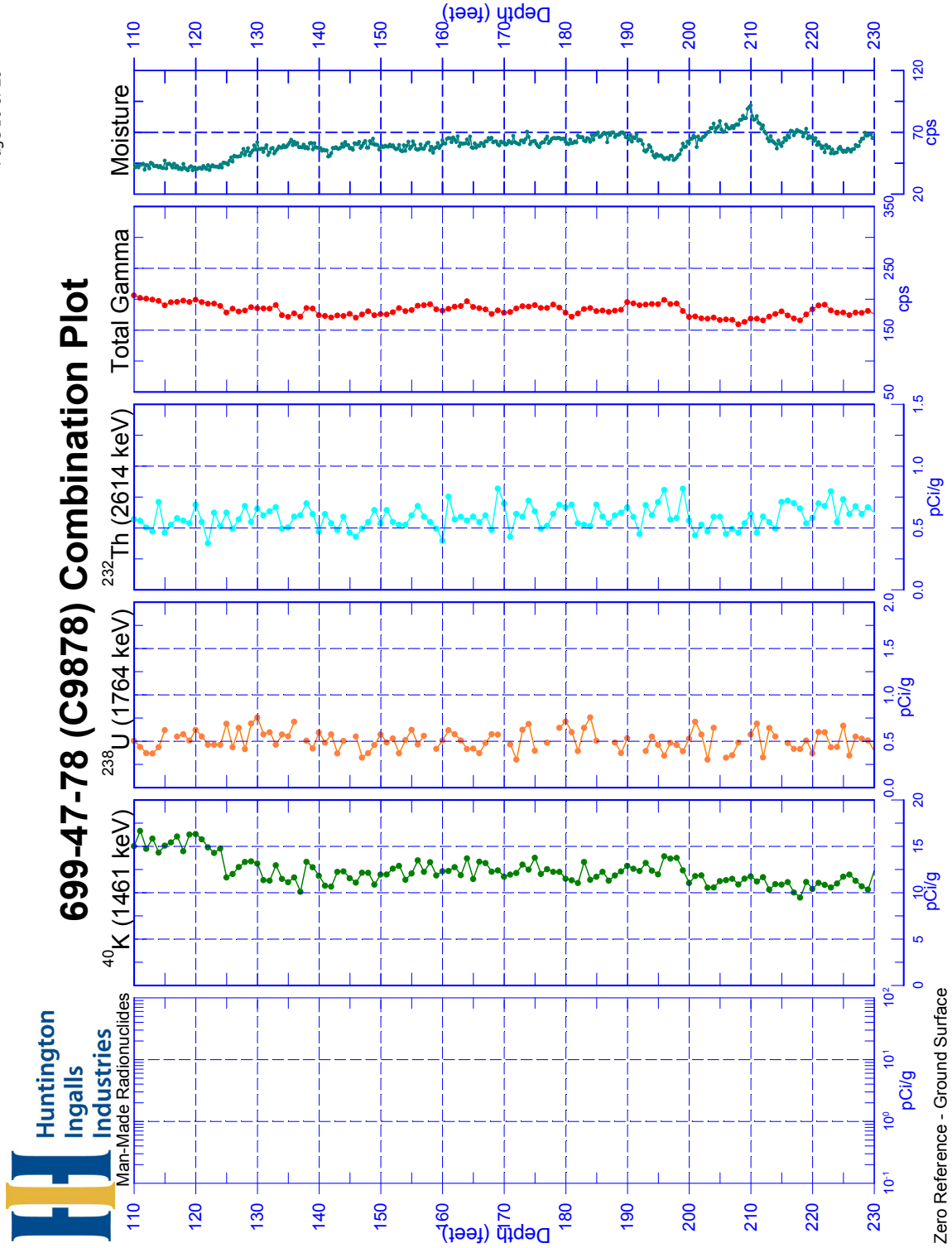
Zero Reference - Ground Surface

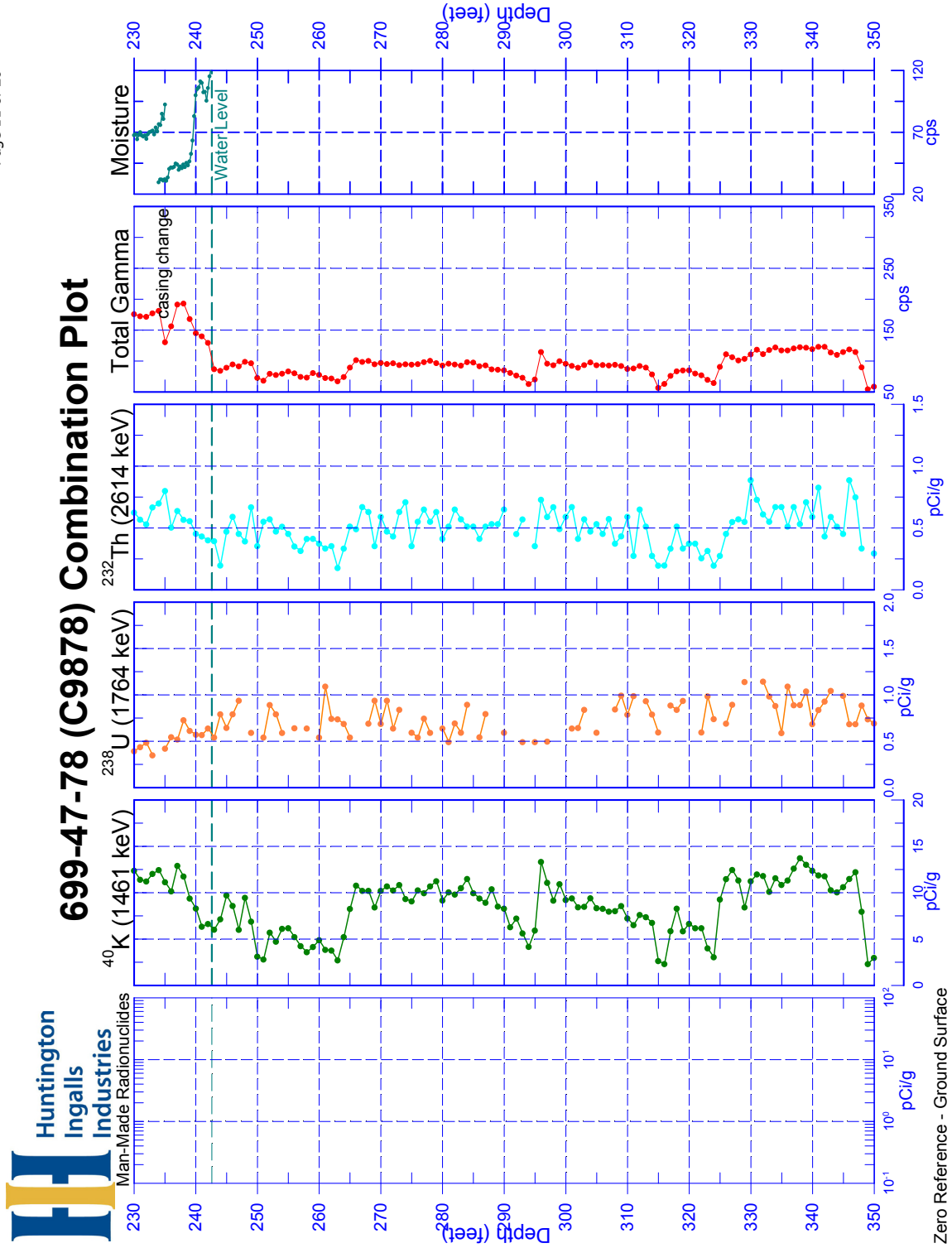
699-47-78 (C9878)
Natural Gamma Logs

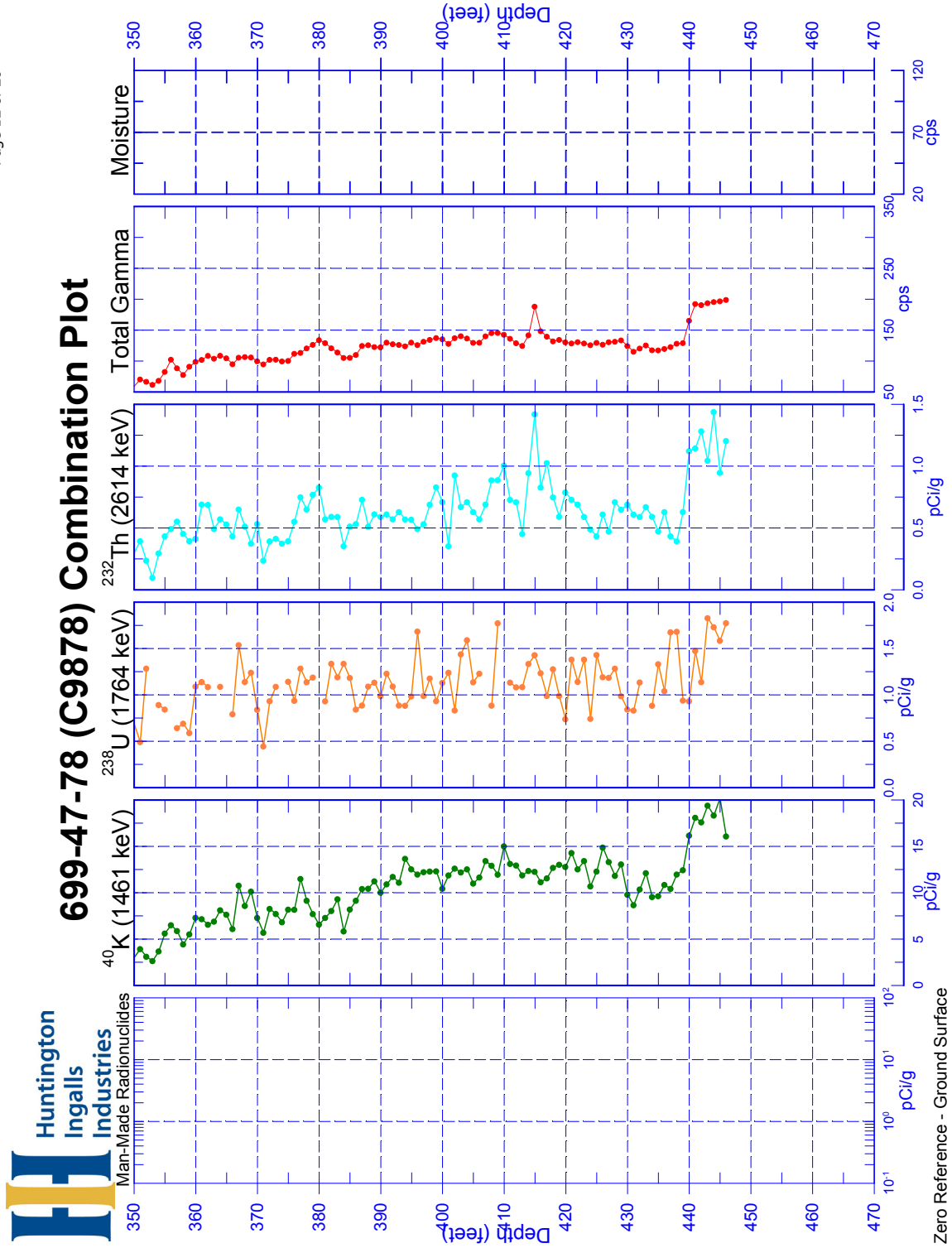


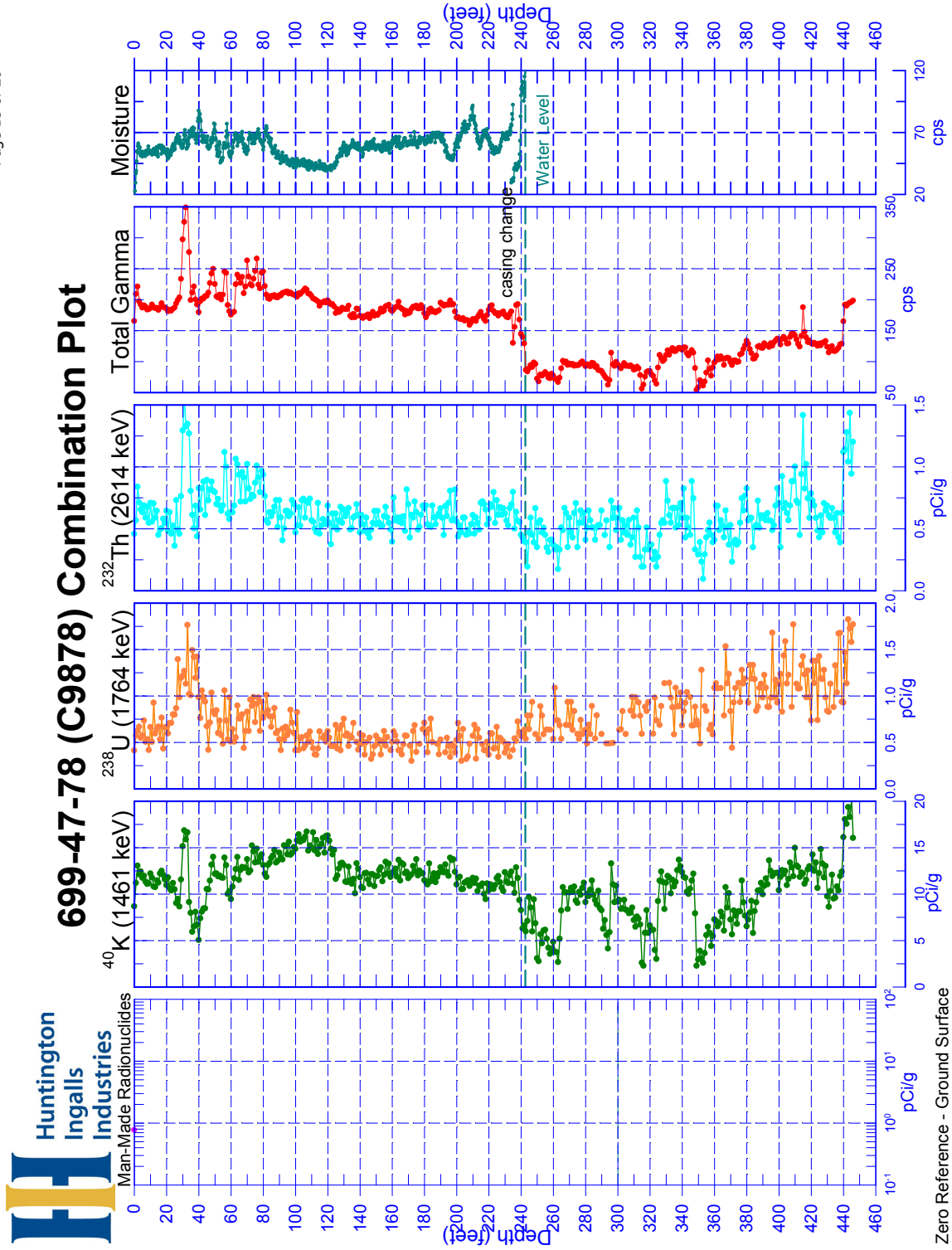
Zero Reference - Ground Surface


Huntington Ingalls Industries
699-47-78 (C9878) Combination Plot
Man-Made Radionuclides
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Moisture
pCi/g
cps
Depth (feet)
Zero Reference - Ground Surface


699-47-78 (C9878) Combination Plot
Huntington Ingalls Industries
Man-Made Radionuclides
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Moisture
Depth (feet)
pCi/g
cps
Zero Reference - Ground Surface

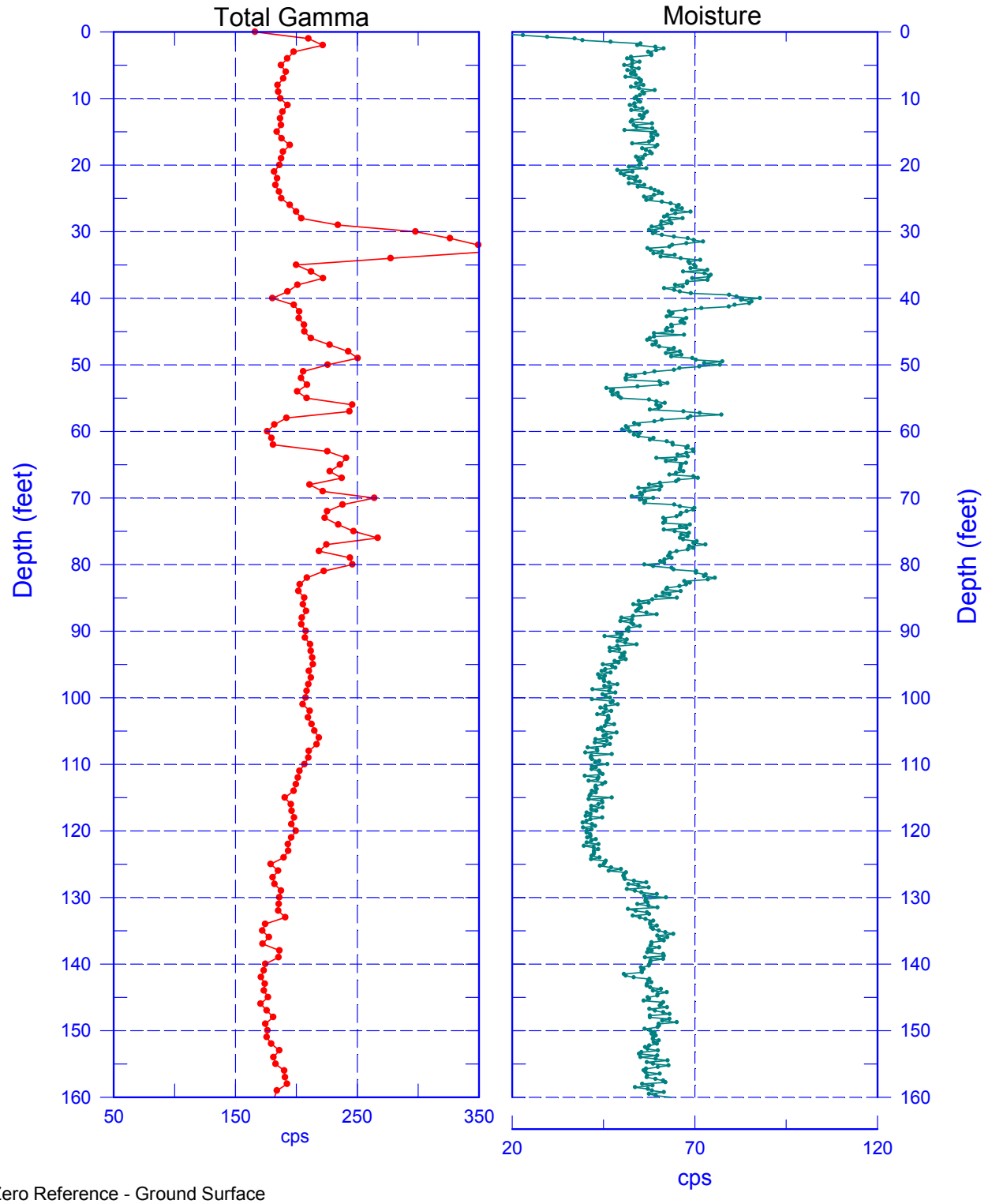

699-47-78 (C9878) Combination Plot
Huntington Ingalls Industries
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Moisture
Casing change
Water Level
pCi/g
cps
Depth (feet)
Zero Reference - Ground Surface


Huntington Ingalls Industries
699-47-78 (C9878) Combination Plot
Man-Made Radionuclides
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Moisture
pCi/g
cps
Depth (feet)
Zero Reference - Ground Surface


Huntington Ingalls Industries
699-47-78 (C9878) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Moisture
casing change
Water Level
Depth (feet)
pCi/g
cps
Zero Reference - Ground Surface

Huntington Ingalls Industries

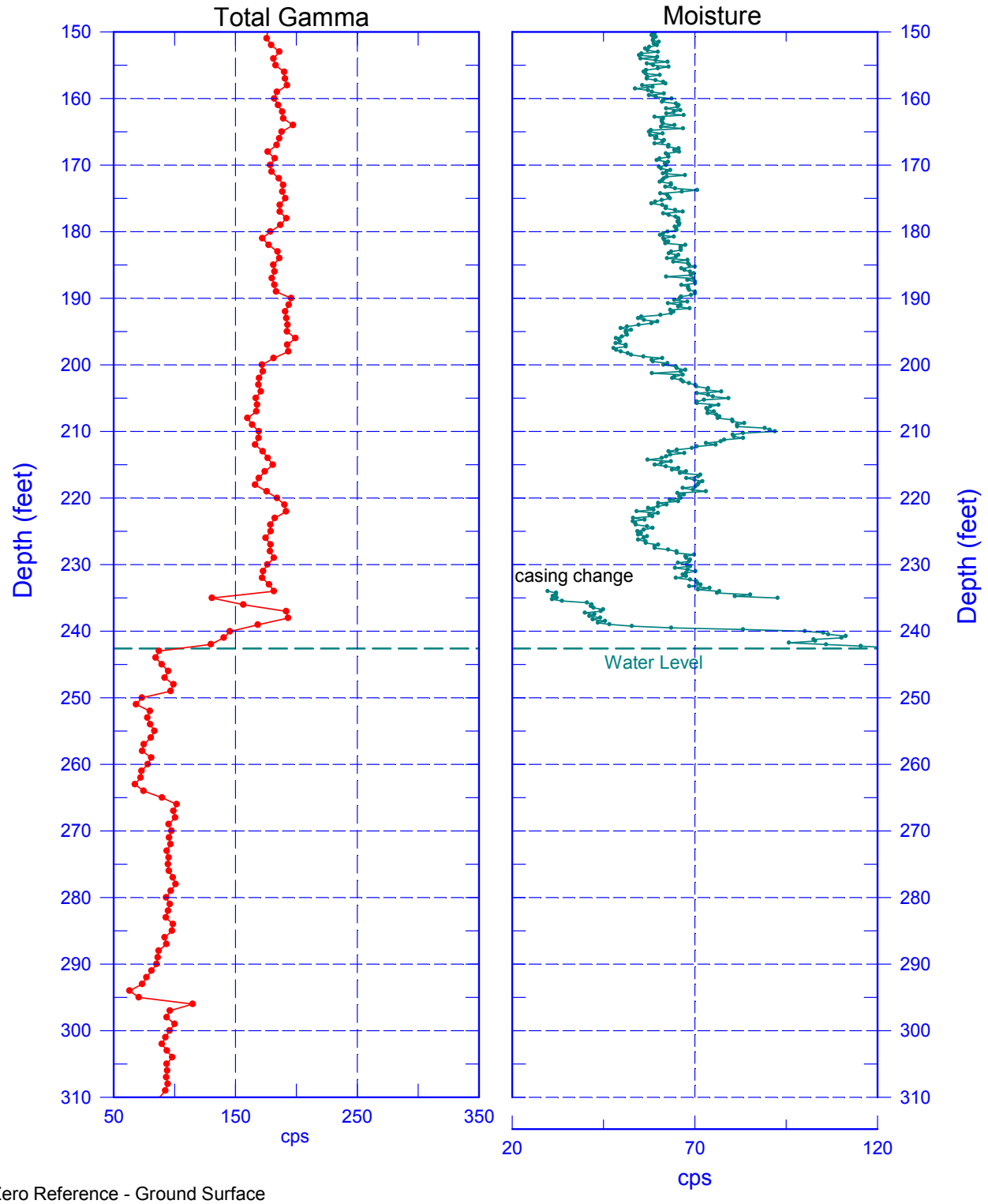
699-47-78 (C9878)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

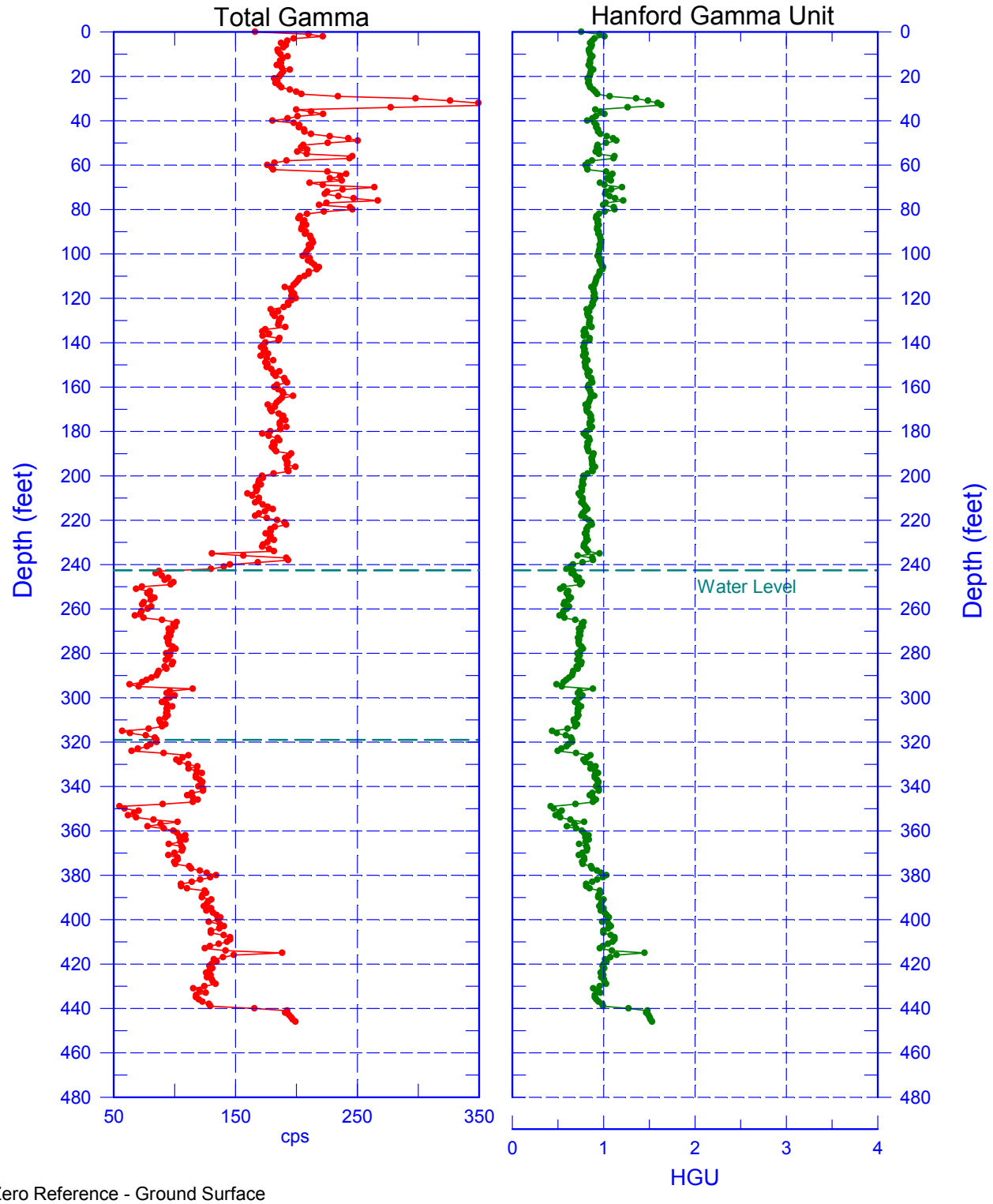
699-347-78 (C9878)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

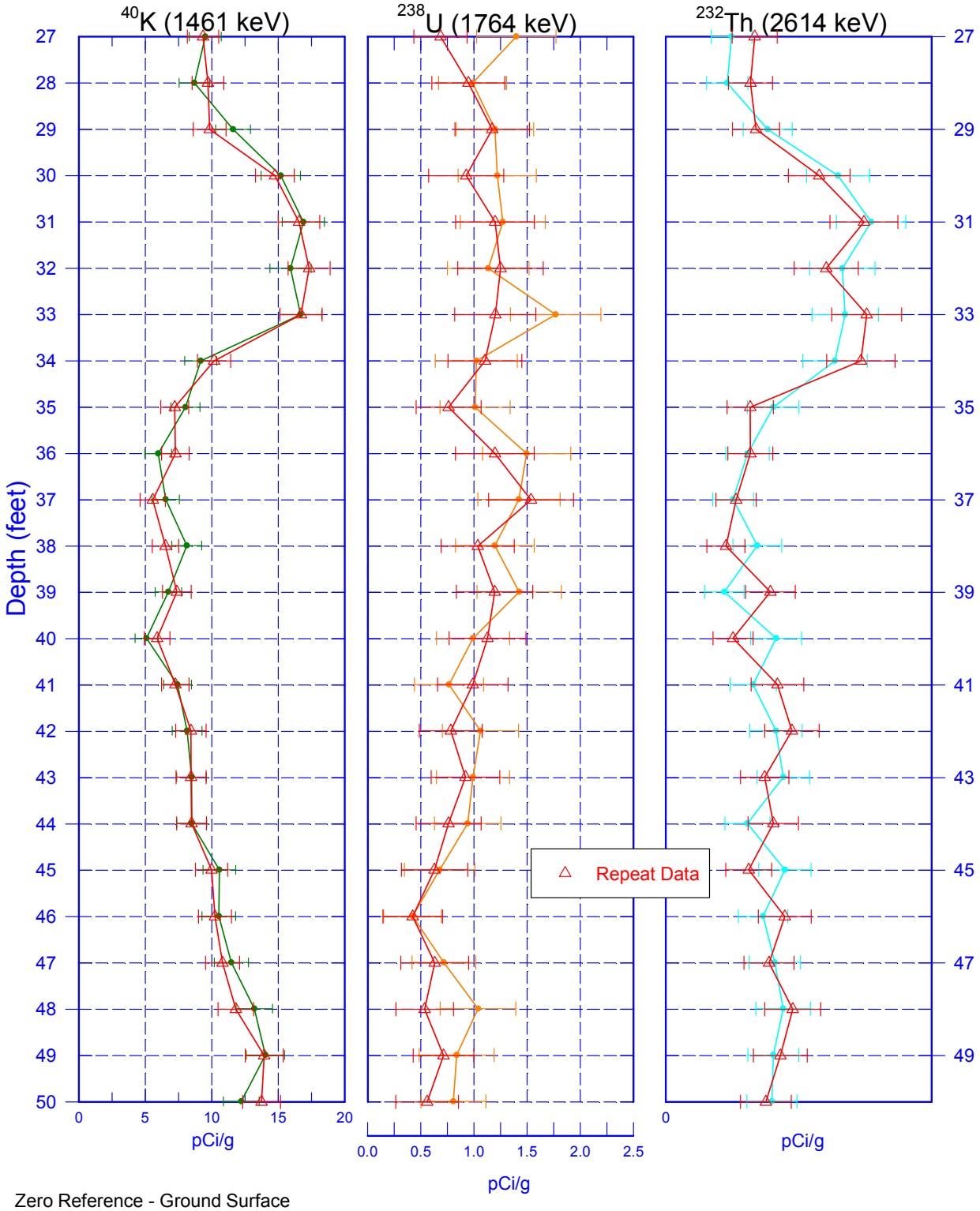
699-47-78 (C9878)
Total Gamma & Hanford Gamma Unit



Zero Reference - Ground Surface

699-47-78 (C9878)

Repeat Section of Natural Gamma Logs

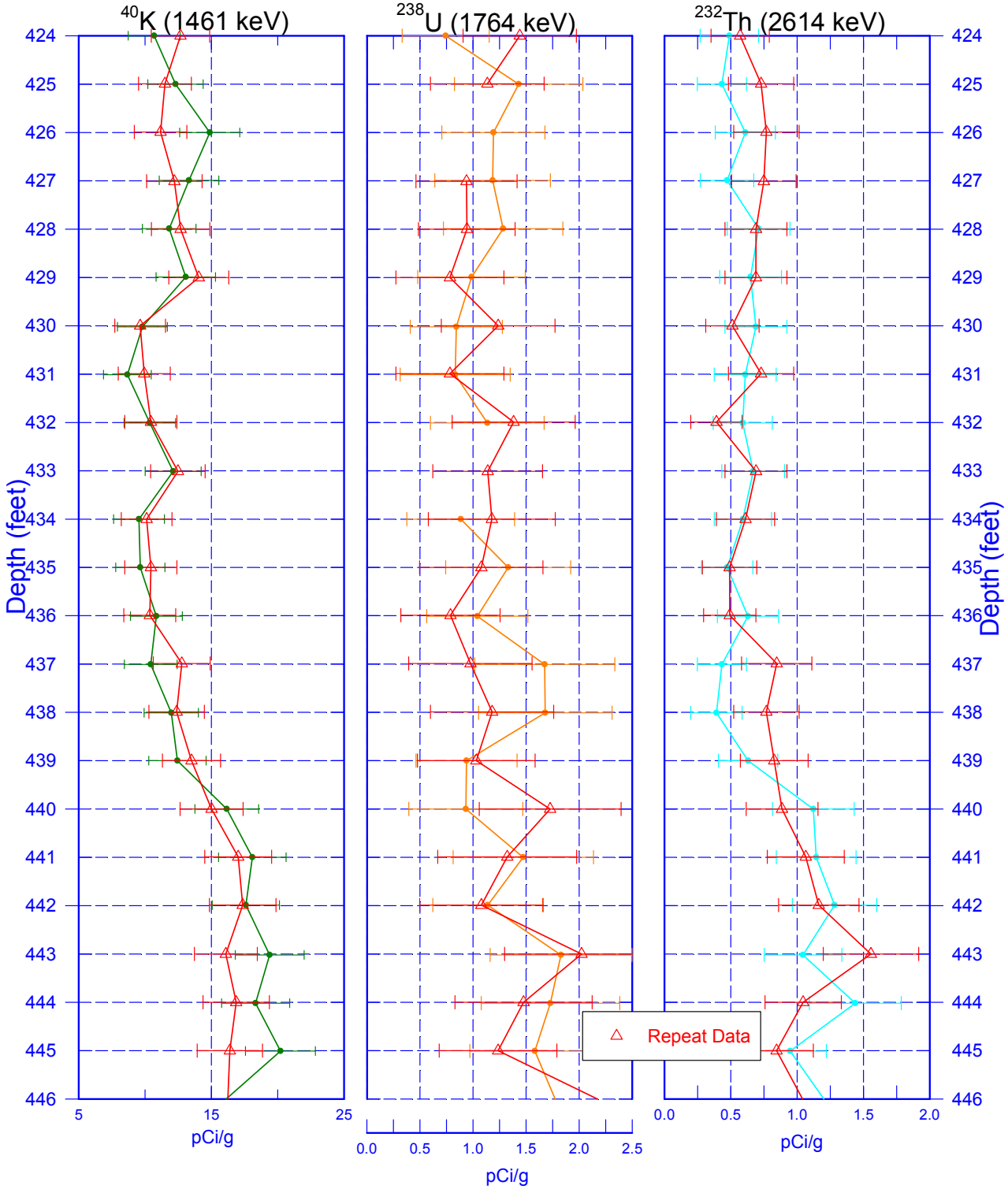


Zero Reference - Ground Surface

Huntington Ingalls Industries

699-47-78 (C9878)

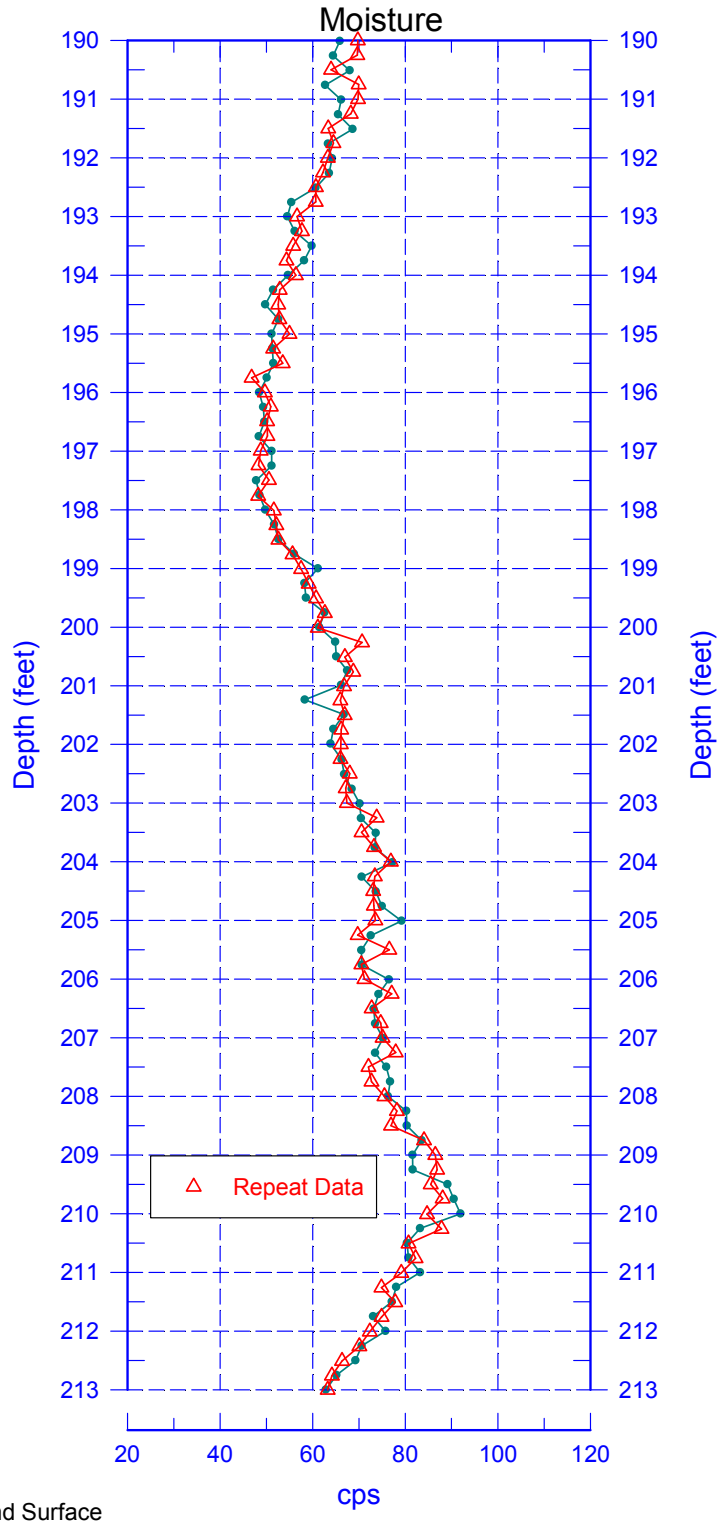
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

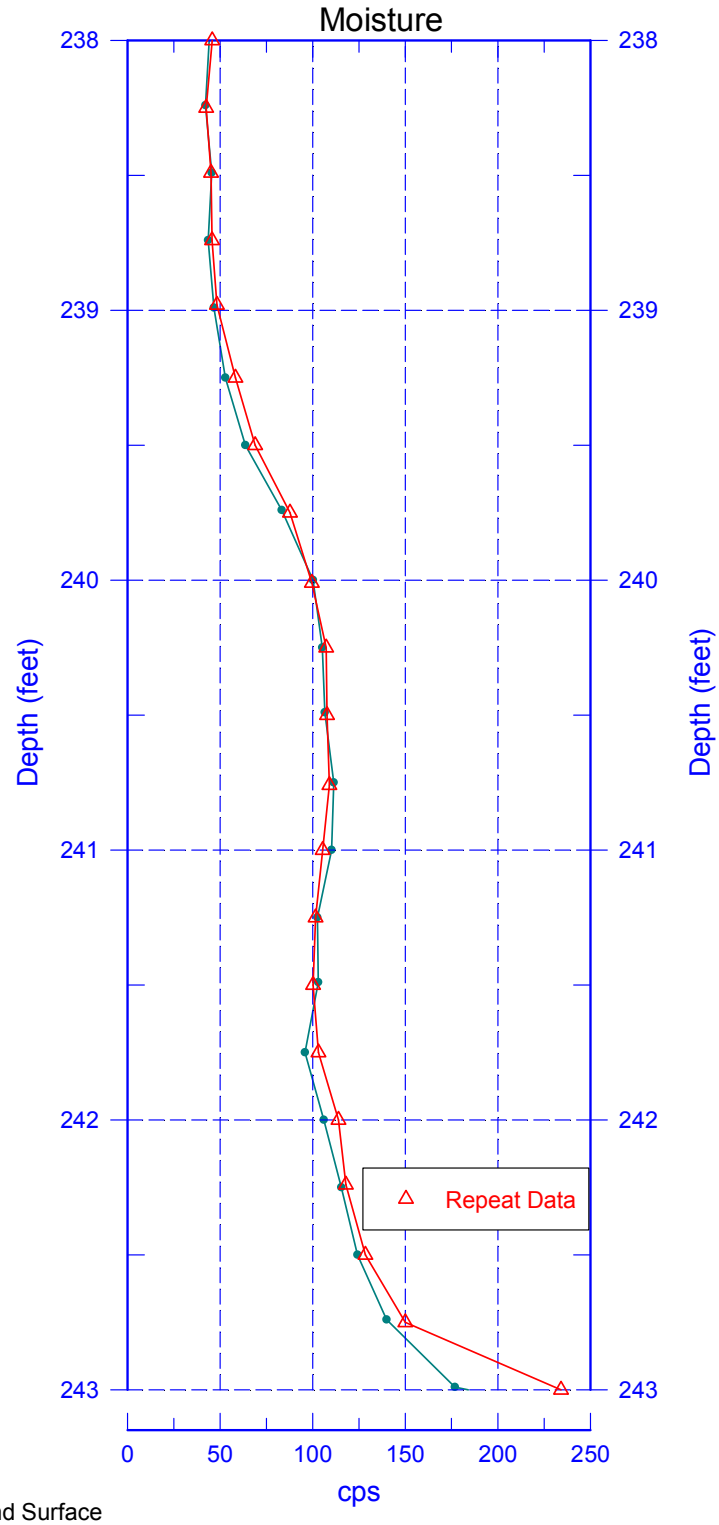
Huntington Ingalls Industries

699-47-78 (C9878)
Moisture Repeat Section



Zero Reference - Ground Surface

699-47-78 (C9878)
Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 09/11/18	Requestor: Matthan G. Wilson (CHPRC)
Date of Survey: 09/12/18	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of 200-ZP-1 Well C9878 (699-47-78) 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	
C9878	699-47-78	566045.53	137800.71		Center of Casing
				209.712	Top Baseplate, N.Edge
				209.682	Top Outer 10"SS Casing, N.Edge
				209.005	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.

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
9-12-18

Appendix B

Well Documentation for C9880 (699-47-78C)

Contents

Well Summary Sheet B-1
Borehole Log B-7
Drill Cutting Photographs B-19
Well Develepment and Testing Data B-30
Log Data Report B-31
Well Survey Data Report B-51

WELL SUMMARY SHEET

Well ID : C9880	Well Name: 699-47-78C	Start Date: 4-10-2018
Project: 2 Injection Wells in the 200-ZP-1 OU	Location: ~900ft North of 200-W-33	Finish Date: 8-24-2018

CONSTRUCTION DATA

Description

Concrete Pad: 0.50 ft above ground surface (ags)

10-in. Protective Casing: 2.97 ft ags - 2.03 ft below ground surface (bgs)

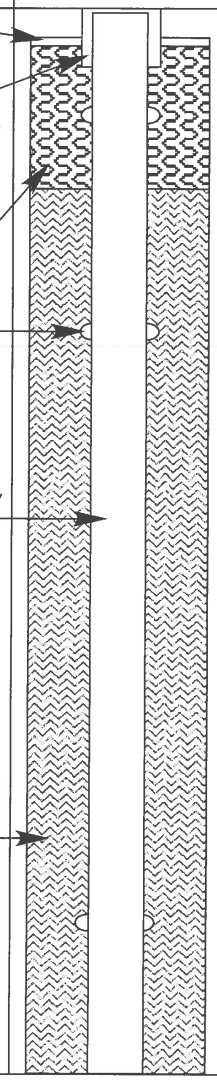
Type I/II Portland Cement Grout: 0.0 - 10.3 ft bgs

Stainless steel centralizer installed above and below screen and every 40 ft

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.97 ft ags - 240.08 ft bgs

Medium Bentonite Chips: 10.3 - 225.7 ft bgs

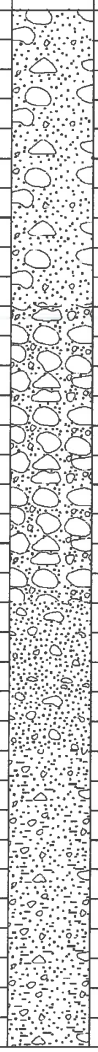
Diagram



GEOLOGIC/HYDROLOGIC DATA

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

Graphic Log



Lithologic Description (ft bgs)

0.0 - 20.0 Gravelly Sand (gS)

20.0 - 40.0 Sandy Gravel (sG)

40.0 - 50.0 Slightly Silty Gravelly Sand ((m)gS)

50.0 - 76.0 Gravelly Silty Sand (gmS)

Reported By:

Print Name	Title	Signature	Date
Tracy Mallgren	Geologist		9-10-2018

Reviewed By:

Print Name	Title	Signature	Date
Jennifer Richart	Well Coordinator	Jennifer Richart	9/17/18

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OR Doc Type:	WMU Code(s):

WELL SUMMARY CONTINUATION SHEET

Well ID: C9880 | Well Name: 699-47-78C | Project: 2 Injection Wells in the 200-ZP-1 OU

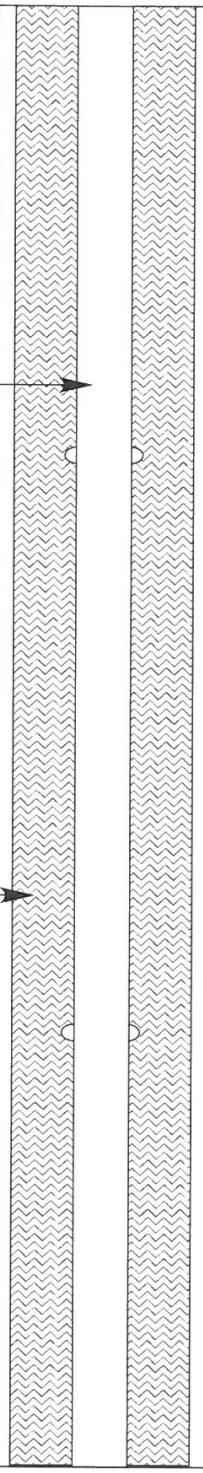
CONSTRUCTION DATA

Description

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.97 ft ags - 240.08 ft bgs

Medium Bentonite Chips: 10.3 - 225.7 ft bgs

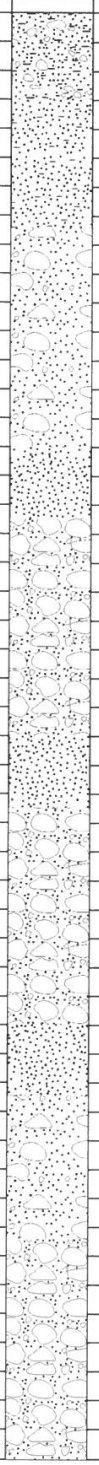
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 70, 80, 90, 100, 110, 120, 130, 140, 150, 160

Graphic Log



Lithologic Description (ft bgs)

- 50.0 - 76.0 Gravelly Silty Sand (gmS)
- 76.0 - 85.0 Slightly Silty Sand ((m)S)
- 85.0 - 100.0 Gravelly Sand (gS)
- 100.0 - 105.0 Sand (S)
- 105.0 - 120.0 Sandy Gravel (sG)
- 120.0 - 125.0 Sand (S)
- 125.0 - 140.0 Sandy Gravel (sG)
- 140.0 - 145.0 Sand (S)
- 145.0 - 155.0 Gravelly Sand (gS)
- 155.0 - 170.0 Sandy Gravel (sG)

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WELL SUMMARY CONTINUATION SHEET

Page 3 of 6

Well ID: C9880 | Well Name: 699-47-78C | Project: 2 Injection Wells in the 200-ZP-1 OU

CONSTRUCTION DATA

Description

Medium Bentonite Chips: 10.3 - 225.7 ft bgs

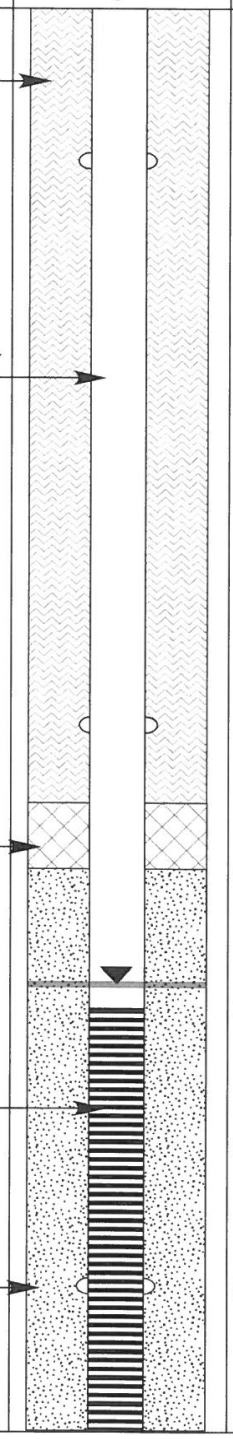
8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.97 ft ags - 240.08 ft bgs

1/4-in. Coated Bentonite Pellet Seal: 225.7 - 230.1 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 240.08 - 460.08 ft bgs

6-9 mesh Premier Silica Filter Pack Sand: 230.1 - 475.6 ft bgs

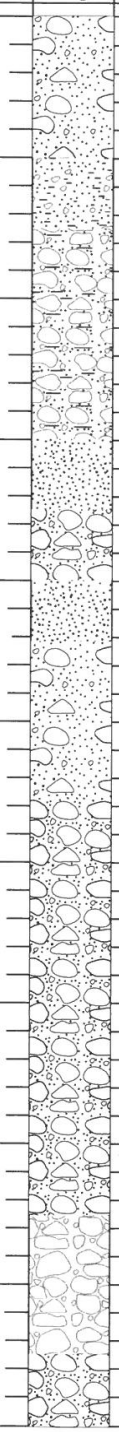
Diagram



GEOLOGIC/HYDROLOGIC DATA

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

Graphic Log



Lithologic Description (ft bgs)

170.0 - 180.0 Gravelly Sand (gS)

180.0 - 185.0 Slightly Silty Gravelly Sand ((m)gS)

185.0 - 200.0 Silty Sandy Gravel (msG)

200.0 - 205.0 Sand (S)

205.0 - 210.0 Sandy Gravel (sG)

210.0 - 215.0 Sand (S)

215.0 - 225.0 Gravelly Sand (gS)

225.0 - 255.0 Sandy Gravel (sG)

Depth to Water: 238.2 ft bgs (08-15-2018)

255.0 - 265.0 Gravel (G)

265.0 - 290.0 Sandy Gravel (sG)

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WELL SUMMARY CONTINUATION SHEET

Page 4 of 6

Well ID: C9880 | Well Name: 699-47-78C | Project: 2 Injection Wells in the 200-ZP-1 OU

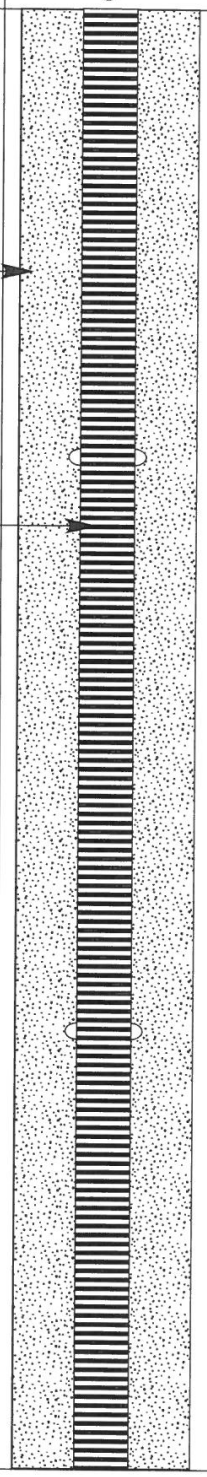
CONSTRUCTION DATA

Description

6-9 mesh Premier Silica Filter Pack Sand: 230.1 - 475.6 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 240.08 - 460.08 ft bgs

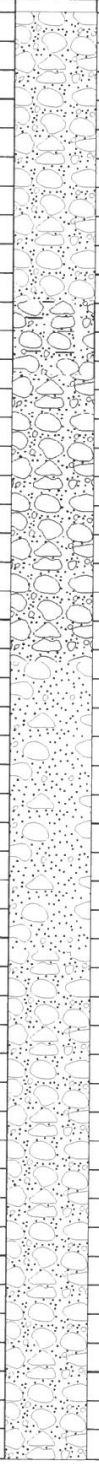
Diagram



GEOLOGIC/HYDROLOGIC DATA

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

Graphic Log



Lithologic Description (ft bgs)

265.0 - 290.0 Sandy Gravel (sG)

290.0 - 295.0 Silty Sandy Gravel (msG)

295.0 - 315.0 Sandy Gravel (sG)

315.0 - 335.0 Gravelly Sand (gS)

335.0 - 385.0 Sandy Gravel (sG)

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WELL SUMMARY CONTINUATION SHEET

Page 5 of 6

Well ID: C9880 | Well Name: 699-47-78C | Project: 2 Injection Wells in the 200-ZP-1 OU

CONSTRUCTION DATA

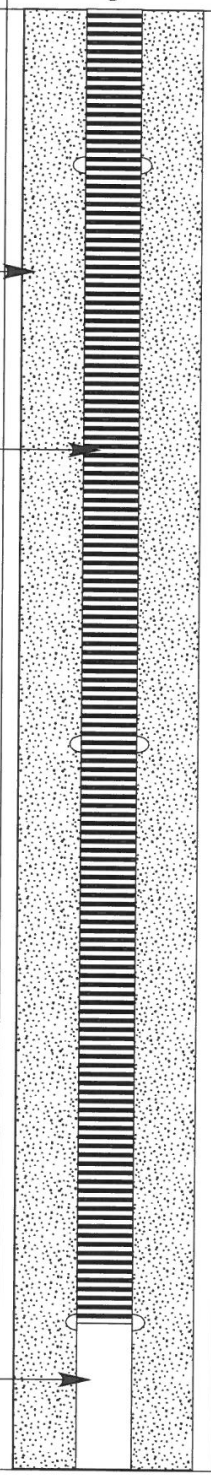
Description

6-9 mesh Premier Silica Filter Pack Sand: 230.1 - 475.6 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, 75-slot (0.075 in.) Stainless Steel Screen: 240.08 - 460.08 ft bgs

8-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 460.08 - 470.09 ft bgs

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 370, 380, 390, 400, 410, 420, 430, 440, 450, 460

Graphic Log

Lithologic Description (ft bgs)

335.0 - 385.0 Sandy Gravel (sG)

385.0 - 390.0 Gravelly Sand (gS)

390.0 - 464.0 Sandy Gravel (sG)

~460.4 - 470.4 10-ft of 1-in. galvanized steel tremie pipe remains in the borehole

464.0 - 475.6 Basalt

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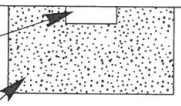
WELL SUMMARY CONTINUATION SHEET

Page 6 of 6

Well ID: C9880	Well Name: 699-47-78C	Project	2 Injection Wells in the 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 Sump: 460.08 - 470.09 ft bgs		470		464.0 - 475.6 Basalt
6-9 mesh Premier Silica Filter Pack Sand: 230.1 - 475.6 ft bgs				Total Depth: 475.6 ft bgs (06-06-2018)
		480		
		490		
		500		
		510		
		520		
		530		
		540		
Straightness Test: Pass, 07-12-2018		550		
Depths are in ft below ground surface.				
Borehole drilled with 16-1/2-in. O.D. casing from 0.00 - 222.3 ft bgs				
Borehole drilled with 14-in. O.D. casing from 222.3 - 463.7 ft bgs		560		
Borehole drilled with 12-3/8-in. O.D. drill bit from 463.6 - 475.6 ft bgs				
All temporary drill casing was removed from the ground.				

A-6006-992 (Rev 2)

BOREHOLE LOG

Page 1 of 12
Date: 4.17.18

Well ID: C9880 | Well Name: C699-47-78C | Location: 900' N of 200-W-33
Project: Install of 2 Injection Wells in 200-ZP-1 GW 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			0-20': gravelly Sand (gS) g=10% s=85% m=5% Gravel: v fine to med pebble. avg 5mm. Mod-poor sorted 15% fel, 85% maf, ang. Sand: v fine-v. coarse well to mod sorted. 25% fel, 75% maf. ang-subang Silt nonplastic. Wet, no rxn HCl 2.5Y 4/3 Olive Brown.	Air Rotary Drilling with 16"/15 1/2" Temp. casing. Grab samples collected every 5 ft or at change in lithology.
5	G			16"/15 1/2" 0.0-221.9' bgs 14"/13 1/4" 221.9-463.7' bgs 8 5/8" drill rods + 12" bit 463.7-475.6' bgs
10	G		@ 10' gravel ↑ 20% s ↓ 75% m=5% color = 2.5Y 3/2 Very dark grayish brown	0.0-15.9': ~160 gal H_2O added
15	G			15.9-35': ~1660 gal added
20	G		20-40': sandy Gravel (sG) g=45% s=50% m=5% Gravel: v fine to coarse pebble, max 20mm. Mod sorted. 15% fel, 85% maf. Ang. Sand: v fine - v. coarse poor sorted, 25% fel, 75% maf, ang., wet no rxn HCl Silt: non plastic. 2.5Y 5/4 light olive brown.	
25	G			
30	G		@ 30' m ↑ 8% g=42% s=50% Gravel: avg. 4mm, max 15mm 10% fel, 90 maf	

Reported By: Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 8/30/18 (Date)

Reviewed By: Sarah Springer (Print Name) | Sr. Geologist (Title) | Signature | 8/22/18 (Date)

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OR Doc Type: | WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 12

Date: 4.17.18

Well ID: C9880 | Well Name: 699-47-78C | Location: 900' North 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		@ 35' mf 10% g-55% s=35% Sandy Gravel (sG)	Air Rotary Drilling 16"/15½" Temporary: 0.0-221.9' bgs 14"/13¼" 221.9-463.7' bgs 8⅝" drill rod + 12" bit
40	G		40-50': slightly silty gravelly Sand (mlgS) g: 15% s: 70% m=15% Gravel: v. fine pebble, 2mm avg. Well sorted 30% fel, 70% maf. ang-sub round. Sand: v. fine to coarse. med avg. Mod sorted. 45% fel, 65% maf. ang. Wet. Weak rxn to HCl, 2.5Y 5/4 light olive brown.	463.7-475.6' bgs. Grab samples collected every 5' or change in lithology
45	G			35-55' ≈ 80 gal added H_2O
50	G		50-~~55~~ 76' gravelly silty Sand (gmS) g: 15% s=55% m=30% Gravel: v. fine to fine pebble, 4mm avg, mod sort. 40% fel, 60% maf. ang-subround. Sand. v. fine to coarse, med avg. Mod sorted. 45% fel, 65% maf. ang. Wet 2.5Y 5/4 light olive brown Silt non plastic. Mod rxn HCl	
55	G			
60	G			
65	G			
70	G			

Reported By:

Tracy Mallgren — Print Name | Geology 37 — Title | Signature | Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 12

Date: 4.18.18

Well ID: C9880 | Well Name: 699-47-78C | Location: 900' North 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				Air Rotary Drilling with 16" | 15 1/2" Temporary casing 0.0-221.9' bgs 14" | 13 1/4" 221.9-463.7' bgs 8 5/8" drillrods 12" bit 463.7-457.6' bgs. Grab samples collected every 5' or at change in lithology.
	G		76-85': slightly silty Sand ((m)S) g=Trace s=85% m=15% Gravel: Trace very fine pebbles Sand: v.fine to coarse, avg med, mod to well sorted. 50% fel, 50% maf. sub ang. Wet mod rxn HCl. 2.5Y 5/4 light olive brown	
80	G			
				75-95': ~12.4 gal H_2O added
85	G		85-100: gravelly Sand (gS) g=10% s=80% m=10% Gravel: very fine to coarse pebble, 5mm avg. ~20mm max, mod sort, 20% fel, 80% maf, sub ang. Sand: v.fine to v.coarse, avg c-vc, well sorted, 40% fel, 60% maf, ang, Wet, Weak rxn HCl 2.5Y 5/4 light olive brown.	
90	G		@ 90' g=20% s=70% m=10% g: 20% fel, 80% maf s=40% fel, 60% maf	
95	G			
				95-115': ~160 gal H_2O added
100	G		100-105: Sand(S) g=Trace s=90% m=10% Gravel: 2-10mm v fine to med pebbles. 80% maf. Sand: v fine to fine, mod-well sort, 65% fel, 45% maf sub ang. Wet. Weak rxn. HCl 2.5Y 5/4 light olive Brown.	
105	G		105-120': sandy Gravel (sG) g=35% s=60% m=5% Gravel: v.fine to med pebbles, 2-10mm, 4mm avg. Mod sort, 20% fel, 80% maf, ang. Sand: v.fine to v.coarse, avg. m-c, 30% fel, 70% maf, ang-sub ang, Wet. Weak rxn HCl. 2.5Y 5/4 light olive brown.	
110	G		@ 110' g=55% s=45% m=5%	

Reported By:

Tracy Mallgren — Print Name

Geologist — Title

Signature

5/20/10 — Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 12

Date: 4-24-18

Well ID: C9880 | Well Name: C699-47-78C | Location: 900' North 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		105-120: Sandy Gravel (sG) @ 115' g=55 s=40 m=5%. Gravel: 2-40mm v. fine to v. coarse pebbles, 20% fel, 80% maf sub ang-sub round. Sand: v fine-v. coarse, avg. c. 30% fel, 70% maf. Wet. Weak rxn HCl 2.5Y 3/3 Dark Olive Brown.	Air Rotary Drilling with 16"/15 1/2" temporary casing 0.0-221.9' bgs 14"/13 3/4" 221.9-463.7' bgs 8 5/8" drill rods 12" bit 463.7-457.6' bgs. Grab samples collected every 5' or as change in lithology
120	G		120-125: Sand (S) g=Trace s=95 m=5 Sand: v fine to coarse, avg fine-med. 30% fel 70% maf, mod sort, ang. Dry No rxn HCl 2.5Y 3/3 Dark Olive Brown.	~~TM 8-6-18 115-122'~~
125	G		125-140: Sandy Gravel (sG) g=55 s=40 m=5 Gravel: v fine to med pebble, avg 5mm, poor sort, 45% fel, 55% maf, sub ang-sub round Sand: v fine-v. coarse, med avg., mod sort, 45% fel, 55% maf, sub ang. Wet. No rxn HCl, 2.5Y 4/4 Olive Brown.	122-125': ~130 gal H_2O added
130	G		@ 130' g=35% s=60% m=5% g: 40 fel, 60 maf s=50/50 maf-fel	130-135': ~40 gal H_2O added
135	G		@ 135' g=45% s=50% m=5% g: 50/50 maf/fel	135-141': ~46 gal H_2O added
140	G		140'-145': Sand (S) g=5% s=90% m=5% Gravel: v fine to medium pebbles, avg 3mm, Mod sort, 40% fel, 60% maf, ang. Sand: v fine to v. coarse, avg m-c 50/50 maf/fel, sub ang. Wet. No rxn HCl 2.5Y 5/3 lt Olive Brown.	141-155': ~186 gal H_2O added
145	G		145-155: gravelly Sand (gS) 10% g, 85% s, 5% m Gravel: v fine to med pebbles, 40% fel, 60% maf, ang-sub ang. Sand: v fine-v coarse, med avg. mod sort, sub ang, Wet. No rxn HCl. 2.5Y 4/2 Dark grayish Brown.	
150	G			

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | [signature] (Signature) | 8/20/12 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 4.25.18

Well ID: C9880 | Well Name: 699-47-78C | Location: 900' North 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'-170': Sandy Gravel (sG) 40% g, 55% s, 5% m Gravel: v fine - coarse pebble, 3mm avg., poor sort, 60% fel, 40% maf. ang - sub ang. Sand: v fine - v. coarse, med. avg., mod sort, 70% fel, 30% maf. sub ang. Wet, No rxn HCl 2.5Y 5/3 light Olive Brown	Air Rotary Drilling with 16" | 15 1/2" Temporary casing 0.0 - 221.9' bgs 14" | 13 1/4" 221.9 - 463.7' bgs 8 5/8" drillrod 12" bit 463.7 - 457.6' bgs Grab samples collected every 5' or at change in lithology
160	G		@ 160' g = 55% s = 45 m = Trace g = 50/50 fel/maf, ang - round s = 60/40 fel/maf. 2.5Y 4/3 Olive Brown	
165	G		~~@ 165'~~ JM 4/25/18	155-169: ~229 gal H_2O added
170	G		170-180: gravelly Sand (gS) g: 20% m=5 s=75% Gravel: v. fine to med. pebble 5mm avg, 40% fel 60% maf. ang - sub round. Mod sort. Sand: v. fine to v. coarse, med. avg, 40% fel, 60% maf, ang. Wet. No Rxn HCl. 2.5Y 3/2 Very Dark grayish Brown.	169-175': ~120 gal H_2O added
175	G		@ 175' color change 2.5Y 4/4 Olive Brown Sand avg v. fine to fine.	175-185': ~145 gal H_2O added
180	G		180-185': slightly silty gravelly Sand (msgS) g = 10% s = 75% m = 15% Gravel: v. fine to coarse pebble, avg 2mm, poor sort, 60% fel, 40% maf, sub ang - subround. Sand: v fine to med. avg fine 70% fel, 30% maf. Wet. 2.5Y 5/4 lt. Olive brown No rxn HCl	
185	G		185-200: silty sandy Gravel (msG) g: 45% s: 40% m: 15% Gravel: v. fine to v. coarse pebble, avg 2mm, poor sort, 65% fel, 35% maf, ang - sub ang. Sand: v. fine - med. avg fine, well sort, 70% fel, 30% maf. Wet. No rxn HCl 2.5Y 5/4 lt. Olive brown.	185-215': ~75 gal H_2O added
190	G		@ 190' g ≈ 55% s ≈ 30% m = 15 Silt = non plastic	

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A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5.2.18

Well ID: C9880 | Well Name: 699-47-78C | Location: 900' North 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		185-200': silty sandy Gravel (msG)	Air Rotary Drilling with
			@ 195: g=55% s=30% m=15% Gravel: v. fine to	16"/15 1/2" temporary casing
			v. coarse pebble, avg. 4mm, poorly sorted, 65% fel, 35% mcf	0.0 - 221.9' bgs
			ang-subang. Sand: v fine to med, avg fine, well sorted,	14"/13 1/4" 221.9-463.7' bgs
			70% fel, 30% mcf. Wet. No rxn HCl 2.5Y 5/4 lt Olive Brown	8 5/8" drilled + 12" bit
200	G			463.7-457.6' bgs - Grab
			200-205: Sand (S) g=2% s=98% m=T	samples collected every 5'
			Gravel: v fine to med pebble, avg. 4mm, poor sort, 75%	or at change in lithology.
			fel, 25% mcf, sub. ang. Sand: v fine to v. coarse, avg.	
			c-vc, 85% fel, 15% mcf, subang, Wet. 2.5Y 6/4	
205	G		lt. yellowish Brown. No rxn HCl, Silt trace nonplastic.	
			205-210': sandy Gravel (sG) g=70%, s=25%, m=5%	
			Gravel: v fine to med pebble, 4mm avg, poor sort,	
			60% fel, 40% mcf, subang-round. Sand: v fine-med,	
210	G		fine avg. 85% fel, 15% mcf. Wet. No rxn HCl, 2.5Y 5/4	
			lt. Olive Brown. Silt = nonplastic	
			210-215': Sand (S) g=5 s=90 m=5%	
			Gravel: v fine to med pebble, 4mm avg., poor sort, 60% fel	
			40% mcf, subang-round, Sand: v fine-v. coarse, fine avg.	
215	G		85% fel, 15% mcf, well sort Wet. No rxn HCl, no color change	
			215'-220' gravelly Sand (gS) g=20 s=75 m=5	
			Gravel: v. fine to coarse pebble, avg. 4mm, poor	
			sort, 60% fel, 40% mcf, subang-round. Sand: v fine-	
			v. coarse, v fine to fine avg. 85% fel, 15% mcf, well	
220	G		sort, Wet. No rxn HCl 2.5Y 5/4 lt. Olive Brown	
			@ 220': g: 70% fel/30% mcf	
225	G		225-255': sandy Gravel (sG) g=55% s=40% m=5%	
			Gravel: v. fine to med. pebble, max 15mm, avg 5mm	
			poor sort, 70% fel, 30% mcf, ang - subround	
			Sand: v fine - v. coarse, avg med, mod sort, 85% fel,	
			15% mcf, subang, Wet - no rxn HCl 2.5Y 5/4	
230	G		light olive brown.	
			@ 230' 2.5Y 5/3 light olive brown	

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BOREHOLE LOG (Cont.)

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Date: 5.9.18

Well ID: C9880 | Well Name: 699-47-78C | Location: ~900' North 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		225-255': sandy Gravel (sG) g=55%. s=40%. m=5% Gravel: v.fine to med pebble, max 15mm, avg 5mm poor sort 70% fel, 30% mef, ang-~~subang~~ TM 5/31/18 subround Sand: v.fine-v.coarse, avg med, mod sort, 85% fel, 15% mef, subang, Wet - no rxn HCl 2.5Y 5/3 light Olive Brown	Air Rotary Drilling with 16"/15½" temporary casing 0.0-221.9' bgs 14"/13¾" 221.9-463.7' bgs 8⅝" drill rods + 12" bit 463.7-475.6' bgs. Grab samples collected every 5' or w/ change in lithology. Water level: 238.7 (8/14/18)
240	G		@240' Gravel max ≈ 20mm g% ≈ to 65%, s=35%, m=Trace Sand: avg. coarse	
245	G		@245' ~~g% ≈ to 60%~~ TM 5/31/18, s=30%, g=65% m≈5% Gravel: sub round-round max 30mm avg ~10mm.	
250	G		@250': Mod rxn HCl	
255	G WS 55		255-265': Gravel (G) g=85%, s=15%, m=Trace Gravel: v.fine to v.coarse pebble, max 45mm avg 10mm, poor sort, 60% fel, 40% mef ang-round. Sand: fine to v.coarse, avg coarse, 70% fel, 30% mef, sub ang. Wet, No rxn HCl.	255.2-257.2 ~~255.4-255.4~~ TM 5/31/18 = plug spoon 255.3': Water Sample
260	G		@260' 100% gravel, Trace sand. 2.5Y 5/6 light Olive Brown	
265	G		265-290': sandy Gravel (sG) g=75, s=20 m=5 Gravel: v.fine to v.coarse pebbles, avg 10mm, poorly sorted, 60% fel, 40% mef, ang-round. Sand: med-v.coarse grained, coarse avg., poorly sorted, 70% fel, 30% mef, ang-subang, Wet. 2.5Y 5/3 light Olive Brown No rxn HCl	
270	G		@270' Sand size: v.fine to v.coarse	

Reported By: Tracy Mallgren (Print Name) Geologist (Title) [signature] (Signature) 8/20/15 (Date)

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BOREHOLE LOG (Cont.)

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Date: 5·14·18

Well ID: C9880 | Well Name: C699-47-78C | Location: ~900' North 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	G WS		265-290': sandy Gravel (sG)	Air Rotary Drilling with
			@ 275: g=40%, s=60%, m=Trace	16"/15" Temporary casing
			Gravel: v fine to v. coarse pebbles, 10-15 mm avg.	0.0-221.4' bgs
			50 mm max, poorly sorted, ~~60%~~ 35 fel (insoluble), ~~40%~~ 65 maf (insoluble),	14"/13¼" 221.9-463.7' bgs
			ang-round. Sand: v. fine to v. coarse, coarse avg.	8⅝" drill rod & 12" bit
280	G		40% fel, 60% maf, ang-subang. Wet. No Rxn HCl	463.7-475.6' bgs. Grab
			2.5Y 5/4 light Olive Brown	samples collected every 5'
				or at change in lithology.
				275.5': Water Sample
285	G		@ 285: g=60%, s=35%, m=5%	
			Gravel avg fine pebbles, 40% fel, 60% maf	
			Sand: v. fine to v. coarse, poorly sorted	
290	G		290-295: silty sandy Gravel: (msG) g=55%, s=30%,	
			m=15%. Gravel: v. fine to v. coarse pebbles, avg.	
			fine pebbles, poorly sorted, 50% fel, 50% maf. ang-	
			round. Sand: v. fine to coarse sand, mod. sorted,	
			subang. Wet. No rxn HCl, 2.5Y 5/4 light Olive Brown	
295	G WS		Silt: nonplastic	
				295.3': Water Sample
			295-315: sandy Gravel (sG) g=45% s=55% m=Trace	
			Gravel: v. fine to v. coarse pebbles, max 55 mm,	
			avg. med pebbles, poorly sorted, ang-round	
300	G		Sand: v fine to coarse, avg fine-coarse, mod	
			sort, 70% fel 30% maf, subang Wet 2.5Y 5/4	
			light Olive Brown.	
305	G		@ 305 g=30% s=70% m=Trace	
310	G			

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 8/20/18 (Date)

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BOREHOLE LOG (Cont.)

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Date: 5·17·18

Well ID: C9880 | Well Name: 699-47-78C | Location: 900' North 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		315-335: gravelly Sand (gS) g=15, s=80, m=5%. Gravel: med to coarse pebbles, avg 20-30mm, mod. sorted, 75% fel, 25% maf, sub round-round Sand: vfine to med, avg med, well sorted, 10% fel 90% maf - fractured basalt from drilling. Wet 2.5Y 5/4 light Olive Brown	Air Rotary Drilling with 16"/15 1/2" Temporary casing 0 to 221.9' bgs 14"/13 3/4" 221.9-463.7' bgs 8 5/8" drillrods 12" bit 463.7-457.6' bgs. Grab samples collected every 5' or at change in lithology.
320	G			
325	G		@ 325' g↑=20%, s: 75%, m=5% Gravel: fine to v. coarse pebble, med peb. avg, occ. v. coarse peb. Sand: vfine to v. coarse, med-coarse avg, T. v. coarse, 70% fel, 30% maf.	
330	G		Sample from Split Spoon: 334.6-335.1 65% g, 20% s, 15% m, max 80mm, Two color 2.5Y 3/3 Dark Olive Brown + 4/4 Olive Brown. Strong rxn HCl. Moist M: ~10% clay + 5% silt mod. plasticity	
335	G ⊥ WS		@ 335' g↑=35%, s=60%, 5% m 335-385': Sandy Gravel g=35, s=60, m=5 Gravel: v. fine - v. coarse pebble, med 40% avg, max 80mm 30% fine + c pebbles, T v. coarse pebbles. poor sort v. occ. small cobbles, round. Sand vfine to v. coarse, 80% med-c, 20% v. fine-fine, trace v. coarse. 70% fel, 30% maf, subang, Wet. Weak rxn HCl	334.6-335.1: split spoon 335.3': ~~sp~~ water sample
340	G			
345	G		@ 345' g=60% maf maf ↑ from fractured basalts s=65% maf No rxn HCl g↑ ~~45~~ 65%, s↓ 30% m=5% Sand avg↑ coarse	
350	G		@ 350' g↑=50% s↑=45% m=5% Gravel=65% fel, 35% maf, 30% mp, 40% f-vf peb, 20% coarse peb, 10% v. coarse peb. Sand: 55% fel, 45% maf, sub ang, 2.5Y 5/6 Olive Brown	

Reported By: Tracy Mallgren (Print Name) Geologist (Title) (Signature) 5/20/18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5·21·18

Well ID: C9880 | Well Name: 699-47-78C | Location: 900' North 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		335-385' sandy Gravel (sG)	Air Rotary Drilling with
			@355: Gravel: 30% Sand: 45% Silt: 5%	16"/15½" temporary casing
			Gravel: vfine to v.coarse pebbles. 40% vfine-fine,	0.0-221.9' bgs
			30% med, 20% coarse, 10% v.coarse. 65% fel, 35% maf,	14"/13¼" 221.9-463.7' bgs
			Round, poor sort. Sand: v fine-coarse, trace v.coarse.	8⅝" drill rods & 12" bit
360	G		40% med, 30% fine, 20% v fine. 10% coarse. 55% fel,	463.7-~~457~~ 475.6' bgs
			45% maf, sub cng, Wet No rxn HCl 2.5Y 5/6	Grab samples collected
			Olive Brown.	every 5' or at change in
			@360' g↑60% s=35% m=5%	lithology.
			g=30% v. fine 40% fine pebbles. 2-5 mm fractured	
365	G		15% mpeb, 10% coarse + 5% v coarse.	
			@365' g↓55% s=40% m=5%	
			g=75% fel, <20mm fractured, max 90mm	
			s=60% fel, well sort 60% med, 30% vfine-fine	
			10% coarse.	
370	G		@370' g↓50% s=45% m=5%	
375	G		@375' g↑60%, s=35% m=5%	
			Gravel: 10% vcpeb, 20% cpeb, 30% mpeb, 20% fp	
			10% vfine peb 70% fel, 30% maf	
			Sand: 10% vfine, 10% fine, 50% med, 20% c, 10% vc	
380	G		85% fel 15% maf mod sort.	
385	G		~~@385' g↓~~ 385-390': gravelly Sand (gS)	
			g=15%, s=80%, m=5%. Gravel: vfine to med	
			pebble, 40% vf, 40% fine, 20% med, max 10mm	
			Mod sort, 70% fel, 30% maf, round. Sand: med-coarse	
390	G		90% med, well sort. 85% maf, sub cng, Wet No rxn HCl	
			2.5Y 5/4 Light Olive Brown	
			390-464': sandy Gravel (sG)	
			g=60% s=30% m=5%	

Reported By:

Tracy Mallgren — Print Name | Geologist — Title | Signature | 8/20/18 — Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 5.24.18

Well ID: C9880 | Well Name: C699-47-78C | Location: ~900' North 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		390-464': sandy Gravel (sG)	Air Rotary Drilling with
			@395: g=50%, s=45%, m=5%.	16"/15½" temporary casing
			Gravel: v. fine - v. coarse pebble. 20% v fine, 20% fine	0.0-221.9' bgs
			10% med, 30% coarse, 20% v. coarse peb. Poor sort	14"/13¼" 221.9-463.7' bgs
			55% mafic fel, 45% maf, subround-round. Sand: v fine-	8⅝" drillrods & 12" bit
400	G		coarse. 5% v fine, 10% fine, 80% med, 5% coarse, Mod sort,	463.7-475.6' bgs. Grab
			60% fel, 40% maf, sub ang. Wet. 2.5Y 5/4 light Olive	samples collected every 5'
			Brown.	or w/ change in lithology.
			@400' g↑ 65% s=30% m=5%	
405	G			
410	G			
415	G	WS	@415' g↓ 50%, s=45% m=5%	415.3-417.6': split spoon
	SS		Gravel: 40% v fine peb, 30% f peb, 20% med peb, 10%	415.8': water sample
			coarse peb. 40% fel, 60% maf, subang-round.	
			Sand: 10% vf, 20% f, 40% med, 20% coarse, 10% v. coarse	
			poor sort, 55% fel, 45% maf, subang.	
420	G		@420' g↑=60% s=35% m=5%	
			gravel: 60% fel, 40% maf ~~Sand~~	
425	G		@425' g↓=45% s=50% m=5%	
			Sand: 70% fel, 30% maf	
430	G		@430' g↑ 45% s=35% m=Trace	
			40% fel, 60% maf gravel avg. 10mm	

Reported By:

Tracy Mallgren (Print Name) | Geologist (Title) | Signature | 8/20/18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 2 of 2

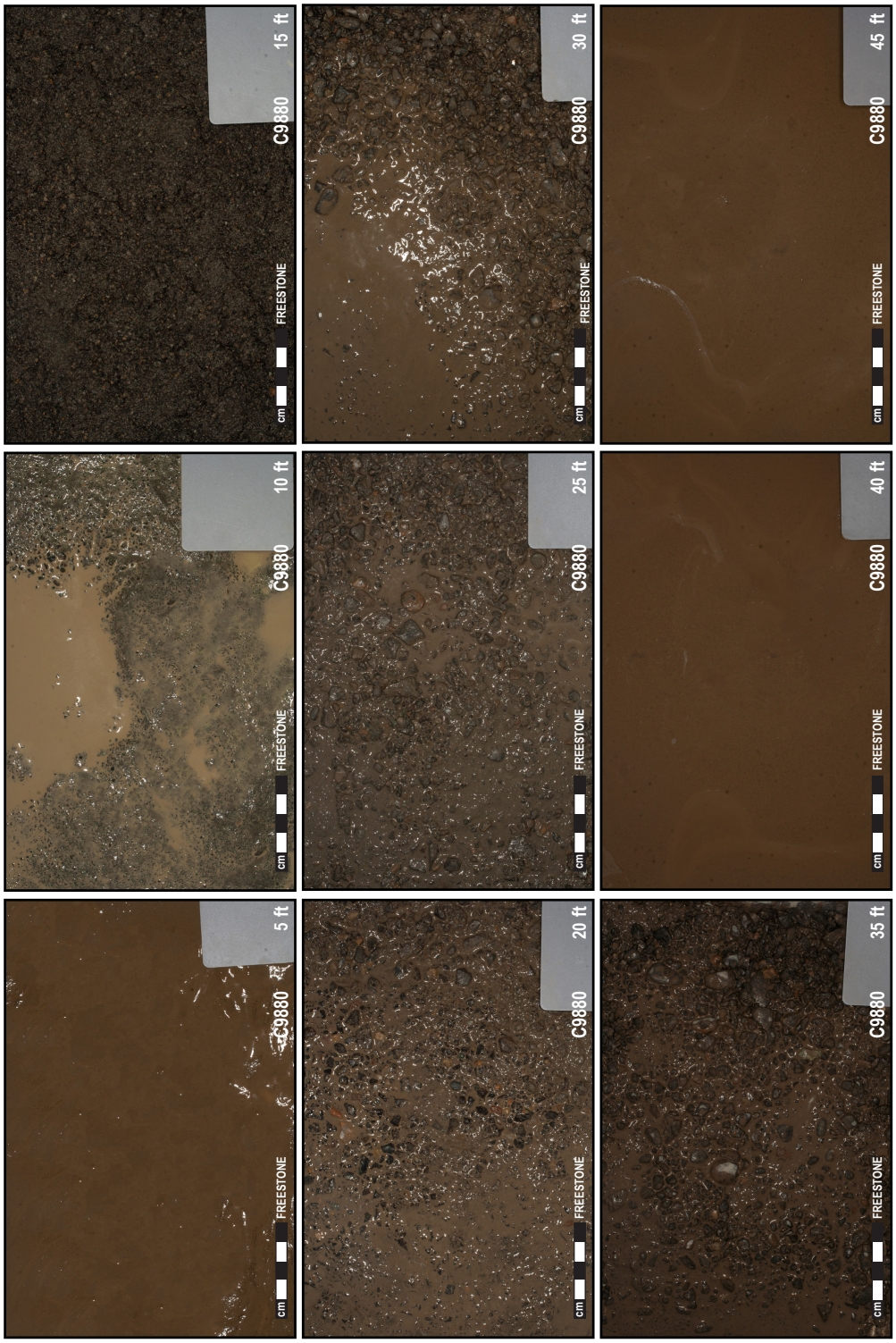
Date: 6.6.18

Well ID: C9880 | Well Name: 699-47-78C | Location: ~900' North 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 LOS		390-464: Sandy Gravel (SG)	Air Rotary Drilling with
			@435' g=40%, s=55%, m=5%	16"/15 1/2" temporary casing
			Gravel: v. fine - v. coarse pebble. avg. fine pebble	0.0-221.9' bgs
	SS		~5mm 80% fel, 20% maf, sub round, ang. poor sort	14"/13 1/4" 221.9-463.7' bgs
			Sand: v fine - v coarse ~70% med, well sort,	8 5/8" drill rod + 12" bit
440	G		~~78%~~ fel, 30% maf sub ang. Wet No rxn HCl 2.5Y	463.7-~~45~~ 475.6' bgs
			5/4 light Olive brown.	Grab samples collected every
			@440' mafics & basalt ↑ g=60% maf	5' or change in lithology.
			max g ↑ to 45mm	435.6': water sample
				437.1-439.6': split spoon
445	G		@~~445'~~ 447' s ↑ 60%, g=40%, m=trace	
			gravel maf=75% basalt, sand maf ↑ 30%	
	G		Color change: 2.5Y 4/1 dark gray	
450	G		@450' g=Max size ↑ 50mm, avg 10mm 70% maf	
			sand=65% maf, 35% fel Color change 2.5Y	
			5/2 Grayish brown	
455	G		@455' g=20% fel, 80% maf s=20% fel, 80% maf	
				456.5-458.0': split spoon
	SS			
460	G			
	G			
465			464-475.6: Basalt	
			100% Basalt - no apparent weathering	
			2-30mm, angular, No rxn HCl	
			10YR2/1 Black	
	G			
470				
	G			

Reported By: Tracy Mallgan (Print Name) | Geologist (Title) | (Signature) | 8/20/18 (Date)

A-6006-993 (REV 0)



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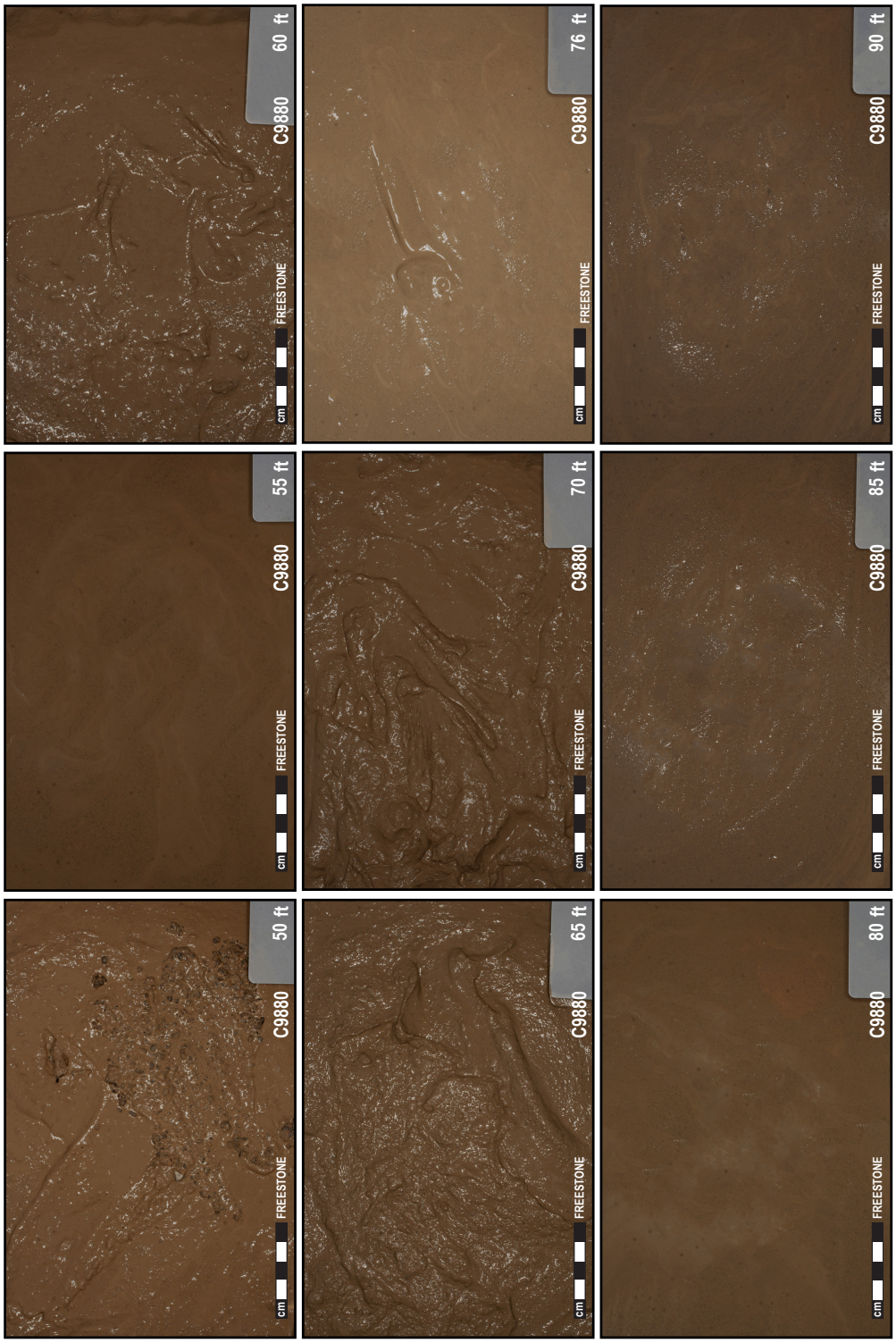
Drill Cutting Photographs for C9880 (699-47-78C)



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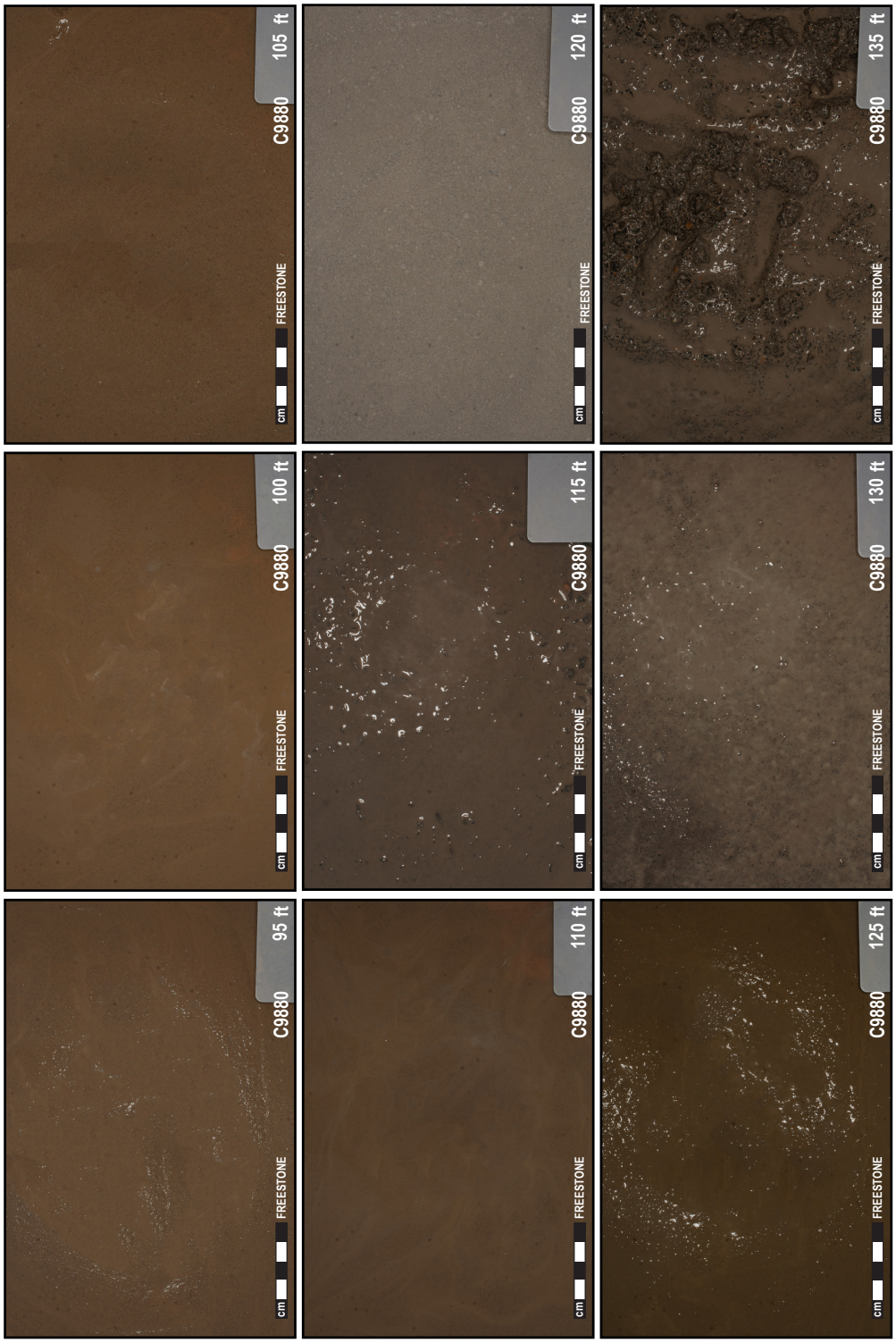
Drill Cutting Photographs for C9880 (699-47-78C)



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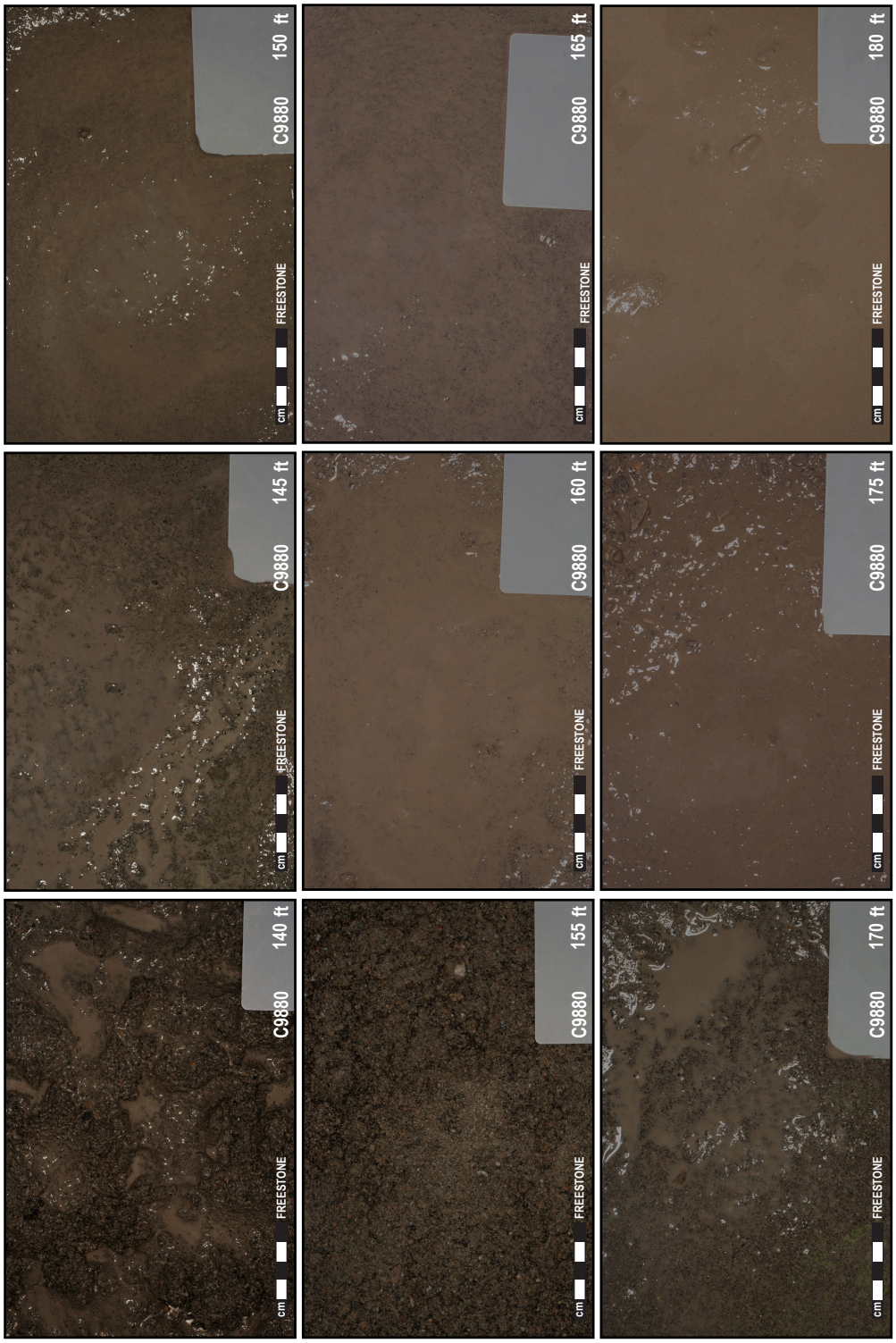
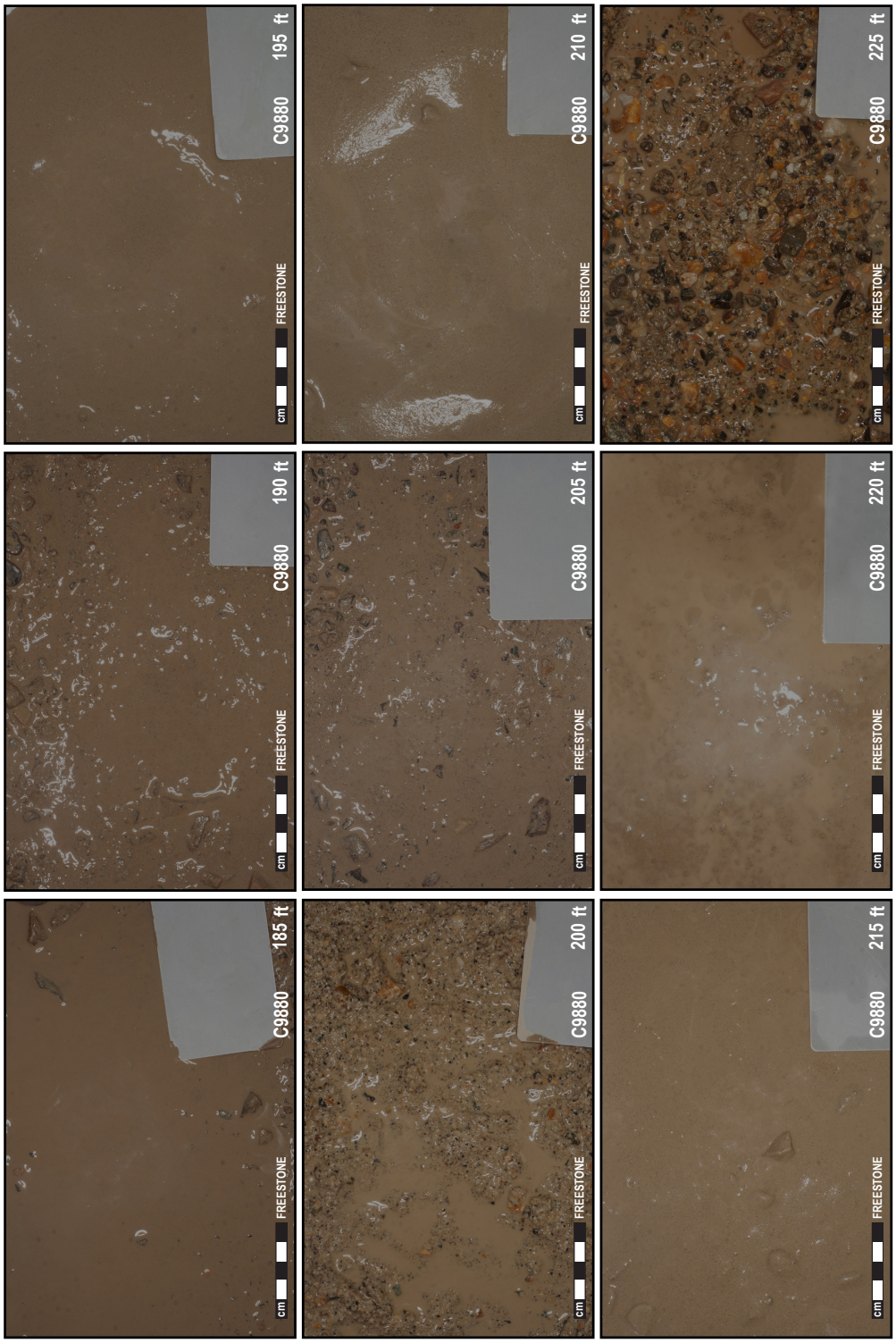
Drill Cutting Photographs for C9880 (699-47-78C)



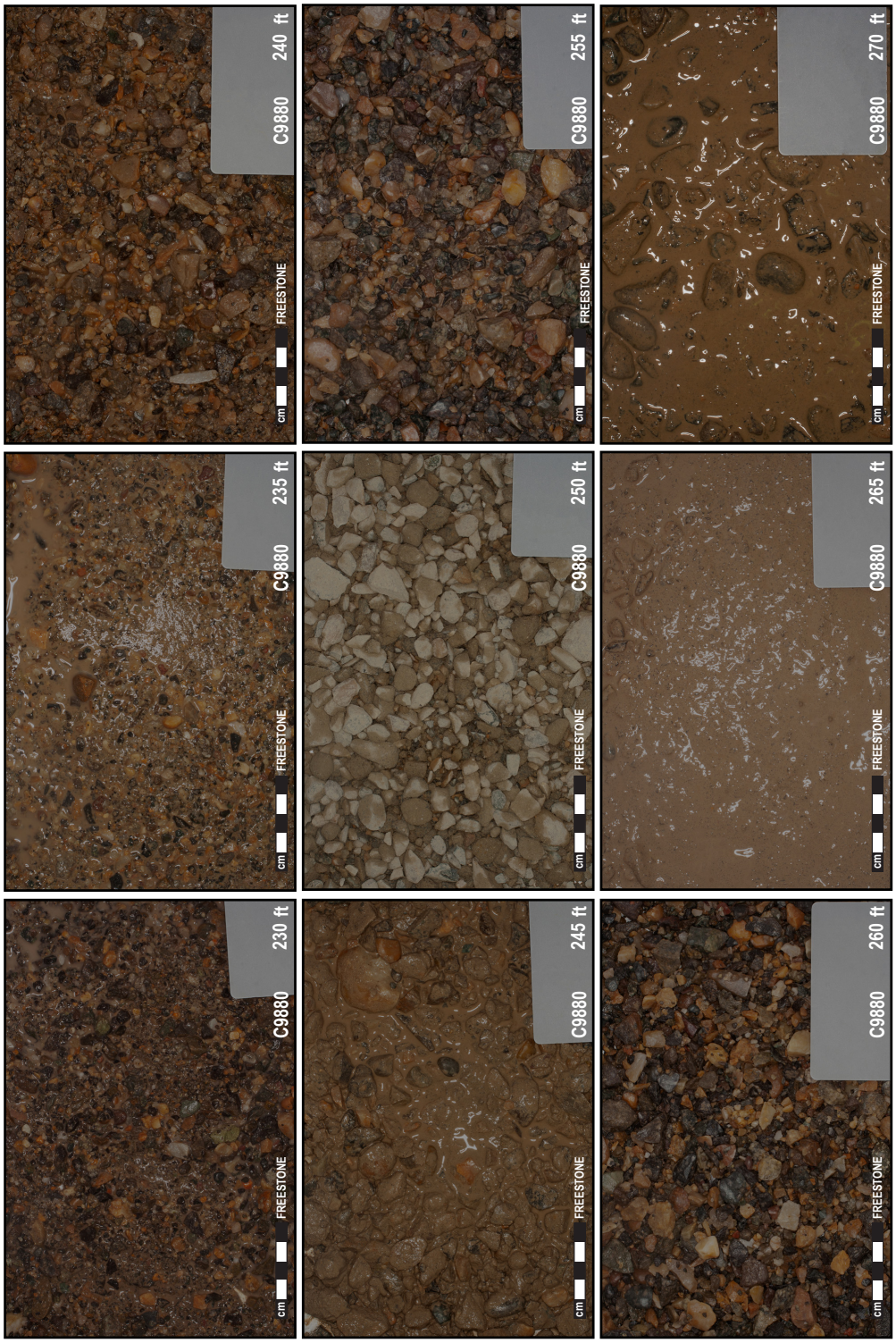
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)



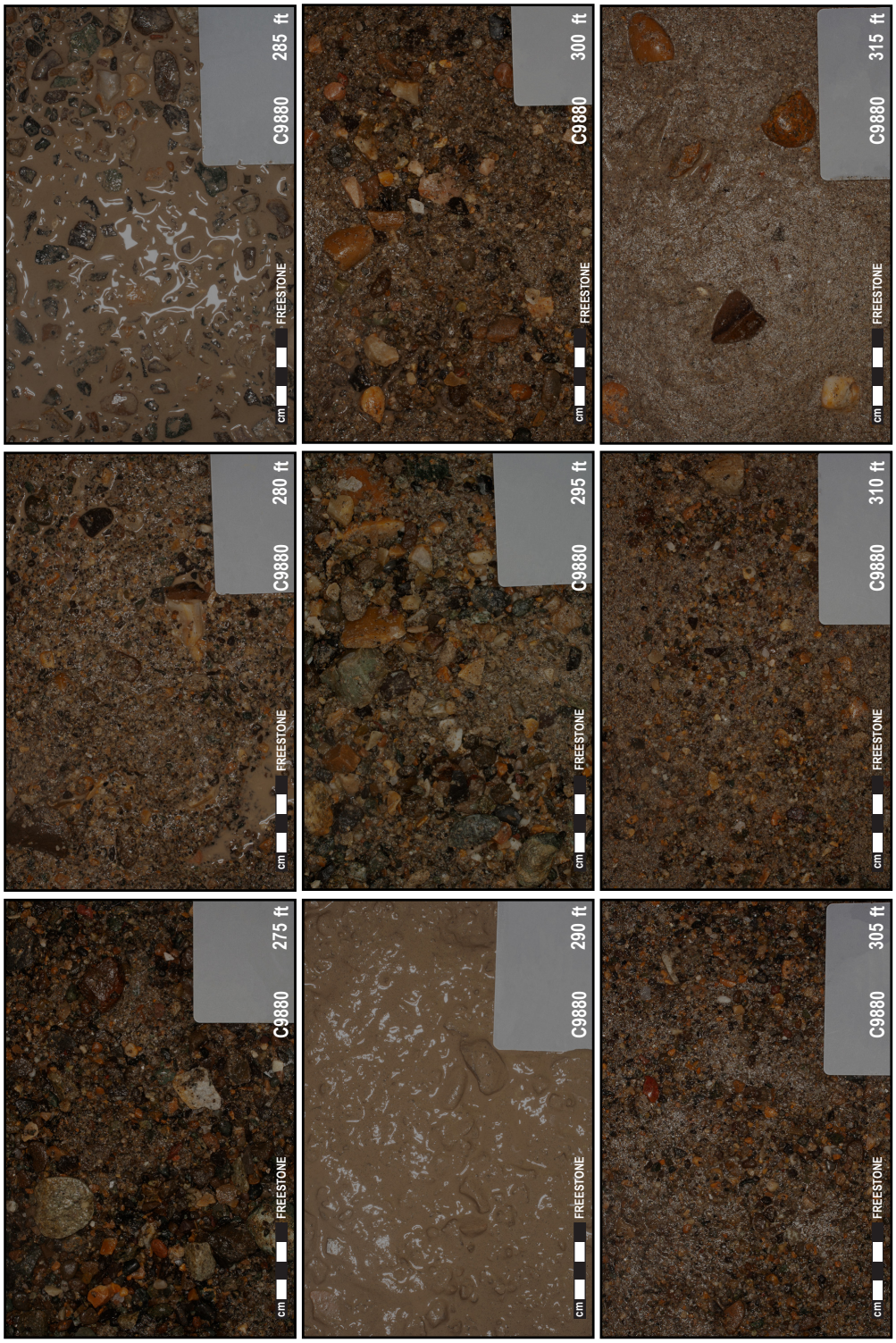
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)



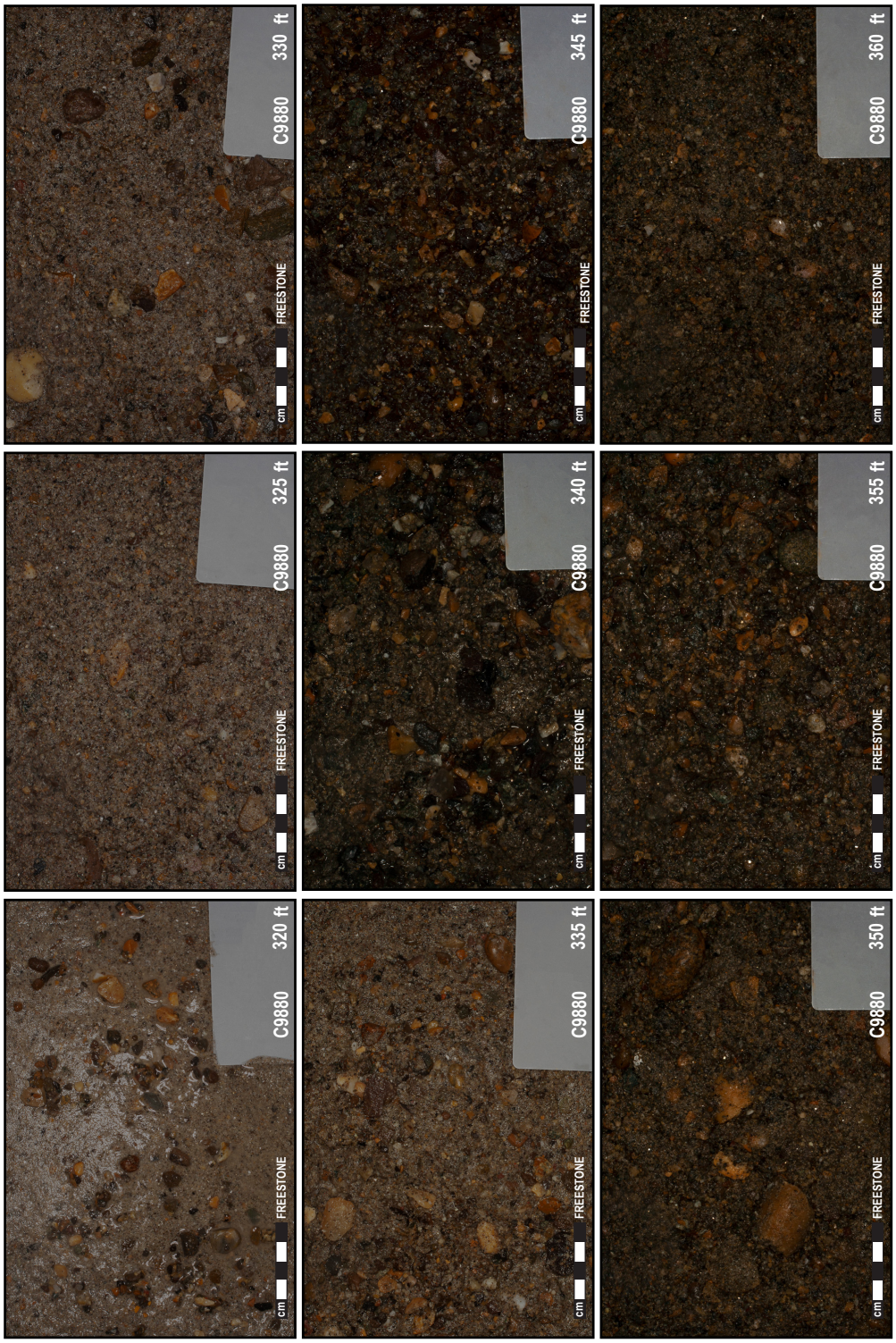
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)



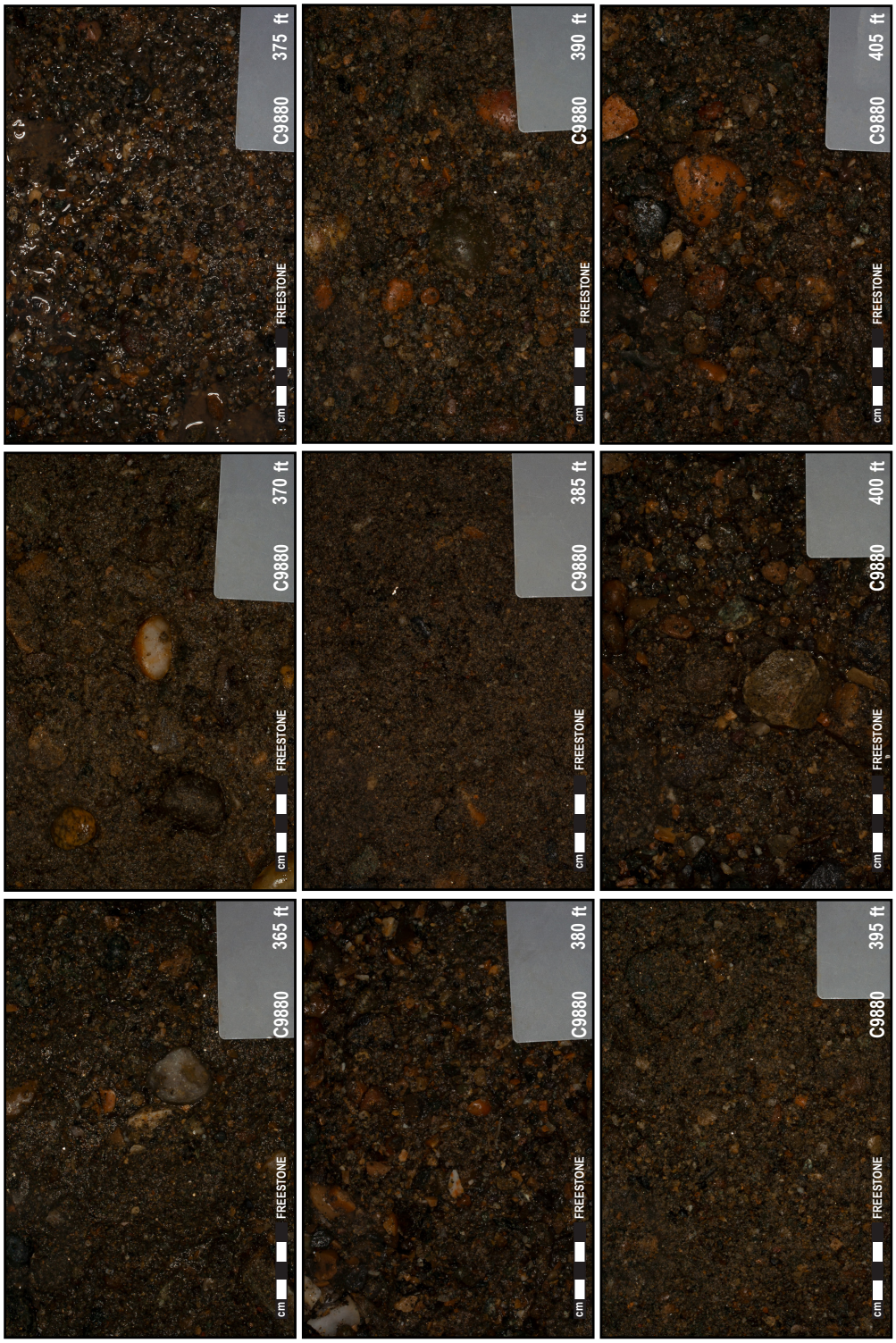
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)



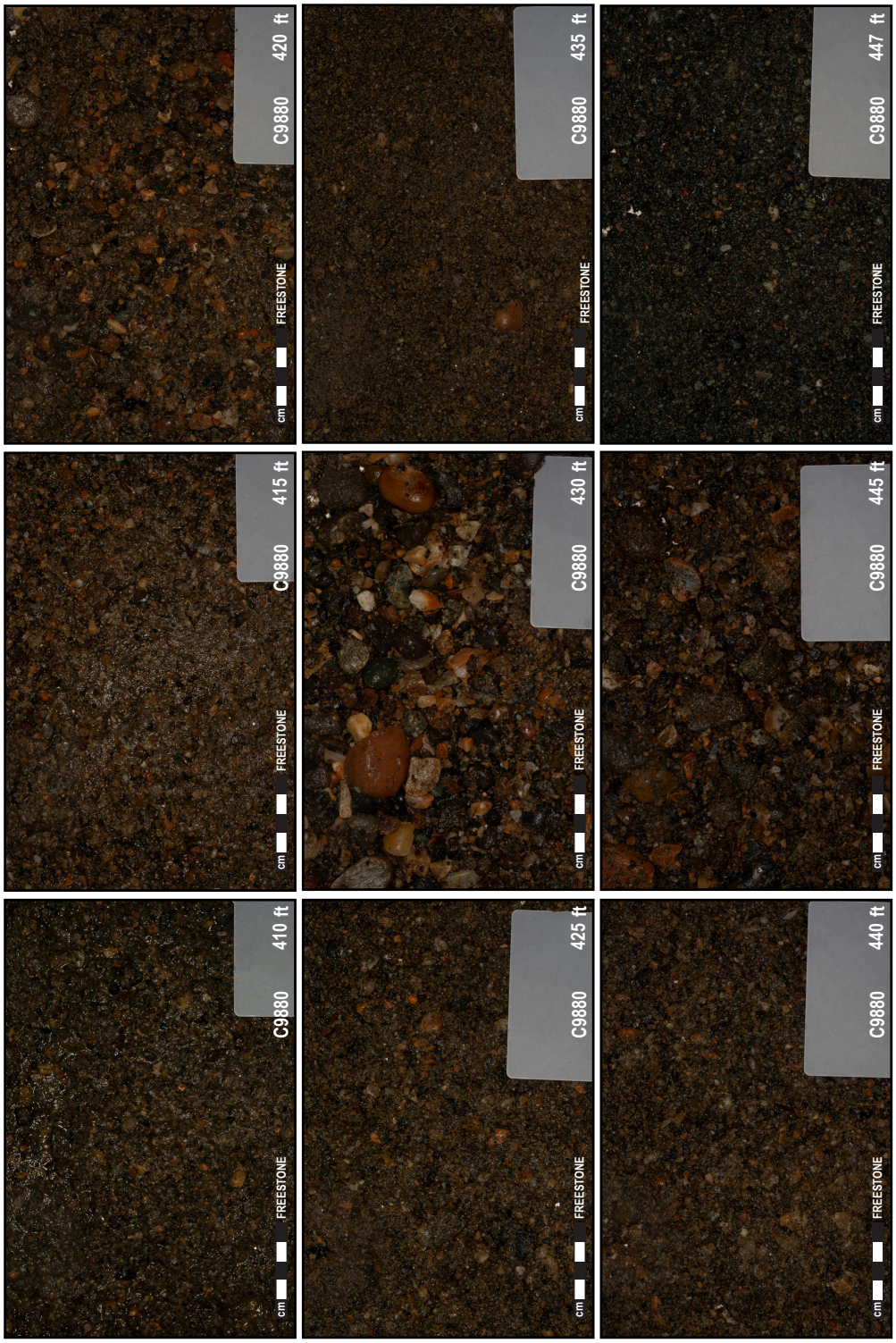
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)



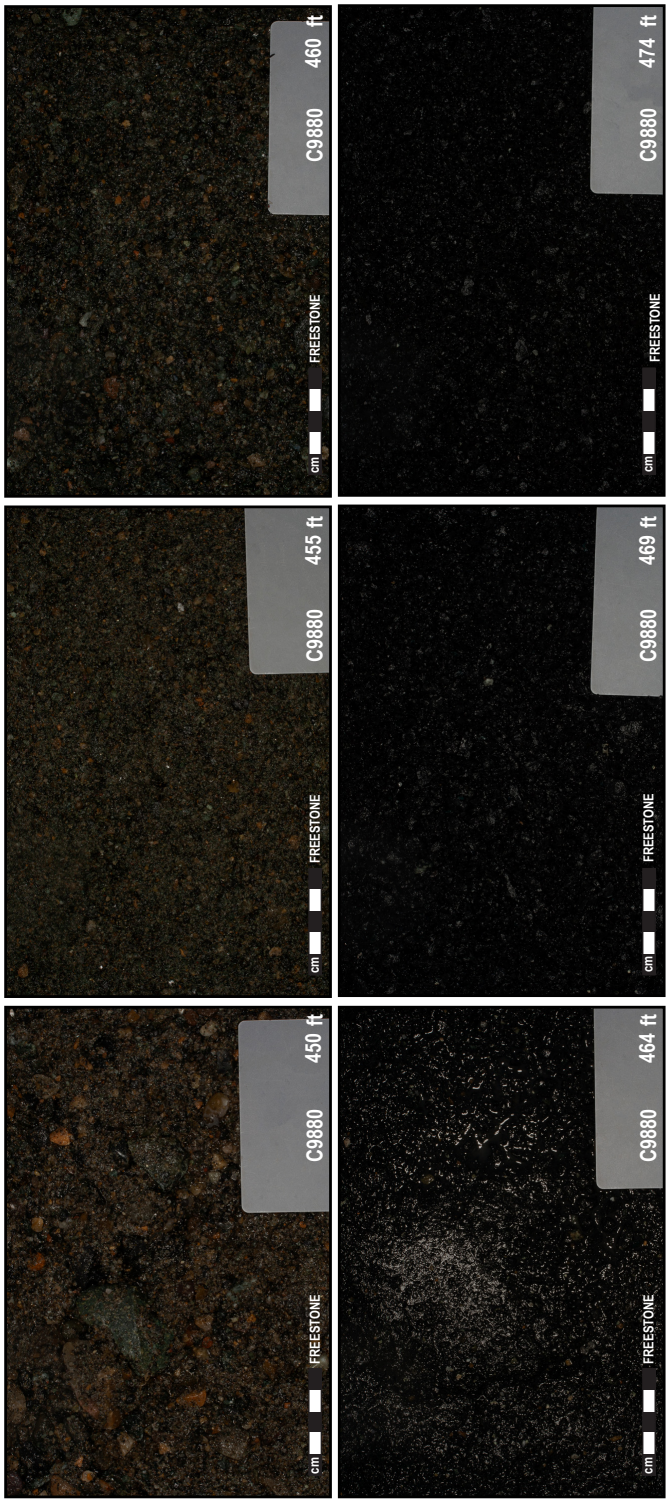
FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)



FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)



FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9880 (699-47-78C)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9880 | Well Name: 699-47-~~78C~~ 78C (JLR 9/17/18) | Date: 8.14.18

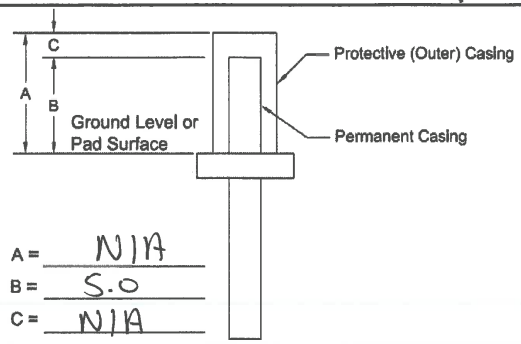
Location: ~1900' North of 200-W-33

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: 8.14.18	238.7'bgs	238.5'bgs
Date: ~~8.16.18~~ TMB 8.15.18	238.18'bgs	238.2'bgs
8.15.18 DEPTH TO BOTTOM:		
Date: ~~8.16.18~~ TMB 8.15.18	469.9'bgs	469.5'bgs
Date:		



A = N/A
B = 5.0
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)
424.54	16.6	419.5	225	4.62	0912	1056	80	4.83
382.04	29.3	377.0	21.9	4.28	1230	1333	120	~~3~~ TMB 9/16 4.09
318.74	31.5	313.7	9.29	2.69	1435	1516	125	3.97
* 276.54	27.2	271.50	29.6	3.46	0700	0858	125	4.60 *
						JLR 9/17/18		

Total Pumped: 44,430 gal

Pump Model: Grundfos QF2305400-11

Troll Serial Number and Pressure Range (PSI and depth): 546780 210m/692ft vented

Comments:

* From 0841-0858 on 8.15.16 gpm was 360gpm & max drawdown of 10.84' - STRESS TEST * (6,120 gal) - 33.2 gpm/ft

C9880_develop_int#1_8-14-18
C9880_develop_int#2_8-14-18
C9880_develop_int#3_8-14-18
C9880_develop_int#4_8-15-18

Prepared By:

Tracy Mallgren (Print Name) | [signature] (Signature) | 8.16.18 (Date)

Reviewed By:

Jennifer Richart (Print Name) | [signature] (Signature) | 9/17/18 (Date)

For Office Use Only

OR Doc Type: | WMU Code(s):

Page 1 of 1 | A-6005-205 (REV 2)

Huntington Ingalls Industries

Technical Solutions

699-47-78C (C9880)
Log Data Report

Borehole Information

Log Date	2018-06-14	Filename	C9880_HG-NM_2018-06-14	Site	200-ZP-1

DTW[1] (ft)	DTW Date	DTW Source	Drill Date	Total Depth (ft)	Depth Datum
239	06/13/18	HII	06/07/18	475.6	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.)		Thickness (in.)	Top (ft)	Bottom (ft)
			Outer	Inside			
Welded Steel	Dual Rotary	0.9	16	15 1/4	3/8	-0.9	255.1
Welded Steel	Dual Rotary	1.7	14	13 1/4	3/8	-1.7	463.7

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up and casing diameters. The maximum logging depth achieved was 466 ft, approximately two ft below reported casing depth. Zero reference is ground surface.

This borehole was originally drilled and logged to 221 ft inside a 16-in. OD casing in April 2018. The borehole was subsequently deepened approximately 33 ft with additional 16-in. casing to 255 ft where casing changed to 14-in. OD casing for the remainder of the borehole. This interval (221 to 255 ft) was logged within two casings June 13, 2018.

Logging Equipment Information

Logging System	Gamma 5TB	Type	60% Coaxial HPGe (SGLS)
Effective Calibration Date	11/28/2017	Serial No.	54-TP-13441B
Calibration Reference	HGLP-CC-167, 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	11/14/2017	Serial No.	H34055445
Calibration Reference	HGLP-CC-164, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

Logging System	Gamma 4NC	Type	60% Coaxial HPGe (SGLS)
Effective Calibration Date	12/07/2017	Serial No.	45-TP-22010A
Calibration Reference	HGLP-CC-168, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

[1] depth to water inside casing

Huntington Ingalls Industries

Technical Solutions

Logging System	Gamma 4MC	**Type**	He-3 (CPN 503DR) NMLS
Effective Calibration Date	12/04/2017	**Serial No.**	H340207279
Calibration Reference	HGLP-CC-165, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

SGLS Log Run Information

Log Run	**1**	**2 Repeat**	**6**	**7**	**8 Repeat**
HEIS Number	1020198	1020199	1020200	1020201	1020202
Date	04/27/18	04/27/18	06/13/18	06/14/18	06/14/18
Logging Engineer	Meisner/Felt	Meisner/Felt	Spatz	Spatz/McClellan	Spatz/McClellan
Start Depth (ft)	0.0	199.0	220.0	415.0	440.0
Finish Depth (ft)	221.02	221.02	423.03	466.0	465.01
Count Time (sec)	100	100	100	100	100
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA	NA
Pre-Verification	C9880FTB20180 427AV00CAB1	C9880FTB20180 427AV00CAB1	C9880FTB20180 613AV00CAB1	C9880FTB20180 614BV00CAB1	C9880FTB20180 614BV00CAB1
Start File	AD000000	BD019900	AD022000	BD041500	CD044000
Finish File	AD022102	BD022102	AD042303	BD046600	CD046501
Post-Verification	C9880FTB20180 427BV00CAA1	C9880FTB20180 427BV00CAA1	C9880FTB20180 613AV00CAA1	C9880FTB20180 614CV00CAA1	C9880FTB20180 614CV00CAA1
Depth Return Error (in.)	N/A	2.0 high	1.35 ft high	N/A	6 low
Comments	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made

NMLS Log Run Information

Log Run	**3**	**4**	**5 Repeat**	**9**	**10 Repeat**
HEIS Number	1020203	1020204	1020205	1020206	1020207
Date	04/26/18	04/27/18	04/27/18	06/14/18	06/14/18
Logging Engineer	Felt/McClellan/ Meisner	Felt/ Meisner	Felt/ Meisner	Spatz/McClellan	Spatz/McClellan
Start Depth (ft)	0.0	189.0	190.0	221.0	236.0
Finish Depth (ft)	190.0	222.01	212.0	239.0	238.74
Count Time (sec)	15	15	15	15	15
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	0.25	0.25	0.25	0.25	0.25
Log Speed (ft/min)	NA	NA	NA	NA	NA
Pre-Verification	C9880FPB20180 426AV00CAB1	C9880FPB20180 427BV00CAB1	C9880FPB20180 427BV00CAB1	C9880FPB20180 614AV00CAB1	C9880FPB20180 614AV00CAB1
Start File	AD000000	BD018900	CD019000	AD022100	BD023600

Log Run	3	4	5 Repeat	9	10 Repeat
Finish File	AD019000	BD022201	CD021200	AD023900	BD023874
Post-Verification	C9880FPB20180 426AV00CAA1	C9880FPB20180 427CV00CAA1	C9880FPB20180 427CV00CAA1	C9880FPB20180 614BV00CAA1	C9880FPB20180 614BV00CAA1
Depth Return Error (in.)	3.0 high	N/A	1.5 high	N/A	0.5 low
Comments	None	None	None	None	None

Logging Operation Notes

A centralizer was not installed on the sondes for the first casing to 221 ft. A centralizer was installed for the remainder of the borehole.

Analysis Notes

Analyst	P.D. Henwood	Date	06/22/18
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

Casing corrections for a 3/8-in. thick casing were applied to the SGLS log data from ground surface to 220 ft, 3/4-in. from 221 to 255 ft, and 3/8 to the bottom of the borehole.

A water correction was applied below 239 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 FTB20171128 and DNC20171207 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

An interpreted data set was created for this borehole. Depth overlaps from consecutive log runs were removed from 220 and 221 ft and from 415 to 423 ft. This results in a data set where only one data point is presented for each depth.

Neutron moisture data are reported in counts per second (cps) as there is no calibration available to convert to volumetric moisture for the large diameter casings.

HGU[2] 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.

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 may increase in sediments of relatively high silt or clay content.

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

[2] Hanford Gamma Unit

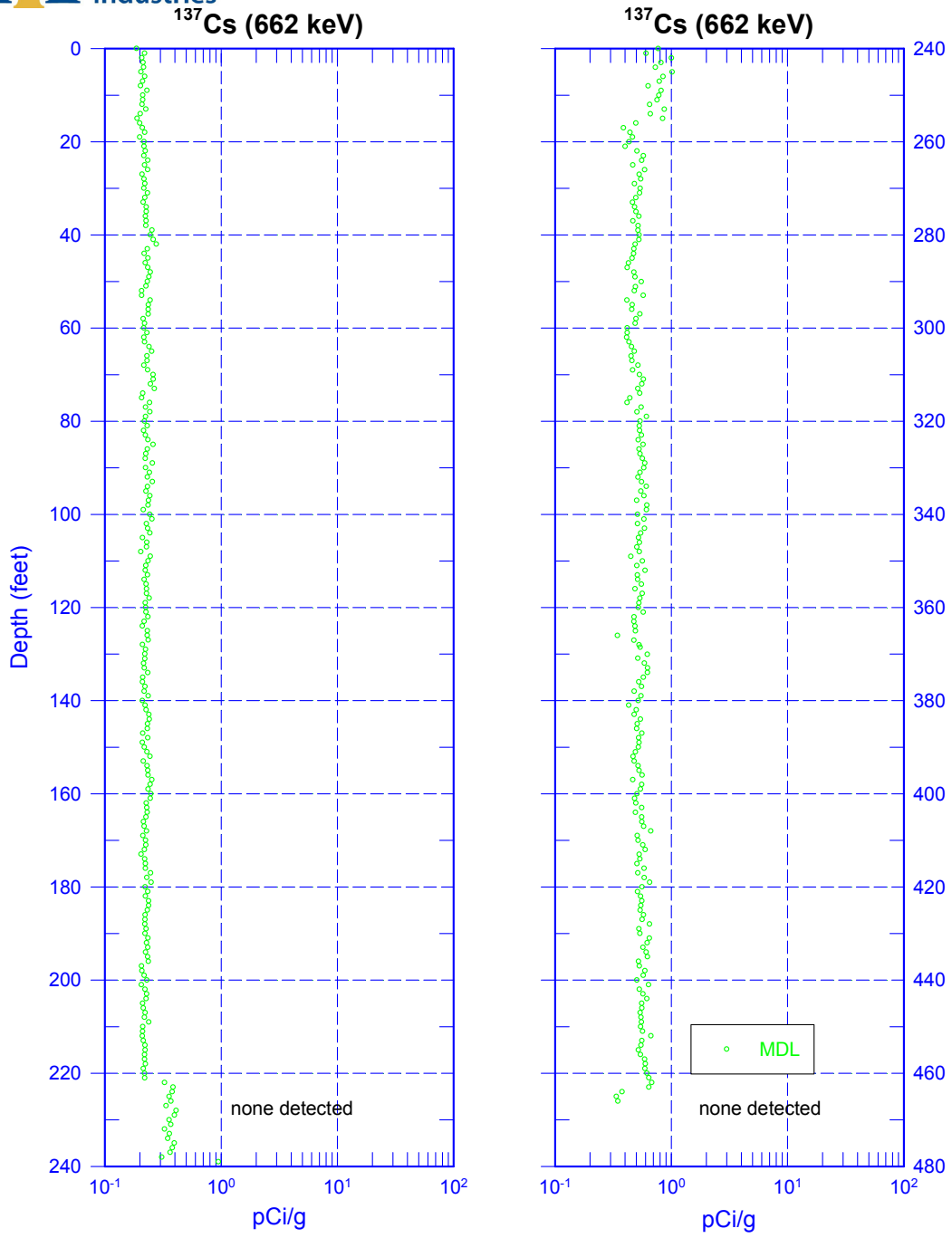
List of Log Plots

Depth Reference is ground surface.

Manmade Radionuclides (0-480 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (150-310 ft)
Natural Gamma Logs (310-470 ft)
Combination Plot (0-120 ft)
Combination Plot (110-230 ft)
Combination Plot (230-350 ft)
Combination Plot (350-470 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 (199-202 ft)
Repeat Section of Natural Gamma Logs (440-460 ft)
Moisture Repeat Section (190-212 ft)
Moisture Repeat Section (236-239 ft)

Huntington Ingalls Industries

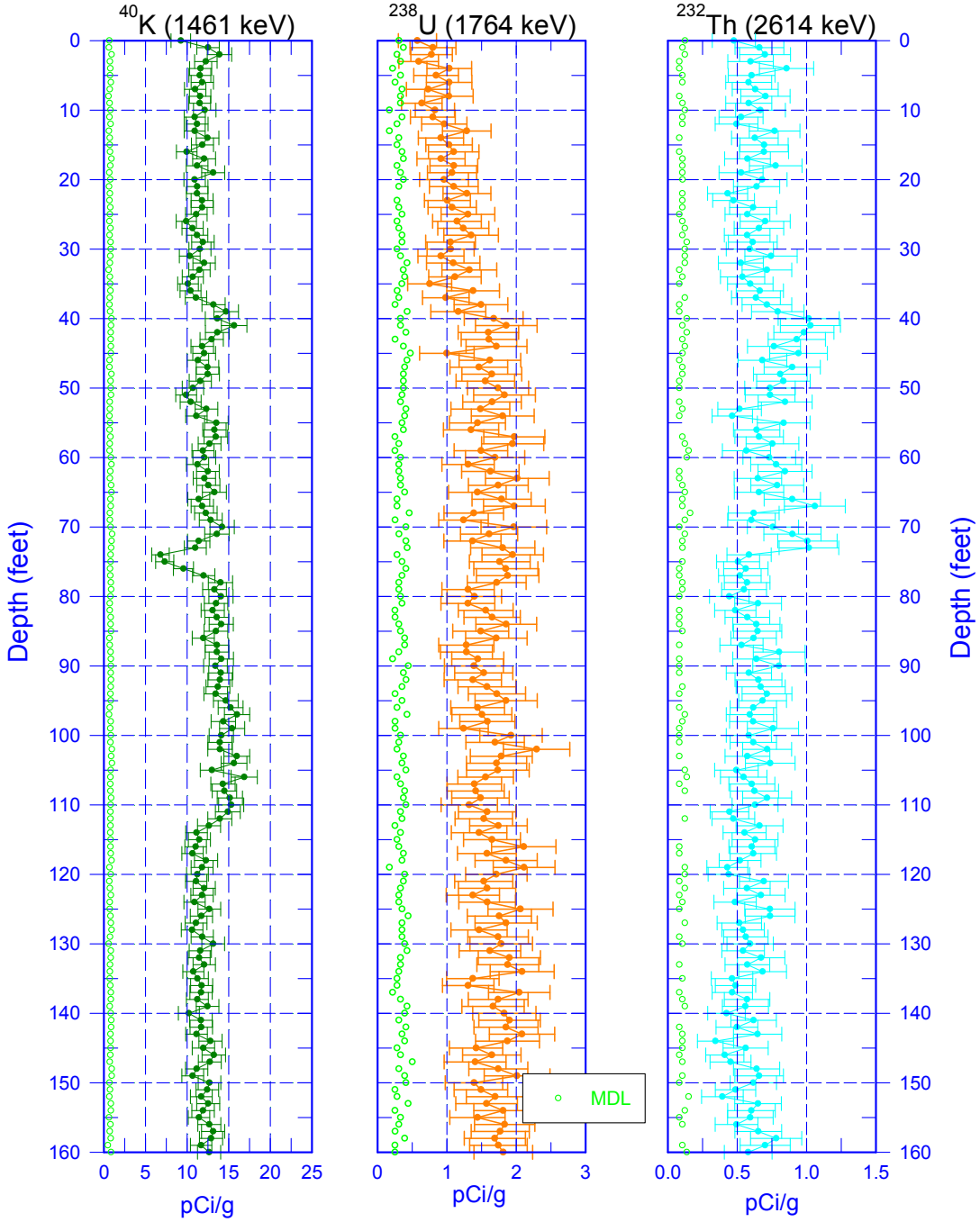
699-47-78C (C9880)
Manmade Radionuclides



Zero Reference - Ground Surface

Huntington Ingalls Industries

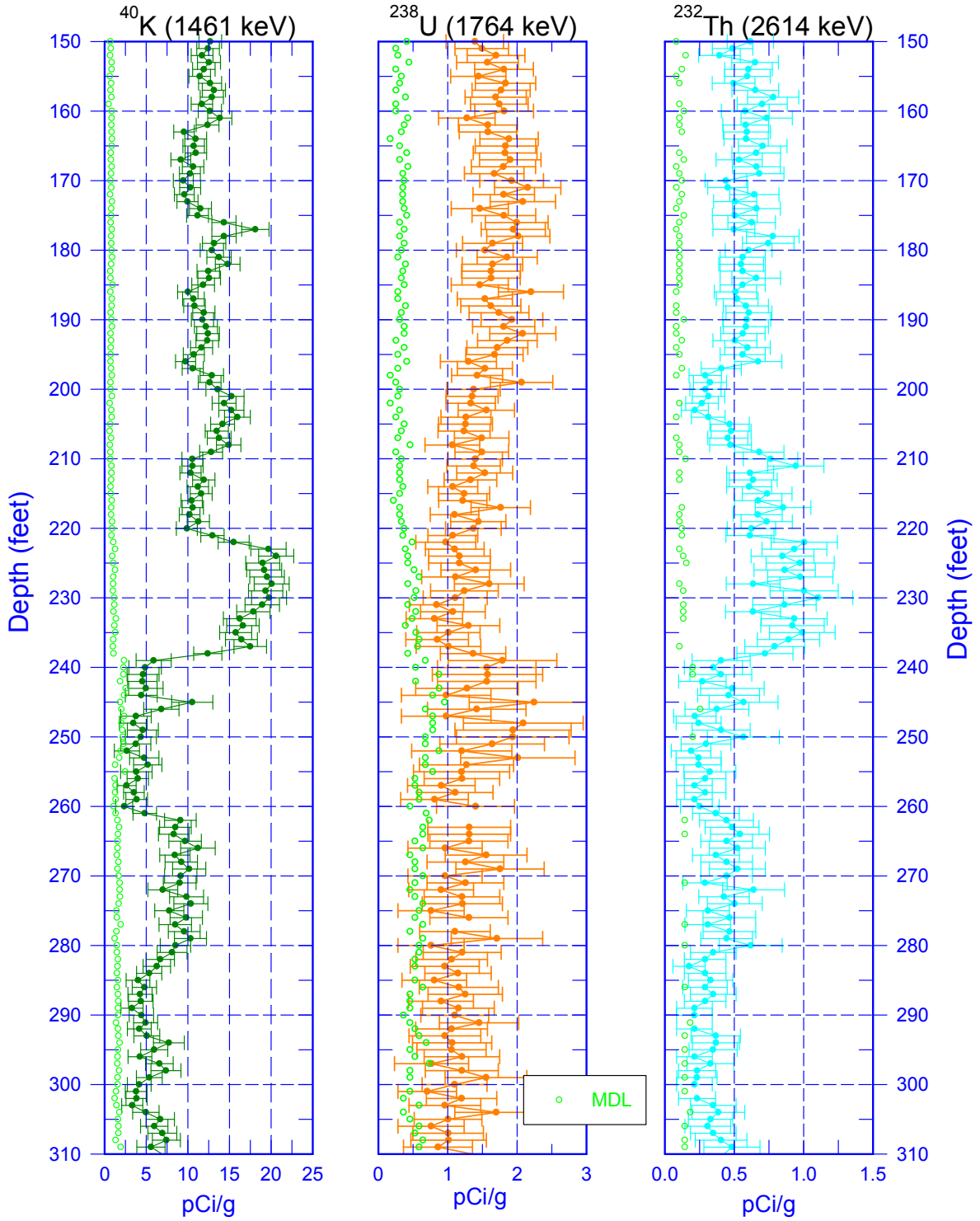
699-47-78C (C9880)
Natural Gamma Logs



Zero Reference - Ground Surface

Huntington Ingalls Industries

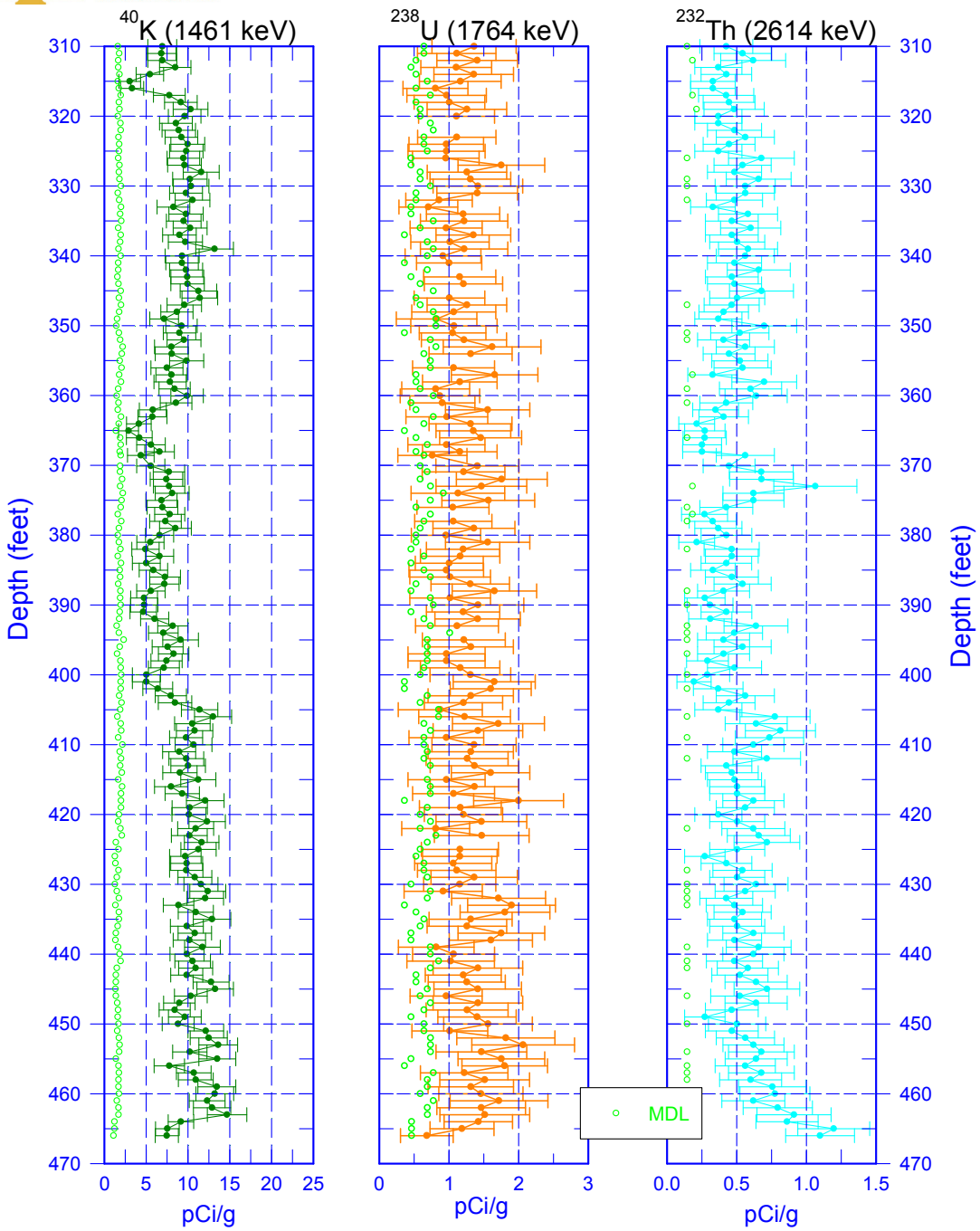
699-47-78C (C9880)
Natural Gamma Logs



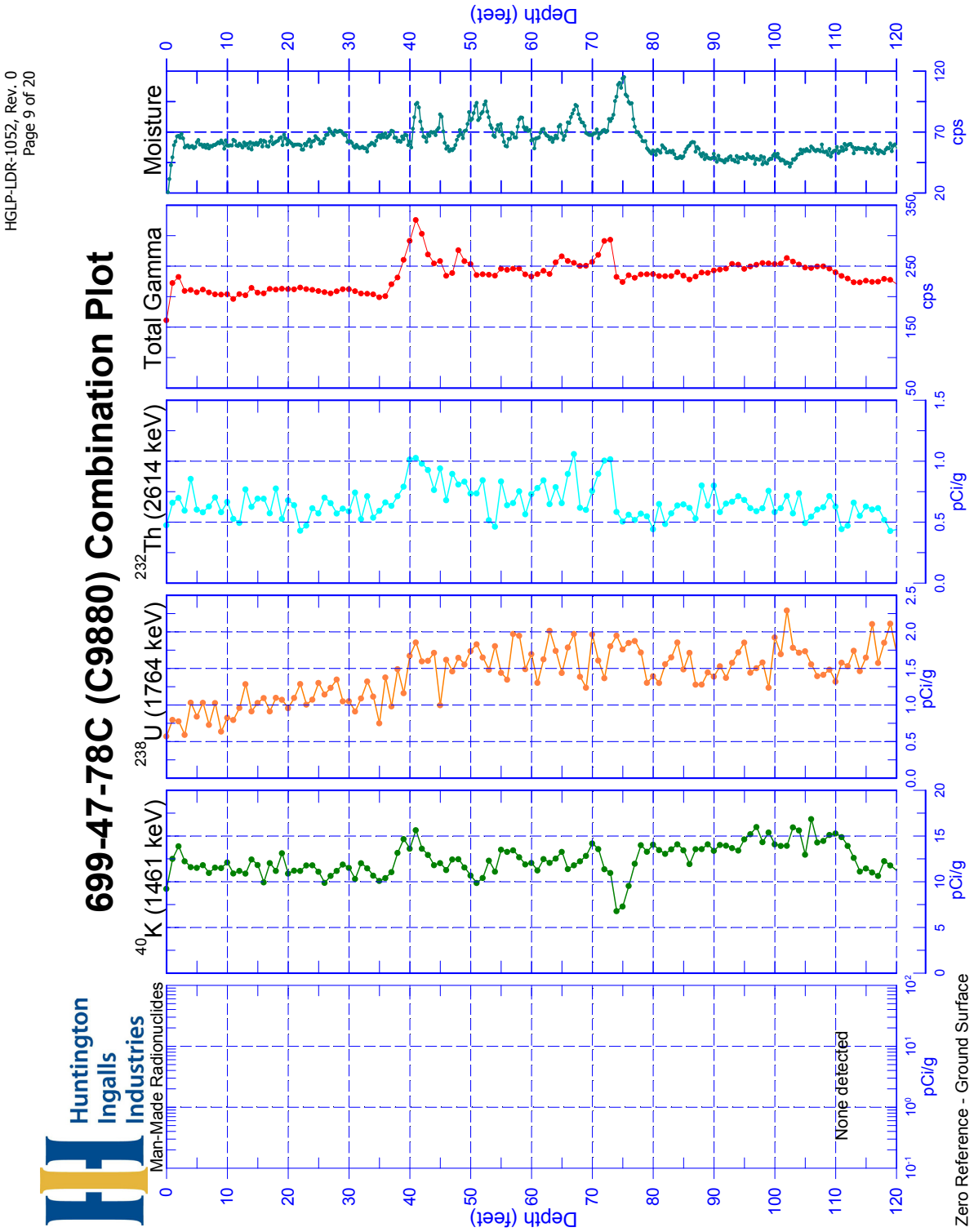
Zero Reference - Ground Surface

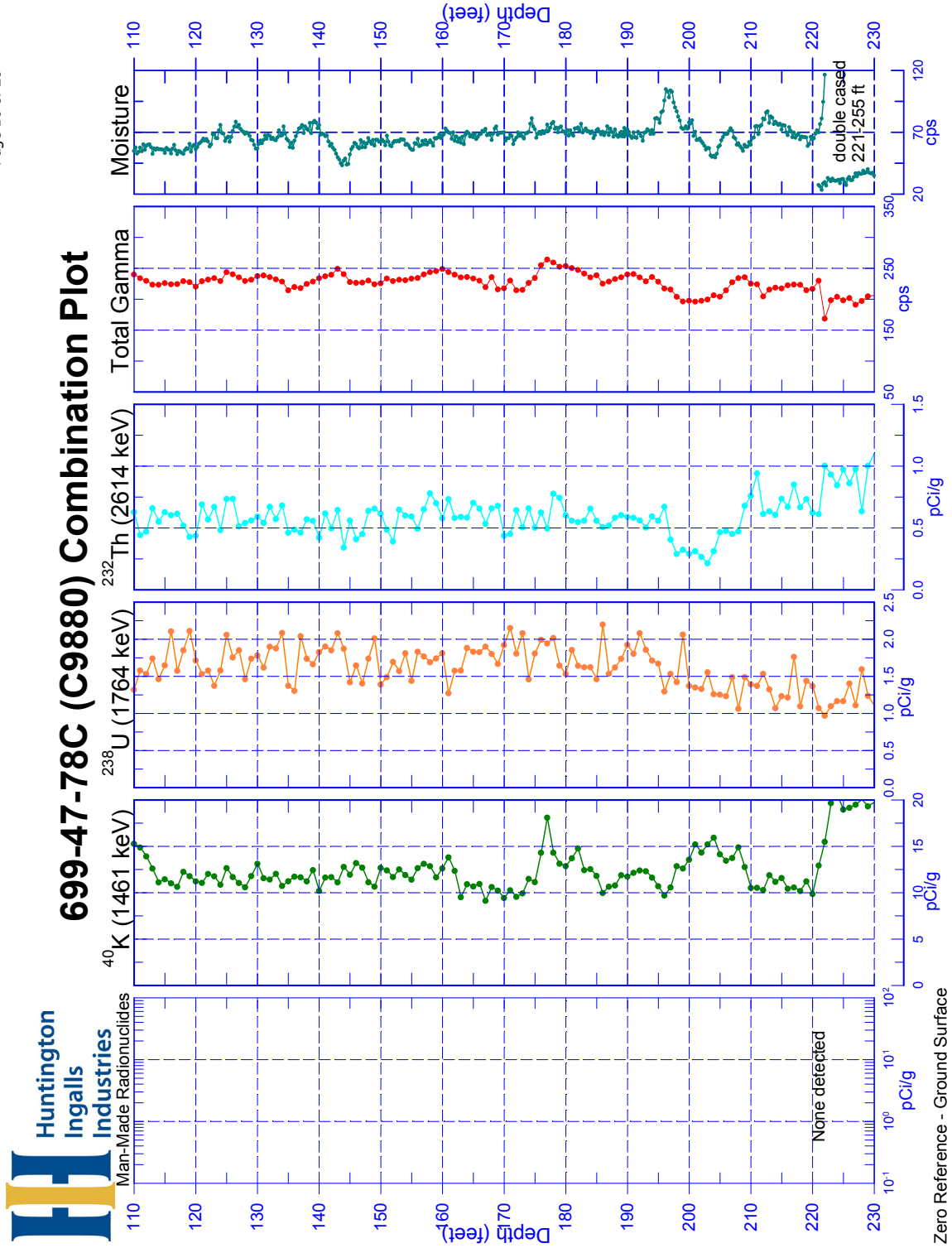
Huntington Ingalls Industries

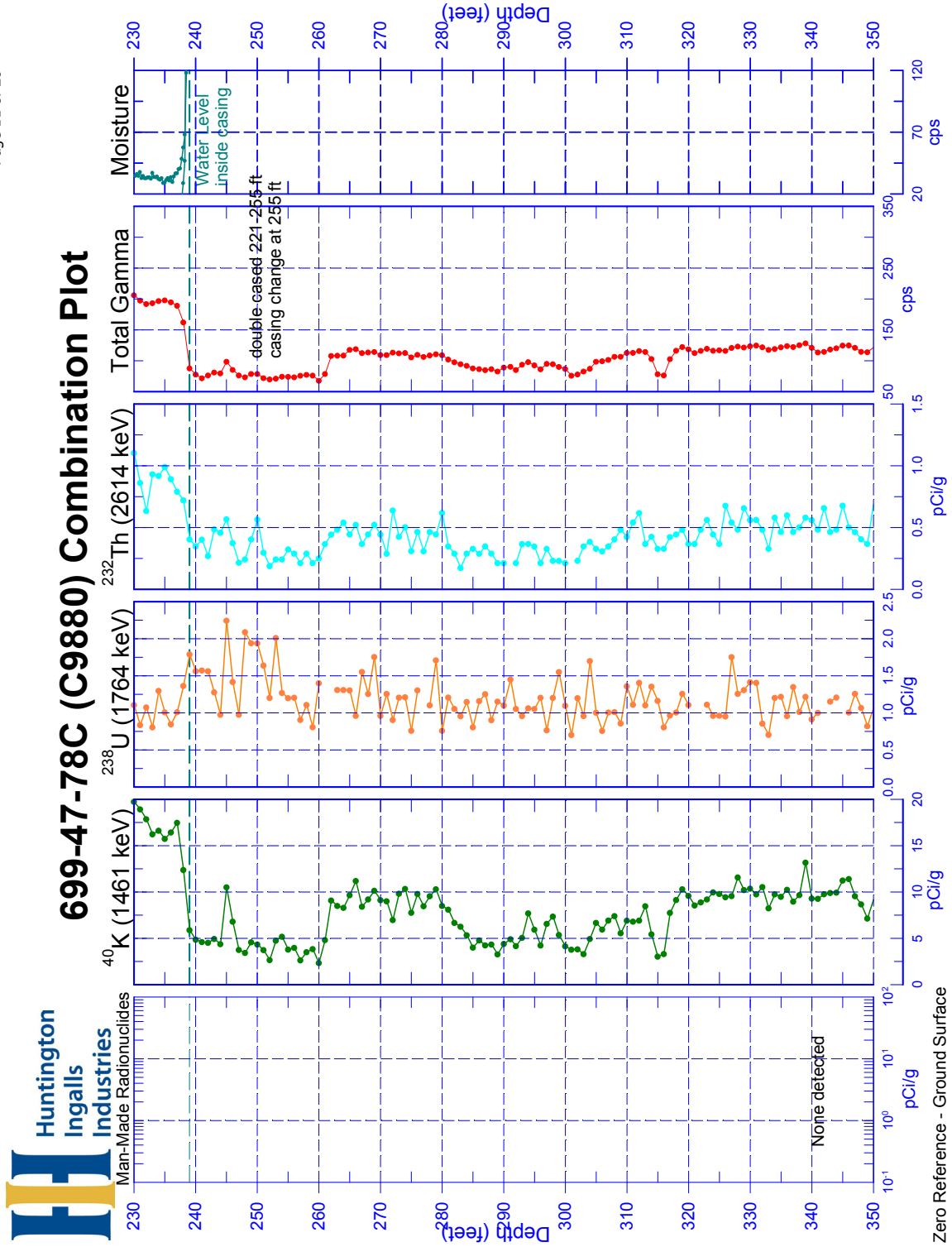
699-47-78C (C9880)
Natural Gamma Logs

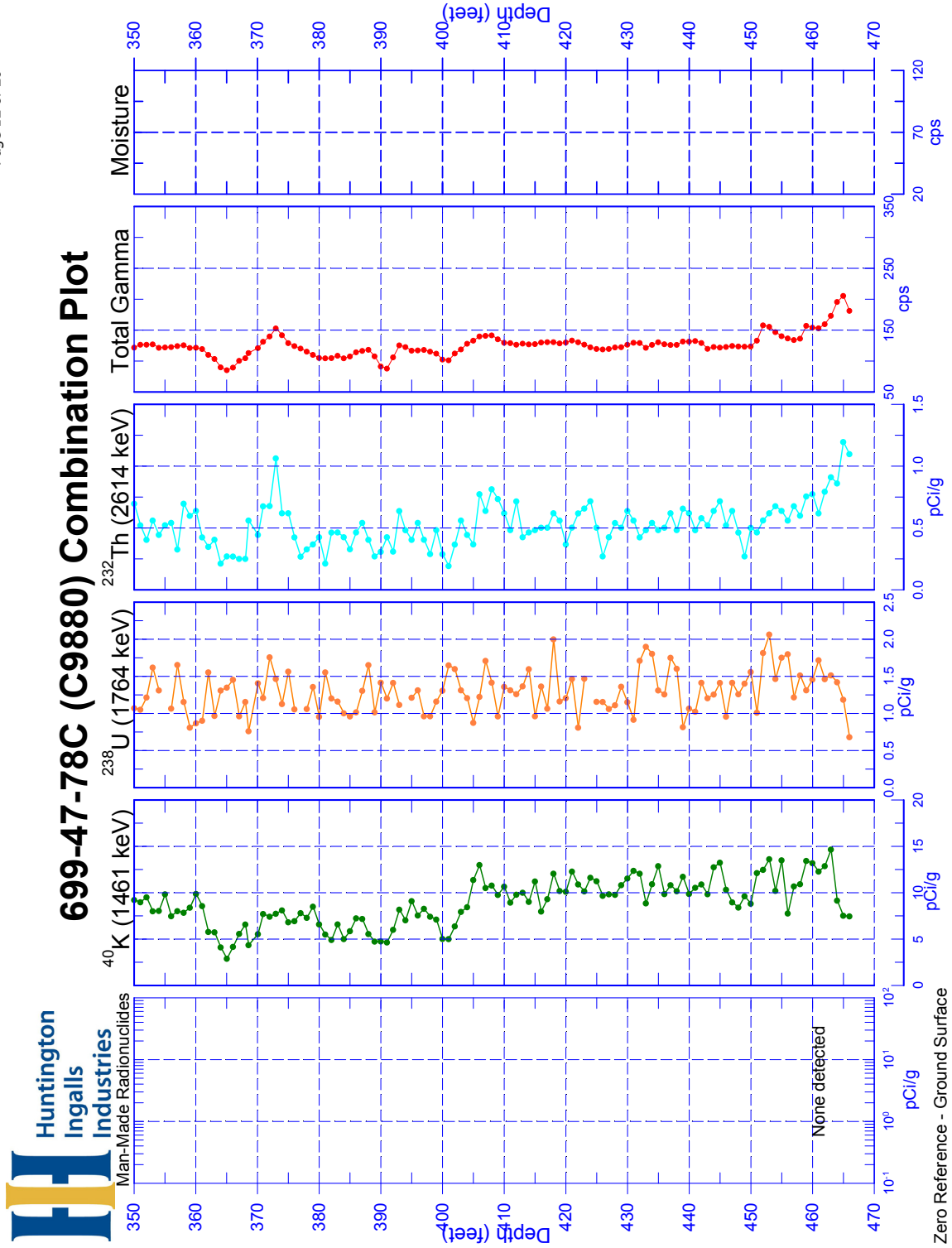


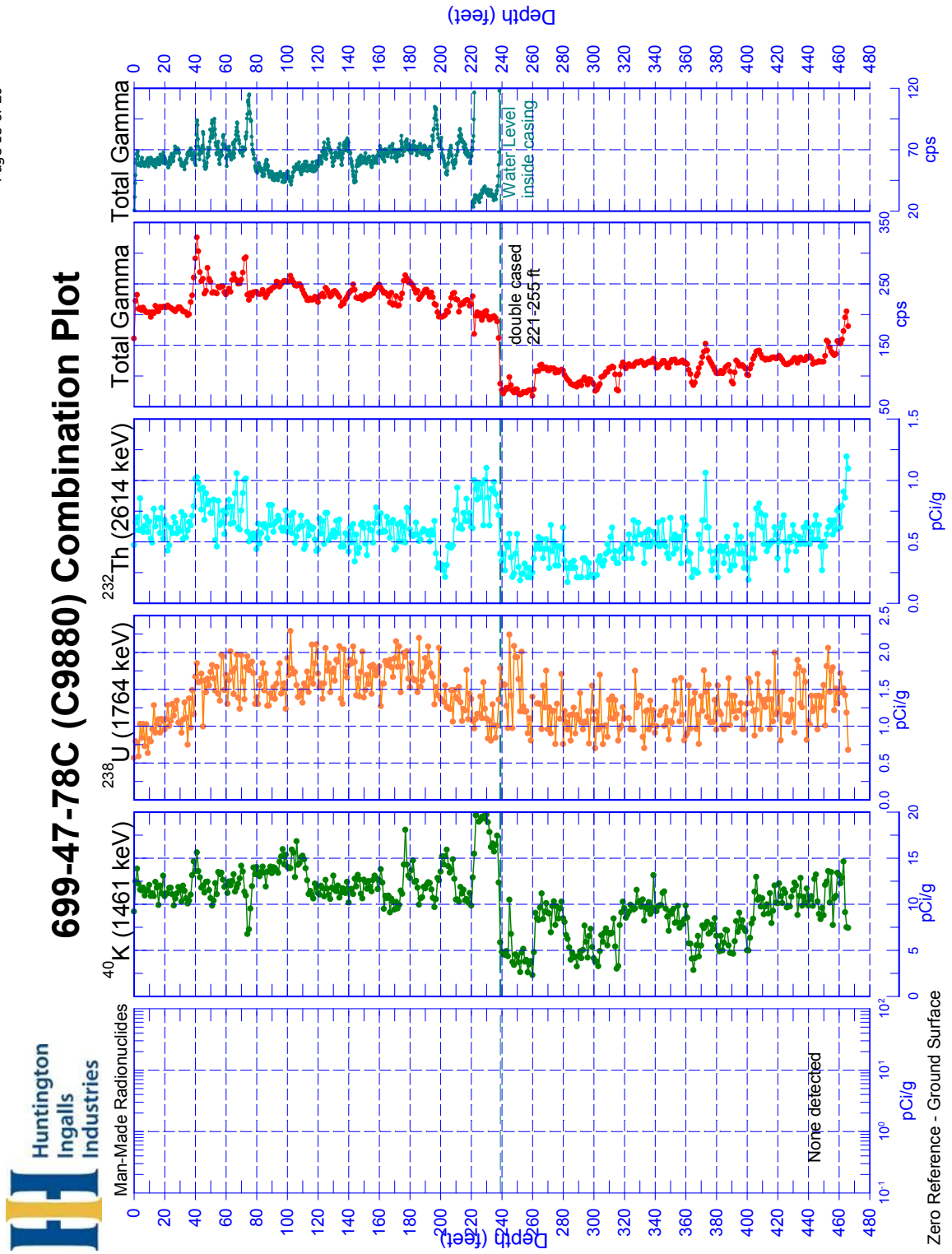
Zero Reference - Ground Surface


HGLP-LDR-1052, Rev. 0
Page 9 of 20
Huntington Ingalls Industries
699-47-78C (C9880) Combination Plot
Man-Made Radionuclides
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Moisture
None detected
pCi/g
cps
Depth (feet)
Zero Reference - Ground Surface


699-47-78C (C9880) Combination Plot
Huntington Ingalls Industries
Man-Made Radionuclides
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Moisture
Depth (feet)
pCi/g
cps
None detected
double cased 221-255 ft
Zero Reference - Ground Surface

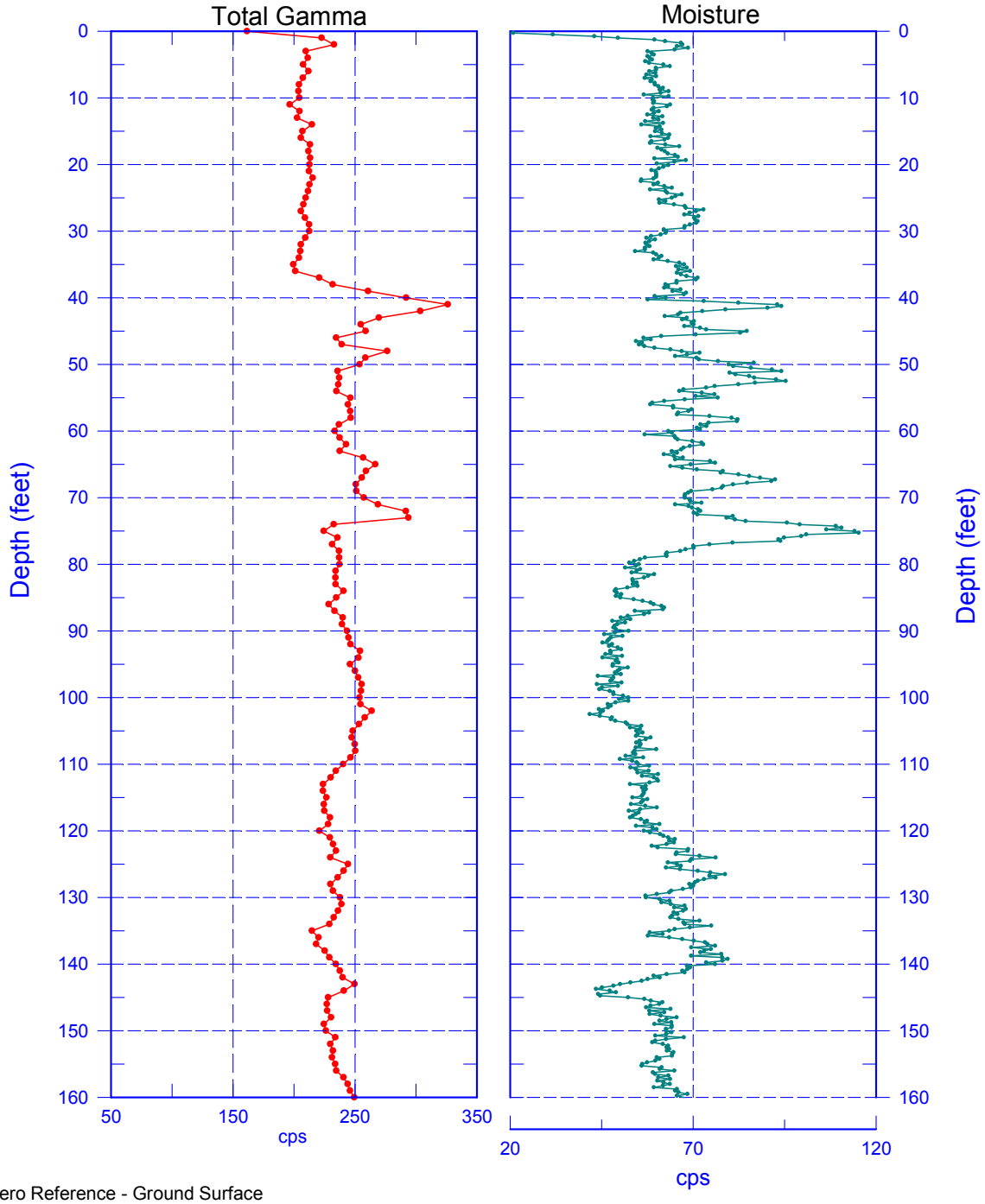

699-47-78C (C9880) Combination Plot
Huntington Ingalls Industries
Man-Made Radionuclides
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Moisture
Water Level inside casing
double cased 221-255 ft
casing change at 255 ft
None detected
pCi/g
cps
Depth (feet)
Zero Reference - Ground Surface


699-47-78C (C9880) Combination Plot
Huntington Ingalls Industries
Man-Made Radionuclides
None detected
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Moisture
pCi/g
cps
Depth (feet)
Zero Reference - Ground Surface


Huntington Ingalls Industries
699-47-78C (C9880) Combination Plot
Man-Made Radionuclides
None detected
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Total Gamma
double cased 221-255 ft
Water Level inside casing
Depth (feet)
pCi/g
cps
Zero Reference - Ground Surface

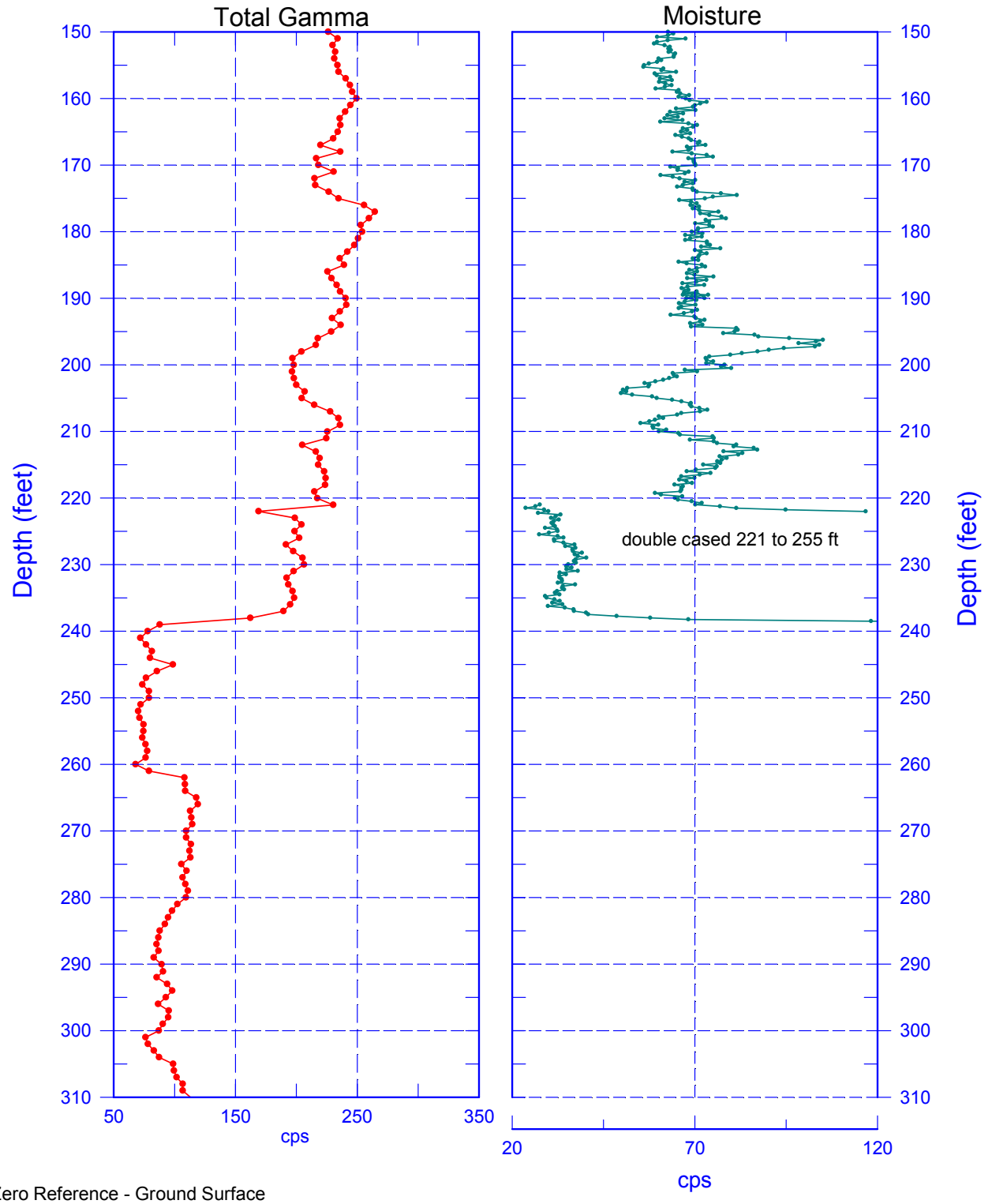
Huntington Ingalls Industries

699-47-78C (C9880)
Total Gamma & Moisture



Zero Reference - Ground Surface

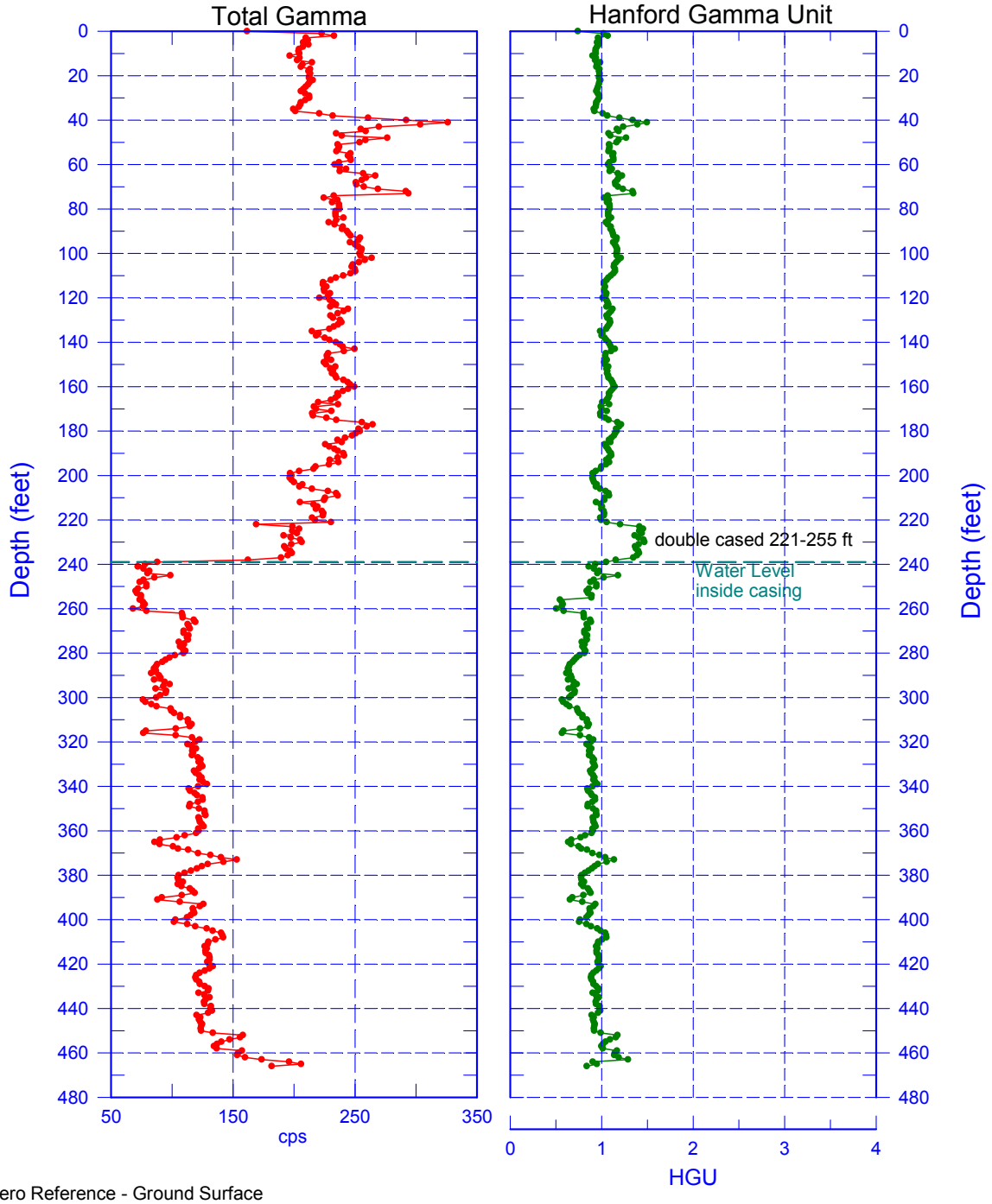
699-347-78C (C9880)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

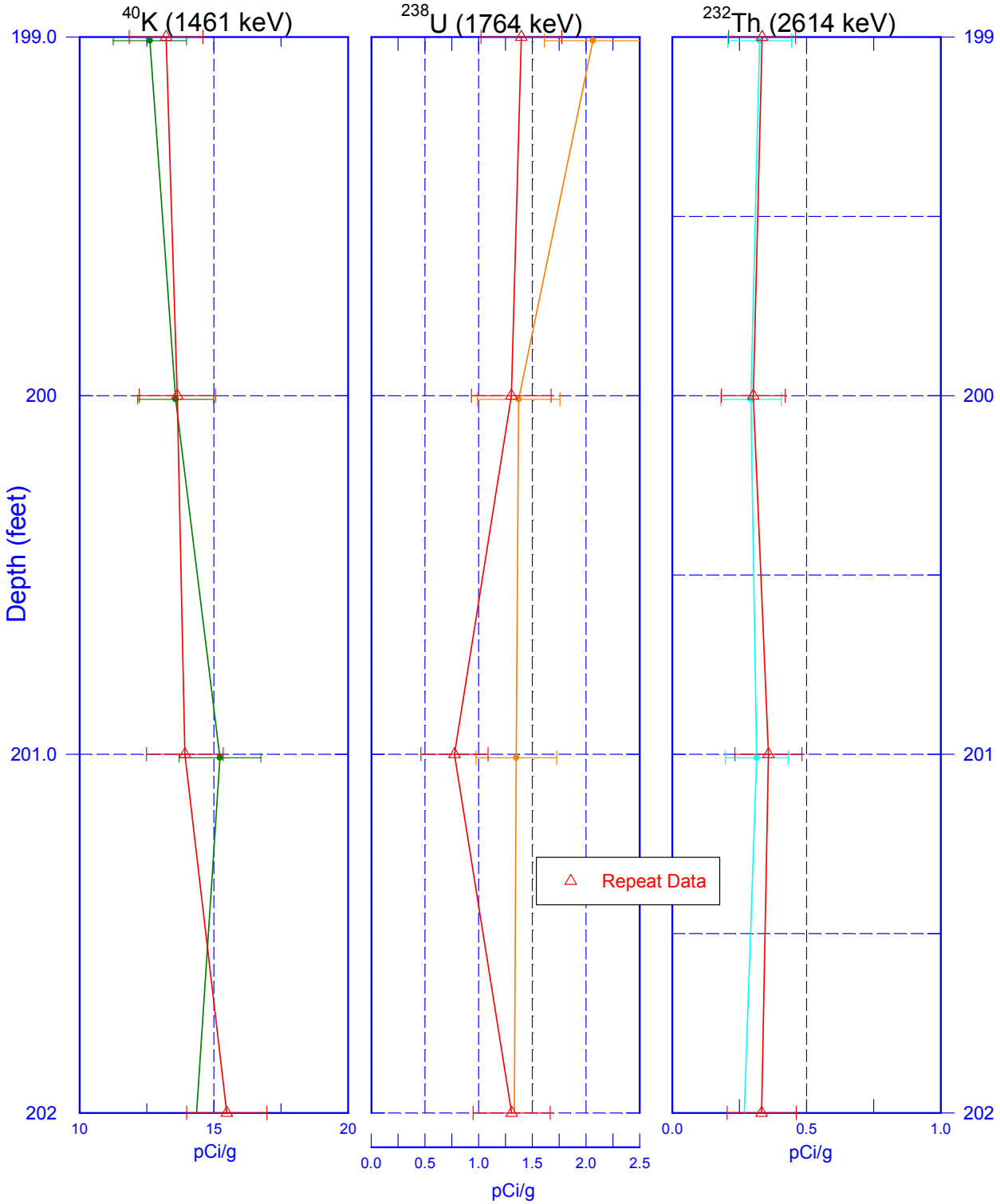
699-47-78C (C9880)
Total Gamma & Hanford Gamma Unit



Zero Reference - Ground Surface

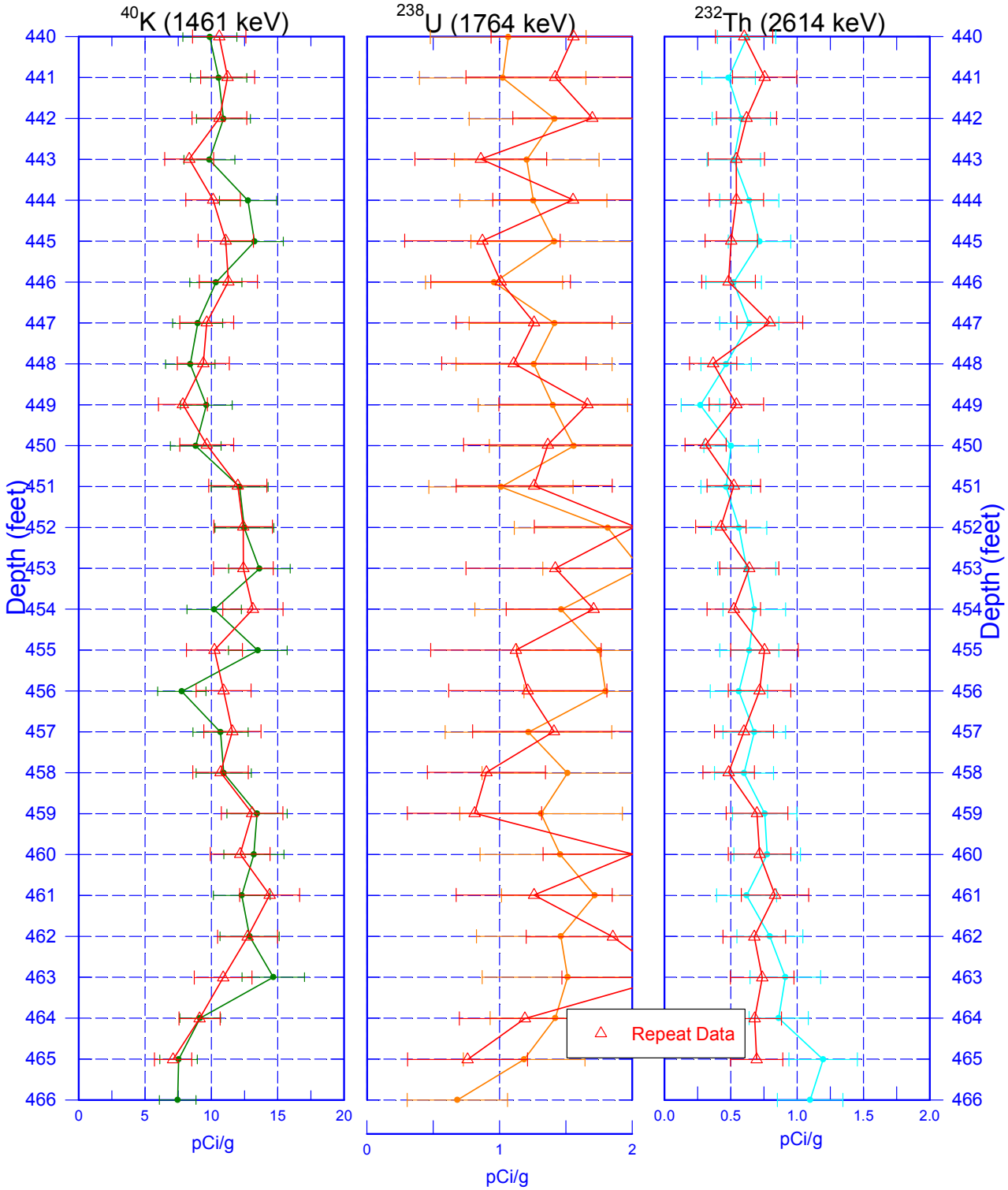
699-47-78C (C9880)

Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

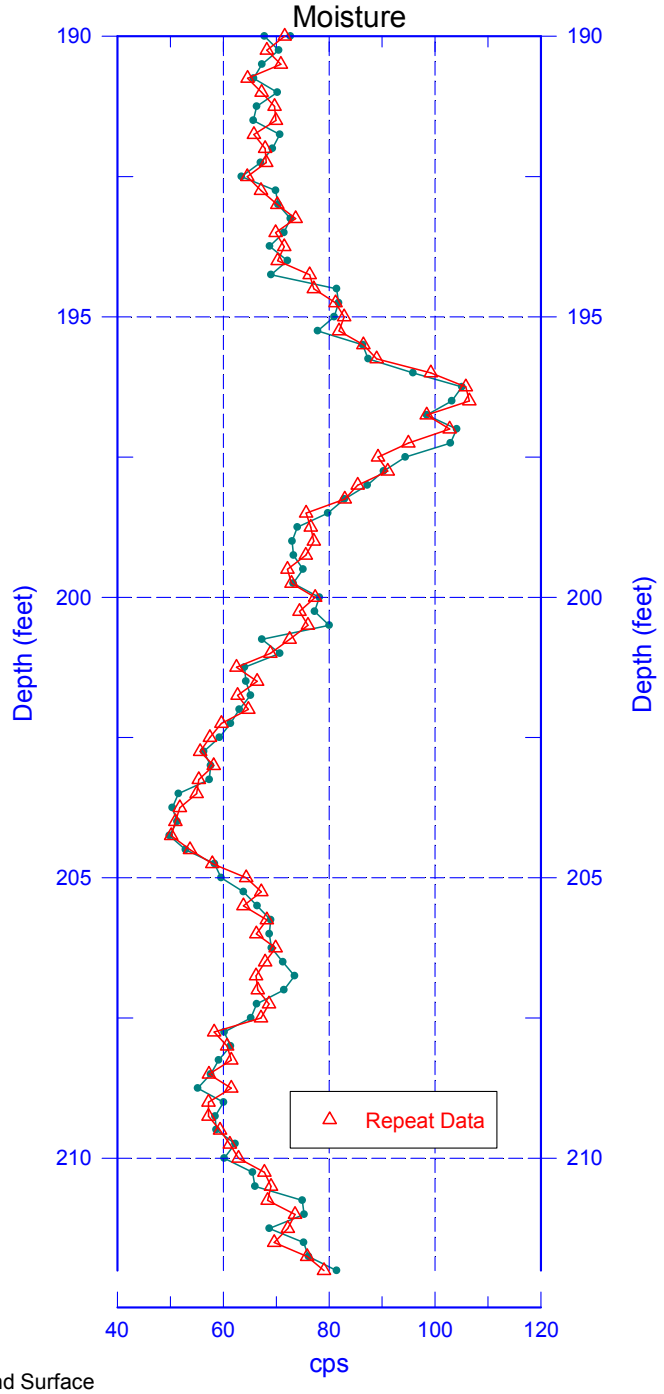
699-47-78C (C9880)
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

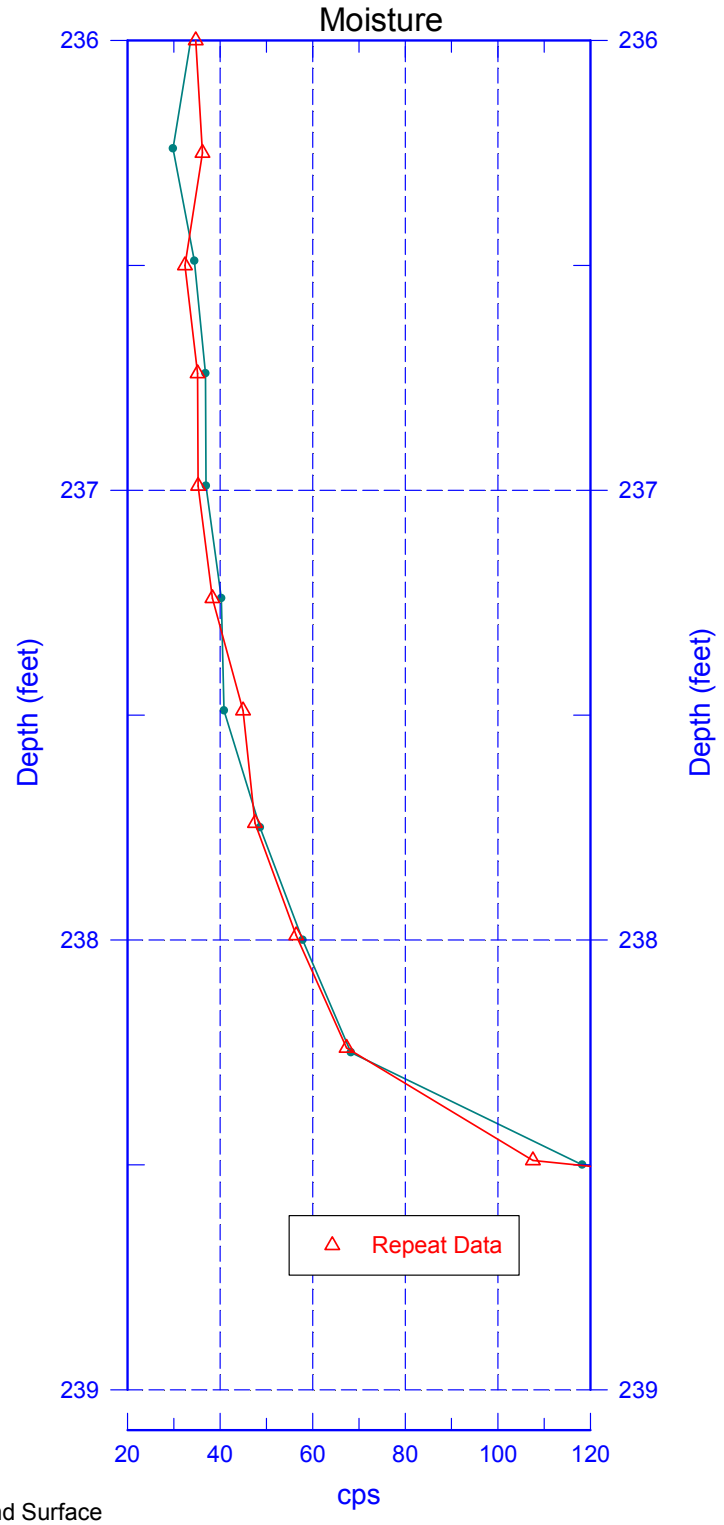
Huntington Ingalls Industries

699-47-78C (C9880)
Moisture Repeat Section



Zero Reference - Ground Surface

699-47-78C (C9880)
Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 08/29/18	Requestor: Matthan G. Wilson (CHPRC)
Date of Survey: 09/04/18	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of 200-ZP-1 Well C9880 (699-47-78C) 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	
C9880	699-47-78C	566046.21	138045.76		Center of Casing
				208.661	Top Baseplate, N.Edge
				208.633	Top Outer 10"SS Casing, N.Edge
				207.904	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.

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
9.4.18

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A-6003-659 (REV 1)

Appendix C

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

Well Construction Variance: Greater than Five Feet of Filter Pack above the Screen
March 7, 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) 373-9068
[Provided by K.M. Whitley, CHPRC, Soil & Groundwater Remediation Project, Well Coordinator, (509) 373-4929]

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

Well Name	Well ID	Easting	Northing	Operable Unit	Purpose
699-47-48	C9878	566047.4	137801.02	200-ZP-1	Injection
699-47-87C	C9880	566046.1	138045.91	200-ZP-1	Injection

The specific regulation(s) that cannot be followed; comparable alternative specification; and justification for the request:
A variance is requested for constructing the 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 wells supporting the 200 West Groundwater Pump-and-Treat system. The U.S. Department of Energy is requesting the sand filter pack extend 10 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. Figure 1 illustrates the locations of the new 200-ZP-1 wells.

Figure 2 illustrates the conceptual well design for the injection wells planned for the 200-ZP-1 OU. If no Ringold Lower Mud (RLM) is present, as shown in Figure 2, the well will be completed with the base set into basalt. 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 injection of treated groundwater and well maintenance activities 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 that would reduce injection capacity and ultimately impact the through put of the pump-and-treat system. Therefore it is prudent to extend the sand filter packs beyond the 5 foot maximum specified in WAC 173-160-450 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 planned to have approximately 10 ft of filter pack sand extend beyond the top of the screened interval for all of the wells listed in this variance request. Depths from the surface to groundwater range from 236 – 239 feet in the vicinity of these wells, so the additional filter pack will not significantly reduce the overall length of the annular seal in the annulus of the well. All other aspects of the completion for these wells will be in accordance with WAC requirements.

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

Well Construction Variance: Greater than Five Feet of Filter Pack above the Screen
March 7, 2018

Concurrence & date: Kelly Whitley 3/8/18 — K.M. Whitley, S&GRP Well Coordinator

Concurrence & date: Dwayne Crumpler 3/9/18 — Dwayne Crumpler, WDOE, Nuclear Waste Program, Richland, WA 99354

Concurrence & date: 3/13/18 — Cheryl Whalen, WDOE, Section Manager, Nuclear Waste Program, Richland, WA 99354

Well Construction Variance: Greater than Five Feet of Filter Pack above the Screen
March 7, 2018

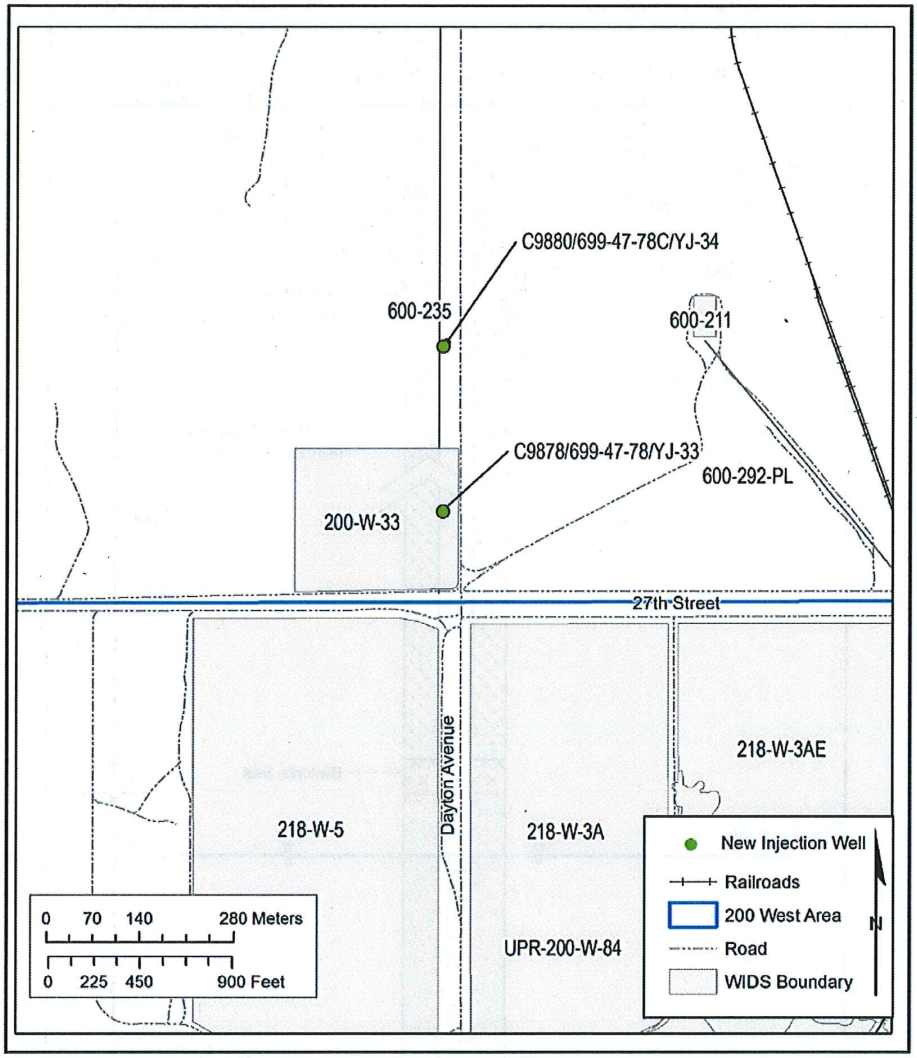

Figure 1. Map of 200-ZP-1 Well Locations.

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Well Construction Variance: Greater than Five Feet of Filter Pack above the Screen
March 7, 2018

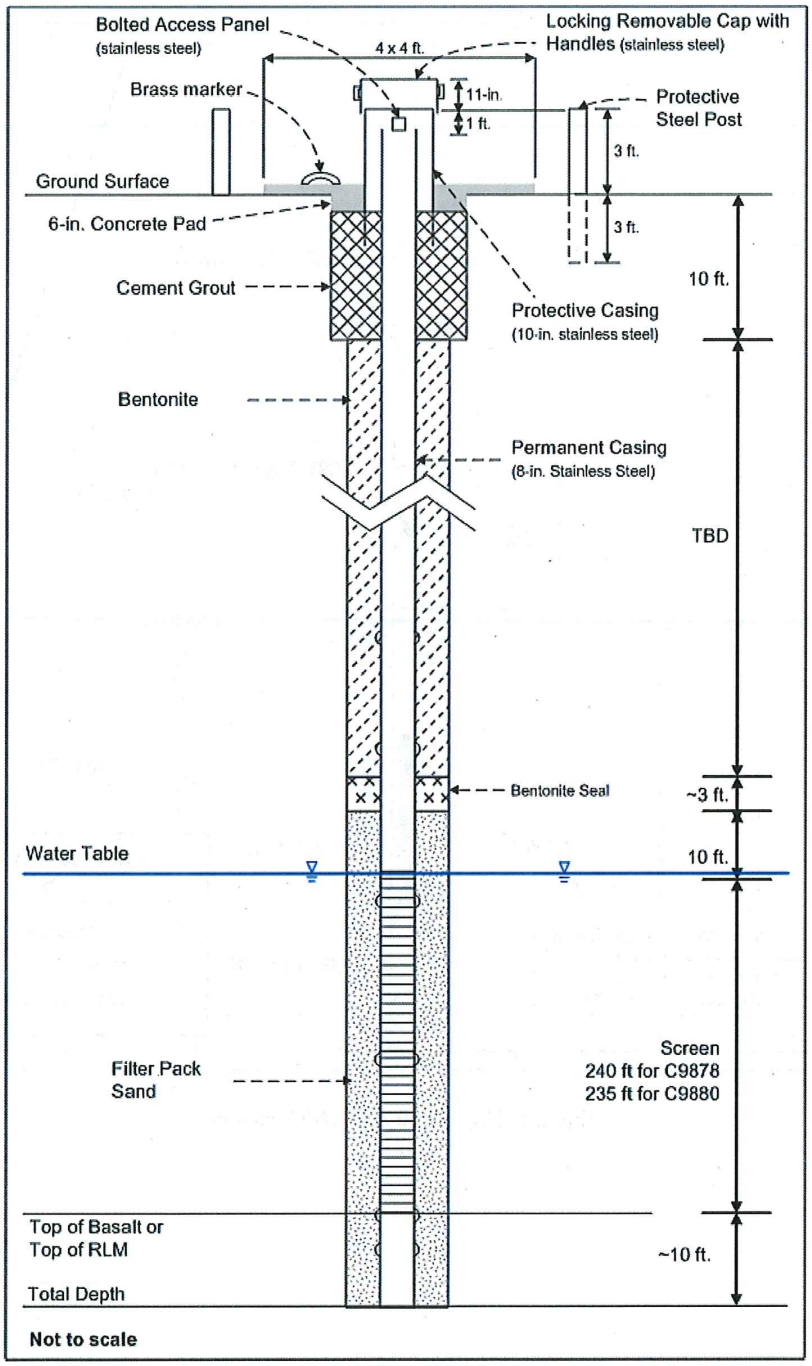

Figure 2. Proposed 200-ZP-1 Injection Well Design.

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