

Borehole Summary Report for the Installation of Four Monitoring Wells at the 100-KR-4 Operable Unit, FY 2017

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



**P.O. Box 1600
Richland, Washington 99352**

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Terms

bgs	below ground surface
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CHPRC	CH2M Hill Plateau Remediation Company
cm	centimeter
CrVI	hexavalent chromium
D.O.	dissolved oxygen
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
ID	identification
hp	horsepower
in.	inch
NMLS	Neutron Moisture Logging System
NR	not recorded
NTU	Nephelometric Turbidity Units
OU	operable unit
RUM	Ringold Formation member of Wooded Island – “upper mud” unit
Rwie	Ringold Formation member of Wooded Island - unit E
SGLS	Spectral Gamma Logging System
SN3	Stoller Newport News Nuclear, Inc.
TD	total depth
WAC	Washington Administrative Code

Metric Conversion Chart

Into Metric Units			Out of Metric Units		
<i>If you know</i>	<i>Multiply by</i>	<i>To get</i>	<i>If you know</i>	<i>Multiply by</i>	<i>To get</i>
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 summarizes field activities that took place during the installation of four groundwater dual-purpose monitoring wells in the 100-K Area of the Hanford Site. The four new wells will support the delineation of groundwater contamination within the 100-KR-4 groundwater Operable Unit (OU). The wells were installed as part of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)* preferred remedial alternative set forth in DOE/RL-2013-33, *Remedial Design/Remedial Action Work Plan for the 100-KR-4 Groundwater Operable Unit Interim Action*. Field activities carried out during the installation of the four new wells included drilling, soil and groundwater sampling, well construction, and development.

The 100-K Area, located in the northwestern portion of the Hanford Site along the southern shoreline of the Columbia River and is located approximately 27 miles north-northwest of Richland, Washington. The 100-K Area includes the 100-K East and 100-K West Reactor Areas and adjacent portions of the 600 Area. Groundwater contamination at the 100-KR-4 OU originated from discharges of contaminated waste water and chemical solutions during the period of operation of the 105KE and 105KW plutonium production reactors. Groundwater contamination by hexavalent chromium (Cr[VI]), which is the basis for the current interim remedial action, originated from planned discharges of chromium-treated cooling water, primarily to the ground at the 116-K-2 Trench, and from planned and unplanned releases of concentrated sodium dichromate solution used to treat the reactor cooling water. Other groundwater co-contaminants of concern are strontium-90, carbon-14, nitrate, trichloroethene, and tritium (DOE/RL-2013 33).

The current interim remedy at 100-KR-4 OU consists of three pump-and-treat systems that capture contaminated groundwater, treat it to remove Cr(VI), and inject the treated water back into the aquifer. The interim remedy is currently capturing the Cr(VI) plume, however, additional activities can increase contaminant removal for aquifer restoration, refine the area conceptual site model, and optimize the effectiveness of pump-and-treat systems (SGW-59936, *FY2017 Plume Containment and Remediation Utilization Plan*).

Drilling and construction of the four new wells occurred from April 3, 2017, through September 28, 2017, and was performed by Carpenter Drilling LLC, under the direction of CH2M HILL Plateau Remediation Company (CHPRC). Freestone Environmental Services, Inc. provided well site geology and well construction documentation services and Stoller Newport News Nuclear, Incorporated (SN3) provided geophysical logging services. Sediment and groundwater samples were collected by the CHPRC Soil and Groundwater Remediation Project.

1.1 Purpose and Scope

This document summarizes the observations and measurements made during the drilling and installation of four new wells in the 100-KR-4 OU. This summary report includes the field notes and forms prepared during the drilling of the wells, construction details, well development data, and geologic observations. Additional information provided in this report includes 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-60464, *Description of Work for the Installation of Four 100-KR-4 Groundwater Operable Unit Monitoring Wells, FY2017*. Soil and groundwater samples were collected in accordance with DOE/RL-2013-36-ADD4, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan, Addendum 4: Wells 199-K-227, 199-K-228, 199-K-229, and 199-K-230*.

Appendices A (C9711), B (C9712), C (C9713), and D (C9714) 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.

All drilling data are reported in the original units recorded at the time of measurement. Table 1-1 lists the wells' identification number and name, and Figure 1-1 presents the well locations. The four new wells will hereafter be referred to in the text by the borehole identification number (e.g., C9711).

Table 1-1. Identification of New Wells in the 100-KR-4 Operable Unit

Borehole ID	Well Name	Ecology Tag ID	Northing ^a	Easting ^a	Brass Survey Marker Elevation ^b	Field Activity Dates	
			meters			Initiate Field Work	Conclude Field Work ^c
C9711	199-K-227	BKG 055	146851.61	569538.69	143.19	5/16/2017	8/29/2017
C9712	199-K-228	BJB 521	146775.64	569393.12	143.35	4/3/2017	7/27/2017
C9713	199-K-229	BKG 059	146311.08	568867.99	145.66	5/3/2017	9/28/2017
C9714	199-K-230	BJB 517	146759.31	568738.15	135.69	4/3/2017	7/18/2017

a. Northing and easting coordinates are based on Washington State Plane Coordinates NAD83, North American Datum of 1983.

b. Vertical elevation values are based on NAVD88, North American Vertical Datum of 1988 and are rounded to 0.01 meter.

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

Ecology = Washington State Department of Ecology

ID = identification

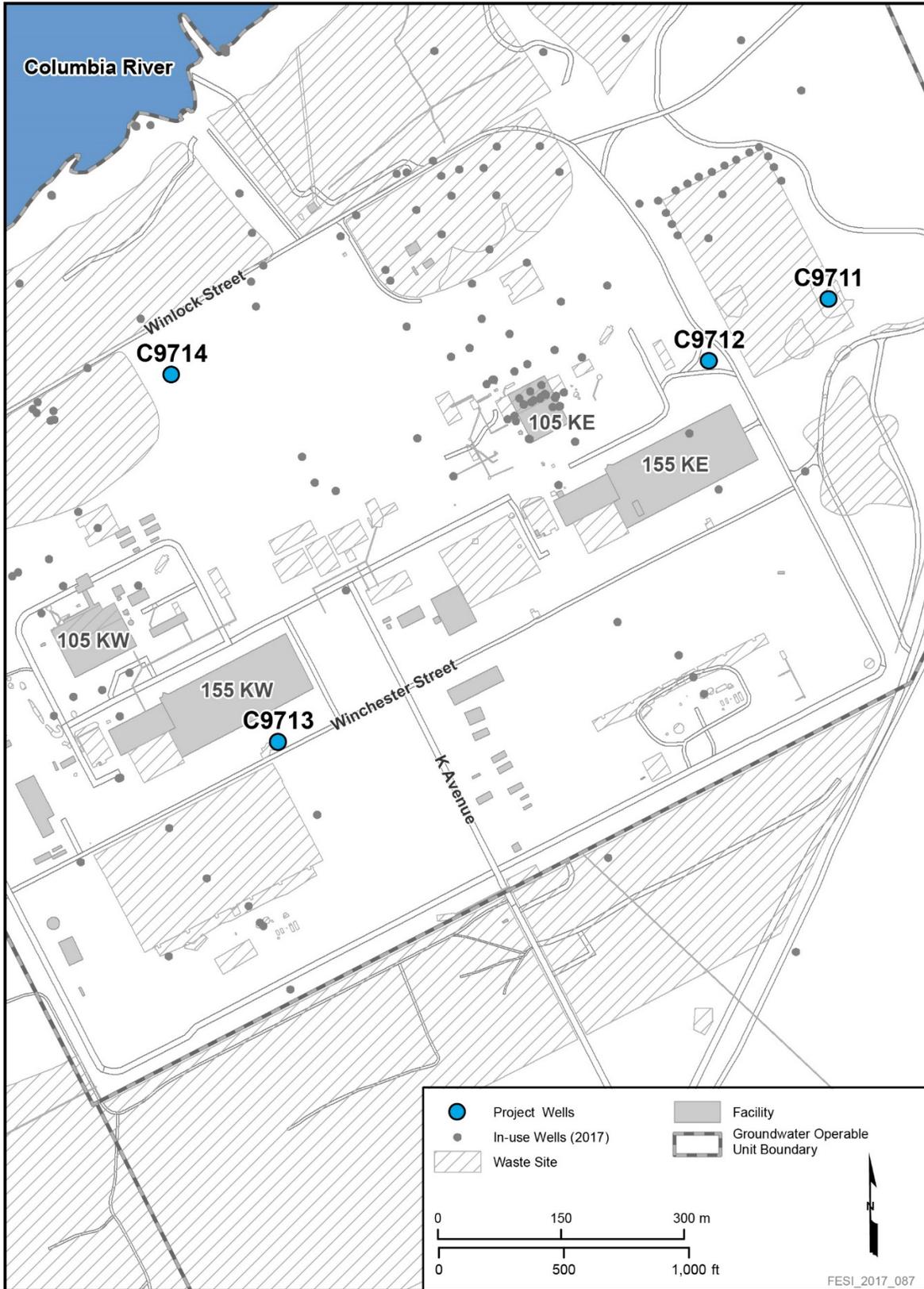


Figure 1-1. New Well Locations in the 100-KR-4 Operable Unit

2 Drilling, Sampling, and Well Construction Activities

This section summarizes field activities associated with the four new wells. Drilling, sampling, well construction, and development details common to all 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*. Well construction 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 145.1 to 191.3 feet below ground surface (ft bgs), extending between 5.7 and 7.9 ft into the Ringold Formation member of Wooded Island – “upper mud” unit (RUM). Boreholes were drilled, constructed, and developed using a Bucyrus Erie Model 22-W Series Three Cable Tool drilling rig (Figure 2-1). Temporary threaded carbon steel casing with an



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

outer-diameter of 10 3/4-in. was used to ensure the annulus has a “minimum of four inches greater in diameter than the nominal size of the permanent casing”, in accordance with WAC 173-160.

Archive samples were collected from the drill cuttings at each borehole, except for C9711, at 5-ft intervals and at changes in lithology. Archive samples were not collected at C9711 due to the presence of tritium contamination. Archive samples were not collected if the drill cuttings were interpreted as backfill. Samples were placed in labeled pint-sized glass jars and sequential chip tray compartments for archive storage. Scaled digital photographs of drill cuttings were taken in the field to accompany field descriptions. Borehole geologic logs and drill cutting photographs are presented in Appendices A through Appendix D.

Where contamination was not present, 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 for C9712, C9713, and C9714 which was used to determine the

appropriate screen slot size for each completed well. Due to the presence of tritium contamination, a sieve analysis was not performed at C9711 but sieve analyses, filter pack and screen selection at nearby wells was used to guide the selection of the filter pack and well screen.

At each borehole, sediment samples were collected for physical and chemical analyses in the upper, mid to upper, and bottom of the unconfined aquifer. Sediment samples were collected using a split spoon sampler with four separate polycarbonate liners. Decontaminated 4-in. diameter split spoon samplers were driven 2.5 ft through the sampling interval or until refusal. Additional grab samples were collected

from the core barrel at C9711 to characterize tritium contamination. Split spoon and grab sample depths with associated Hanford Environmental Information System (HEIS) numbers are included for each well in Section 2.2.

During drilling, depth-discrete groundwater samples were collected at the upper, mid to upper, and bottom of the unconfined aquifer using a temporary submersible pump. 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) stabilized within 10 percent 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.

After total depth (TD) was achieved and prior to well construction, each borehole was logged using SN3'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 each borehole. Log Data Reports of all geophysical logging results, provided by SN3, are presented in Appendices A through D.

2.1.2 Health and Safety Screening

A radiological control technician (RCT) performed radiological surveys of the drill cuttings, geologic samples, temporary drive casing, core barrel, and drillers' control station every morning and afternoon. The radiological control technician used standard field screening instruments to detect and measure alpha, beta, and gamma radiological contamination, if present. No field measurements above background levels were reported during drilling activities. However, at C9711, laboratory analysis of smears from groundwater-contacted tools, drilling equipment, and sediments were positive for tritium. C9711 was under continuous RCT coverage once native soil was encountered. Depths of measured radioactivity from tritium contamination at C9711 are included in Section 2.2.1.

Air quality monitoring was performed by an industrial hygienist technician using a hand-held gas meter and a photo-ionizing detector. Monitoring was performed at least twice daily of the drillers' breathing zone near the wellhead, fresh drill cuttings, and geologic samples. No field measurements above background levels were reported during drilling activities.

2.1.3 Well Construction and Development

The four new wells were constructed using 6-in. nominal diameter, Schedule 10, 304/304L stainless steel casing, V-slot continuous wire wrap stainless steel screen and a sump with end cap. Centralizers were installed above and below the screen and at 40-ft intervals to ground surface. The primary filter pack consists of either 8-12, 8-16, or 10-20 mesh Colorado Silica Sand extending from below the well sump to between 2.78 and 4.31 ft above the top of the screen. 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 until measured settling met CHPRC well development specifications (e.g., less than 0.1 ft of settling in 15 minutes of surging). Annular seal materials include 3/8-in. bentonite pellets, medium granular bentonite crumbles or chips, and type I/II/V cement grout. High strength concrete mix was used to seal the final 0.25 to 1.00 ft of annular space. 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 was conducted at each well. Development was performed in three to five intervals using a 25-horsepower (hp) Referred pump or 5-hp Grundfos submersible pump. Each interval was pumped until water was less than 5.0 nephelometric turbidity units (NTU) and additional water quality parameters (e.g., conductivity, pH, and temperature) stabilized. The water level was monitored using an In-Situ Inc., Level TROLL¹ 700 pressure transducer accompanied by a Rugged Reader². 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 and 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					Material				Filter Pack Size (mesh)
		Screen and Casing Diameter (inch)	Screen Slot Size (inch)	Blank Casing ^a	Screen ^a	Sump/ End Cap ^a	Surface Seal ^b	Annular Seal ^c	Bentonite Seal ^d	Primary Filter Pack ^e	
C9711	174.3	6	0.040	+1.60 – 63.38	63.38 – 168.41	168.41 – 173.41	0.0 – 10.8	10.8 – 55.6	55.6 – 59.2	59.2 – 174.3	10 – 20
C9712	167.2	6	0.065	+2.05 – 71.01	71.01 – 161.01	161.01 – 166.00	0.0 – 10.7	10.7 – 63.5	63.5 – 66.7	66.7 – 167.2	8 – 12
C9713	191.34	6	0.050	+1.95 – 74.08	75.08 – 185.39 ^f	185.39 – 190.40	0.0 – 10.65	10.65 – 68.2	68.2 – 72.2	72.2 – 191.34	8 – 16
C9714	145.1	6	0.030	+2.00 – 43.00	43.00 – 68.01	138.04 – 143.04	0.0 – 9.9	9.9 – 34.7	34.7 – 38.7	38.7 – 145.1	10 – 20
			0.040		68.01 – 138.04						

- a. Schedule 10, Type 304/304L Stainless Steel.
- b. Type I/II/V cement grout.
- c. Medium bentonite chips.
- d. Coated bentonite pellets (3/8-in.).
- e. Premier Colorado Silica sand.
- f. Screen separated by approximately 0.25 ft at 105.9 feet below ground surface.
- + = above ground surface.
- ft bgs = feet below ground surface.
- ID = identification.

Table 2-2. Well Development Information

Borehole ID	Static Water Level		Intake Depth (ft bgs)	Duration (min)	Average Flow Rate (gpm)	Final Turbidity (NTU)	Maximum Drawdown (ft)	Total Gallons Pumped ^a
	ft bgs / date							
C9711	70.45	8/23/2017	167.55	92	290	3.26	23.9	26,680
	71.06	8/28/2017	146.45	31	250	2.42	10.09	7,750
			124.35	29	250	2.17	9.27	7,250
			104.25	29	220	2.19	15.1	6,380
			92.7	141	96	1.82	7.08	13,536
C9712	71.6	7/20/2017	157.75	76 ^b	260	2.28	22.9	19,760
	69.5	7/24/2017	126.8	37 ^b	270	1.72	20.7	9,990
			105.75	32 ^b	270	2.87	19.6	8,640
	70.0	7/25/2017	94.75	75 ^b	110	4.02	4.0	8,250
C9713	81.15	9/27/2017	185.6	76	60	1.72	4.81	4,560
			164.45	49	76	2.39	4.59	3,724
			143.2	25	56	1.22	4.65	1,400
			121.95	22	67	1.07	4.50	1,474
			100.07	57	72	0.67	4.27	4,104

Table 2-2. Well Development Information

Borehole ID	Static Water Level		Intake Depth (ft bgs)	Duration (min)	Average Flow Rate (gpm)	Final Turbidity (NTU)	Maximum Drawdown (ft)	Total Gallons Pumped ^a
	ft bgs / date							
C9714	51.2	7/17/2017	130.2	24	72	17.2	5.51	1,728
	51.3	7/18/2017	130.2	67	varied ^c	1.16	23.87	~10,000
			109.0	19	120	1.21	7.99	2,280
			84.7	23	150	3.58	3.06	3,450

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

b. Due to frequent pump starts and stops, total pump time and purge volumes are approximate.

c. Pump rate varied from 125 to 350 gpm. See Appendix D for specific time intervals and flow rates.

ft bgs = feet below ground surface.

gpm = gallons per minute.

ID = identification.

min = minutes

NTU = nephelometric turbidity unit.

2.2.1 Well 199-K-227 (C9711)

Borehole C9711 was drilled from ground surface to a TD of 174.3 ft bgs on May 16, 2017 through July 6, 2017. The borehole was drilled using 8 3/4-in. and 6 3/4-in. core barrel, and carbide button bit, with 10 3/4-in. threaded temporary casing. No water was added to the borehole during drilling operations. A borehole straightness test was successfully performed on July 31, 2017.

Three split spoon soil samples were collected and are detailed in **Error! Not a valid bookmark self-reference.** Four groundwater samples were collected and are summarized in Table 2-4. The final groundwater sample was collected during well development. Eight soil grab samples were collected at 5-ft increments beginning at 35 ft bgs and are detailed in Table 2-5.

Due to the inability to detect tritium in the field using standard field-screening instruments, smears of groundwater-contacted tools, sediment, and articles of clothing were collected by the RCT and sent to the on-site central counting facility. Tritium contamination was detected from 68.5 ft bgs to TD. Tritium smear results and corresponding depths are summarized in Table 2-6.

Following placement of the 10 3/4-in. temporary casing, the borehole was logged using NMLS and SGLS. NMLS was performed on July 10, 2017 from ground surface to a depth of 68.0 ft bgs and SGLS was performed on July 10, 2017 and July 11, 2017 from ground surface to a depth of 171.0 ft bgs.

Well construction took place from July 31, 2017 through August 29, 2017. The well was constructed as a 6-in. nominal diameter monitoring well with a 105.03-ft, 40-slot (0.040-in.) screened interval and a 5-ft sump with end cap. From TD to surface, the annulus was filled with a 115.1-ft interval of 10-20 mesh sand, 3.6-ft interval of 3/8-in. bentonite pellets, 44.8-ft interval of bentonite chips, and 10.8-ft interval of cement grout. All temporary casing was removed during well construction. The permanent monument, surface seal, pad and posts were installed on August 29, 2017. See Table 2-1 and Appendix A for well construction details.

Well development occurred on August 23, 2017 through August 28, 2017 with a 25-hp Referred submersible pump. Well development information may be found in Table 2-2. Static water level was measured before well development at 70.45 ft bgs.

Table 2-3. C9711 Split Spoon Samples

Date	Sample Depth (ft bgs)	Sample Method	Media	Recovery %	HEIS number
6/8/2017	72.0 – 74.5	Split spoon	Soil	100	B39HX6, B39HX7, B39WB3
6/19/2017	95.8 – 98.3			100	B39HX8, B39HX9
6/28/2016	149.1 – 151.6			100	B39HY0, B39HY1, B39WB5

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-4. C9711 Groundwater Sample Collection Summary

Date	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS number
5/26/2017	79.7	Submersible Pump	12	775	25.5	8.48	B39HY5, B39HY6, B39HY7, B39HY8, B39HY9
6/19/2017	96.0		6	582	79.3	9.32	B39J00, B39J01 B39J02, B39J03, B39J04, B39J05, B39J06, B39J07, B39J08
6/28/2017	147.7		9	1,520	161	6.75	B39J10, B39J11, B39J012, B39J13
8/28/2017	92.7 ^a		96	13,536	1.82	NR	B39J15, B39J16, B39J18, B39J19, B39J23, B39J24, B39J25, B39J26, B39J27, B39J28

a. Sample collected during the 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.

NR = not recorded.

Table 2-5. C9711 Soil Grab Samples

Date	Sample Depth (ft bgs)	Sample Method	Media	HEIS number
5/17/2017	35	Grab	Soil	B39HW5
	40			B39HW6
	45			B39HW7, B39HW8, B39HW9
5/18/2017	50			B39HX0
6/1/2017	55			B39HX1
	60			B39HX2, B39HX3
	65			B39HX4
6/8/2017	72			B39HX5

Table 2-5. C9711 Soil Grab Samples

Date	Sample Depth (ft bgs)	Sample Method	Media	HEIS number
------	-----------------------	---------------	-------	-------------

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-6. C9711 Tritium Smear Results

Date	Sample Depths (ft bgs)	Sample Method	Location	Highest measured (dpm/100 cm ²)
6/5/2017	68.5 – 71.0	Smear	Core barrel	132
6/7/2017	71.0 – 72.4			2,799
6/8/2017	72.0 – 73.5			25,923
6/13/2017	73.5 – 79.8			1,185
6/14/2017	79.8 – 82.0			832
6/15/2017	82.0 – 93.0			1,076
6/19/2017	93.0 – 95.8			1,336
6/20/2017	95.8 – 104.0			742
6/21/2017	104.0 – 120.2			Bailer
6/22/2017	120.2 – 136.0		778	
6/26/2017	136.0 – 140.0		390	
6/27/2017	140.0 – 148.2		Bailer/Core barrel	572
6/28/2017	148.2 – 151.0		Core barrel	316
6/29/2017	151.0 – 161.0			637
7/3/2017	161.0 – 166.1			612
7/5/2017	166.1 – 169.5			242
7/6/2017	169.6 – 174.2			183

cm = centimeter.

dpm = disintegrations per minute.

ft bgs = feet below ground surface.

2.2.2 Well 199-K-228 (C9712)

Borehole C9712 was drilled from ground surface to a TD of 162.3 ft bgs on April 3, 2017 through May 11, 2017. The borehole was drilled using 8 3/4-in. and 6 3/4-in. core barrel, and carbide button bit, with 10 3/4-in. threaded temporary casing. No water was added to the borehole during drilling operations. A borehole straightness test was successfully performed on July 7, 2017.

Three split spoon soil samples were and are detailed in Table 2-7. Four groundwater samples were collected and are summarized in Table 2-8. The final groundwater sample was collected during well development.

Following placement of the 10 3/4-in. temporary casing, the borehole was logged using NMLS and SGLS. NMLS was performed on May 15, 2017 from ground surface to a depth of 76.5 ft bgs and SGLS was performed on May 16, 2017 from ground surface to a depth of 167.0 ft bgs.

Well construction took place from July 10, 2017 through July 27, 2017. The well was constructed as a 6-in. nominal diameter monitoring well with a 90.00-ft, 65-slot (0.065-in.) screened interval and a 4.99-ft sump with end cap. From TD to surface, the annulus was filled with a 100.5-ft interval of 8-12 mesh sand, 3.2-ft interval of 3/8-in. bentonite pellets, 52.8-ft interval of bentonite chips, and 10.7-ft interval of cement grout. All temporary casing was removed during well construction. The permanent monument, surface seal, pad and posts were installed on August 27, 2017. See Table 2-1 and Appendix B for well construction details.

Well development occurred on July 20, 2017 through July 25, 2017 with a 25-hp Referred submersible pump. Well development information may be found in Table 2-2. Static water level was measured before well development at 71.6 ft bgs.

Table 2-7. C9712 Split Spoon Samples

Date	Sample Depth (ft bgs)	Sample Method	Media	Recovery %	HEIS number
4/18/2017	73.4 – 75.9	Split spoon	Soil	100	B39J91, B39J92
4/27/2017	115.7 – 118.2			100	B39J93, B39J94
5/8/2016	159.2 – 161.7			100	B39J95, B39J96, B39J97, B39LJ2

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-8. C9712 Groundwater Sample Collection Summary

Date	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS number
4/20/2017	83.4	Submersible Pump	10.0	1,130	3.47	9.43	B39JB0, B39JB1
4/27/2017	117.3		10.2	2,070	166	8.02	B39JB2, B39JB3, B39JB4
5/9/2017	158.4		8.6	1,230	871	6.60	B39JB6
7/25/2017	94.75 ^a		110	7,900	4.35	NR	B39JC0, B39JC1, B39JC2, B39JC4, B39JC5, B39JC6, B39JC8, B39JB7, B39JB8

a. 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.

NR = not recorded.

2.2.3 Well 199-K-229 (C9713)

Borehole C9713 was drilled from ground surface to a TD of 191.3 ft bgs on May 3, 2017 through June 22, 2017. The borehole was drilled using 8 3/4-in. and 6 3/4-in. core barrel, and carbide button bit, with 10 3/4-in. threaded temporary casing. No water was added to the borehole during drilling operations. A borehole straightness test was successfully performed on July 19, 2017.

Three split spoon soil samples were collected and are detailed in Table 2-9. Four groundwater samples were collected and are summarized in

Table 2-10. The final groundwater sample was collected during well development.

Following placement of the 10 3/4-in. temporary casing, the borehole was logged using NMLS and SGLS. NMLS was performed on June 23, 2017 from ground surface to a depth of 85.51 ft bgs and SGLS was performed on June 22, 2017 from ground surface to a depth of 188.02 ft bgs.



Figure 2-2. Stainless-Steel Corrugated Well Screen Patch

Well construction took place from July 19, 2017 through August 30, 2017. The well was constructed as a 6-in. nominal diameter monitoring well with a 110.31-ft, 50-slot (0.050-in.) screened interval and a 5.01-ft sump with end cap. From TD to surface, the annulus was filled with a 119.14-ft interval of 8-16 mesh sand, 4.0-ft interval of 3/8-in. bentonite pellets, 57.55-ft interval of bentonite chips, and 10.65-ft interval of cement grout. All temporary casing was removed during well construction. The permanent monument, surface seal, pad and posts were installed on August 27, 2017. See Table 2-1 and Appendix C for well construction details.

On August 7, 2017, while back-pulling the temporary casing, the stainless-steel screen separated at approximately 105.9 ft bgs. All permanent casing joints and the screen were inspected using a submersible camera and no other separations were noted. The failure occurred at a welded joint and the separation is approximately 2-in. wide. The separation may have allowed native formation to pass through and collect in the sump. CHPRC gave approval to finish well construction apart from lowering any tools passed the screen separation.

On September 26, 2017, the well screen was patched with a 3.0-ft long, 6.0-in. nominal diameter corrugated stainless-steel sleeve (Figure 2-2) provided by a representative from Guardino Well Drilling, Inc. The patch was placed using a hydraulic powered swage tool (Figure 2-3) and is located between 103.4 ft bgs and 106.4 ft bgs. During the initial attempt to patch the well, a patch sleeve slipped off the swage tool and fell down the well. The patch was unable to be retrieved and remains in the sump.

Well development occurred on September 28, 2017 with a 5-hp Grundfos submersible pump. Well development information may be found in Table 2-2. Static water level was measured before well development at 81.35 ft bgs.



Figure 2-3. Hydraulic Swage Tool

Table 2-9. C9713 Split Spoon Samples

Date	Sample Depth (ft bgs)	Sample Method	Media	Recovery %	HEIS number
5/16/2017	79.4 – 81.9	Split spoon	Soil	65	B39K41, B39K42, B39WH8, B39K43,
5/31/2017	130.1 – 131.1	Split spoon	Soil	100	B39K44, B39WH9, B39K45
6/15/2017	170.9 – 172.9	Split spoon	Soil	50	B39K46, B39K47, B39WJ0

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-10. C9713 Groundwater Sample Collection Summary

Date	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS number
5/17/2017	87.0	Submersible Pump	4.2	510	7.45	10.05	B39K50, B39K51, B39K52
6/1/2017	129.8		9.1	1600	7.78	7.24	B39K53, B39K54
6/15/2017	171.0		8.1	930	825	6.41	B39K55, B39K56
9/28/2017	100.07 ^a		72	2400	1.10	8.25	B39K57, B39K58, B39K61, B39K62, B39K63, B39K65

a. Sample collected during fifth 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.

2.2.4 Well 199-K-230 (C9714)

Borehole C9714 was drilled from ground surface to a TD of 145.1 ft bgs on April 3, 2017 through May 2, 2017. The borehole was drilled using 8 3/4-in. and 6 3/4-in. core barrel, and carbide button bit, with 10 3/4-in. threaded temporary casing. No water was added to the borehole during drilling operations. A borehole straightness test was successfully performed on May 2, 2017.

Three split spoon soil samples were collected and are detailed in Table 2-11. Four groundwater samples were collected and are summarized in Table 2-12. The final groundwater sample was collected during well development.

Following placement of the 10 3/4-in. temporary casing, the borehole was logged using NMLS and SGLS. NMLS was performed on May 4, 2017 from ground surface to a depth of 48.76 ft bgs and SGLS was performed on May 3, 2017 from ground surface to a depth of 144.0 ft bgs.

Well construction took place from June 26, 2017 through July 12, 2017. The well was constructed as a 6-in. nominal diameter monitoring well with a 25.01-ft, 30-slot (0.030-in.) screened interval, a 70.03-ft, 40-slot (0.040-in.) screened interval, and a 5.00-ft sump with end cap. From TD to surface, the annulus was filled with a 106.4-ft interval of 10-20 mesh sand, 4.0-ft interval of 3/8-in. bentonite pellets, 24.8-ft interval of bentonite crumbles, and 9.9-ft interval of cement grout. All temporary casing was removed during well construction. The permanent monument, surface seal, pad and posts were installed on July 12, 2017. See Table 2-1 and Appendix D for well construction details.

Well development occurred on July 13, 2017, through July 18, 2017, with a 25-hp Referred submersible pump. Well development information may be found in Table 2-2. Static water level was measured before well development at 51.2 ft bgs.

Table 2-11. C9714 Split Spoon Samples

Date	Sample Depth (ft bgs)	Sample Method	Media	Recovery %	HEIS number
4/10/17	49.1 – 51.6	Split spoon	Soil	100	B39K70, B39K71, B39K72, B39K73, B39L46
4/20/17	95.0 – 97.5			50	B39K76, B39K77, B39K78, B39K79, B39K80, B39KH0
4/27/17	133.2 – 135.7			75	B39K83, B39K84, B39K85, B39K86, B39K87, B39K88, B39L48

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-12. C9714 Groundwater Sample Collection Summary

Date	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS number
4/12/17	59.0	Submersible Pump	7.5	1200	8.88	9.42	B39K93, B39K94, B39K96, B39K97
4/19/2017	93.0		8.3	800	24.6	8.52	B39KC4, B39KC5, B39KC7, B39KC8, B39KC9
4/27/2017	132.0		15	1500	>1000	7.59	B39KD1, B39KD2, B39KD3, B39KD4, B39KD5, B39KD6
7/18/2017	130.2 ^a		150	3,400	2.01	7.93	B39KD7, B39KD8, B39KD9, B39KF0, B39KF1, B39KF2, B39KF3

a. Sample collected during first 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 of the 100-KR-4 OU near the four new wells and presents the stratigraphy encountered during the drilling of each well.

3.1 General Stratigraphy of the 100-KR-4 Operable Unit

Major stratigraphic units encountered during this project include the RUM, the Ringold Formation member of Wooded Island – unit E (Rwie), the Hanford formation, and Holocene surficial deposits.

Depending on proximity to former facilities and remediation sites, the ground surface of the 100-K Area has been disturbed by grading, construction, and demolition work. Remediation processes have resulted in non-native backfill material placement in the 100-K Area.

The Hanford formation disconformably overlies the Rwie and largely consists of cataclysmic flood deposits related to episodic glacial outburst floods that resulted in varying grain size from high-energy gravel rich deposits to low-energy silts and sands. The gravel-dominated strata within Hanford formation ranges from approximately 50% to 80% basalt (WHC-SD-EN-TI-011, *Geology of the Northern Part of the Hanford Site: An outline of Data Sources and the Geologic Setting of the 100 Areas*). The sand fraction consists of loose, fine-to-course-grained sand, that are comprised of, on average, 50% mafic-rich minerals and 50% silicates, with a “salt and pepper” appearance (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*). The Hanford formation has a thickness of 27 ft at C9713 and 53 ft at C9712.

Beneath the Hanford formation, the Ringold Formation in the 100-K Area includes the semi-indurated, fluvial silty sandy gravel of the Rwie and the thick sequence of silt and clay of the RUM. The Rwie is characterized as clast-supported gravels with very fine to very coarse-grained sand matrices and lesser silt fractions. Clasts associated with the Rwie are predominately quartzite and silicic volcanics, varying between 35% and 90%. The uppermost unconfined aquifer is contained predominantly within the Rwie sediment and is confined by the low-permeability RUM (SGW-46279, *FY2017 Conceptual Framework and Numerical implementation of 100 Areas Groundwater Flow and Transport Model*). The RUM facies consist of variably cemented overbank flood deposits and paleosols comprised of silty and clayey sediments. At the three boreholes in which the Hanford formation and Rwie contact could be identified, the Rwie varies in thickness from 102.5 ft at C9712 to 140.0 ft at C9713.

Drilling continued from 5.7 to 7.9 ft into the RUM. The saturated thickness varied from 75.7 at C9714 to 103.6 ft at C9713 but can fluctuate significantly in response to stage changes in the Columbia River downstream of Priest Rapids Dam.

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 through D.

Stratigraphic unit contacts included in this document are based on field drill cuttings examination (e.g., lithology, texture, color, reaction to 10% dilute hydrochloric acid [HCl], etc.) and drilling observations (e.g., drill rate) in the field. As such, the unit contacts included herein should not be considered final. 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 Well 199-K-227 (C9711)

The stratigraphic units encountered during drilling of C9711 were the Rwie and RUM. Recovered sediments from C9711 are primarily sandy gravel, silty sandy gravel and slightly silty sandy gravel.

The upper 43 ft of the borehole consists of reworked Hanford formation backfill that alternates between sandy gravel from 5 to 20 ft bgs and from 35 to 43 ft bgs, and silty sandy gravel from 2 to 5 ft bgs and from 20 to 35 ft bgs. The gravel fraction varies from 40% to 50% and is primarily very-fine to fine pebbles, poorly sorted, and 85% mafic in composition. The sand fraction varies from 35% to 48% and is poorly sorted and 90% mafic in composition. The silt fraction ranges from 10% to 15% and is dark gray (2.5Y 4/1) in color.

At 43 ft bgs, sediments are sandy gravel, comprised of 32% gravel, 50% sand, and 18% silt. The poorly sorted gravel fraction is 50% mafic and the sand is poorly sorted with a mafic content decreasing from 90% to 40%. The gravel and sand are well-rounded and the sediments are generally a light olive brown (2.5Y 5/4) color. The distinct change in sediment characteristics indicate the contact between the backfill and the Rwie. Sediments from 43 to 75 ft bgs are silty sandy gravel comprised of 25% gravel, 42% to 60% sand, and 10% to 22% silt. The sand fraction is poorly sorted very-fine to coarse sands that are subangular to subrounded. Isolated groupings of clasts show weak induration and localized reactions with HCl.

Sandy gravel is the dominant lithology between 75 to 124 ft bgs, with an interval of sand from 81 to 85 ft bgs, and an interval of silty sandy gravel from 90 to 102 ft bgs. Within the sandy gravel, gravel percentage varies between 30% and 60%. Gravel distribution varies from very-fine pebble to medium pebble and subrounded to rounded clasts. The sand fraction was described from a distance due to tritium contamination. The poorly sorted sand fraction is subangular to subrounded, and predominantly fine and medium grained. A weak, localized reaction to HCl at 72 ft bgs, was noted.

The interval from 124 to 151 ft bgs, consists of silty sandy gravel comprised of 30% gravel, 55% sand, and 15% silt. The gravel fraction is poorly sorted, very-fine to medium pebbles, 75% felsic in composition and subangular to round. The sand fraction is poorly sorted and 80% felsic in composition. At 145 ft bgs, localized sediments react weakly to HCl and silt/clay clasts are present. At 151 ft bgs, a gravelly sand lens comprised of 15% gravel, 75% sand, and 10% silt occurs. The gravel fraction is 90% felsic and poorly sorted. The sand fraction is 95% felsic in composition with approximately 30% of the sand comprised of mica. The sediment has localized weak reaction to HCl. Sediments are slightly silty gravelly sand from 155 to 160 ft bgs and consists of 18% gravel, 70% sand, and 12% silt. The poorly sorted gravel is 85% felsic in composition and subround to round in clast-shape. The sand fraction is poorly sorted and 90% felsic in composition. The sediment is olive brown (2.5Y 4/3), with no reaction to HCl. From 160 to 168.3 ft bgs, a sandy gravel comprised of 32% gravel, 60% sand, and 8% silt is present with poorly sorted gravel and sand fractions are 90% felsic.

A gradational contact between the Rwie and the RUM begins at 168.3 ft bgs. Sediments were silt with some very-fine to medium pebbles and very coarse sand and transitioned to highly plastic, light olive brown (2.5Y 5/4) silt and clay of the RUM by 174.3 ft bgs (TD). At the time of drilling, the saturated thickness was approximately 98 ft at C9711, but will fluctuate in response to river level changes at Priest Rapids dam.

3.2.2 Borehole Geology for Well 199-K-228 (C9712)

Stratigraphic units encountered during drilling of C9712 were the Hanford formation, Rwie, and RUM. Recovered sediments from C9712 are primarily sandy gravel, slightly silty gravelly sand, silty sandy gravel.

The sediments encountered from ground surface to 6 ft bgs consist of reworked Hanford formation backfill. Sandy gravel from 6 to 40 ft bgs, is comprised of 38% gravel, 60% sand, and 2% silt. The gravel fraction is poorly sorted very-fine to medium pebbles that are 60% to 95% mafic in composition with subangular to subrounded clasts. The sand fraction is poorly sorted and 20% to 65% mafic in composition. The sediments do not react to HCl and are very dark gray (2.5Y 3/1) in color. An interval of slightly silty sand from 40 to 41 ft bgs is 2% gravel, 83% sand, 15% silt. The gravel fraction is primarily very-fine pebbles that are 90% mafic, subangular to subrounded clasts. The sand fraction is fine to medium-grained sand that are 20% mafic, subround to round, and olive brown (2.5Y 4/6) in color. At 41 ft bgs, the sediment is silty sandy gravel comprised of 30% gravel, 55% sand, and 15% silt. The mafic content of the gravel fraction decreases from 90% to 60%, primarily fine to coarse pebbles. An interval of slightly silty sandy gravel from 46 to 54 ft bgs is 15% gravel, 70% sand, and 15% silt. The sediments are 60% mafic in the gravel fraction and 20% mafic in the sand fraction. From 54 to 65 ft bgs, another interval of sandy gravel consists of 35% gravel, 55% sand, and 10% silt. The poorly sorted gravel fraction is primarily very-fine to medium pebbles that are 70% mafic in composition and the poorly sorted sand fraction is primarily fine to medium sand that are 50% mafic in composition.

At 59 ft bgs, felsic content in the sandy gravel increases from 30% to 50% in the gravel fraction and from 50% to 70% felsic in the sand fraction, which may indicate the contact between the Hanford formation and Rwie. From 59 to 95 ft bgs, the retrieved sediments are primarily light olive brown (2.5Y 6/5) sandy gravel comprised of 35% gravel, 55% sand, and 10% silt. The gravel fraction is poorly sorted, primarily fine to medium pebbles with 5% of the gravel fraction made of cobbles. The sand fraction is poorly sorted, primarily fine to medium-grained, with about 15% of the sand fraction comprised of mica. At 70 ft bgs, the sediment has a very strong reaction with HCl and hard nodules of caliche were observed.

From 95 to 104 ft bgs, sediments are silty sandy gravel comprised of 40% gravel, 39% sand, and 21% silt. The gravel fraction is poorly sorted very-fine pebbles to large cobbles that are 70% felsic and subangular to round. The sand fraction is poorly sorted and 50% felsic. Slightly silty gravelly sand is present from 104 to 110 ft bgs, sediments are primarily moderately sorted, comprised of 28% gravel, 60% sand, and 12% silt. Retrieved sediments are 80% mafic in composition, primarily very-fine to fine pebbles in the gravel fraction and coarse to very-coarse sand. Sandy gravel from 110 to 155 ft bgs is comprised of 35% gravel, 55% sand, 10% silt. The gravel fraction is poorly sorted, 85% felsic, and subround to round clasts. The sand fraction is moderately sorted, primarily very-fine to medium sand that is 90% felsic in composition and brown (10YR 5/3). A gravelly sand interval is present from 155 ft bgs and 161.5 ft bgs, comprised of 13% gravel, 70% sand, and 17% silt.

A gradational contact between the Rwie and the RUM occurs from 161.5 to 162 ft bgs. At 162 ft bgs, the recovered sediments are 100% silt and clay and dry, and light olive brown in color. Caliche nodules within the RUM react very strongly with HCl. Drilling continued in the RUM until TD at 167.2 ft bgs. At the time of drilling, the saturated thickness was approximately 92 ft at C9712, but will fluctuate in response to river level changes at Priest Rapids dam.

3.2.3 Borehole Geology for Well 199-K-229 (C9713)

Stratigraphic units encountered during drilling of C9713 were the Hanford formation, Rwie and RUM. Recovered sediments from C9713 are primarily sandy gravel.

The upper 18 ft of the borehole consist of reworked Hanford formation sandy gravel backfill. The sandy gravel is comprised of 60% gravel, 37% sand, and 3% silt. The gravel fraction is moderately sorted with clasts ranging from very fine pebble to cobble, and 80% mafic in composition. The sand fraction is well sorted, medium to coarse sand, 60% mafic in composition, and light gray (10YR 7/1) in color. The native Hanford formation sandy gravel is present from 18 to 31.5 ft bgs and is dark gray (5YR 3/1) in color.

A coarsening downward sequence occurs from 31.5 to 115 ft bgs with sediments transitioning from silt and clay, to sand, to sandy gravel, and finally gravel. At 32 ft bgs, sediments are 100% silt, brown (10YR 5/3) in color which coarsens to a well sorted, very-fine to fine sand, yellowish brown (10YR 5/4) in color at 34 ft bgs. The sand interval from 34 to 40 ft bgs is 20% mafic and contains trace amounts of iron oxide staining and mica grains. Sediments from 40 to 110 ft bgs are sandy gravel, which grades into gravel at 110 ft bgs. The sandy gravel is 40% gravel, 58% sand, and 2% silt with sand and gravel 50% mafic in composition. The sand fraction is well sorted, primarily medium to coarse in grain size.

A gradational contact between the sandy gravel of the Hanford formation and the sandy gravel of the Rwie may be present beginning at 45 ft bgs. Gravel content increases to 70% with a corresponding decrease in sand content to 28% and 2% silt, and an increase in mica with iron oxide staining. Quartzite and granitic cobbles are present at 48 ft and 55 ft bgs, respectively, and the gravel and sand fractions are 70% felsic in composition.

Gravel is present from 110 to 115 ft bgs. The sediments are comprised of 85% gravel, with fine to very coarse pebbles that are 50% mafic and basalt-rich; 10% sand, very-fine to fine grained, 80% felsic in composition; and 5% silt and clay. Sediments are dark grayish brown (10YR 4/2) in color and calcium carbonate cement is present in the matrix and reacts strongly reaction to HCl.

Sandy gravel is present from 115 to 185 ft bgs. Within the interval from 115 to 150 ft bgs, the gravel fraction increases with depth from 25% to 60%, the sand content decreases from 70% to 38%, and silt content decreases from 5% to 2%. Gravel size also increases with depth from an average clast-size of very-fine to fine pebbles, to very-coarse pebbles to cobbles at 150 ft bgs. The average grain size of sand is very-fine to fine, and 5% to 30% mafic in composition. Between 150 and 185 ft bgs, the moderately sorted gravel fraction decreases from 60% to 2% and decreases in average size from coarse pebbles and cobbles to fine and medium pebbles. The sand fraction varies between 60% and 68% and is 20% to 30% mafic in composition, and grayish brown (2.5Y 5/2) to dark grayish brown (2.5Y 4/2) in color. Beginning at 167 ft bgs, silt nodules are present with a strong reaction with HCl.

The contact between the RUM and Rwie was encountered at 185 ft bgs and extends to 191.3 ft bgs (TD). The RUM, comprised of 85% silt, 13% sand, and with 2% gravel, is olive brown (2.5y 4/4) when wet and pale brown (10YR 6/3) in color when dry. Very high cementation and a weak reaction with HCl was noted. At the time of drilling, the saturated thickness was approximately 103.6 ft at C9713, but will fluctuate in response to river level changes at Priest Rapids dam.

3.2.4 Borehole Geology for Well 199-K-230 (C9714)

The contact between the Hanford formation and the Rwie could not be inferred at this borehole but drilling terminated in the RUM. Recovered sediments from C9714 were predominately sandy gravel with occasional sand lenses that vary between 2 and 5.5 ft in thickness.

The upper 2 ft of the borehole consist of crushed gravel drill pad, and from 2 to 7 ft bgs, sediments are 100% sand that is primarily coarse-grained. Sediments are sandy gravel from 7 to 73 ft bgs, with a sandy silt lens from 52 to 54 ft bgs. The sandy gravel ranges in composition from 65% to 70% gravel, 30% to 35% sand and up to 2% silt. The poorly sorted gravel fraction varies between 65% and 75%, and 35% of the gravel clasts are cobble-sized, ranging between 80 and 160 mm, and subangular to well-rounded, and 70% to 80% felsic in composition. The sand fraction is very-fine to medium sand with subangular to subrounded grains, ranging in felsic content from 70% to 90%, and grayish brown (2.5Y 5/2) in color. The sandy silt lens is comprised of 40% very well sorted fine sand and 60% silt. The sand is light gray (2.5Y 7/1) in color with a moderate reaction with HCL.

An interval of sand occurs from 73 to 78 ft bgs, comprised of 8% gravel, 90% sand, and 2% silt. The gravel fraction is primarily comprised of subangular to rounded, very-fine to medium pebbles. The sand fraction ranges from very-fine sand to coarse-grained sand that is 75% felsic in composition.

Sediments retrieved from 78 to 126.5 ft bgs are sandy gravel. Gravel percentages vary between 65% and 80%, sand varies from 20% to 30%, and silt ranges between trace amounts and 5%. Gravel clasts consist of subangular to rounded very-fine pebbles to large cobbles, primarily well to moderately sorted. Sand grains are subrounded to subangular, very-fine to very-coarse-grained sand that is moderately to well sorted with intervals of mica-rich sand. Between 92 and 94 ft bgs, sediments are comprised of 100% moderately sorted fine to coarse sand.

Between 126.5 and 132 ft bgs, sediments are sand, corresponding to a decrease in gravel percentage from 80% to 3%, a corresponding increase in sand to 95% with 2% silt. The gravel is comprised of very-fine pebbles to fine pebbles, while the sand fraction is primarily very-fine to medium sand. At 132 ft bgs, gravel percentages increase to 70%, and sand decreases to 28% with 2% silt. Gravel clasts vary between very-fine pebbles and cobbles. Sand grains vary in size from very-fine to very-coarse, with an average grain size of medium and fine.

A sharp contact between the Rwie and the RUM occurs at 137.2 ft bgs. The RUM is 90% silt and clay, and 10% very-fine to fine grained sand and extends to the TD of 145.1 ft bgs. At the time of drilling, the saturated thickness was approximately 75.7 ft at C9714, but will fluctuate in response to river level changes at Priest Rapids dam.

4 Waste Management

Waste generated during the activities described in this document was managed per DOE/RL-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable*, as amended by applicable change notices. Waste generated throughout the performance of this project included vadose zone drill cuttings and miscellaneous solid waste such as sampling equipment, plastic, paper, and personal protective equipment. All waste was managed as Investigation-Derived Waste and surveyed by Radiological Control Technicians and Industrial Hygiene personnel prior to transfer and disposal at Environmental Restoration Disposal Facility (ERDF).

All vadose zone drill cuttings were managed near the borehole in tip dumpsters, and then placed in designated waste roll off boxes. Miscellaneous solid waste associated with drill cuttings, including nitrile gloves, plastic bags used to collect drill cuttings, and other waste associated with sampling activities, were contained in plastic bags and placed in the designated roll off box. Following surveys, roll off boxes were transported to the ERDF for disposal.

Purgewater, groundwater samples, and decontamination fluids generated during well drilling, sample screening, and analysis were managed as purgewater in accordance with purgewater guidance provided in DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*, and DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*. Purgewater was 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 through D, 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 Carpenter Drilling LLC (drilling contractor) participated in the acceptance inspection for C9712 and C9714 on August 17, 2017, for C9711 on September 14, 2017 and for C9713 on September 28, 2017. 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 will be prepared to document well acceptance.

7 References

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Appendix A

Well Documentation for C9711 (199-K-227)

Contents

Well Summary Sheet	A-1
Borehole Log	A-4
Drill Cutting Photographs	A-11
Well Development and Testing Data	A-14
Log Data Report	A-15
Well Survey Data Report	A-28

WELL SUMMARY SHEET	Page <u>1</u> of <u>3</u>
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Well ID : C9711	Well Name: 199-K-227	Start Date: 5/16/2017
Project: Four 100-KR-4 OU Monitoring Wells	Location: 1100' NE of 105-KE	Finish Date: 8/29/2017

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
Concrete Pad: 0.50 ft above ground surface (ags)		0		0.0 - 2.0 Crushed Gravel Drill Pad
8.64-in Protective Casing: 3.10 ft ags - 1.90 ft below ground surface (bgs)		10		2.0 - 43.0 Backfill (reworked Hanford Fm)
Type I/II/V Portland Cement Grout: 0.0 - 10.8 ft bgs		20		
6-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank: 1.60 - 63.38 ft bgs		30		
8-20 mesh Bentonite Crumbles: 10.8 - 55.6 ft bgs		40		43.0 - 50.0 Silty Sandy Gravel (msG)
3/8-in Coated Bentonite Pellet Seal: 55.6 - 59.2 ft bgs		50		50.0 - 55.0 Slightly Silty Gravelly Sand (m)sG
6-in I.D. Schedule 10, Type 304/304L, 40-slot (0.04 in.) Stainless Steel Screen: 63.38 - 168.41 ft bgs		60		55.0 - 60.0 Silty Sandy Gravel (msG)
		65		60.0 - 65.0 Slightly Silty Gravelly Sand (m)sG
		70		65.0 - 75.0 Silty Sandy Gravel (msG)

Reported By: Henry Lanman Geologist [Signature] 8/29/17
 Print Name Title Signature Date

Reviewed By: Kelly Whitley Well Coordinator [Signature] 9/5/17
 Print Name Title Signature Date

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OR Doc Type:	WMU Code(s):
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WELL SUMMARY CONTINUATION SHEET			Page 2 of 3	
Well ID: C9711	Well Name: 199-K-227	Project: Four 100 KR-4 OU Monitoring Wells		
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
		70		65.0 - 75.0 Silty Sandy Gravel (msG) Static Water Level: 70.5 ft bgs (8/29/2017)
				75.0 - 81.0 Sandy Gravel (sG)
		80		
				81.0 - 85.0 Sand (S)
				85.0 - 90.0 Sandy Gravel (sG)
		90		90.0 - 102.0 Silty Sandy Gravel (msG)
		100		
				102.0 - 124.0 Sandy Gravel (sG)
		110		
		120		
				124.0 - 151.0 Silty Sandy Gravel (msG)
		130		
		140		
				151.0 - 155.0 Gravelly Sand (gS)
				155.0 - 160.0 Slightly Silty Gravelly Sand (m)gS
		160		
				160.0 - 168.3 Sandy Gravel (sG)

10-20 mesh Premier Colorado Silica Filter Pack Sand: 59.2 - 174.3 ft bgs

6-in I.D. Schedule 10, Type 304/304L, 40-slot (0.04 in.) Stainless Steel Screen: 63.38 - 168.41 ft bgs

WELL SUMMARY CONTINUATION SHEET		Page 3 of 3	
Well ID: C9711	Well Name: 199-K-227	Project : Four 100 KR-4 OU Monitoring Wells	
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Lithologic Description (ft bgs)
6-in I.D. Schedule 10, Type 304/304L, 40-slot (0.040 in.) Stainless Steel Screen: 63.38 - 168.41 ft bgs Stainless steel centralizer installed above and below screen and every 40 ft 6-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 168.41 - 173.41 ft bgs 10-20 mesh Premier Colorado Silica Filter Pack Sand: 59.2 - 174.3 ft bgs		170 180 190 200 210 220 230 240 250 260	168.3 - 174.3 Silt (M)
Straightness Test: Pass, 07/31/2017 Total Depth: 174.3 ft bgs Depths are in ft below ground surface. Borehole drilled with 10 3/4-in O.D. casing from 0.0 - 173.0 ft bgs All temporary drill casing was removed from the ground.			

A-6006 000 (Rev. 0)

BOREHOLE LOG				Page <u>1</u> of <u>7</u>
Well ID: <u>C9721</u>		Well Name: <u>199-K-227</u>		Date: <u>5/17/17</u>
Project: <u>Installation of 4 monitoring wells in the 100-KR-4 groundwater on</u>			Location: <u>1100' NE of 105-KE Reactor</u>	
Reference Measure Point: <u>Ground surface</u>				
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' - 2' Drilling Peed (reworked Hartford Fm.) silt HL 5/17/17	Cable tool w/ drive barrel, 10 3/4" casing
5	G		2' - 5' Sandy Gravel (SG) m SG @ 5': 42.5% gravel, 42.5% sand, 15% silt Gravel: 35% Vfp, 20% fp, 10% mp, 15% cp, 15% vcp, 5% cobbles; max. size = 260mm; PS; M:F = 15:85; A-R Sand: 20% vFs, 20% Fs, 25% Ms, 25% Cs, 30% vCs; PS; M:F = 10:90; SA-SR 2.5y, 4/1, dark gray; moist, no rxn w/ HCl.	DTW: 70.3' bgs 2' - 43': documentation shows backfill in this area between 35' and 55'; contact b/w backfill and native Bingham seen @ 43'.
10	G		@ 10': 50% gravel, 35% sand, 15% silt Gravel: 30% vfp, 30% fp, 15% mp, 10% cp, 10% vcp, 3% cobble; max size = 230mm; PS; F:M = 10:90; A-R. sand: 10% vFs, 10% Fs, 15% Ms, 30% Cs, 35% vCs; PS; M:F = 90:10; A-R. Moist, no rxn w/ HCl; 2.5y 4/1, dark gray; ↑ fines due to large rock crushed during drilling.	
15	G		15' - 20' Sandy Gravel SG @ 15': 45% gravel, 45% sand, 10% silt Gravel: 35% vfp, 20% fp, 10% mp, 15% cp, 15% vcp, 5% cobble; max. size = 170mm; PS; F:M = 15:85; A-R Sand: 10% vFs, 10% Fs, 15% Ms, 30% Cs, 35% vCs; PS; F:M = 10:90; A-SR. Moist, no rxn w/ HCl; 2.5y 4/1, dark gray	
20	G		20' - 30' Silty Sandy Gravel mSG @ 20': 45% gravel, 43% sand, 12% silt Gravel: 30% vfp, 30% fp, 15% mp, 12% cp, 10% vcp, 5% cobble; max size = 210mm; PS; F:M = 10:90; A-R. Sand: 15% vFs, 15% Fs, 20% Ms, 25% Cs, 25% vCs; PS; F:M = 10:90; SA-SR Moist, no rxn w/ HCl; 2.5y 5/1, gray.	
25	G		@ 25': 42% gravel, 38% sand, 20% silt Gravel: 35% vfp, 30% fp, 20% mp, 10% cp, 10% vcp, 5% cobble; max size = 150mm; PS; F:M = 10:90; A-R. sand: 10% vFs, 10% Fs, 20% Ms, 30% Cs, 30% vCs; PS; M:F = 95:5; SA-SR. Moist, no rxn w/ HCl; 2.5y 5/2, grayish brown; silt coating most clasts.	
30			not used HL 5/17/17	

Reported By: <u>Henry Lanman</u> Geologist <u>[Signature]</u> 5/17/17	
Print Name	Title
Reviewed By: <u>Sarah Springer</u> geologist (LG) <u>[Signature]</u> 09-05-17	
Print Name	Title
For Office Use Only	
OR Doc Type:	WMU Code(s):

BOREHOLE LOG (Cont.)				Page 2 of 7
Well ID: C9711		Well Name: 199-K-227		Date: 5/17/17
Location: 1100' NE of 105-KE Reactor				
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
30	G		@ 30': 40% gravel, 42% sand, 18% silt Gravel: 35% VFP, 20% FP, 12% MP, 10% CP, 10% VCP, 8% cobbles; max size = 130mm; PS; F:M = 10:90; A-R. sand: 0% VFs, 15% Fs, 20% Ms, 20% Cs, 35% VCs; PS; Si. Fel, 95% maf. SA-SB.	Cable tool w/ dive barrel, 10 3/4" temp. casing
35	G *		Moist, no rxn w/ HCl, 2.5y 4/1, dark gray 35-43' Sandy Gravel sG @ 35': 50% gravel, 44% sand, 6% silt Gravel: 25% VFP, 20% FP, 15% MP, 15% CP, 15% VCP, 10% cobbles; max size = 145mm; PS; F:M = 15:85; A-SR/R	* grab sample collected for lab analysis
40	G *		sand: 35% VCs, 20% Fs, 20% Ms, 15% Cs, 10% VCs; PS; F:M = 10:90; A-SR Moist, no rxn w/ HCl; 2.5y 4/2, dark grayish brown; lots of drilling fines (basalt), thus skewing sand/gravel ratios/grain size distribution.	
45	G *		@ 40: 44% gravel, 48% sand, 8% silt Gravel: 25% VFP, 20% FP, 15% MP, 10% CP, 15% VCP, 15% cobbles; PS; max size = 110mm; F:M = 10:90; A-R. sand: 40% VFs, 30% Fs, 10% Ms, 10% Cs, 10% VCs; PS; F:M = 5:95; SA-R	
50	G *		Moist, no rxn w/ HCl; 2.5y 4/2, dark grayish brown; like 35', lots of drilling fines skewing percentages. 43-50' silty Sandy Gravel mSG	43' = contact between backfill and Ringold Frm.
55	*		@ 45': 32% gravel, 50% sand, 18% silt Gravel: 30% VFP, 20% FP, 15% MP, 15% CP, 15% VCP, 5% cobbles; max size = 100mm; PS; F:M = 50:50; SR-R. sand: 25% VFs, 15% Fs, 30% Ms, 15% Cs, 15% VCs; PS; F:M = 60:40; SA-SB Moist, rxn w/ HCl; 2.5y 5/4, H. olive brown 50-55' slightly silty (gravelly) Sand (m)SG @ 50': 25% gravel, 60% sand, 15% silt Gravel: 40% VFP, 20% FP, 10% MP, 10% CP, 10% VCP, 10% cobbles; Max size = 150mm; PS; F:M = 20:30; SA-R. sand: 50% VFs, 15% Fs, 10% Ms, 10% Cs, 10% VCs; PS; F:M = 50:50; SA-SR; moist, no rxn w/ HCl, 2.5y 5/4, H. olive brown; lots of drilling fines (skewed sand grain size distribution/M:F ratios); stuck on basalt boulder @ 50' bgs.	
not used H.C. 5/17/17				

Reported By:

Henry Larman
Print Name

Geologist
Title

Signature

5/17/17
Date

BOREHOLE LOG (Cont.)			Page <u>3</u> of <u>7</u>
			Date: <u>6/5/17</u>
Well ID: <u>C9711</u>	Well Name: <u>199-K-227</u>	Location: <u>1100' NE OF 105-KE</u>	
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
55	G *		55-60' Silty Sandy Gravel (mSG) @ 55': 30% gravel, 52% sand, 18% silt Gravel: 30% VFP, 20% Fp, 20% Mp, 15% Cp, 10% Vcp, 5% cobb; max. size = 110mm; F:M = 90:10; SA-R; PS. Sand: 25% VF, 29% F, 20% Ms, 15% Cs, 15% VCS; PS; F:M = 85:15; SA-SR; moist, no rxn w/ HCl; 2.5y 5/4, lt. olive brown; still high amt. of drilling fins.
60	G *		60-65' Slightly Silty Gravelly Sand (m)SG @ 60': 25% gravel, 55% sand, 20% silt Gravel: 35% VFP, 25% Fp, 17% Mp, 10% Cp, 10% Vcp, 3% cobb; max. size = 125mm; PS; F:M = 80:20; SA-R. Sand: 25% VF, 25% F, 20% Ms, 15% Cs, 15% VCS; PS; F:M = 80:20; SA-SR. Wet, weak rxn w/ HCl; 2.5y 6/3, lt. yellowish brown.
65	G *		65-75' Silty Sandy Gravel (mS(G)) @ 65': 35% gravel, 45% sand, 20% silt Gravel: 55% VFP, 15% Fp, 10% Mp, 10% Cp, 5% Vcp, 5% cobb; max. size = 85mm; PS; F:M = 90:10; SA-R. Sand: 35% VF, 30% F, 15% Ms, 10% Cs, 10% VCS; PS; F:M = 75:25; SA-SR; wet, strong rxn w/ HCl; 2.5y 4/3, olive brown; driller added water to drill to this depth.
70	G *		@ 72': 38% gravel, 40% sand, 22% silt Gravel: 35% VFP, 35% Fp, 15% Mp, 7% Cp, 5% Vcp, 3% cobb; max. size = 80mm; PS; F:M = 60:40; SA-R. Sand: 25% VF, 25% F, 20% Ms, 15% Cs, 15% VCS; PS; F:M = 60:40; SA-SR; wet, localized rxn w/ HCl (on certain sides of pebbles); 2.5y 5/6, lt. olive brown; rough flow skewing %s/distributions.
75	G *		75-81' Sandy Gravel (SG) @ 75': 40% gravel, 50% sand, 10% silt Gravel: 60% VFP-Mp, 40% Cp-cobb; max size = ~150mm; PS; SA-SR/R. sand: unknown grain size percentages Wet, 2.5y 4/3, olive brown; looks fairly similar to 72'
75	G *		DTW: 720 (6/18/17) 72' = last grab by FES due to tritium content. NCO's took option grab sample @ 75'; HEIS #'s B394V2, B394J8 Tritium smear @ 72.4 = 2799 DPM Split spoon collected 72.0-74.5' bgs Water sample collected @ 79.8' bgs.
80	W		not used by FES HL 6/20/17

Reported By:

Henry Lanman
Print Name

Geologist
Title

Signature

6/5/17
Date

BOREHOLE LOG (Cont.)				Page <u>5</u> of <u>7</u>
Well ID: <u>C9711</u>		Well Name: <u>199-K-227</u>		Date: <u>6/22/17</u>
		Location: <u>1100' NE of 105-KE</u>		
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
105			102-124' Sandy Gravel SG	Cable tool w/ drive barrel, 10 3/4" temp casing.
	@ 105': 55% gravel, 35% sand, 10% silt		Gravel: 40% VFP-Mp, 60% Cp-cobble; max. size = 140mm; PS; F:M = 85:25; SA-R.	Tritium smear @ 105 = 742 DPM; sample observed/described from afar.
110			Sand: poorly sorted, F:M = 90:10; Wet, 2.5y 5/2, grayish brown.	
	@ 112': 38% gravel, 52% sand, 10% silt		Gravel: 80% VFP-Mp, 10% Cp-Vcp, 10% cobble; max. size = ~90mm. PS. F:M = 90:10. SR-R.	@ 112': begin using hand tool, button bit.
115			Sand: poorly sorted. F:M = 80:10; Wet, 2.5y 4/2, dark grayish brown. Drill rate = ~0.05 ft/min.	* sample usually described due to tritium contamination. DPM = 828 (smear)
	@ 120': 30% gravel, 60% sand, 10% silt		Gravel: 60% VFP-Fp, 40% Mp-Cp, 41% Vcp-cobble; max. size = 80mm. F:M = 90:10; A-R; PS	
120			Sand: poorly sorted, F:M = 85:15; Wet, 2.5y 5/3, lt. olive brown. color/grain size distribution skewed due to drilling mud/sand pump. Drill rate = 0.05'/min, consistent for 112'-120' interval, suggesting relatively uniform substrate.	
	@ 124' HL 124 124-151' Silty Sandy Gravel (MSG)			
125			@ 124': 30% gravel, 55% sand, 15% silt	* Sample described, w/o handling, visually due to tritium contamination. DPM = 829 (smear).
			Gravel: 80% VFP-Mp, 20% Cp to cobbles; max. size = ~60mm (at a minimum); PS; F:M = 75:25; SA-R.	
		Sand: 30% VF ₂ -Ms, 70% Cs-Vcs; PS; F:M = 80:20; Wet, 2.5y 5/3, lt. olive brown. Drill rate = 0.02 ft/min, suggesting a coarsening in substrate.		
130		@ 131': 40% gravel, 40% sand, 20% silt	* Sample described, w/o handling, visually due to tritium contamination. DPM = 729 (smear)	
		Gravel: 85% VFP-Mp, 10% Cp-Vcp, 5% cobble. Max. size = >50mm; PS; F:M = 80:20; SA-R.		
135		Sand: 50% VF ₂ -Ms, 50% Cs-Vcs; PS; F:M = 70:10; Wet, 2.5y 5/3, lt. olive brown; drill rate = 0.02 ft/min, suggesting similar lithology to 124'.		
		@ 135': 30% gravel, 30% sand, 20% silt	* Sample described, w/o handling, visually due to tritium contamination. DPM = 729 (smear)	
		Gravel: 50% VFP-Mp, 50% Cp-cobble; max. size = 20mm; F:M = 80:20; SR-R. Sand: poorly sorted, F:M = 80:20; Wet, 2.5y 5/3, lt. olive brown. Drill rate = 0.02 ft/min, get more gravel and general coarsening of sediment.		
140				

Reported By:

Henry Lanman
Print Name

Geologist
Title

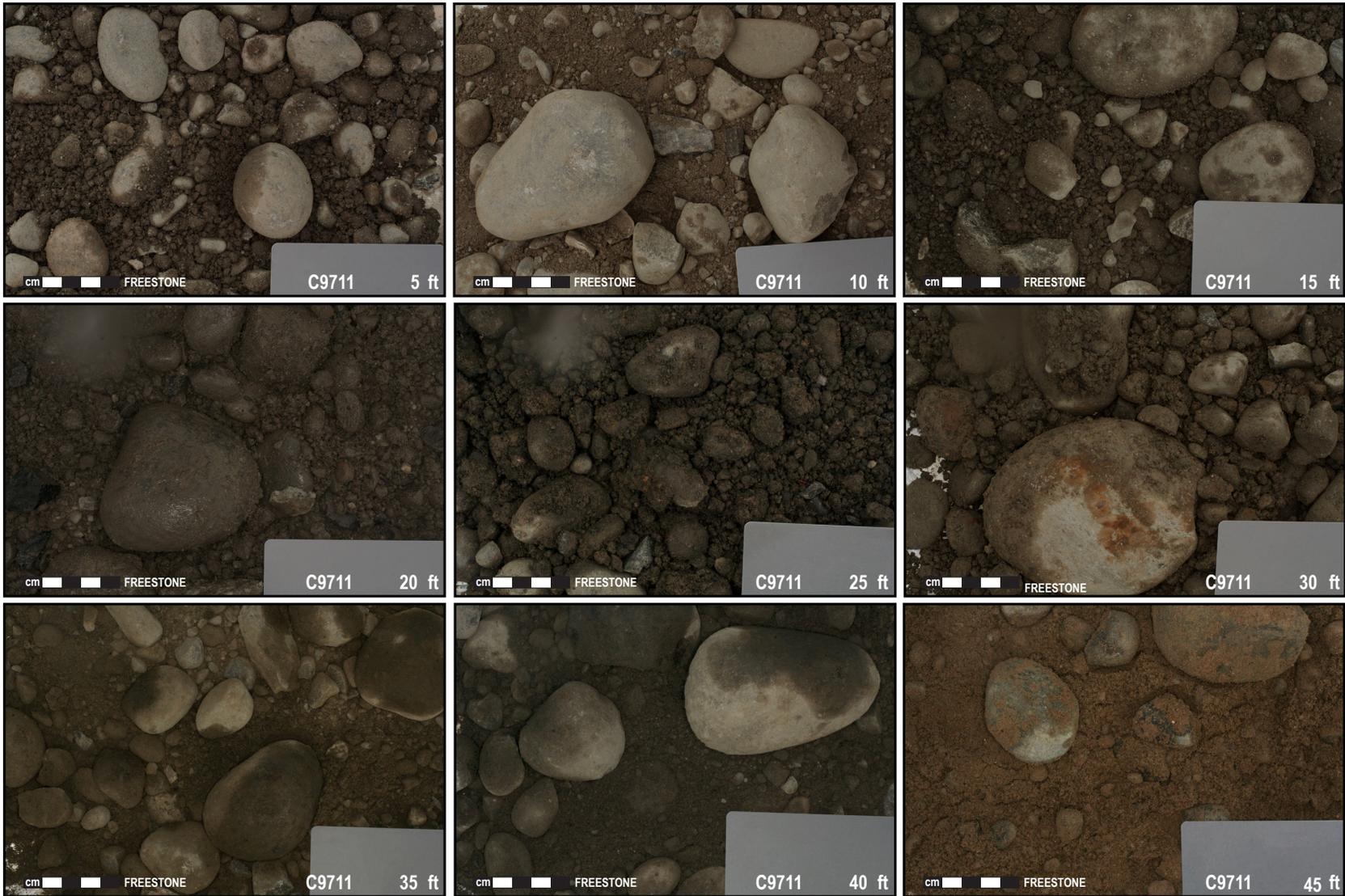
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6/22/17
Date

Not used by
FES: HL
6/29/17

BOREHOLE LOG (Cont.)			Page 6 of 7	
			Date: 6/29/17	
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
Well ID: C9711		Well Name: 199-K-227		Location: 1100' NE of 105-KIE
140	Hand Tool		124-151' Silty Sandy Gravel mS G	Cable tool w/ hard tool; 10 3/4" emp. casing.
			@ 140': 48% gravel, 40% sand, 12% silt	@ 140': given permission to handle samples again by Kelly Whitley/Kim Schuyler DPM = 408 (smear)
145			Gravel: 20% VFP, 20% FP, 20% MP, 20% CP, 15% VCP, 5% cobble; max. = 100mm; PS; F:M = 90:10; SR-R.	
			Sand: 20% VFs, 25% Fs, 30% Ms, 25% Cs, 20% VCs; PS; F:M = 90:10; SA-SR; Wet, no rxn w/ HCl, 2.5y 5/2, grayish brown. Sample taken from sand pump, potentially skewing grain size distributions.	
			@ 145': 40% gravel, 40% sand, 20% silt	@ 145': sweep hard tool for core barrel
150			Gravel: 25% VFP, 20% FP, 15% MP, 10% CP, 15% VCP, 15% cobble; max. size = 100mm; PS; F:M = 90:10; SR-R.	@ 140' sweep occurred
			Sand: 20% VFs, 30% Fs, 30% Ms, 10% Cs, 10% VCs; PS; F:M = 85:15; SA-SR. wet, weak, localized rxn w/ HCl, 2.5y 5/3, lt. olive brown. silt/clay clots abundant w/ sand/gravel inside.	146' = first sample.
			151-155' Gravelly Sand gS gS	Splitspoon collected @ 149.1-151.6' bgs
			@ 151': 15% gravel, 75% sand, 10% silt	Water sample collected @ 149.4' bgs.
			Gravel: 40% VFP, 20% FP, 15% MP, 15% CP, 10% VCP, 4% cobble; max. = 60mm; F:M = 90:10; PS; SA-R.	@ 146': DPM = 478 (smear)
	Sand: 30% VFs, 30% Fs, 25% Ms, 10% Cs, 5% VCs; PS; F:M = 95:5; SA-R. Wet, localized rxn w/ HCl on certain pebbles, 2.5y 4/3, olive brown. Abundance of mica (~30% of sand).	@ 151': DPM = 316 (smear)		
	155-160' Slightly Silty Gravelly Sand (M) gS			
	@ 155': 18% gravel, 70% sand, 12% silt	@ 155': DPM = 273 (smear)		
	Gravel: 40% VFP, 15% FP, 10% MP, 10% VCP, 10% cobble; max. size = 100mm; PS; F:M = 85:15; SA-R			
	Sand: 25% VFs, 20% Fs, 20% Ms, 15% Cs, 10% VCs; PS; F:M = 90:10; SA-SR; wet, 2.5y 4/3, olive brown. No rxn. w/ HCl.			
	160-1683' Sandy Gravel sG			
	@ 160': 32% gravel, 60% sand, 8% silt	@ 160': DPM = 657 (smear)		
	Gravel: 20% VFP, 25% FP, 15% MP, 15% CP, 15% VCP, 10% cobble; max. = 95mm; PS; F:M = 90:10; SA-R			
	Sand: 25% VFs, 20% Fs, 20% Ms, 15% Cs, 10% VCs; PS; F:M = 90:10; SA-SR; Wet, no rxn w/ HCl; 2.5y 4/3; olive brown.			
	Total Depth: 174.3' (7/6/17)	casing to 173.0'		
	Depth to Water: 70.3' (7/6/17)			
Reported By: Henry Lanman		Geologist	Signature	6/29/17

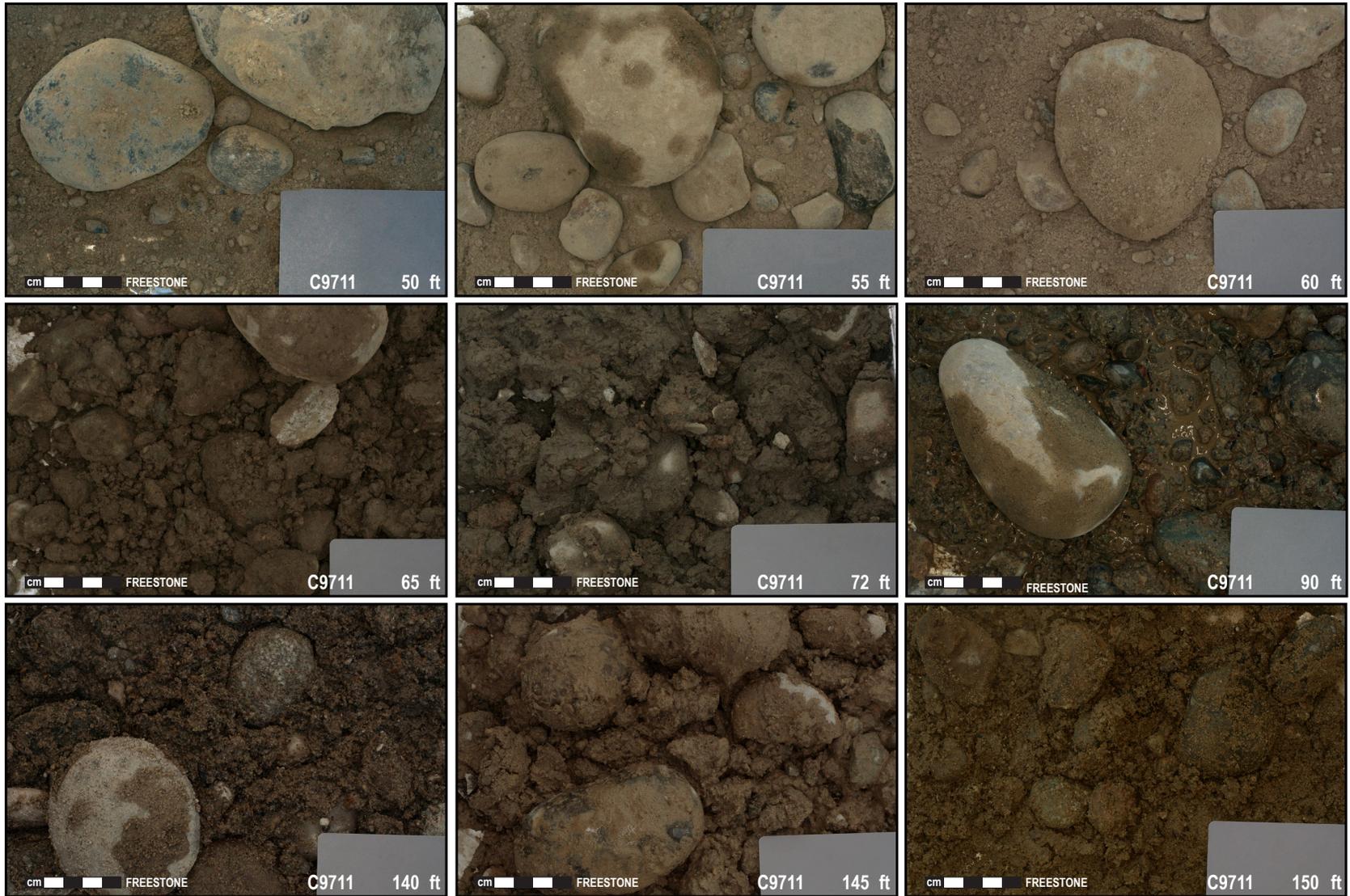
A-11



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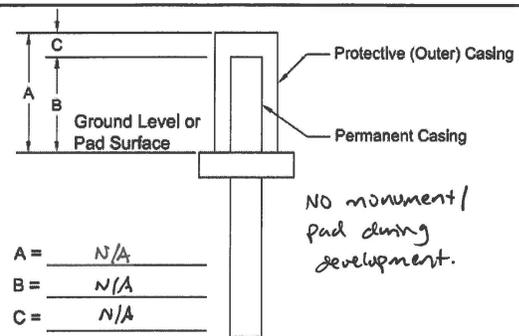


Drill Cutting Photographs for Borehole C9711 (199-K-227)



Drill Cutting Photographs for Borehole C9711 (199-K-227)



WELL DEVELOPMENT AND TESTING DATA															
Well ID: C9711			Well Name: 199-K-227				Date: 08/30/2017								
Location: 1100 ft NE of 105-KE															
Reference Measuring Point (unless otherwise noted): TOP OF OUTER CASING (TOC)															
Has the well been surveyed? <input type="radio"/> Yes <input checked="" type="radio"/> No					Does the well have a cement pad? <input type="radio"/> Yes <input checked="" type="radio"/> No										
Initial Conditions					 <p style="font-size: small;">A = <u> N/A </u> B = <u> N/A </u> C = <u> N/A </u></p> <p style="font-size: small;">NO monument / Pad during development.</p>										
		Start of Job		End of Job											
STATIC WATER LEVEL:															
Date: <u>8/23/17</u>	70.45' bgs									NA					
Date: <u>8/28/17</u>	NA		71.06' bgs												
DEPTH TO BOTTOM:															
Date: <u>8/23/17</u>	173.4' bgs				NA										
Date: <u>8/28/17</u>	NA		173.4' bgs												
Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbidity (NTU)		Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)							
			Initial	Final											
167.55	12	92.44	179	3.26	*	*	290	23.85							
146.45	25	70.01	13.8	2.42	1003	1034	250	10.09							
124.35	27	48.14	15.8	2.17	1115	1144	250	9.27							
104.25	15	27.85	12.8	2.19	1224	1253	220	15.10							
92.7	14	17.88	4.27	1.82	*	*	96	7.08							
Total Pumped: 61,000 gal															
Pump Model: 25hp Preferred Pump S/N: 82130346; Model: 6FP225 D250-9															
Troll Serial Number and Pressure Range (PSI and depth): S/N: 428494, 70m/231ft															
Comments: *Due to frequent pump starts and stops, total pump times and purge volumes are provided below for intervals #1 and #5: Int.#1: 92 minutes, 26,000 gal Int.#5: 141 minutes, 14,000 gal															
Prepared By: Henry Lanman <i>K. Schuyler</i> signed on behalf of H. Lanman Signature - K. Schuyler 8/30/17															
Reviewed By: <i>Kelly Whitley</i> Signature 9/5/17															
For Office Use Only															
OR Doc Type:					WMU Code(s):										



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199-K-227 (C9711) Log Data Report

Borehole Information

Log Date	2017-07-11	Filename	C9711_HG-NM_2017-07-11	Site	100-KR-4
DTW¹ (ft)	70.2	DTW Date	07/10/2017	DTW Source	SN3
		Drill Date	07/06/17	Total Depth (ft)	174.3
				Depth Datum	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.)		Thickness (in.)	Top (ft)	Bottom (ft)
			Outer	Inside			
Threaded Steel	Cable Tool	1.1	10 7/8	9 5/8	9/16	-1.1	173

Borehole Notes

The logging engineer measured casing thickness. Drill depth and casing depth were provided by the wellsite geologist. Depth to water was recorded by SN3 personnel at 70.2 ft prior to logging. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 4Nc	Type	60% HPGe SGLS ²
Effective Calibration Date	04/18/17	Serial No.	45-TP-22010A
Calibration Reference	HGLP-CC-154, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0

Logging System	Gamma 4Mc	Type	NMLS ³ He-3 (CPN 503)
Effective Calibration Date	04/19/17	Serial No.	H340207279
Calibration Reference	HGLP-CC-155, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0

SGLS Log Run Information

Log Run	1	2 Repeat	5	6 Repeat	
HEIS Number	1019950	1019951	1019952	1019953	
Date	07/10/17	07/10/17	07/11/17	07/11/17	
Logging Engineer	Spatz/McClellan	Spatz/McClellan	Spatz	Spatz	
Start Depth (ft)	0.01	42.0	67.0	158.0	
Finish Depth (ft)	68.0	49.0	171.0	169.0	
Count Time (sec)	100	100	100	100	
Live/Real	R	R	R	R	
Shield (Y/N)	N	N	N	N	
MSA Interval (ft)	1.0	1.0	1.0	1.0	
Log Speed (ft/min)	N/A	N/A	N/A	N/A	
Pre-Verification	C9711DNC2017 0710AV00CAB 1	C9711DNC2017 0710AV00CAB 1	C9711DNC2017 0711CV00CAB1	C9711DNC2017 0711CV00CAB1	

¹ depth to water inside casing

² Spectral Gamma Logging System

³ Neutron Moisture Logging System

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Log Run	1	2 Repeat	5	6 Repeat	
Start File	AD000001	BD004200	CD006700	DD015800	
Finish File	AD006800	BD004900	CD017100	DD016900	
Post-Verification	C9711DNC2017 0710BV00CAA 1	C9711DNC2017 0710BV00CAA 1	C9711DNC2017 0711DV00CAA 1	C9711DNC2017 0711DV00CAA 1	
Depth Return Error (in.)	N/A	0.0	N/A	1.0 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			
HEIS Number	1019954	1019955			
Date	07/10/17	07/10/17			
Logging Engineer	Spatz/McClellan	Spatz/McClellan			
Start Depth (ft)	0.0	42.01			
Finish Depth (ft)	68.0	49.0			
Count Time (sec)	15	15			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.25	0.25			
Log Speed (ft/min)	N/A	N/A			
Pre-Verification	C9711DMC2017 0710AV00CAB 1	C9711DMC2017 0710AV00CAB 1			
Start File	AD000000	BD004201			
Finish File	AD006800	BD004900			
Post-Verification	C9711DMC2017 0710BV00CAA 1	C9711DMC2017 0710BV00CAA 1			
Depth Return Error (in.)	N/A	0.5 high			
Comments	None	None			

Logging Operation Notes

A centralizer was installed on the SGLS and NMLS sondes.

Pre- and post-survey verification measurements met the acceptance criteria for the established systems.

Analysis Notes

Analyst	P.D. Henwood	Date	07/27/17
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated in an EXCEL template identified as DNC20170418_CC-154 for the SGLS, using an efficiency function and corrections for casing and dead time as determined during annual response checks.



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The HGU⁴ 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 Model 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).

A water correction was applied below 69.8 ft, approximately 0.4 ft above the depth measured the prior day. It appeared, based on the gamma logs, the water had recovered between July 10 and July 11, 2017.

Results and Interpretations

No manmade radionuclides were detected.

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

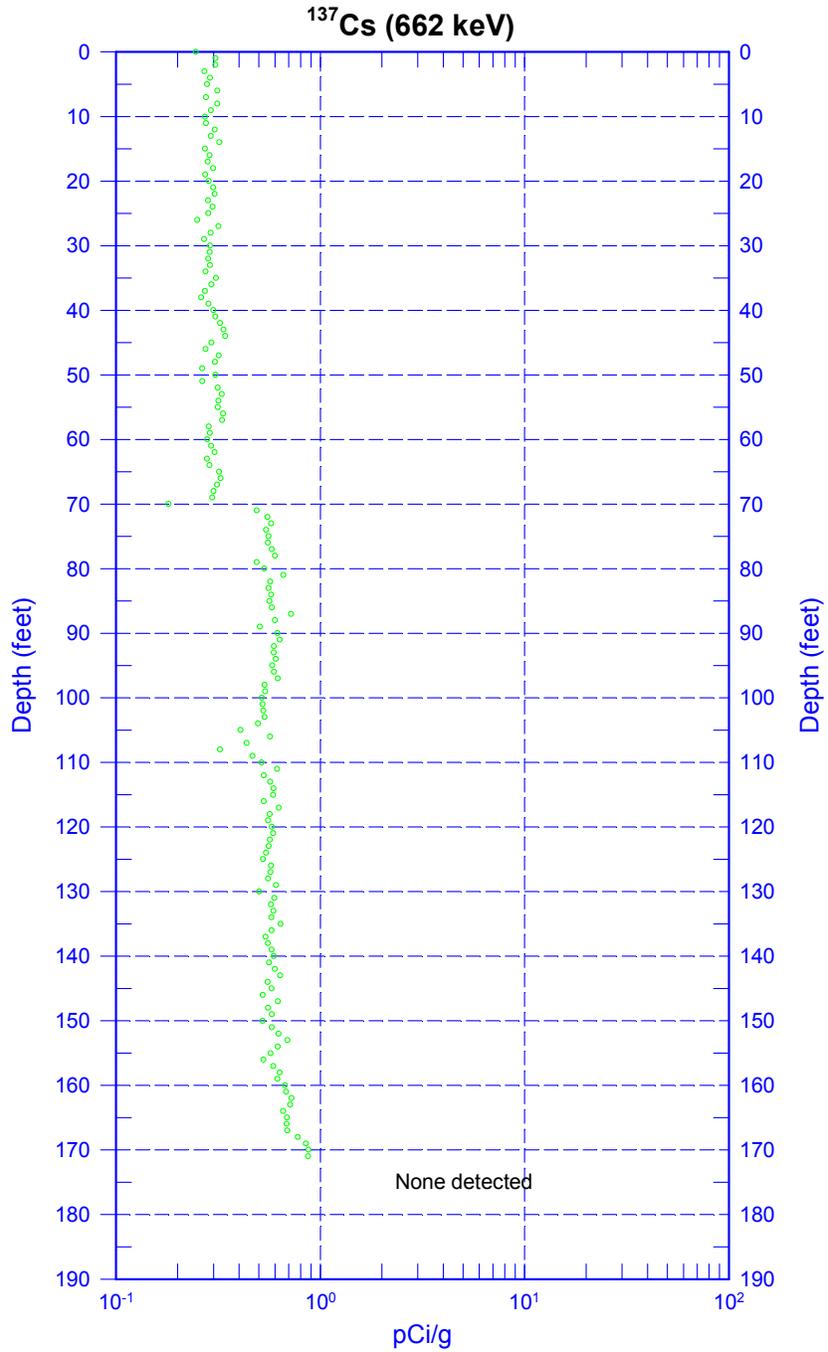
Depth Reference is ground surface.

- Manmade Radionuclides (0-190 ft)
- Natural Gamma Logs (0-190 ft)
- Combination Plot (0-120 ft)
- Combination Plot (110-230 ft)
- Combination Plot (0-190 ft)
- Total Gamma & Moisture (0-190 ft)
- Total Gamma & Hanford Gamma Unit (0-190 ft)
- Repeat Section of Natural Gamma Logs (42-49 ft)
- Repeat Section of Natural Gamma Logs (158-169 ft)
- Moisture Repeat Section (42-49 ft)

⁴ Hanford Gamma Unit



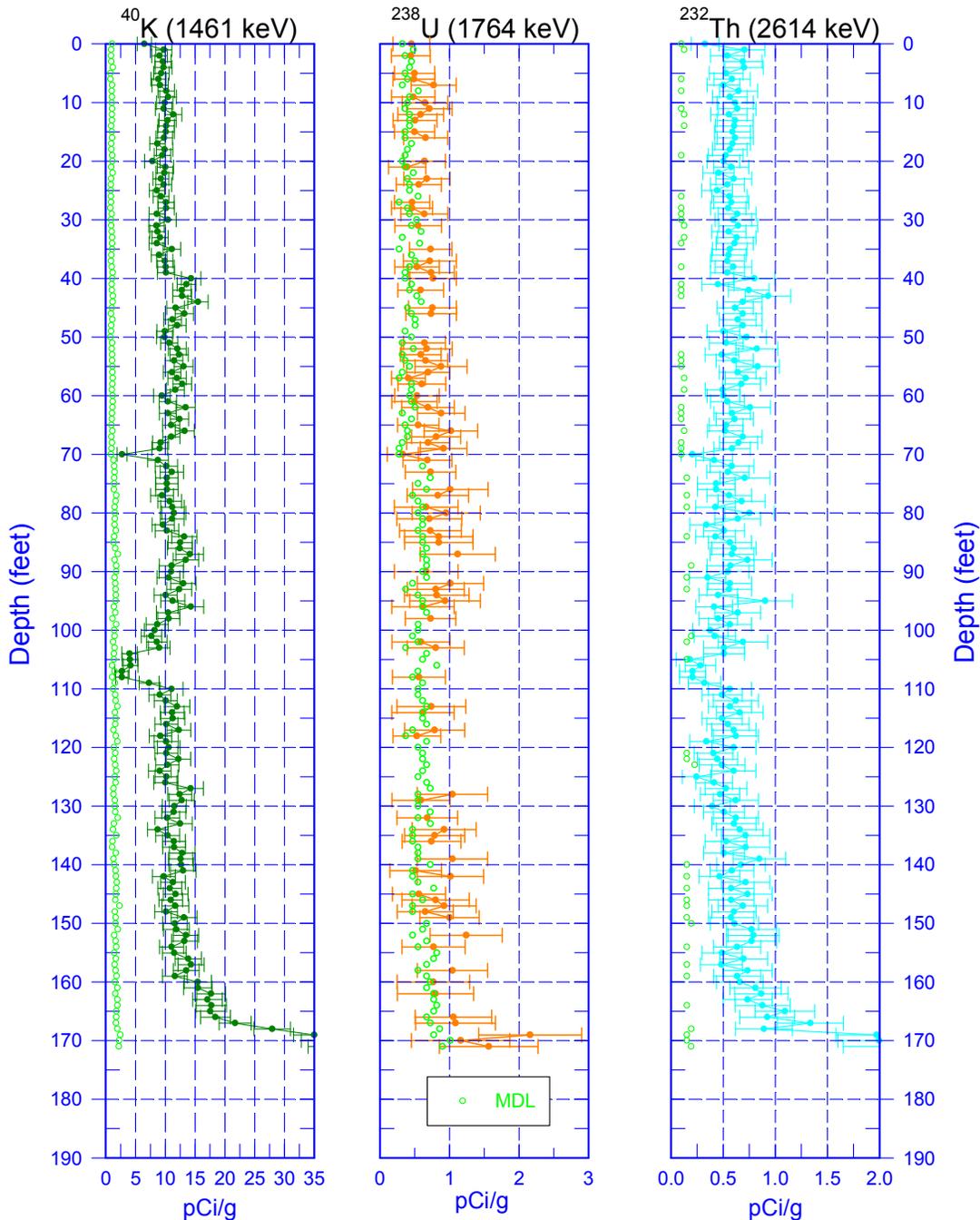
199-K-227 (C9711) Manmade Radionuclides



Zero Reference - Ground Surface

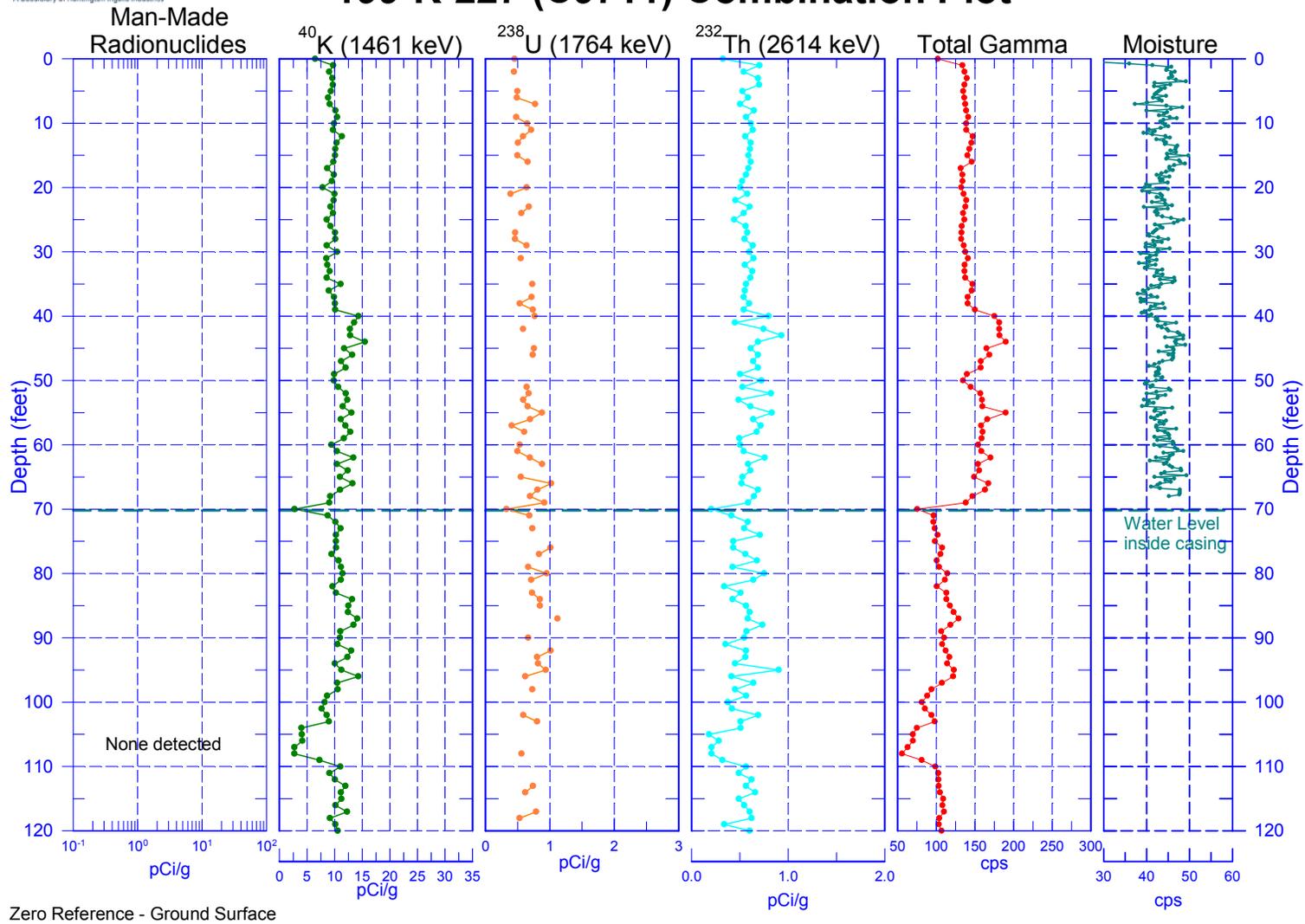


199-K-227 (C9711) Natural Gamma Logs



Zero Reference - Ground Surface

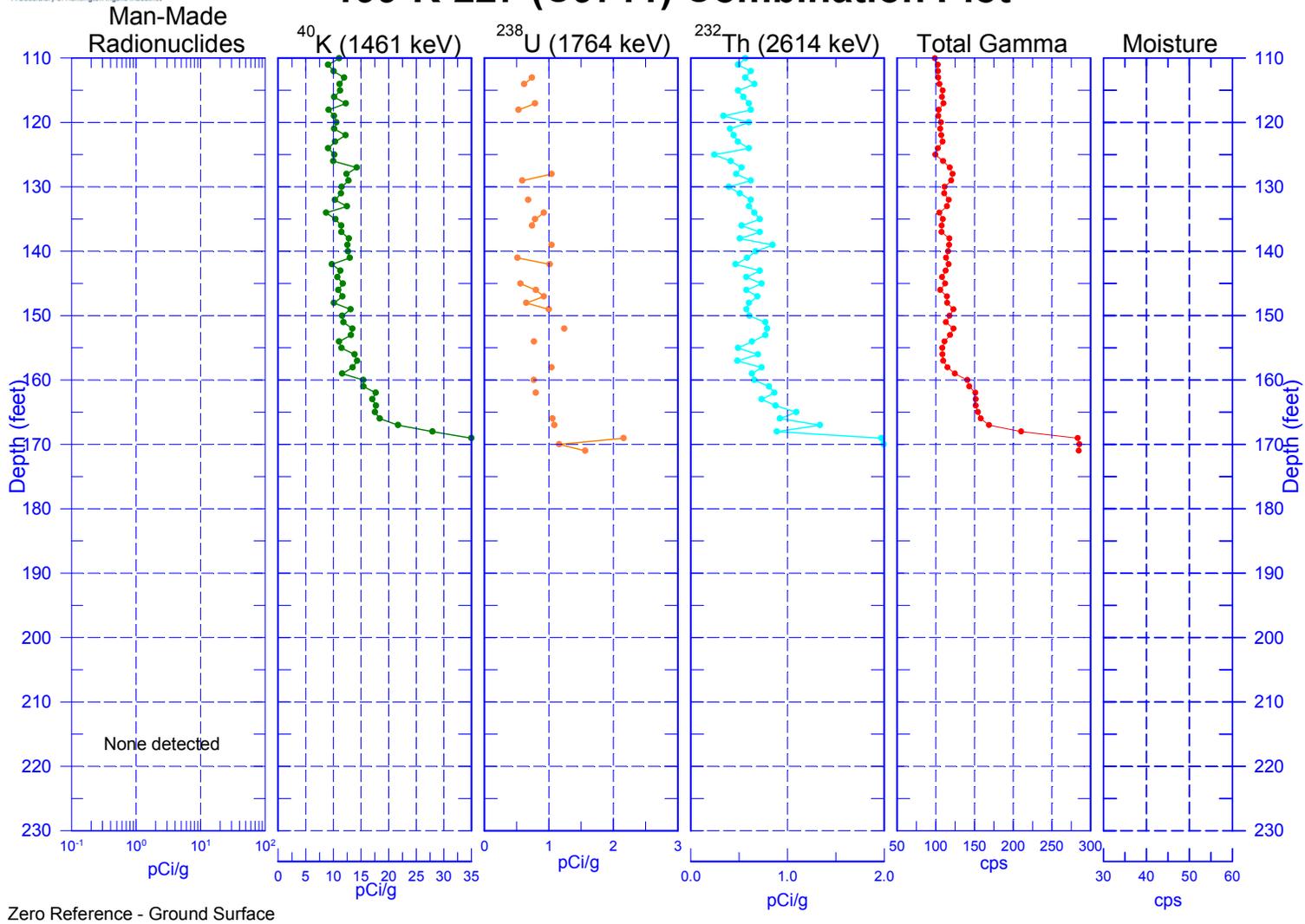
199-K-227 (C9711) Combination Plot



A-20

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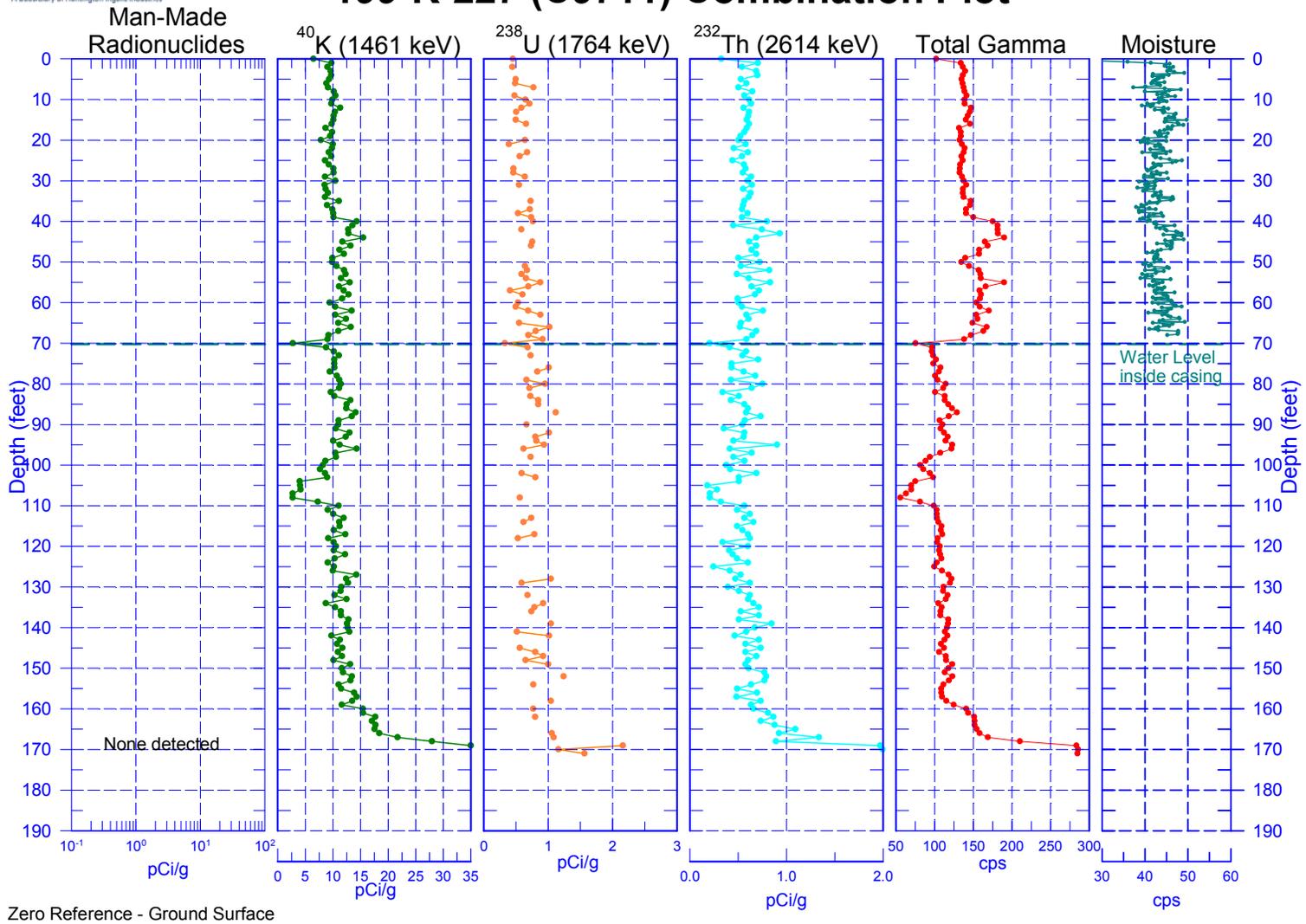
199-K-227 (C9711) Combination Plot



A-21

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199-K-227 (C9711) Combination Plot

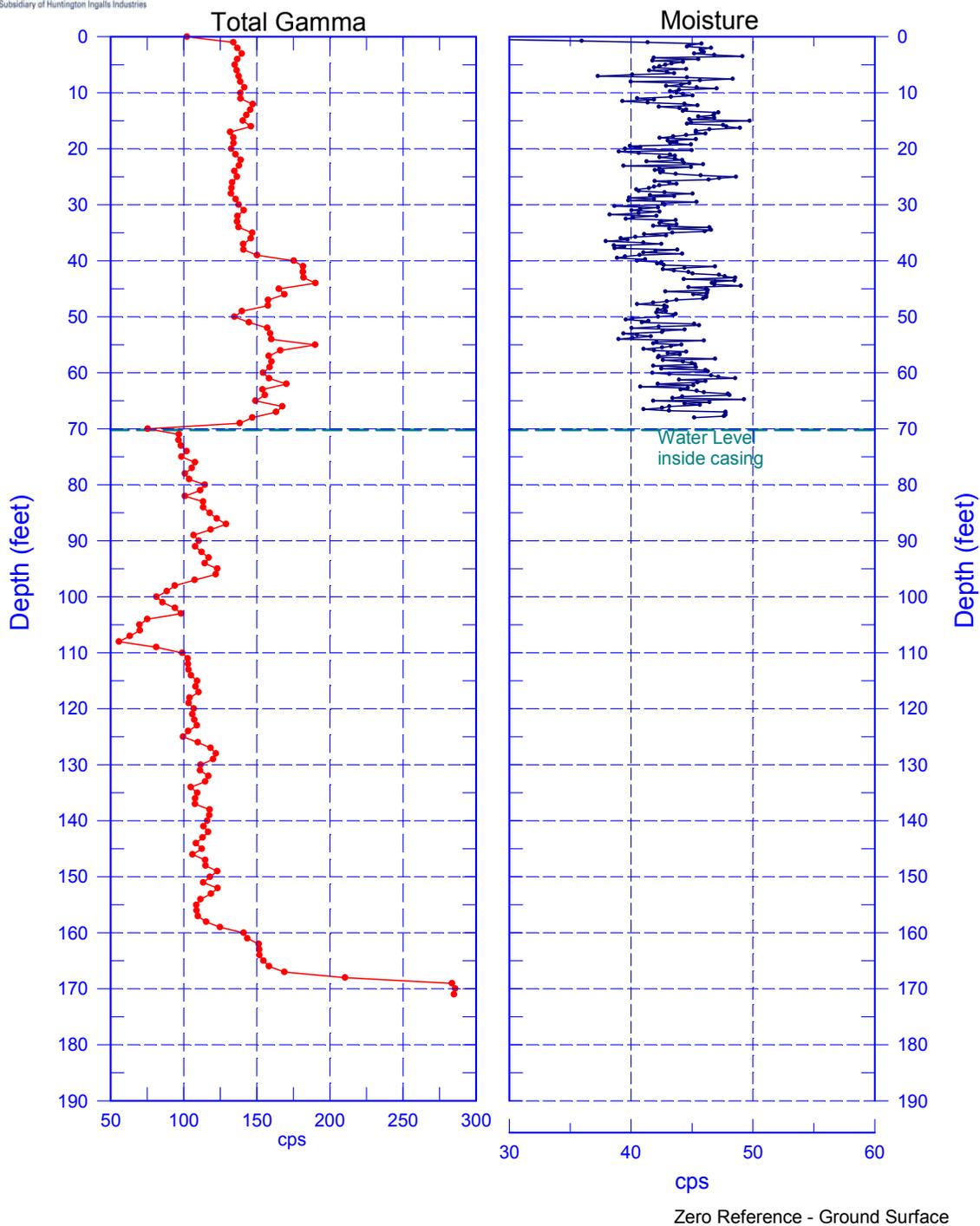


A-22

SGW-61094, REV. 0

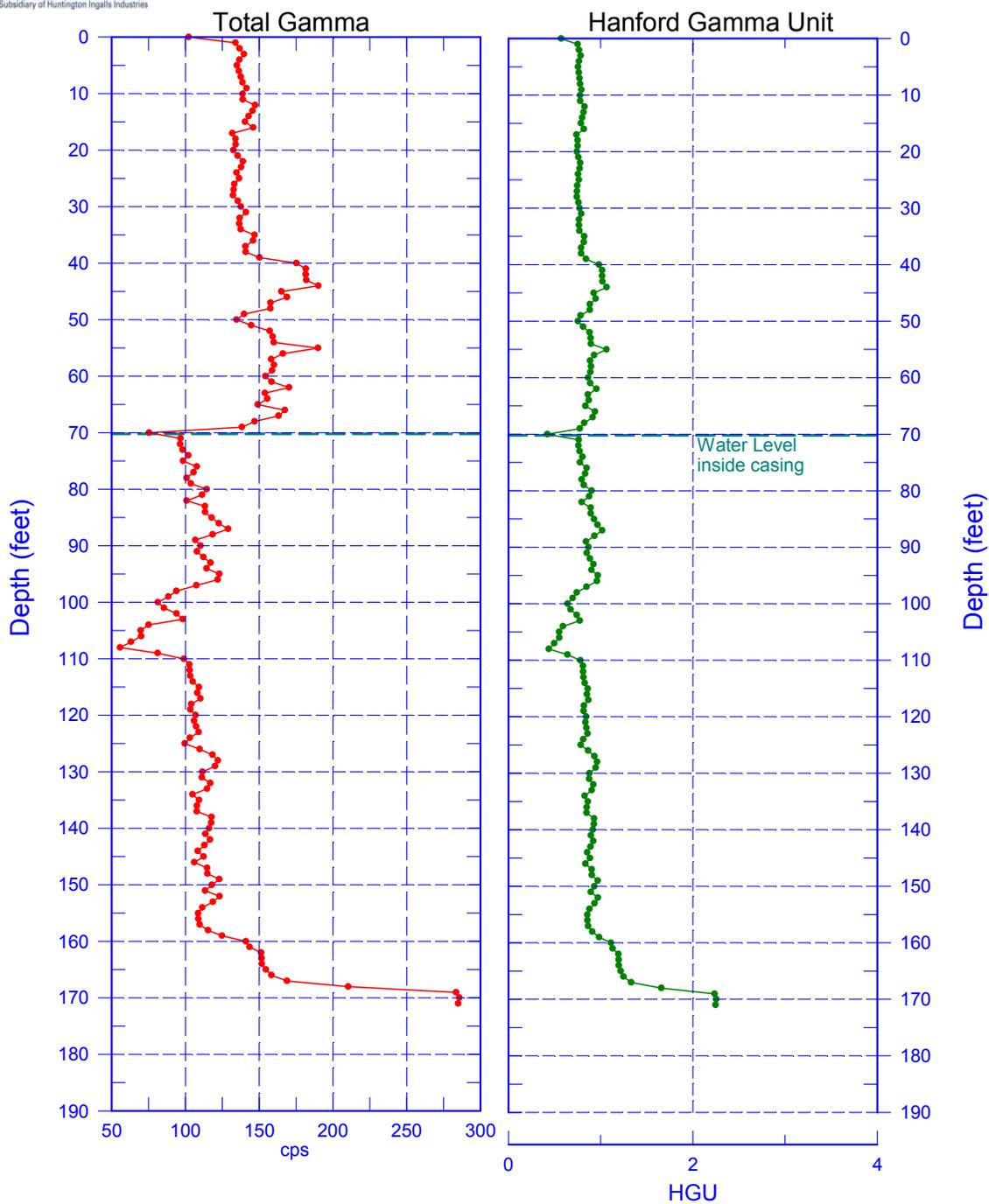


199-K-227 (C9711) Total Gamma & Moisture





199-K-227 (C9711) Total Gamma & Hanford Gamma Unit

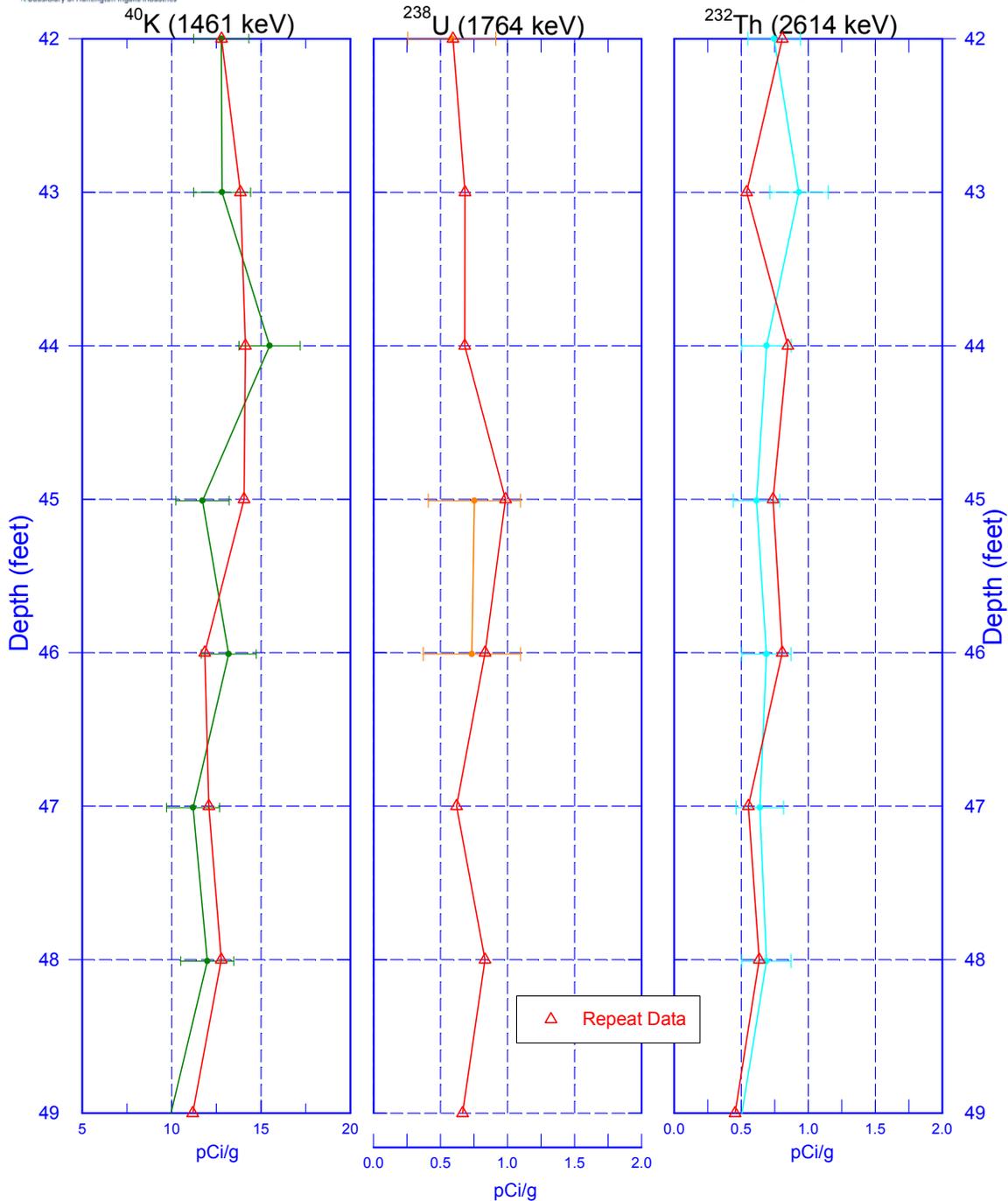


Zero Reference - Ground Surface



199-K-227 (C9711)

Repeat Section of Natural Gamma Logs

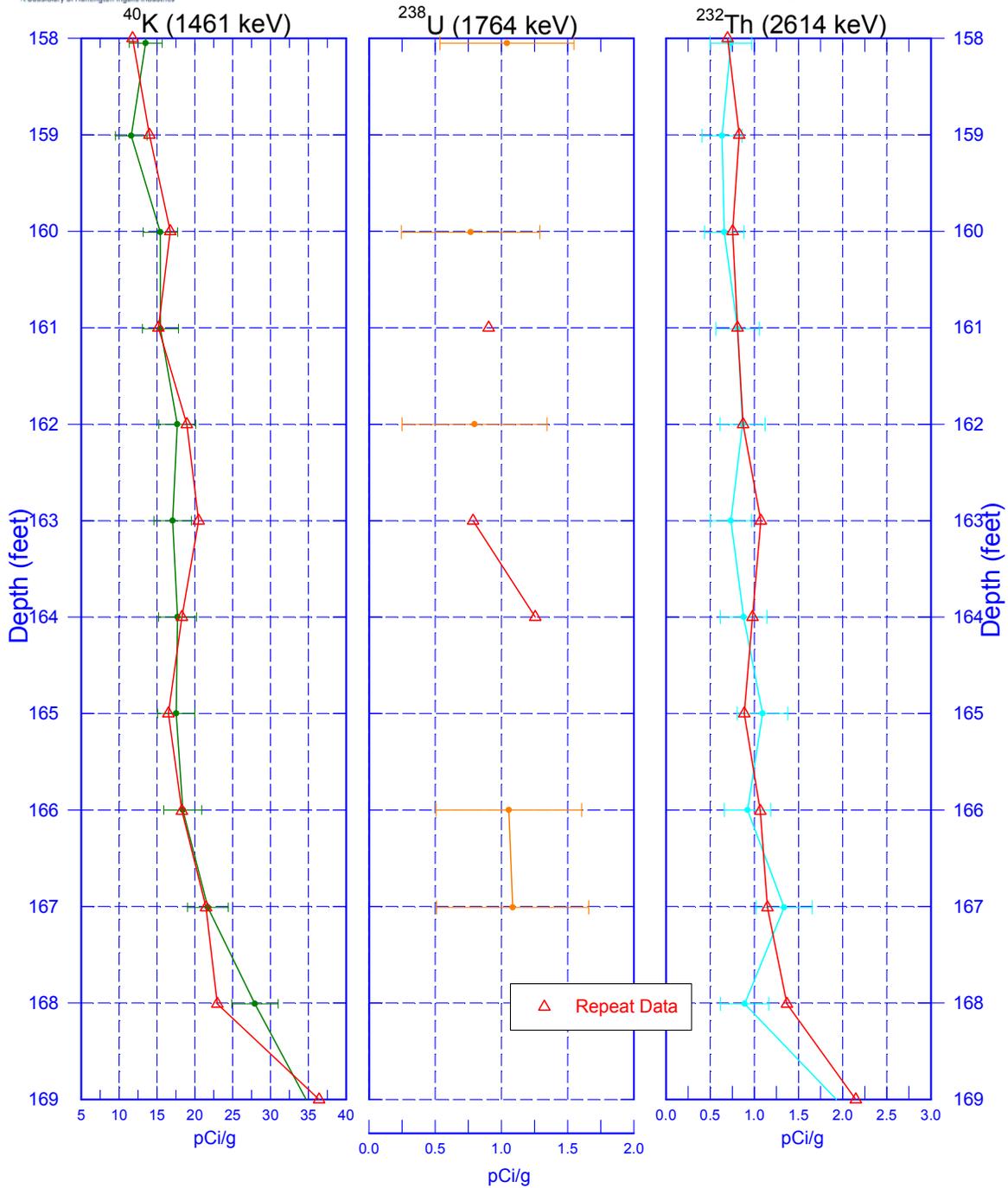


Zero Reference - Ground Surface



199-K-227 (C9711)

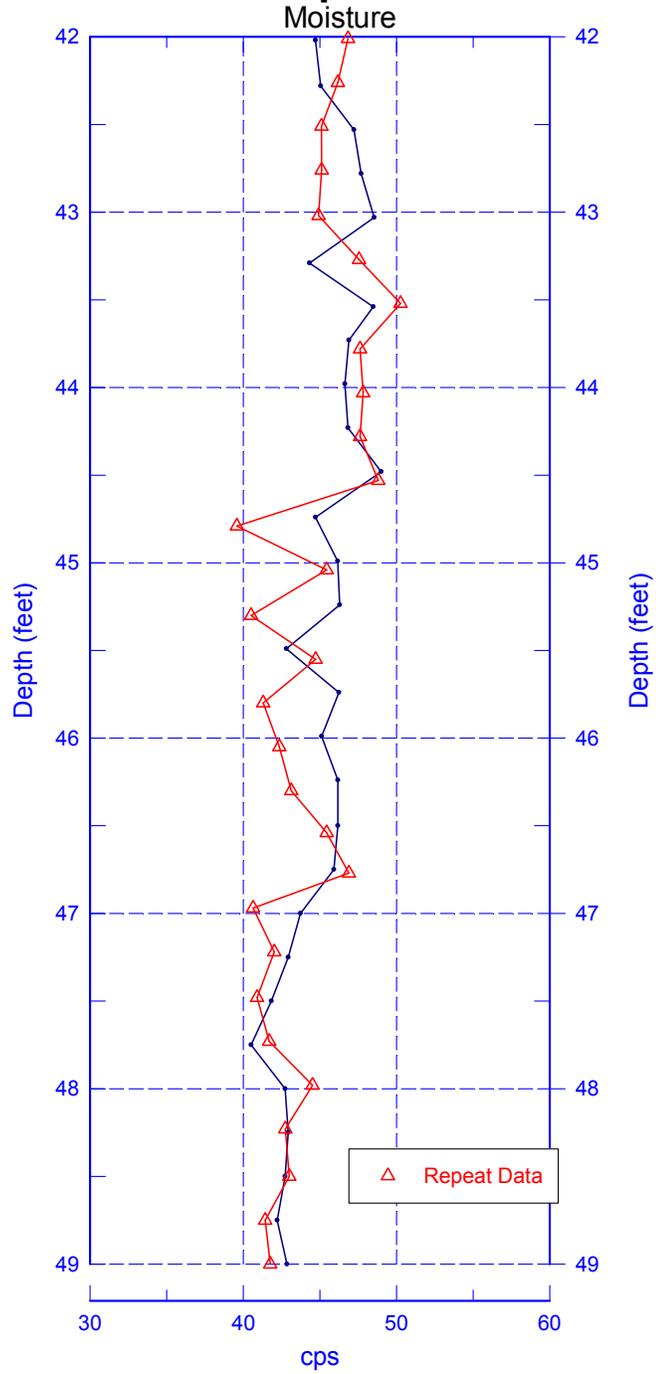
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



199-K-227 (C9711) Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT					
Project:			Prepared By: Neil P. Fastabend		
			Company: CHPRC		
Date Requested: 08/30/17			Requestor: Steven E. Imhoff (CHPRC)		
Date of Survey: 09/12/17			Surveyor / Company: Lawrence B. Munnell (CHPRC)		
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9711 (199-K-227) located in 100K Area.			Horizontal Datum: NAD83 (91)		
			Vertical Datum: NAVD88		
			Units: Meters		
			Hanford Area Designation: 100K		
Coordinate System: Washington State Plane Coordinates (South Zone)					
Horizontal Control Monuments: Washington State Reference Network					
Vertical Control Monuments: M49 (COE) and T324 (COE)					
Well ID	Well Name	Easting	Northing	Elevation	
C9711	199-K-227	569538.69	146851.61		Center of Casing
				143.964	Top Outer Casing, N.Edge, Stamped X
				143.509	Top Inner 6"SS Casing, N.Edge
				143.191	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:					
<p>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.</p>					

Appendix B

Well Documentation for C9712 (199-K-228)

Contents

Well Summary Sheet	B-1
Borehole Log	B-3
Drill Cutting Photographs	B-11
Well Development and Testing Data	B-16
Log Data Report	B-17
Well Survey Data Report	B-28

WELL SUMMARY SHEET			Page <u>1</u> of <u>2</u>	
Well ID : C9712		Well Name: 199-K-228		Start Date: 4/3/2017
Project: Four 100-KR-4 OU Monitoring Wells		Location: 500 ft E of 105-KE		Finish Date: 7/27/2017
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
Concrete Pad: 0.50 ft above ground surface (ags) 6-in Protective Casing: 3.05 ft ags - 1.95 ft below ground surface (bgs) Type I/II Portland Cement Grout: 0.0 - 10.7 ft bgs 6-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.05 ft ags - 71.01 ft bgs Stainless steel centralizer installed above and below screen and every 40 ft Medium Bentonite Chips: 10.7 - 63.5 ft bgs 3/8-in Coated Bentonite Pellet Seal: 63.5 - 66.7 ft bgs 8-12 mesh Premier Colorado Silica Filter Pack Sand: 66.70 - 167.2 ft bgs			0.0 - 0.4 Crushed Gravel Drill Pad 0.4 - 4.0 Backfill 4.0 - 6.0 Silty Sandy Gravel (msG) 6.0 - 40.0 Sandy Gravel (sG) 40.0 - 41.0 Slightly Silty Sand (mS) 41.0 - 46.0 Silty Sandy Gravel (msG) 46.0 - 54.0 Slightly Silty Gravelly Sand ((m)sG) 54.0 - 65.0 Sandy Gravel (sG) 65.0 - 70.0 Slightly Silty Gravelly Sand ((m)sG)	
Reported By: <u>Kim Schuyler</u> Geologist <u>Kim Schuyler</u> 8/30/17 Print Name Title Signature Date				
Reviewed By: <u>Kelly Whitley</u> Well Coordinator <u>Kelly Whitley</u> 9/5/17 Print Name Title Signature Date				
For Office Use Only				
OR Doc Type:		WMU Code(s):		

WELL SUMMARY CONTINUATION SHEET			Page 2 of 2	
Well ID: C9712	Well Name: 199-K-228	Project Four 100-KR-4 OU Monitoring Wells		
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
6-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.05 ft ags - 71.01 ft bgs		70		Static Water Level: 70.0 ft bgs (7/27/2017)
8-12 mesh Premier Colorado Silica Filter Pack Sand: 66.70 - 167.2 ft bgs		80		70.0 - 95.0 Sandy Gravel (sG)
Stainless steel centralizer installed above and below screen and every 40 ft		90		95.0 - 104.0 Silty Sandy Gravel (msG)
6-in I.D. Schedule 10, Type 304/304L, 65-slot (0.065 in.) Stainless Steel Screen: 71.01 - 161.01 ft bgs		100		104.0 - 106.0 Slightly Silty Gravelly Sand ((m)sG)
		110		106.0 - 107.0 Sandy Gravel (sG)
				107.0 - 110.0 Slightly Silty Gravelly Sand ((m)sG)
				110.0 - 155.0 Sandy Gravel (sG)
		120		155.0 - 156.0 Gravelly Sand (gS)
				156.0 - 161.0 Slightly Silty Gravelly Sand ((m)sG)
		130		161.0 - 161.5 Silty Sandy Gravel (msG)
				161.5 - 167.2 Mud (M)
6-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 161.01 - 166.00 ft bgs		140		
Straightness Test: Pass, 07/07/2017 Total Depth: 167.2 ft bgs		150		
Depths are in ft below ground surface. Borehole drilled with 10 3/4-in O.D. casing from 0.0 - 167.0 ft bgs All temporary drill casing was removed from the ground.		160		

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BOREHOLE LOG				Page <u>1</u> of <u>8</u>
Well ID: <u>C9712</u>		Well Name: <u>199-K-228</u>		Date: <u>4/3/17</u>
Project: <u>Installation of 4GW wells in 100-KR-40U</u>			Location: <u>500' E of 105-KF</u>	
			Reference Measure Point: <u>BGS</u>	
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 - 0.4' Gravel Drill pad	Cable tool, 10 3/4" ID /
			0.4' - 4' Backfill (Hartford + surficial deposits, reworked, sandy gravel)	9 3/4" ID steel casing
			4' - 6' (Silty Sandy Gravel (MSG))	
5	G		@ 5' 38% gravel, 49% sand, 17% silt Gravel: 17% VFP, 30% FP, 40% MP, 5% CP, 5% VCP, 3% cobble; max. clast size = 70mm; 10% Fel. 90% maf; SA-SR	
			Sand: 15% VF _s , 15% F _s , 15% M _s , 25% C _s , 30% VC _s ; PS; 35% Fel 65% maf; SA-SR	
			Moist, no rxn w/ HCl, 2.5y 4/4, olive brown; High clay content -> balls in hand well (tan color).	
			6' - 40' Sandy Gravel (SG)	
			@ 10' 38% gravel, 60% sand, 2% silt	
10	G		Gravel: 38% VFP, 35% FP, 15% MP, 5% CP, 5% VCP, 2% cobble; PS: 5% Fel 95% maf; SR	
			Sand: 5% VF _s , 5% F _s , M _s 30%, 30% C _s , 30% VC _s ; PS, 40% Fel 60% maf, SA-SR	
			Moist, no rxn w/ HCl, 2.5y 3/8, very dark grayish brown; lots of fines from drilling in sample.	
			@ 16' 40% gravel 55% sand, 5% silt	
15	G		Gravel: 20% VFP, 10% FP, 10% MP, 25% CP, 25% VCP, 10% cobble; max. clast = 170mm; PS; 25% Fel; 75% maf; SA	
			Sand: 25% VF _s , 20% F _s , 10% M _s , 20% C _s , 25% VC _s ; PS, 35% Fel 65% maf; SA.	
			Moist, no rxn w/ HCl, 2.5y 3/1, very dark gray; mixed w/ fines from large cobble @ 13-14'	
			@ 20' 40% gravel, 48% sand, 12% silt	
20	G		Gravel: 8% VFP, 40% FP, 30% MP, 10% CP, 10% VCP, 2% cobble, max. clast = 90mm; 5% Fel 95% maf, SR.	
			Sand: 10% VF _s , 15% F _s , 15% M _s , 30% C _s , 30% VC _s ; PS; 30% Fel, 70% maf, SA-SR.	
25	G			
30	G			

Reported By: Henry Larman Geologist [Signature] 4/4/17
 Print Name Title Signature Date

Reviewed By: Sarah Springer geologist (LG) [Signature] 09-05-17
 Print Name Title Signature Date

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OR Doc Type: _____ WMU Code(s): _____

BOREHOLE LOG (Cont.)				Page 2 of 8
Well ID: CA712		Well Name: 199-K-228		Date: 4/4/16
Location: 500' E of 105-KIE				
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			Moist, no rxn w/ HCl; 2.5y 3/1 very dark gray; silt/clay matrix on clasts = 2.5y 5/3 (unbroken clasts) @ 25' 40% gravel, 55% sand, 5% silt Gravel: 9% VFP, 9% FP, 30% MP, 40% CP, 10% VCP, 2% cobbles; max. clast = 110mm; PS; 15% Fel 85% maf; SR-R Sand: 10% VFS, 10% FS, 20% MS, 30% CS, 30% VCS; PS, 35% Fel 65% maf; SA	Cable Tool, 10 3/4" OD temporary casing w/ drive barrel
40	G		Moist, no rxn w/ HCl; 2.5y 4/2; dark grayish brown; coarse sand increases in %; good sample recov. @ 27.5 50% gravel, 47% sand, 3% silt Gravel: 20% VFP, 40% FP, 40% MP, 1% VCP, VCP, cobble. max clast = 35mm; average clast = 35mm; MS, 5% Fel 95% maf; SA-R Sand: 5% VFS, 10% FS, 25% MS, 30% CS, 30% VCS; PS; 40% Fel 60% maf; SA-SR; slight rxn w/ HCl on some pebbles; 2.5y 4/2 dark grayish brown	
45	G		@ 29.5: 50% gravel, 38% sand, 12% silt Gravel: 30% VFP, 20% FP, 20% MP, 15% CP, 10% VCP, 5% cobb; max size = 80mm; PS; 20% Fel 80% maf; SA-SR. Sand: 10% VFS, 10% FS, 10% MS, 30% CS, 40% VCS; PS; 50% Fel 50% maf; SA-SR	
46			Moist, weak rxn w/ HCl on some clasts; 2.5y 4/1 dark gray; silt coating clasts w/ sand m.t.; 2.5y 6/4 @ 34' 55% gravel, 43% sand, 2% silt	
47			Gravel: 30% VFP, 30% FP, 15% MP, 20% CP, 5% VCP, 1% cobb; max size = 45mm; avg size = 5mm; PS; 30% Fel 70% maf; SA-SR	
48			Sand: 10% VFS, 10% FS, 10% MS, 30% CS, 40% VCS; PS, 7% Fel, 8% maf, 20% maf, 30% maf, 35% maf	
49			30% Fel, 70% maf; SA-SR	
50			Moist, no rxn w/ HCl, 2.5y 4/1, dark gray	51' - 53' Hand tool
51			40-41' slightly silty sand @ 40' 2% gravel, 83% sand, 15% silt	
52	G		Gravel: 70% VFP, 15% FP, 5% MP, 5% CP, 5% VCP, 1% cobb; max size = 80mm, PS, 10% Fel 10% maf; SA-SR	
53			Sand: 5% VFS, 35% FS, 50% MS, 5% CS, 5% VCS; MS, 80% Fel, 20% maf; SR-R Moist, no rxn w/ HCl; 2.5y 4/6; olive brown; bentonite-rich sand;	

Reported By:

Henry Lanman
Print Name

Geologist
Title

Signature

4/4/16
Date

BOREHOLE LOG (Cont.)				Page <u>3</u> of <u>8</u>
				Date: <u>4/13/17</u>
Well ID: <u>C9712</u>		Well Name: <u>199-K-228</u>		Location: <u>500' E of 109KE</u>
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
60	G		<p>41 - 46': silty sandy gravel (MSG) @ 41: 30% gravel, 55% sand, 20% silt Gravel: 10% VFP, 30% Fp, 30% Mp, 30% Cp, 5% Vcp, 5% cob; PS; 40% Fe, 60% maf; SR-R Sand: same as 40' Moist, no rxn w/ HCl, 2.5y 3/3; light yellowish brown; same as 40' grab, but higher abundance of gravls and increase in silt.</p>	<p>cable tool w/ drive barrel & 10 3/4" Temporary casing</p>
65	G		<p>46 - 54: slightly silty gravelly sand (M)SG @ 46: 15% gravel, 70% sand, 15% silt Gravel: 25% VFP, 7% Fp, 8% Mp, 30% Cp, 30% Vcp, cl; cob; max size = 60mm; PS; 40% Fe, 60% maf; SA-R Sand: 40% VF, 30% F, 5% Ms, 5% Cs, 15% VCs; PS; 80% Fe, 20% maf; SR-R Moist, no rxn w/ HCl, 2.5y 3/2, grayish brown; Fs is most likely rock flour, yielding higher abundance</p>	
70	G		<p>54 - 59: sandy gravel (SG) @ 54: 35% gravel, 55% sand, 10% silt Gravel: 40% VFP, 35% Fp, 10% Mp, 10% Cp, 5% Vcp, cl; cob; Max size = 70mm; PS; 30% Fe, 70% maf; A-R Sand: 20% VF, 35% F, 35% Ms, 5% Cs, 5% VCs; PS; 50% Fe, 50% maf; A-R Moist, no rxn w/ HCl, 2.5y 5/3; lt. olive brown ↑ angularity and ↓ particle size due to hard tool.</p>	<p>Initial DTW = 73.4 (4/10/17)</p>
75	G		<p>@ 59: sandy gravel (contact Ringold Rwie Member) 35% gravel, 55% sand, 10% silt Gravel: 15% VFP, 30% Fp, 30% Mp, 10% Cp, 10% Vcp, 5% cob; max clast = 100mm; PS; 50% Fe, 50% maf; SR-R Sand: 10% VF, 20% F, 40% Ms, 15% Cs, 15% VCs; PS; 70% Fe, 30% maf; SA-SR Moist, rxn w/ HCl; 2.5y 5/6; lt. olive brown Ringold Fm.; ↑ fizes, and lots of mica (~80% of the Fs).</p>	
			<p>65 - 70: slightly silty gravelly sand (M)GS @ 65: 20% gravel, 65% sand, 15% silt Gravel: 40% VFP, 2% Fp, 3% Mp, 15% Cp, 20% Vcp, 20% cobbles; max size = 10mm; PS/BM (vague bimodal character); 85% Fe, 15% maf; rounded. Sand: 35% VF, 30% F, 20% Ms, 8% Cs, 7% VCs; PS; 80% Fe, 20% maf; SA</p>	

Reported By:

Henry Lanman
Print Name

Geologist
Title

Signature

4/13/17
Date

BOREHOLE LOG (Cont.)				Page 4 of 8
Well ID: C9712		Well Name: 199-K-228		Date: 4/13/17
		Location: 500' E of 100-KE		5
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
80	G		Moist, no rxn w/ HCl; 2.5y 6/5; light yellowish brown; ↑ fines from 59' 70 - 95' Sandy Gravel (SG) @ 70' 35% gravel, 53% sand, 12% silt Gravel: 10% VFP, 25% Fp, 40% Mp, 20% Cp, 5% Vcp, 1% cobble; max size = 70mm; PS, 30% Fel 70% maf	cable Tool w/ 10 3/4" OD temp casing - use drive barrel
	GW		SA-SR Sand: 40% VFs, 25% Fs, 25% Ms, 4% Cs, 1% Vcs; PS; 50% Fel, 50% maf; SA	W=water sample
85	G		Moist, vicious rxn w/ HCl; 2.5y 4/2; dark grayish brown; hard caliche layers (got pieces out of core barrel); @ 75.9' 45% gravel, 50% sand, 5% silt Gravel: 20% VFP, 15% Fp, 10% Mp, 25% Cp, Vcp 15%, 15% cobble; max size = 85mm; 20% Fel 30% maf; PS, SA-R Sand: 20% VFs, 20% Fs, 30% Ms, 10% Cs, 10% Vcs; PS; 85% fel 15% maf; SA-SR	
	G		Wet, moderate rxn w/ HCl; 2.5y 4/2; dark grayish brown; lots of micaceous. Split spoon driven @ this depth. @ 80' 40% gravel, 59% sand, 1% silt Gravel: 35% VFP, 30% Fp, 20% Mp, 10% Cp, 5% Vcp, 1% cobble; max size = 50mm; M-PS; 65% Fel 35% mafic; SA-R. Sand: 25% VFs, 25% Fs, 20% Ms, 15% Cs, 15% Vcs; PS; 85% maf Fel, 15% maf; SA-SR	
90	G		Wet, weak, localized rxn w/ HCl; ↓ silt/cobble from 75.9' and 83' @ 83' ↑ cobble to 20%, ↑ Vcp to 15%, ↓ Mp to 15%, ↓ Fp to 20%, ↓ VFP to 30%; max clast = 150mm @ 84' 30% gravel, 62% sand, 8% silt Gravel: 30% VFP, 25% Fp, 15% Mp, 10% Cp, 10% Vcp, 10% cobb; max. = 155mm; PS; 10% Fel 10% maf; SA-R Sand: 35% VFs, 30% Fs, 15% Ms, 10% Cs, 10% Vcs; PS; 10% Fel, 10% maf; SA-SR	
95	G		Wet, no rxn w/ HCl; 2.5y 6/2; lt. brownish gray; fines may have been washed away during purging. @ 85' 30% gravel 62% sand 8% silt ↓ cobble to trace; ↓ Vcp to 5%, ↓ Fp to 20%, ↓ VFP to 50%	

Reported By: Henry Lanman Geologist [Signature] 4/13/17
Print Name Title Signature Date

BOREHOLE LOG (Cont.)			Page 5 of 8
			Date: 4/24/17
Well ID:	Well Name:	Location:	
C9712	199-K-228	500' E of 105-KE	
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
100	G		@ 90' 30% gravel, 58% sand, 12% silt Gravel: ↓ VFP to 40%; ↑ Mp to 20%; ↑ cobble to 5%; max size = 160mm; higher silt content than 85'
	G		95-104' silty Sandy Gravel (mSG) @ 95' 40% gravel, 39% sand, 21% silt Gravel: 20% VFP, 15% Fp, 15% Mp, 20% Cp, 26% Vcp, 10% cobble; max = 120mm; PS; 70% Fel, 30% Maf; SA-R Sand: 25% VFs, 25% Fs, 20% Ms, 15% Cs, 15% Vcs; PS 50% Maf, 50% Fel; SA-SR
105	G		Wet, weak rxn w/ HCl; 2.5y 5/2, grayish brown; gradational contact from 93' to 95' (↑ in silt/clay).
	G		@ 100' 40% gravel, 35% sand, 25% silt Gravel and sand abundances are the same as 95', but grain size distributions
	G		@ 102' 35% gravel, 45% sand, 20% silt Gravel: 10% VFP, 10% Fp, 20% Mp, 25% Cp, 25% Vcp, 10% cobb; max = 125mm; PS; 30% Fel 70% Maf; SA-R Sand: 30% VFs, 20% Fs, 20% Ms, 20% Cs, 10% Vcs; PS; 40% Fel, 60% Maf; SA-SR
110	G		Moist, viscous rxn w/ HCl; color/grain size/angularity skewed by drilling (drill rate slowed due to hard layer)
	G		104-106' slightly Silty Gravelly Sand(m)GS @ 105' 28% gravel, 60% sand, 12% silt Gravel: 55% VFP, 30% Fp, 5% Mp, 5% Cp, 5% Vcp, trace cobb; max = 60mm; MS; 20% Fel 80% Maf; SA-SR Sand: trace VFs, 5% Fs, 5% Ms, 30% Cs, 60% Vcs; MS, 20% Fel 80% Maf; SA-SR
115	G		Wet, localized rxn w/ HCl; 2.5y 4/2, dark grayish brown; HCl rxn on fine-grained clumps; lesser amounts of caliche than 102 suggest gradational contact b/w 102 and 105; lots of basaltic fire lam drilling → skewed Maf; Fel; fragments of well rounded basalt cobbles in core.
	G		@ 106-107' Sandy Gravel @ 106' 47% gravel, 45% sand, 8% silt Gravel: 35% VFP, 30% Fp, 10% Mp, 10% Cp, 10% Vcp,
Reported By: <u>Henry Lanman</u> Geologist 4/24/17 Print Name Title Signature Date			W = water sample

BOREHOLE LOG (Cont.)			Page 6 of 8	
			Date: 5/3/17	
Well ID:	Well Name:	Location:		
C9712	199-K-228	500' E of 109-KE		
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	
120	G		<p>5% cobbles; Max = 140mm; PS, 40% Fel 60% Mat; SA-R Sand: 20% VFs, 30% Fs, 30% Ms, 10% Cs, 10% Vcs; PS; Fel: 40%, Mat: 40%; SA-R Wet, no rxn w/ HCl, 2.5y 4/2; dark grayish brown; less sorted than 105' 107-110' slightly silty gravelly sand (m) SG @107': 25% gravel, 60% sand, 15% silt Gravel: 25% VFP, 15% FP, 15% MP, 30% CP, 10% VCP, 5% cobb; PS; Fel = 60%, Mat = 40%; Max = 70mm; SA-R sand: 10% VFs, 20% Fs, 40% Ms, 20% Cs, 10% Vcs; PS; Fel = 70%, Mat = 30%; SA-SR Wet, rxn w/ HCl only in fine-grained masses; 2.5y 5/6, lt. olive brown; lighter color, more calcareous and coarser grained than 106' 110-155' sandy gravel (SG) @110': 35% gravel, 55% sand, 10% silt Gravel: 30% VFP, 10% FP, 12% MP, 15% CP, 30% VCP, 3% cobb; max s: 70-80mm; PS; Fel: 85%, Mat: 15%; SA-R sand: 25% VFs, 25% Fs, 35% Ms, 10% Cs, 5% Vcs; MS, 90% Fel, 10% Mat; SA-R Wet, no rxn to HCl; 10YR 9/3, brown; lots of mica (~10% of sand). @115': 47% gravel, 45% sand, 8% silt Gravel: 15% VFP, 15% FP, 25% MP, 20% CP, 20% VCP, 5% cobb; max = 180mm; PS; 80% Fel 20% Mat; SA-R sand: 30% VFs, 20% Fs, 25% Ms, 10% Cs, 5% Vcs; PS; 90% Fel 10% Mat; SA-SR Wet, no rxn w/ HCl; 2.5y 5/3, lt. olive brown; lots of drilling fine. @120': 25% gravel, 70% sand, 5% silt Gravel: 28% VFP, 20% FP, 20% MP, 20% CP, 10% VCP, 2% cobb; max = 80mm; PS; 85% Fel, 15% Mat; SA-R Sand: 30% VFs, 30% Fs, 25% Ms, 10% Cs, 5% Vcs; MS; 90% Fel, 10% Mat; SA-SR Wet, no rxn w/ HCl; 2.5y 6/2, lt brownish yellow. @125': 20% gravel, 70% sand, 10% silt Gravel: 40% VFP, 35% FP, 10% MP, 10% CP, 5% VCP, 2% cobb; Max = 50mm; PS; 70% Fel 30% Mat; SA-R Sand: same characteristics as 120'.</p>	<p>Cable Tool w/ drive barrel & 10 3/4" casing</p>
125	G			
130	G S			S = sample collected for lab analysis
135	G			
Reported By: <u>Henry Lannan</u> <u>Geologist</u> <u>[Signature]</u> <u>5/3/17</u> Print Name Title Signature Date				

BOREHOLE LOG (Cont.)			Page 7 of 8
			Date: 5/8/17
Well ID: C9712	Well Name: 199-K-228	Location: 500' E of 105-KE	
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
140	G		<p>2.5y 5/3 lt. olive brown. Wet, no rxn w/ HCl.</p> <p>@130': 35% gravel, 55% sand, 10% silt</p> <p>Gravel: 35% VFP, 30% Fp, 15% Mp, 10% Cp, 5% Vcp, 5% cobb;</p> <p>Max. size = 90mm; PS; 85% Fel, 15% Mat; SA-R.</p> <p>Sand: same characteristics as 120'.</p> <p>Wet, no rxn w/ HCl; 2.5y 5/3, lt. olive brown.</p> <p>@135': 22% gravel, 70% sand, 8% silt</p> <p>Gravel: 40% VFP, 18% Fp, 19% Mp, 20% Cp, 5% Vcp, 2% cobb;</p> <p>Max. size = 130mm; PS; 60% Fel 40% Mat; SA-R</p> <p>Sand: same characteristics as 120'.</p>
			<p>@140' ^{rs 5/13/17} yellow stained soil encountered</p> <p>S = sediment</p> <p>sample collected @ 140' bgs</p>
145	G		<p>Wet, no rxn w/ HCl; lt. olive brown, 2.5y 5/3</p> <p>@140': 35% gravel, 50% sand, 15% silt</p> <p>Gravel: 35% VFP, 25% Fp, 15% Mp, 15% Cp, 5% Vcp, 5% cobb;</p> <p>Max. size = 125mm; PS = 40% Fel 30% Mat; SA-R</p> <p>Sand: 30% VF, 30% F, 20% M, 10% C, 10% V; PS; 90% Fel 10% Mat</p> <p>Wet, no rxn w/ HCl; 2.5y 5/3, lt. olive brown.</p> <p>@145': 40% gravel, 45% sand, 15% silt</p> <p>Gravel: 40% VFP, 30% Fp, 10% Mp, 10% Cp, 7% Vcp, 3% cobb;</p> <p>Max. size = 120mm; PS; 95% Fel 5% Mat; SA-R</p> <p>Sand: 30% VF, 30% F, 20% M, 10% C, 10% V; PS; 90% Fel 10% Mat; SA-R</p>
			<p>W = water sample collected</p>
150	G		<p>Wet, no rxn w/ HCl; 2.5y 5/3, lt. olive brown</p> <p>@150': 40% gravel, 45% sand, 15% silt</p> <p>Gravel: 30% VFP, 20% Fp, 15% Mp, 20% Cp, 10% Vcp, 5% cobb;</p> <p>Max. size = 80mm; PS; 90% Fel 10% Mat; A-R</p> <p>Sand: 30% VF, 30% F, 25% M, 10% C, 5% V; PS; 90% Fel 10% Mat; SA-SR</p>
155	G		<p>Wet, no rxn w/ HCl; 2.5y 5/2, grayish brown</p> <p>@155' - 156':</p> <p>@155': Gravelly Sand (gS)</p> <p>@155': 13% gravel, 70% sand, 17% silt</p> <p>Gravel: 40% VFP, 30% Fp, 5% Mp, 9% Cp, 5% Vcp, 40% cobb; max. size = 120mm; Bi.M; 60% Fel 40% Mat; A-R</p> <p>Sand: 30% VF, 30% F, 25% M, 10% C, 5% V; PS; 90% Fel 10% Mat; SA-SR</p>
			<p>Wet, no rxn w/ HCl, 2.5y 5/3 lt. olive brown</p> <p>156 - 161' Slightly silty Gravelly Sand (m) gS</p> <p>@156': 13% gravel, 70% sand, 17% silt</p> <p>Gravel: 45% VFP, 30% Fp, 10% Mp, 5% Cp, 5% Vcp, 5% cobb</p>

Reported By:

Henry Lanman

Print Name

Geologist

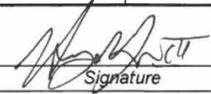
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Signature

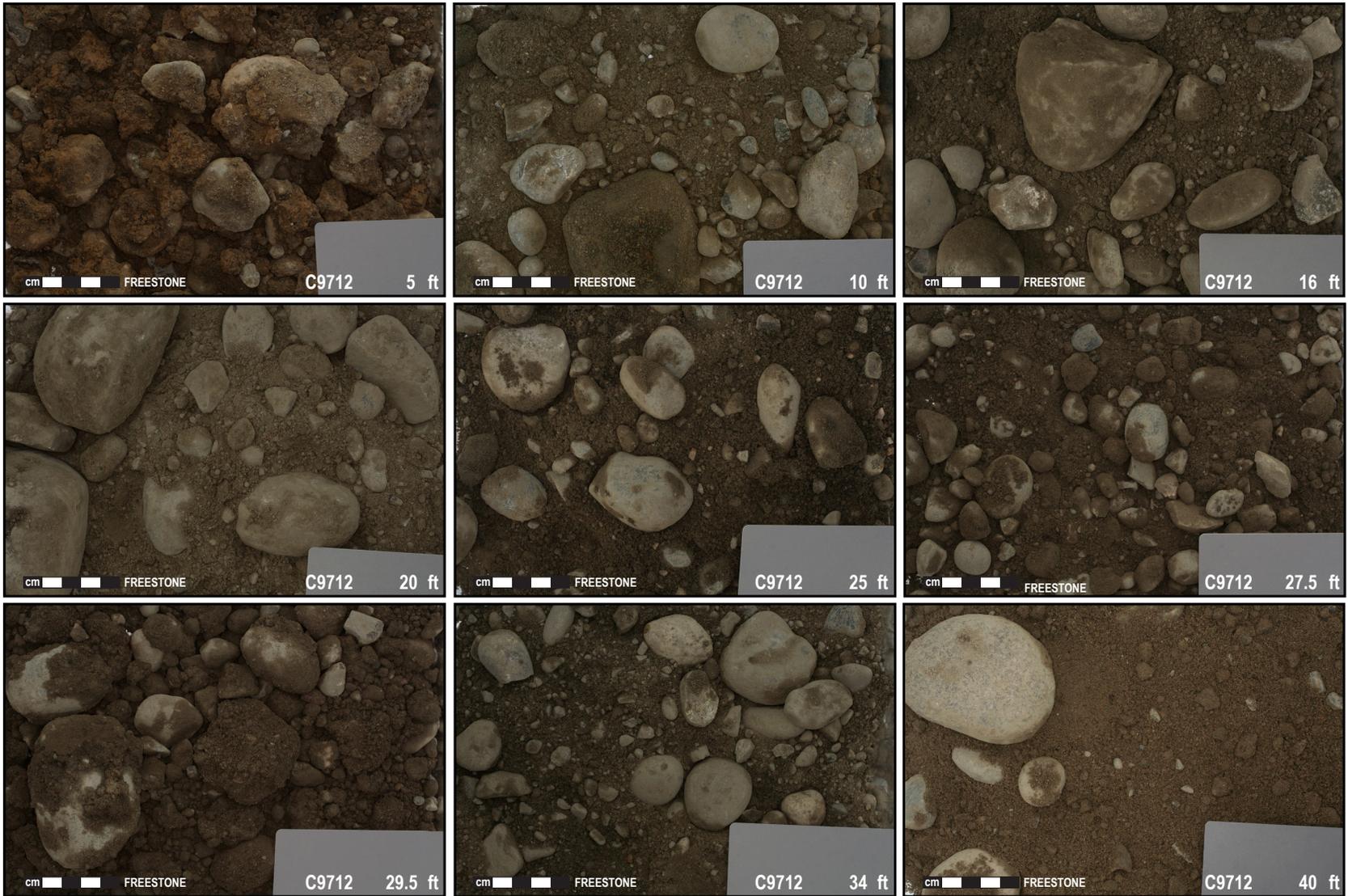
5/11/17

Date

BOREHOLE LOG (Cont.)			Page <u>8</u> of <u>8</u>	
Well ID: <u>C9717</u>		Well Name: <u>199-K-228</u>	Date: <u>5/8/17</u>	
Location: <u>500' E of 105-KE</u>				
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
160	G G G		max size = 110mm; PS; 75% Fel 25% Mat; SA-SR sand: 30% VF, 25% FS, 25% MS, 15% CS, 15% VCS; 70% Fel 30% Mat - PS; SA-SR Wet, no rxn w/ HCl, 25y 5/4, lt. olive brown; clay/silt clots w/ lots of sand	Cable tool, 10 3/4" o.d./9 3/4" i.d. steel casing. 162.3-167.2' Hard tool
165			161-161.5' silty sandy gravel (m SG) @ 161': 30% gravel, 55% sand, 15% silt Gravel: 27% VFP, 25% FP, 20% MP, 20% CP, 5% NP, 3% lobb; max size = lobb; PS; 60% Fel 40% Mat; SA-H Sand: 25% VF, 20% FS, 35% MS, 10% LS, 10% VLS; PS; Fel = 80%; Mat = 20%; SA-SR Wet, no rxn w/ HCl, 25y 4/2, dk gray with brown	@ 161.5': RUM upper contact; abrupt/sharp. silt and clay @ 161.5': v. well-consolidated; high plasticity; sand and gravel fractions vary throughout sample; mica in nodules react vigorously w/ 10% HCl. Gravel: 60% cobb, 30% M peb, 10% F-VE peb; med. sorted; 45% mat, 65% Fel; ang, sub-ang, sub-round, round
170			@ 161.5': 80% silt, 5% sand, 9% gravel, 2.5y 5/4, light olive brown. Sand: 5% VL, 10% C, 75% M, 10% F-VE; well-sorted; 75% mat, 75% Fel; ang, sub-ang, sub-round; wet (sample exterior); CaCO3 nodules react vigorously w/ 10% HCl. Gravel: 60% cobb, 30% M peb, 10% F-VE peb; med. sorted; 45% mat, 65% Fel; ang, sub-ang, sub-round, round	@ 162': 100% silt and clay; high plasticity; v. well-consolidated, slightly less indurated than at 161.5'. Impermeable.
			Total Depth = 72.78 (5/9/17) Depth to water = \uparrow Total Depth = 167.2' bgs (5/11/17)	
175				

Reported By: Amy Lanman Geologist  5/11/17
 Print Name Title Signature Date

B-11

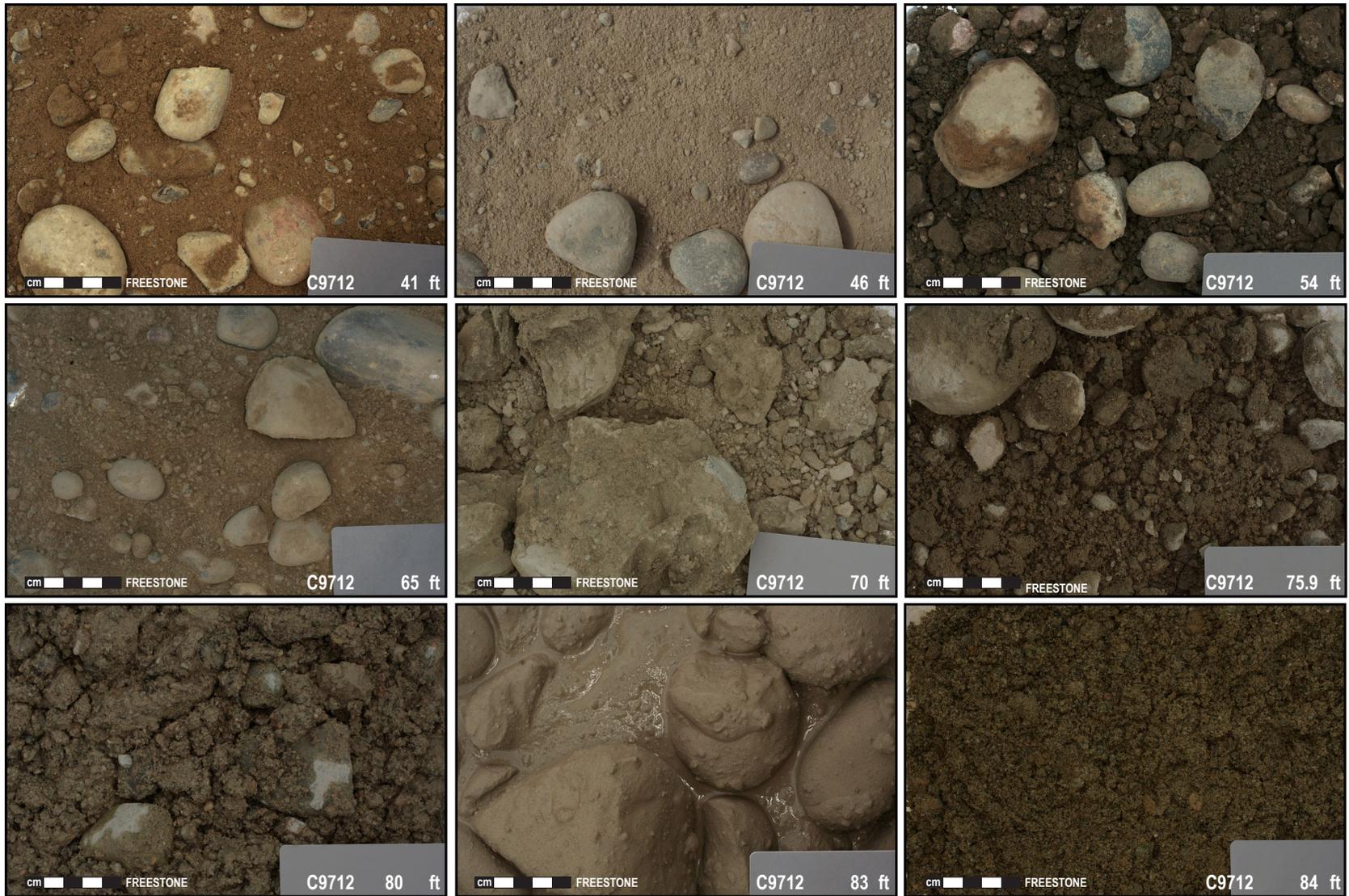


SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9712 (199-K-228)

B-12



SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9712 (199-K-228)

B-13



SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9712 (199-K-228)

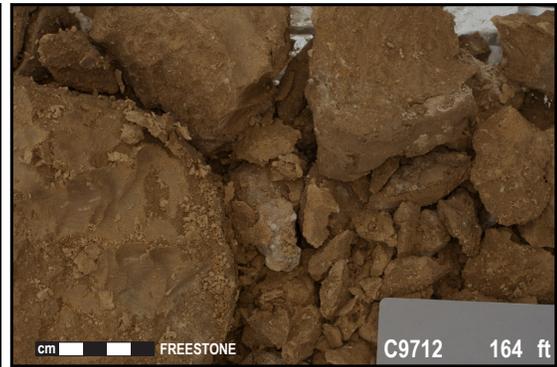
B-14



SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9712 (199-K-228)



B-15

SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9712 (199-K-228)

WELL DEVELOPMENT AND TESTING DATA								
Well ID: C9712			Well Name: 199-K-228			Date: 07/20/2017		
Location: 500 ft E of 105-KE								
Reference Measuring Point (unless otherwise noted): TOP OF OUTER CASING (TOC)								
Has the well been surveyed? <input type="radio"/> Yes <input checked="" type="radio"/> No			Does the well have a cement pad? <input type="radio"/> Yes <input checked="" type="radio"/> No					
Initial Conditions			<p style="margin-left: 20px;">A = <u>N/A</u> B = <u>N/A</u> C = <u>N/A</u></p> <p style="margin-left: 20px;">NO monument/ pad during development</p>					
Start of Job		End of Job						
STATIC WATER LEVEL:								
Date: 7/20/17	71.6' bgs	NA						
Date: 7/25/17	NA	70.0' bgs						
DEPTH TO BOTTOM:								
Date: 7/20/17	165.9' bgs	NA						
Date: 7/25/17	NA	165.3' bgs						
Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbidity (NTU)		Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
			Initial	Final				
157.75	11	83.0	18.5	2.28	*	*	260	22.9
126.8	13	51.71	5.39	1.72	*	*	270	20.7
105.75	14	30.54	4.57	2.87	*	*	270	19.6
94.75	27	19.00	11.1	4.02	*	*	110	4.0
Total Pumped: 46,000 gal								
Pump Model: 25hp Preferred Pump S/N: 82130346; Model: 6FP225 D250-9								
Troll Serial Number and Pressure Range (PSI and depth): S/N: 403065, 70m/231ft								
Comments: *Due to frequent pump starts and stops, total pump times and purge volumes provided below: Int.#1: 76 minutes, 19,000 gal Int.#2: 37 minutes, 10,000 gal Int.#3: 32 minutes, 8,700 gal Int.#4: 75 minutes, 7,900 gal								
Prepared By: Henry Lanman <i>signed on behalf of H. Lanman</i> <div style="display: flex; justify-content: space-between; align-items: flex-end;"> <div style="text-align: center;"> Signature </div> <div style="text-align: center;"> Date 08/14/2017 -K. Schuyler 8/31/17 </div> </div>								
Reviewed By: Kelly Whitley <i>Kelly Whitley</i> <div style="display: flex; justify-content: space-between; align-items: flex-end;"> <div style="text-align: center;"> Signature </div> <div style="text-align: center;"> Date 9/5/17 </div> </div>								
For Office Use Only								
OR Doc Type:			WMU Code(s):					



199-K-228 (C9712) Log Data Report

Borehole Information

Log Date	2017-05-16	Filename	C9712_HG-NM_2017-05-16	Site	100-KR-4
DTW¹ (ft)		DTW Date		DTW Source	
76.5		05/15/2017		SN3	
				Drill Date	
				05/11/17	
				Total Depth (ft)	
				167.2	
				Depth Datum	
					Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.)		Thickness (in.)	Top (ft)	Bottom (ft)
			Outer	Inside			
Threaded Steel	Cable Tool	1.0	10 3/4	9 3/8	9/16	-1.0	167.0

Borehole Notes

The logging engineer measured casing thickness. Drill depth and casing depth were provided by the wellsite geologist. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 1 ALd	Type	60% HPGe SGLS ²
Effective Calibration Date	01/26/17	Serial No.	47-TP-32211A
Calibration Reference	HGLP-CC-150, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0

Logging System	Gamma 1 AHd	Type	NMLS ³ He-3
Effective Calibration Date	02/23/17	Serial No.	H310700352
Calibration Reference	HGLP-CC-151, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0

SGLS Log Run Information

Log Run	3	4		
HEIS Number	1019888	1019889		
Date	05/16/17	05/16/17		
Logging Engineer	Spatz	Spatz		
Start Depth (ft)	0.0	148.0		
Finish Depth (ft)	167.0	165.0		
Count Time (sec)	100	100		
Live/Real	R	R		
Shield (Y/N)	N	N		
MSA Interval (ft)	1.0	1.0		
Log Speed (ft/min)	N/A	N/A		
Pre-Verification	C9712ALD2017 0516AV00CAB 1	C9712ALD2017 0516AV00CAB 1		

¹ depth to water inside casing

² Spectral Gamma Logging System

³ Neutron Moisture Logging System



199-K-228 (C9712) Log Data Report

Borehole Information

Log Date	2017-05-16	Filename	C9712_HG-NM_2017-05-16	Site	100-KR-4
DTW¹ (ft)		DTW Date		DTW Source	
76.5		05/15/2017		SN3	
				Drill Date	
				05/11/17	
				Total Depth (ft)	
				167.2	
				Depth Datum	
					Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.)		Thickness (in.)	Top (ft)	Bottom (ft)
			Outer	Inside			
Threaded Steel	Cable Tool	1.0	10 3/4	9 3/8	9/16	-1.0	167.0

Borehole Notes

The logging engineer measured casing thickness. Drill depth and casing depth were provided by the wellsite geologist. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 1 ALd	Type	60% HPGe SGLS ²
Effective Calibration Date	01/26/17	Serial No.	47-TP-32211A
Calibration Reference	HGLP-CC-150, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0

Logging System	Gamma 1 AHd	Type	NMLS ³ He-3
Effective Calibration Date	02/23/17	Serial No.	H310700352
Calibration Reference	HGLP-CC-151, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0

SGLS Log Run Information

Log Run	3	4		
HEIS Number	1019888	1019889		
Date	05/16/17	05/16/17		
Logging Engineer	Spatz	Spatz		
Start Depth (ft)	0.0	148.0		
Finish Depth (ft)	167.0	165.0		
Count Time (sec)	100	100		
Live/Real	R	R		
Shield (Y/N)	N	N		
MSA Interval (ft)	1.0	1.0		
Log Speed (ft/min)	N/A	N/A		
Pre-Verification	C9712ALD2017 0516AV00CAB 1	C9712ALD2017 0516AV00CAB 1		

¹ depth to water inside casing

² Spectral Gamma Logging System

³ Neutron Moisture Logging System



Stoller Newport News Nuclear

Log Run	3	4			
Start File	AD000000	BD014800			
Finish File	AD016700	BD016500			
Post-Verification	C9712ALD2017 0516BV00CAA 1	C9712ALD2017 0516BV00CAA 1			
Depth Return Error (in.)	N/A	0.5 high			
Comments	No fine gain adjustments made	No fine gain adjustments made			

NMLS Log Run Information

Log Run	1	2 Repeat			
HEIS Number	1019890	1019891			
Date	05/15/17	05/15/17			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	68.0			
Finish Depth (ft)	76.5	76.0			
Count Time (sec)	15	15			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.25	0.25			
Log Speed (ft/min)	N/A	N/A			
Pre-Verification	C9712AHD2017 0515AV00CAB 1	C9712AHD2017 0515AV00CAB 1			
Start File	AD000000	BD006800			
Finish File	AD007650	BD007600			
Post-Verification	C9712AHD2017 0515BV00CAA 1	C9712AHD2017 0515BV00CAA 1			
Depth Return Error (in.)	N/A	0.5 high			
Comments	None	None			

Logging Operation Notes

A centralizer was installed on the SGLS and NMLS sondes.

Pre- and post-survey verification measurements met the acceptance criteria for the established systems.

Analysis Notes

Analyst	P.D. Henwood	Date	06/07/17
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated in an EXCEL template identified as ALD20170126_CC-150 for the SGLS, using an efficiency function and corrections for casing and dead time as determined during annual response checks.



The HGU⁴ 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 Model 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).

A water correction was applied below 76.5 ft.

Results and Interpretations

No manmade radionuclides were detected.

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

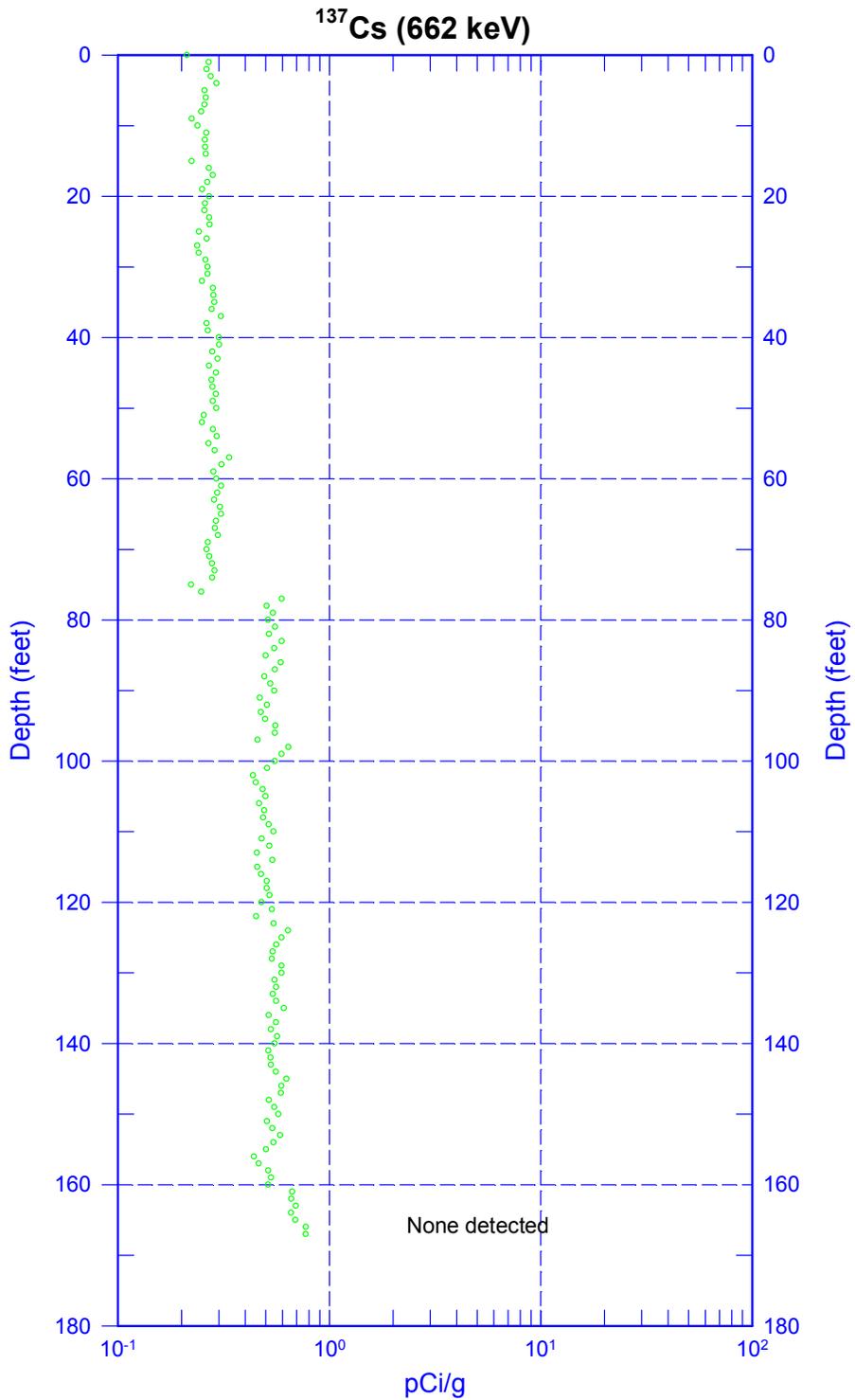
Depth Reference is ground surface.

Manmade Radionuclides (0-180 ft)
Natural Gamma Logs (0-180 ft)
Combination Plot (0-180 ft)
Total Gamma & Moisture (0-180 ft)
Total Gamma & Hanford Gamma Unit (0-180 ft)
Repeat Section of Natural Gamma Logs (148-165 ft)
Moisture Repeat Section (68-76 ft)

⁴ Hanford Gamma Unit



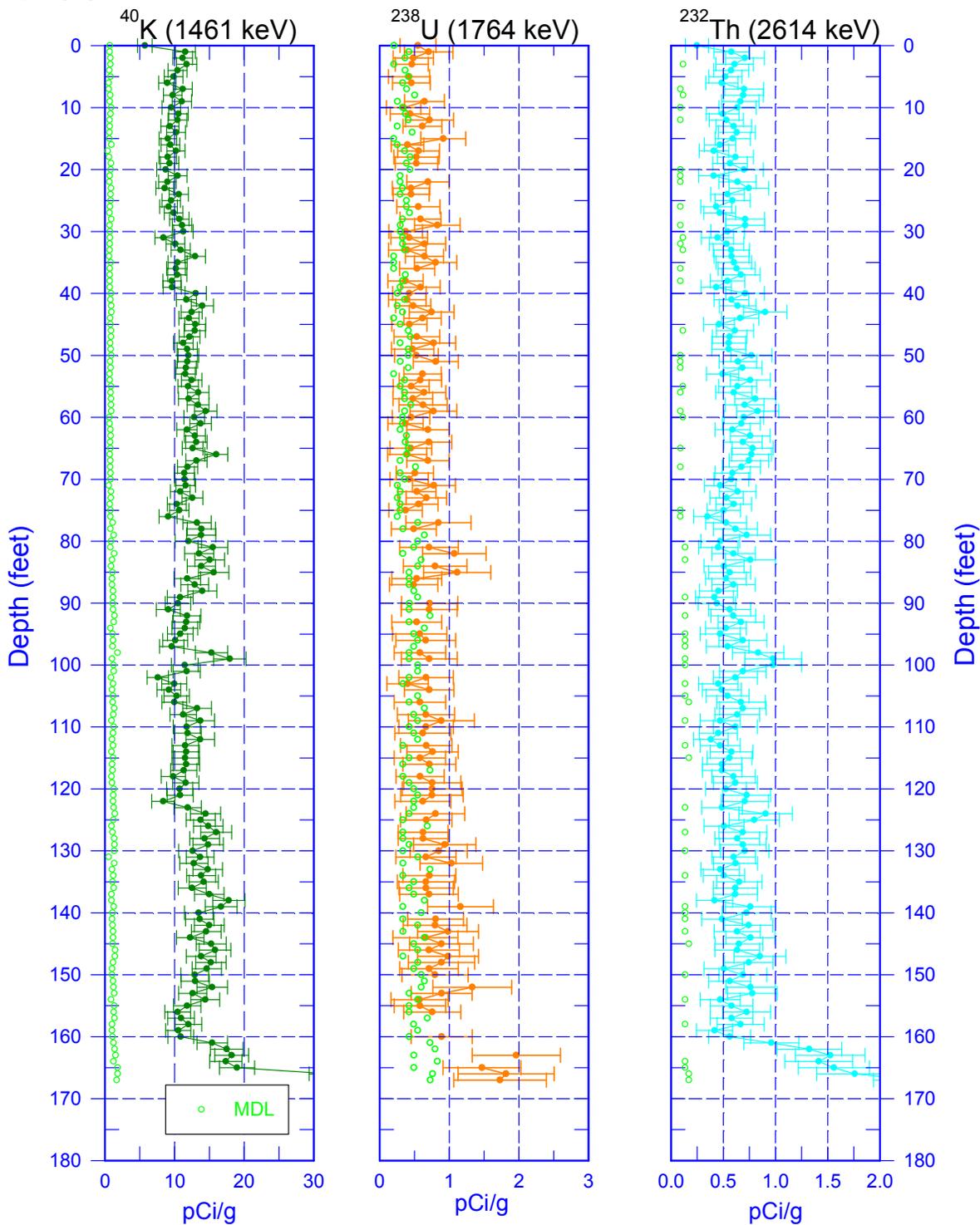
199-K-228 (C9712) Manmade Radionuclides



Zero Reference - Ground Surface

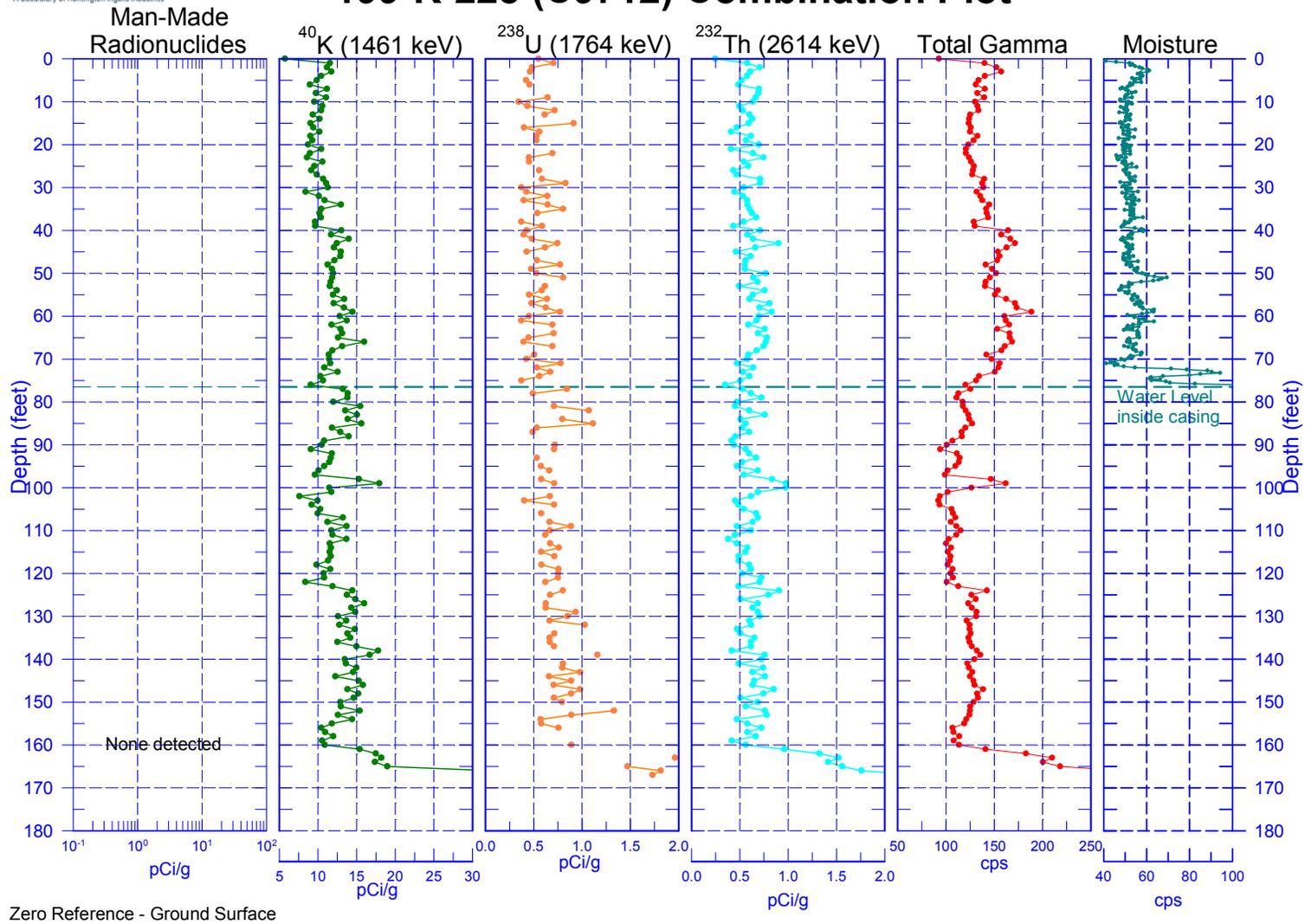


199-K-228 (C9712) Natural Gamma Logs



Zero Reference - Ground Surface

199-K-228 (C9712) Combination Plot

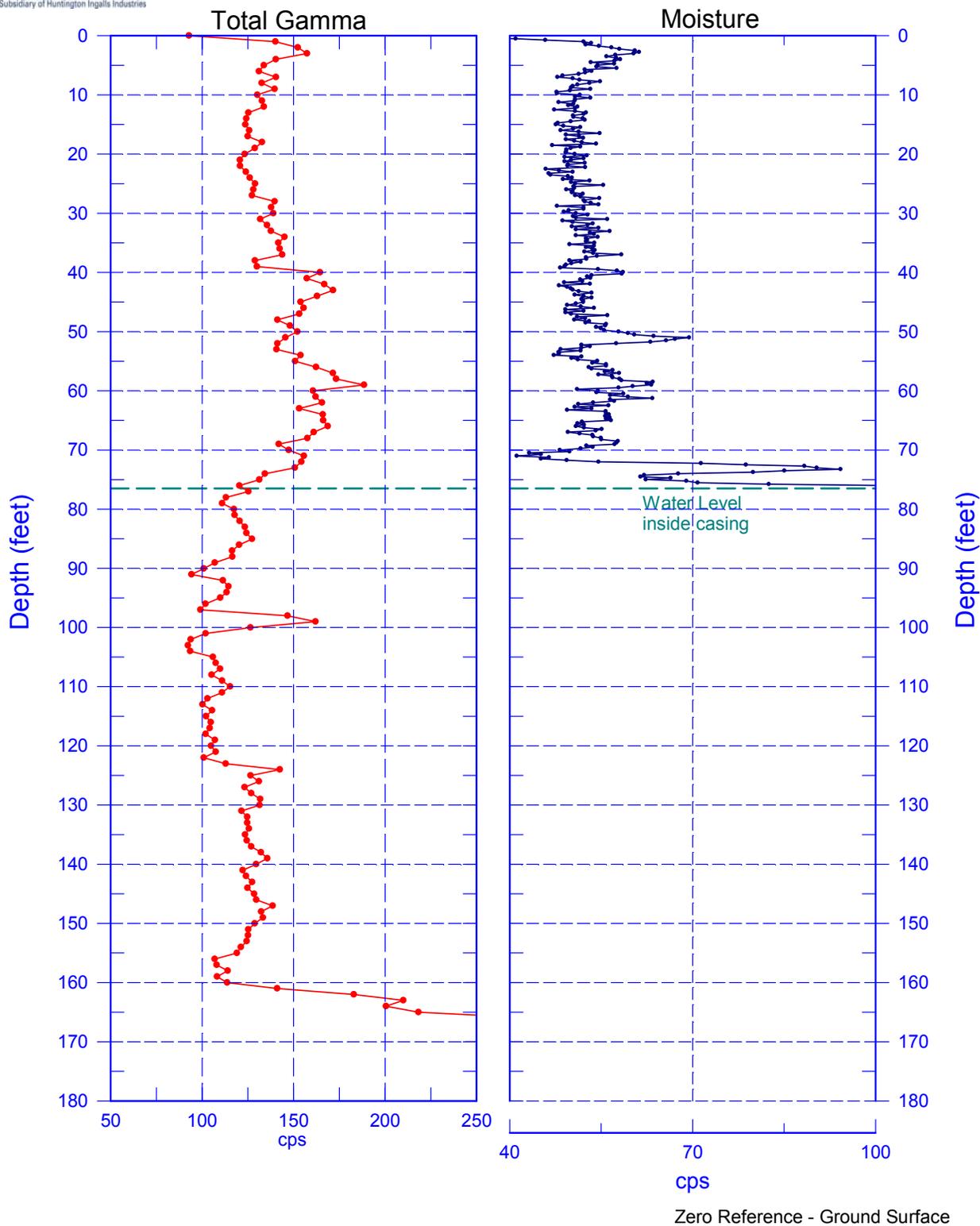


B-23

SGW-61094, REV. 0

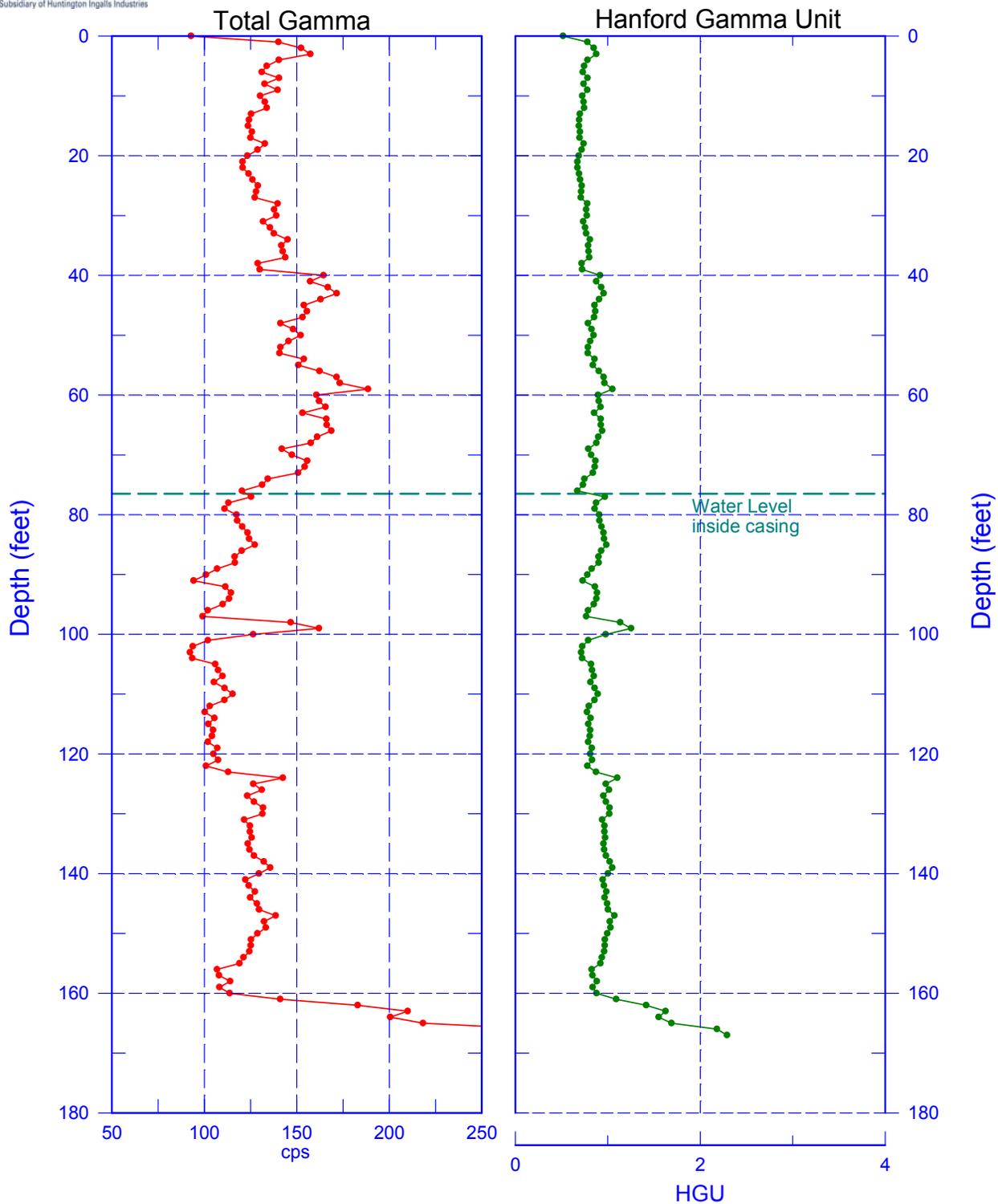


199-K-228 (C9712) Total Gamma & Moisture





199-K-228 (C9712) Total Gamma & Hanford Gamma Unit

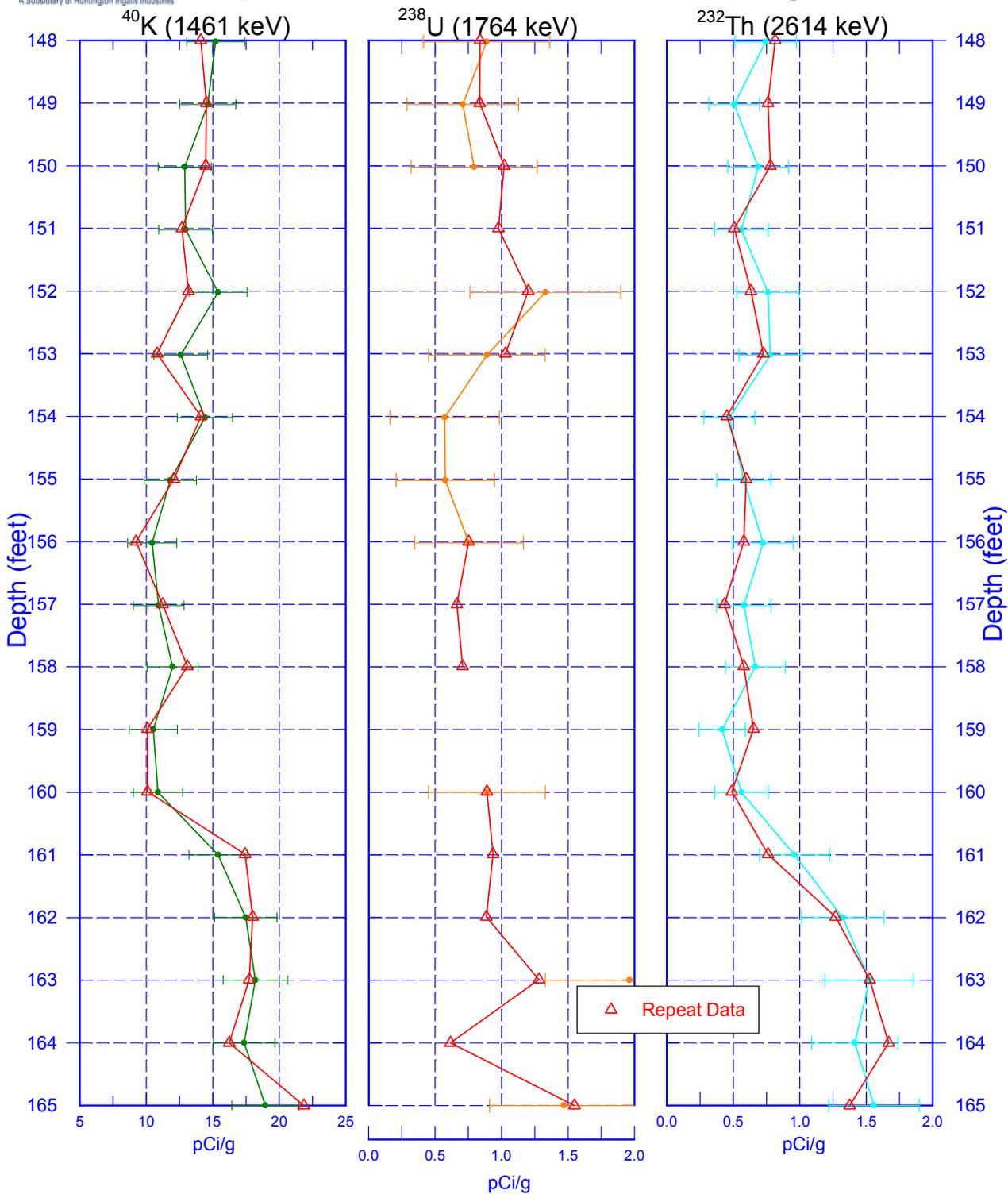


Zero Reference - Ground Surface



199-K-228 (C9712)

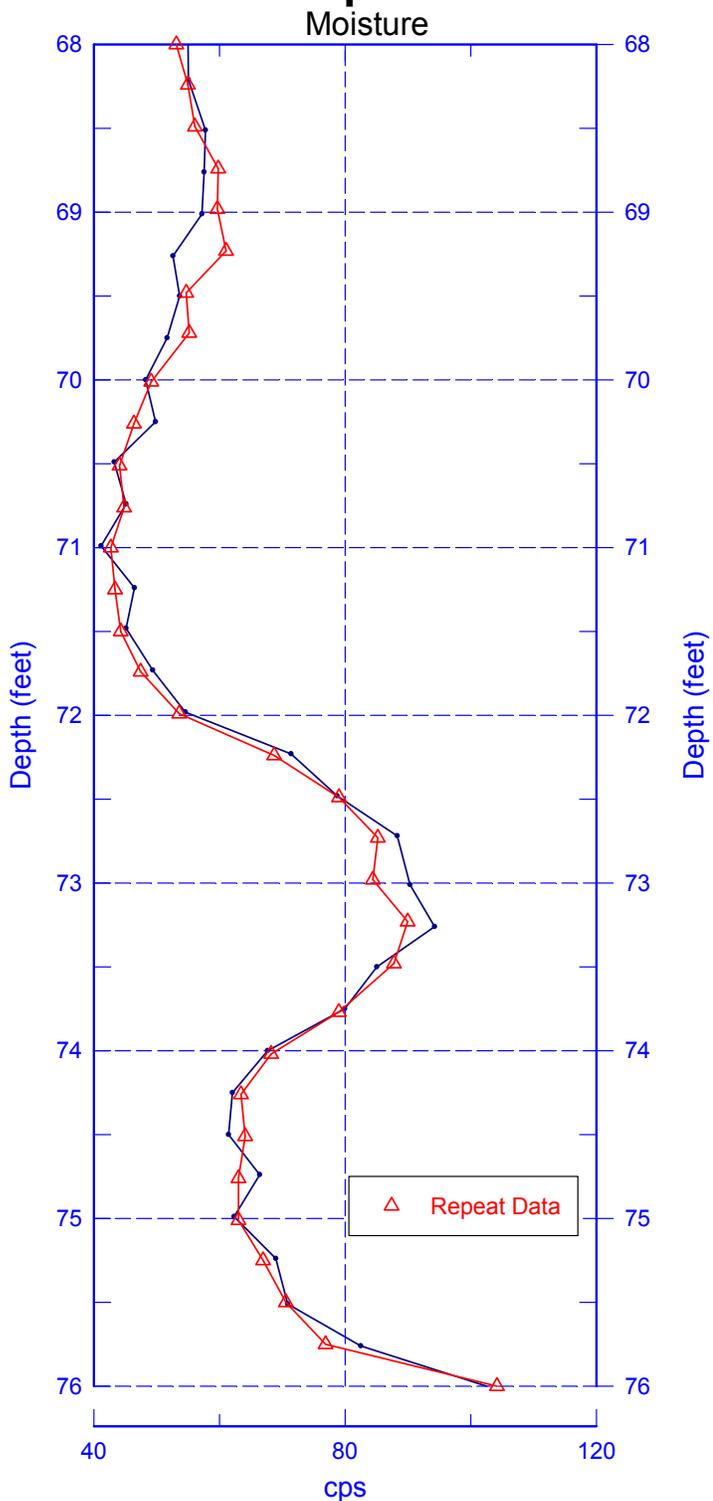
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



199-K-228 (C9712) Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

Project:	Prepared By: Neil P. Fastabend
	Company: CHPRC
Date Requested: 08/16/17	Requestor: Steven E. Imhoff (CHPRC)
Date of Survey: 09/12/17	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9712 (199-K-228) located in 100K Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 100K

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
M49 (COE) and T324 (COE)

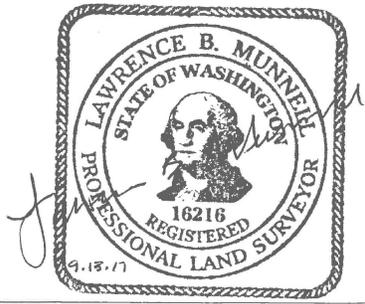
Well ID	Well Name	Easting	Northing	Elevation	
C9712	199-K-228	569393.12	146775.64		Center of Casing
				144.142	Top Outer Casing, N.Edge, Stamped X
				143.843	Top Inner 6"SS Casing, N.Edge
				143.347	Brass Survey Marker

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.



Appendix C

Well Documentation for C9713 (199-K-229)

Contents

Well Summary Sheet	C-1
Borehole Log	C-4
Drill Cutting Photographs	C-9
Well Development and Testing Data	C-14
Log Data Report	C-15
Well Survey Data Report	C-27

WELL SUMMARY SHEET			Page 1 of 1	
Well ID : C9713		Well Name: 199-K-229		Start Date: 5/3/2017
Project: Four 100-KR-4 OU Monitoring Wells		Location: 50m S of 100-KW Transformer Yard Fence		Finish Date: 8/30/2017
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
Concrete Pad: 0.50 ft above ground surface (ags) 8.64-in. Protective Casing: 3.00 ft ags - 2.00 ft below ground surface (bgs) Type I/II Portland Cement Grout: 0.0 - 10.65 ft bgs 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.95 ft ags - 75.08 ft bgs 8-20 mesh Bentonite Crumbles: 10.65 - 68.20 ft bgs Stainless steel centralizer installed above and below screen and every 40 ft 3/8-in. Coated Bentonite Pellet Seal: 68.20 - 72.20 ft bgs			0 5.0 - 5.0 Crushed Gravel Drill Pad 5.0 - 31.5 Sandy Gravel (sG) 10 20 30 31.5 - 35.0 Silt (M) 35.0 - 40.0 Sand (S) 40 40.0 - 110.0 Sandy Gravel (sG) 50 60	0-5.0 Crushed Gravel Drill Pad 5.0-31.5 Sandy Gravel (sG) 31.5-35.0 Silt (M) 35.0-40.0 Sand (S) 40.0-110.0 Sandy Gravel (sG)
Reported By: <u>Kim Schuyler</u> Geologist <u>Kim Schuyler</u> 10-2-2017 <i>Print Name</i> <i>Title</i> <i>Signature</i> <i>Date</i>				
Reviewed By: <u>Kelly Whitley</u> Well Coordinator <u>Kelly Whitley</u> 10/9/17 <i>Print Name</i> <i>Title</i> <i>Signature</i> <i>Date</i>				
For Office Use Only				
OR Doc Type:		WMU Code(s):		

WELL SUMMARY CONTINUATION SHEET		Page 2 of 3		
Well ID: C9713	Well Name: 199-K-229	Project: Four 100-KR-4 OU Monitoring Wells		
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
3/8-in. Coated Bentonite Pellet Seal: 68.20 - 72.20 ft bgs		70		40.0 - 110.0 Sandy Gravel (sG)
6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.95 ft ags - 75.08 ft bgs		80		Static Water Level: 81.35 ft bgs (9/28/2017)
8-16 mesh Premier Colorado Silica Filter Pack Sand: 72.20 - 191.34 ft bgs		90		
6-in. I.D. Schedule 10, Corrugated Stainless Steel Patch: 103.3 - 106.3 ft bgs		100		
Screen Separated by approximately 0.25 ft at 105.9 ft bgs		110		110.0 - 115.0 Gravel (G)
6-in. I.D. Schedule 10, Type 304/304L, 50-slot (0.050 in.) Stainless Steel Screen: 75.08 - 185.39 ft bgs		120		115.0 - 180.0 Sandy Gravel (sG)
		130		
		140		
		150		
		160		

BOREHOLE LOG				Page 1 of 5
Well ID:	Well Name:	Location:	Date: 05/03 → 5/4/2017	
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
0			0'-18' PIT RUN GRAVEL BACKFILL	CABLE TOOL DRILL W/ DRIVE BARREL 1 3/4" OD THREADED CASING
5	G		@ 5' 6" SG SANDY GRAVEL 60% G 37% S 3% M	G - GOOD SAMPLES @ 5' INTERVALS ARCHIVED PINT JAR CHIP TRAY, PHOTOS
10	G		G - 2MM - 85mm VFP - COG, MOD SORTING RND, 80% MAF/20% FEL. S - VFS TO VCS MS & CS DOMINANT, WELL SORTED, SR - ANG 40% FEZ/60% MAF, 10YR 7/1 LT GRAY MOIST, NO HCl RXN	COMPOSITE SIEVE SAMPLES WHERE REQUIRED @ 18' CONSTRUCTION BACKFILL AGAINST SIDE WALL OF WATER TANK EXCAVATION LOC @ 30' TO WEST OF BH.
15	G		@ 18' @ CONTACT WITH NATIVE SOIL INDISTINCT - MAY BE < 2' DEEPER	
20	G		18' TO 32' 31.5' SG SANDY GRAVEL @ 20' SG SANDY GRAVEL 65% G 32% S 3% M. G 2MM - 140mm VFP - COG COBBLE FRACTION 75% OF GRAVEL, POORLY SORTED, RND - SR, 80% MAF/20% FEL / BASALT 80% OF MAF. S - VFS TO VCS	
25	G		MS & CS DOM. WELL SORTED SA, 10% FEZ/ 90% MAF/BASALT DOMINANT, 5YR 3/1 DK GRAY, MOIST, NO HCl RXN @ 24' 2 x 180 mm LONG BOULDERS & MUCH ROCK FLOUR IN CUTTINGS	
30	G		@ 30' G ↓ S ↑, G NOW 40% S = 56% G MAX 60 mm BASALT DOMINANT Silt (M)	
			@ 31.5' DISTINCT EROSIONAL CONTACT LACUSTRINE SEDIMENTARY SEQUENCE BELOW	
			@ 32-34M - CLAY & SILT 100% M	
Reported By: <u>GREG KASZA</u> Geologist <u>Kim Schugler</u> 8/30/17 Print Name Title Signed on behalf of G. Kasza Signature Date Reviewed By: <u>Sarah Springer</u> geologist <u>Sarah Springer</u> 08-05-17 Print Name Title Signature Date				
For Office Use Only				
OR Doc Type:		WMU Code(s):		

West transformer yard

BOREHOLE LOG (Cont.)				Page 2 of 5
				Date: 5/4/2017
Well ID: C9713		Well Name: 199-K-229		Location: 106-KRH-04 15 83119 50m S of 100-K West Transformer yard
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		10 YR 5/3, BROWN, Moist, ST/HCl/Rxn MODERATELY PLASTIC, LAMINATED - 1/8" - 1/2"	CABLE TOOL DRILL BY DRIVE BARREL
			@ 33' INCREASING MICA GRADINGS TO: @ 34' S (SAND) S 98%, M 2%	G-GRAD SAMPLE AT 5' INTERVALS FOR ARCHIVE PHOTO JAN,
40	G		S- 80% MS, 18% VFs & Fs, 10 YR 5/4 YELLOWISH BRN, Moist, WELL SORTED, A-SA	CHIP TRAY & PHOTOS 80% F/20% MAF. TR Fe OX STAIN TR MICA, NO RXN W/HCl
			@ 38' 20% G PRESENT VFP -> Cp	
			40'-110' SG SANDY GRAVEL	
			@ 40' SG SANDY GRAVEL 40% G 58%	
45	G		S, 2% M. G-2mm-6.5mm VFP-COB	
			COB = 50% OF G, POOR SORTED, RND-SRD	
			50% MAF/50% FEL - S-VFs-Vcs, Ms+C _s	
			DOM. WELL SORTED, 80% FEL/50% MAF - BASALT	
			DOMINANT. 10 YR 5/4 YELLOWISH BRN. Moist	
50	G		NO HCl/Rxn, SAT TR MICA	
			@ 45 70% G, 28% S, 2% M	
			↑ MICA, TR Fe OX STAIN	
			@ 48' 2x 200mm QZITE COBBLES	
			@ 55' 3x 120mm x 80mm x 60mm	
55	G		GRANITIC COBBLES	
			@ 60' SG SANDY GRAVEL (60% G)	
			33% S 7% M G-2mm-80mm VFP-COB	
			COB = 20% OF G. POOR SORT, RND-SRND	
			70% FEL/30% MAF - 15% BASALTS. S-VFs-C _s	
			Ms & C _s DOMINANT SIZES WELL SORTED, A-SH	
65	G		70% FEL/30% MAF, DRY, NO HCl/Rxn	
			NO MICA, ↑ TR Fe OX STAIN.	
			@ 61 160mm COBBLE	
			@ 65' NOW 70% G, - 30% COB	
			TO 120mm, 25% S 5% M, TR MICA	
70	G		Moist	
			@ 70' DRY.	

Reported By: GREG KASZA Geologist Kim Schuyler signed on behalf of G. KASZA
 Print Name Title Signature Date 8/30/17
 -Kim Schuyler

BOREHOLE LOG (Cont.)				Page 3 of 5
				Date: 5/15/17
Well ID:	Well Name:	Location: ^{KS #13117} 100-K-229 50m S of 100-K West Transformer yard		
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' SG (SANDY GRAVEL) 70% G, 26% S, 4% M, G - 2MM-100MM VFP - Cob Cob = 25%, CP + VCP = 30% of G, Poor Sort RND - SRND, 75% FEL / 25% MAF. S = VF ₂ -Cs Ms + Fs Dom, Well Sorted, A to SA, 75% FEL / 25% MAF, Moist, No HCl rxn, TR Fe Ox Tr + Mica 7.5YR 6/4 Lt. Brown	CABLE TOOL DRILL W/ DRIVE BARREL SAND PUMP USED WHERE NEEDED G - GRAB SAMPLES SC COMPOSITE SIEVE SAMPLE 4 @ 5' INTERVALS SS SPLIT SPOON SAMPLE GW GROUND WATER WATER TABLE 5/15/17 78.67' BGS
80	G, SC ₁		@ 78.67 WATER TABLE (5/15/17) @ 80' MAX G = 140 mm, mica ↓	
85	G, SC ₂			I-002 SS 79.4-81.9 89' SAND PUMP X 3
90	G, SC ₁		@ 88' BASALT BOUNDER - 200 x 140 x 100 mm @ 90' & 95' MN GRAVELS - FELSICS 20% / MAFICS 70%. BASALTS DOMINATE IN CP & VCP, * MICA ABUNDANT	* FELSICS DOMINATE INS.
95	G, SC ₁		@ 92' 180 x 180 x 80 mm @ 93.5' 220 x 140 x 100 mm	
97	G, SC ₁		@ 97' SAND PUMP →	SC ₁ COMPOSITE 80', 85', 90' & 95' 97' SPX 2
100	G, SC ₂		@ 100' SG (SANDY GRAVEL) G - 75% S - 23% M - 2% 2MM - 120MM VFP - Cob Cob = 30%, CP + VCP = 25%, Poor Sort R - SR, 70% FEL / 30% MAF. S = VF ₂ -Cs Ms + Fs Dom, Well Sorted, A to SA 85% FEL / 15% MAF, WET, 7.5YR 5/2 Brown, No HCl rxn, TR MICA, TR Fe Ox STAIN	SC ₂ COMPOSITE 100', 105', 110' & 115' SPX 4 @ 102'
105	G, SC ₂			8-in basalt boulder @ 109'
110	G		110" H ₅ G (Gravel) 85% gravel, 10% sand, 5% silt/clay, Gravel 35% VFP-MP, 40% CP-VCP, 20% SC-LC, 5% Boulder 50% basalt 50% granitic/other SA-SR, Sand 50% VES-FS, 30% MS-CS, 20% VES, SA-SR, 80% felsic 20% mafic, calcic cement noted reacts strongly wet 10YR 4/2 dark grayish brown	Tight! Fe-oxide nodules noted in matrix to HCl, clay in matrix. signed on behalf of G. Kasza
Reported By:				
Cecilia Kasza		Geologist		
Print Name		Title		
		Kim Schuyler		8/30/17
		Signature		Date

BOREHOLE LOG (Cont.)			Page 4 of 5	
			Date: 6/22/17	
Well ID:	Well Name:	Location:		
19713	19A-K-229	50m S of 100-K West Transformer Yard		
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		115 - 180 sandy gravel (sG) @ 111 - 115' basalt boulder @ 115' Hard Tool slurry, sandy gravel (sG) 25% G, 70% S, 5% silt Gravel: 2-6.0mm VFp - VP, VFp + Fp = 80%, Mp + VP = 20%, mod sorting, ANG - SAND, 25% Fel/75% Mat - 90% basalt Sand: VFs - VCs, Cs + VCs avg, mod sort, SANG - SAND 20% Fel/80% Mat (basalt) Wet, 2.5y 4/3 Olive brown, weak HCl rxn	
120	G		@ 114' 116 x 120 x 100 mm, 140 x 110 x 45mm SANG basalt cob.	
125	G		@ 120 - 140' sandy gravel (sG) 30% G, 67% S, 3% silt Gravel: 2-90mm, VFp - COB, VFp - Mp = 80%, Cp - COB = 20%, mod sorting, SANG - SAND, 70% Fel/30% Mat. Sand: VFs - VCs, VFs + Fs avg, mod sorting SANG - SAND, 80% Fel/20% Mat, wet, 2.5y 3/2 very dark grayish brown, no HCl rxn	
130	G		@ 132.5' 130 x 100 x 50mm RND granite + 135 x 110 x 75 mm RND Quartzite COB	
135	G		@ 135' - 140' sandy gravel (sG) 35% G, 62% S, 3% silt Gravel: 2mm - 90mm VFp - COB, VFp - Mp = 85% Cp - COB = 15%, mod sorting, SAND - RND, 45% Fel/55% Mat. Sand: VFs - VCs, VFs + Fs = 95%, Cs + VCs = 15% SANG - SAND, 80% Fel/20% Mat, wet, 2.5y 4/2 dark grayish brown, weak HCl rxn, Tr mica, Tr FeOx	
140	G		@ 145' Sandy gravel (sG) 45% G, 54% S, 2% silt Gravel: 2-80mm, Fp - COB, Fp - Cp = 15%, VP - Cob = 85% mod - poorly sort, RND, 45% Fel/55% Mat Sand: VFs - VCs, VFs + Fs = 60%, Ms = 30%, 95% Fel/5% Mat, moist, weak HCl rxn, 2.5y 6/3 pale brown, m' Tr mica	
145	G		@ 150' sandy gravel (sG) 60% G, 38% S, 2% silt Gravel: 2-110mm, VFp - Cob, well graded, poor sort, SANG - SAND 50/50 Fel/Mat Sand: VFs - VCs, VFs + Fs = 60%, Ms = 30%, mod sort, SANG - SAND, 70% Fel/30% Mat, moist, 2.5y 4/3 brown, weak HCl rxn, Tr mica.	
150	G			
Reported By: Caleb Grant Print Name			Geologist Title	
			Signature Date: 6/22/17	

BOREHOLE LOG (Cont.)			Page 5 of 5		
Well ID: C9713			Date: 6/8/17		
Well Name: 100-K-229			Location: 50m S of 100-K West Transformer yard		
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 ₁		115 - 180 sandy gravel (sG ₁) @ 154' 40% G ₁ , 60% S, Gravel: VF _p -Cb ₁ VF _p -Mp = 50%, C ₁ -Cb ₁ = 80%, 2-140mm, poorly sorted, ANG-RND Sand: VF _s -VC _s , Fs+Ms avg (40%) ANG-S ₂ W ₂ , 70% Fel/30% Mat, moist, 2.5y 5/2 grayish brown, no HCl rxn, Tr mica	Cable Tool drill rig w/drive barrel. Sand pump used when needed. C ₁ : Carob sample SS: Spiltzaw sample GW: Groundwater sample @ 160.5 ~20 small cbs SRND-RND granitic/basaltic	
160	G ₁		@ 160-165' sandy gravel (sG ₁) @ 160-165' 30% G ₁ , 68% S, 2% silt. Gravel: VF _p -Cb ₁ , VF _p =10%, F _p -C _p =75%, VC _p -Cb _p =15%, mod. poor sort, SANG-RND, 60% Fel/40% Mat, Sand: VF _s -VC _s , Ms=70%, Fs=20%, SANG-SRND, 50% Fel/20% Mat, wet, 2.5y 4/2 dark grayish brown, no HCl rxn	@ 163' 150x140x80 RND granitic cbs @ 164' 200x115x100 large SRND basalt cbs @ 167' 3-5 <5mm silt nodules in core barrel	
165	G ₁		@ 170-173' 30% G ₁ , 67% S, 3% silt moist, weak HCl rxn, 2.5y 3/2 very dark grayish brown, Tr mica, low cementation		
170	G ₁		@ 173-180' 30% G ₁ , 65% S, 5% silt Gravel: VF _p -VC _p , VF _p =15%, Fs+Mp=70%, mod sort, SAND-RND, 85% Fel/15% Mat, 60% granitics, 20% quartzite, 20% basalt Sand: VF _s -VC _s , Fs-C _s =80%, Ms avg, mod sort, SAND-SRND, 90% Fel/20% Mat, moist, 2.5y 4/2 dark grayish brown, moderate HCl rxn, Tr mica, 5-10mm silt nodules	@ 175' increasing silt nodules, 5-10mm	
175	G ₁		185-190 silt (M) @ 185 2% G ₁ , 13% S, 85% silt Gravel: 100% VF _p , well sorted RND-SANG Quartzite + Granitics + Basalt. 90% Fel/10% Mat Sand: 90% VF _s , 10% Fs, well sorted, SANG-SRND 95% Fel/5% Mat, moist, 2.5y 4/4 olive brown whe- vet, 6/3 10YR 6/3 Pale brown when dry weak HCl rxn, Tr mica, very high cementation High plasticity		
180	G ₁				
185	G ₁				
190	G ₁				
					TD = 791.3" (6/22/17) DTW = 78.8' (6/22/17) Depth of casing = 189.5'

Reported By:

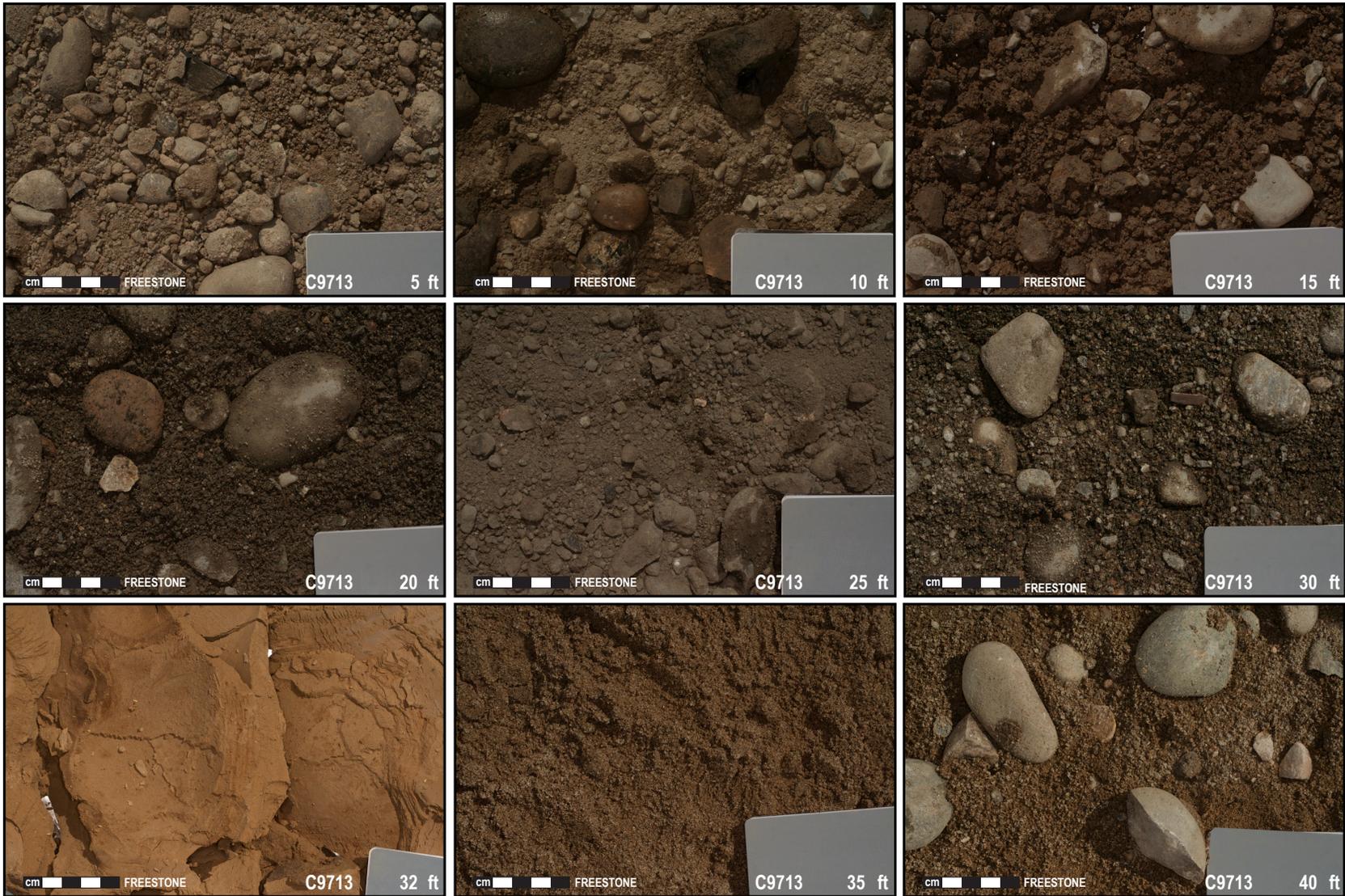
Cabelo Corant
Print Name

Geologist
Title

[Signature]
Signature

6/22/17
Date

C-9

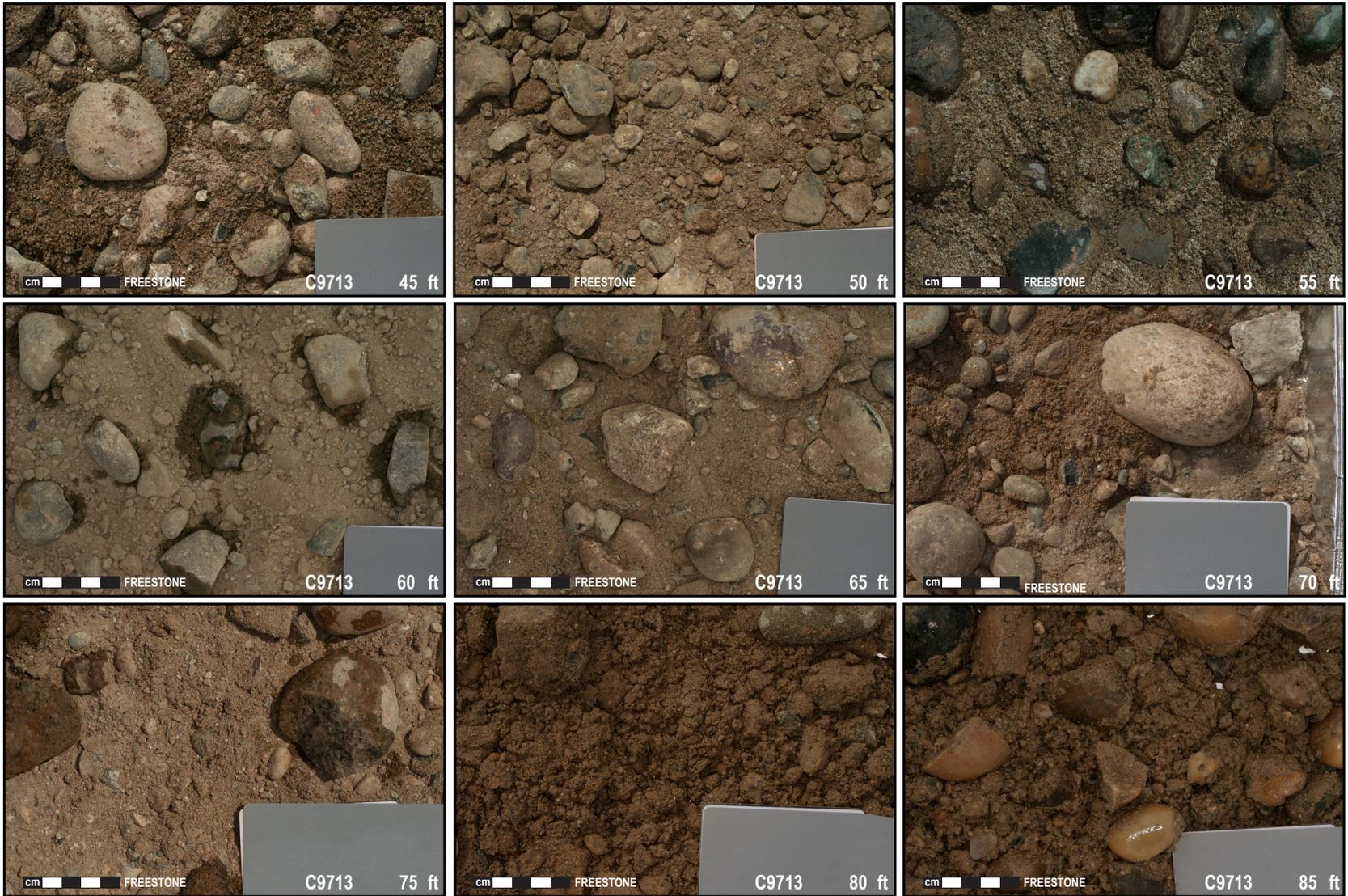


SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9713 (199-K-229)

C-10

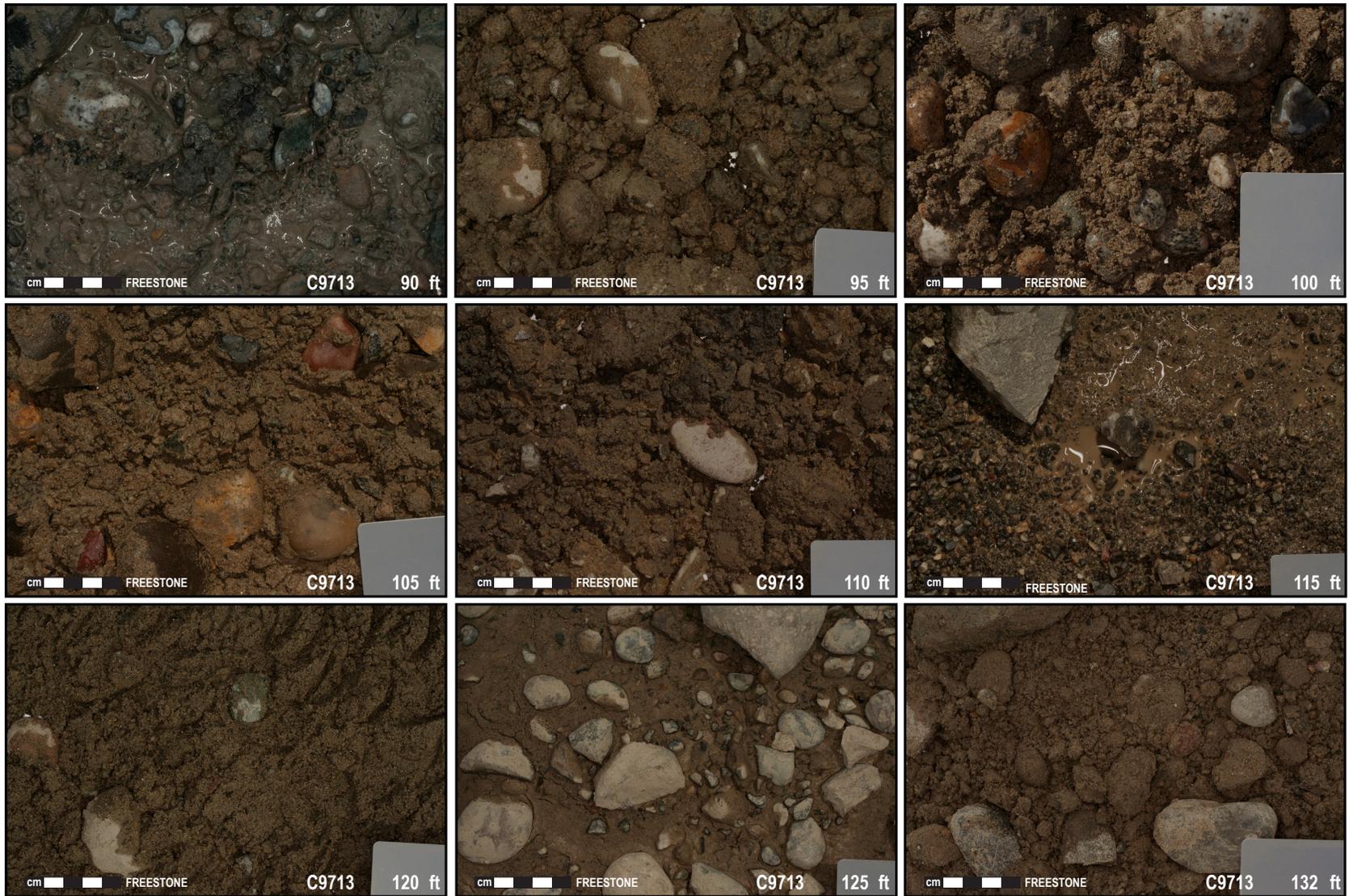


SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9713 (199-K-229)

C-11



SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9713 (199-K-229)

C-12



SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9713 (199-K-229)



WELL DEVELOPMENT AND TESTING DATA														
Well ID: C9713			Well Name: 199-K-229				Date: 9/27-9/28/17							
Location: 100-KR-4 OU 50m South of 100K West Transformer Yard Fence														
Reference Measuring Point (unless otherwise noted): TOP OF OUTER CASING (TOC)														
Has the well been surveyed? <input type="radio"/> Yes <input checked="" type="radio"/> No					Does the well have a cement pad? <input checked="" type="radio"/> Yes <input type="radio"/> No									
Initial Conditions					<p>A = 3.00' B = 1.95' C = 1.05'</p>									
		Start of Job		End of Job										
STATIC WATER LEVEL:														
Date: 9/27/17	81.15' bgs									NA				
Date: 9/28/17	NA		81.35' bgs											
DEPTH TO BOTTOM:														
Date: 9/27/17	191.0' bgs				NA									
Date:	NA				NR									
9/28/17 ↓	Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbidity (NTU)		Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)					
	185.6	12.5	98.40	Initial	Final	0932	1048	60	4.81					
	164.45	16.5	77.07	4.68	2.39	1105	1154	76	4.59					
	143.2	12	56.02	2.50	1.22	1213	1238	56	4.65					
	121.95	15	34.69	1.69	1.07	1245	1307	67	4.50					
	100.07	17	14.08	1.02	0.67	1320	1417	72	4.27					
Total Pumped: 15,250 gallons														
Pump Model: 5hp Grundfos Submersible Pump S/N: 0001; Model: A98924049 45550-9														
Troll Serial Number and Pressure Range (PSI and depth): S/N: 403065, 70m/231ft														
Comments: NR = Not Recorded														
Prepared By:														
Kim Schuyler <i>Print Name</i>			 <i>Signature</i>				10/2/2017 <i>Date</i>							
Reviewed By:														
Keshy Whitley <i>Print Name</i>			 <i>Signature</i>				10/9/17 <i>Date</i>							
For Office Use Only														
OR Doc Type:					WMU Code(s):									



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199-K-229 (C9713) Log Data Report

Borehole Information

Log Date	2017-06-23	Filename	C9713_HG-NM_2017-06-23	Site	100-KR-4
DTW ¹ (ft)	DTW Date	DTW Source	Drill Date	Total Depth (ft)	Depth Datum
88.7	06/23/2017	SN3	06/22/17	191.3	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.)		Thickness (in.)	Top (ft)	Bottom (ft)
			Outer	Inside			
Threaded Steel	Cable Tool	5.3	10 3/4	9 3/8	11/16	-5.3	189.5

Borehole Notes

The logging engineer measured casing thickness. Drill depth and casing depth were provided by the wellsite geologist. Depth to water was recorded by SN3 personnel at 88.7 ft prior to logging. As logging occurred it appears the water inside the casing recovered to approximately 85 ft. Static formation water may be at approximately 77 ft in depth. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 1Ld	Type	60% HPGe SGLS ²
Effective Calibration Date	01/26/17	Serial No.	47-TP-32211A
Calibration Reference	HGLP-CC-150, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0

Logging System	Gamma 1Hd	Type	NMLS ³ He-3 (CPN 503)
Effective Calibration Date	02/23/17	Serial No.	H310700352
Calibration Reference	HGLP-CC-151, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0

SGLS Log Run Information

Log Run	3	4 Repeat		
HEIS Number	1019932	1019933		
Date	06/22/17	06/22/17		
Logging Engineer	Felt/Meisner	Felt/Meisner		
Start Depth (ft)	0.01	120.01		
Finish Depth (ft)	188.02	138.02		
Count Time (sec)	100	100		
Live/Real	R	R		
Shield (Y/N)	N	N		
MSA Interval (ft)	1.0	1.0		
Log Speed (ft/min)	N/A	N/A		

¹ depth to water inside casing

² Spectral Gamma Logging System

³ Neutron Moisture Logging System

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Log Run	3	4 Repeat			
Pre-Verification	C9713ALD2017 0622AV00CAB 1	C9713ALD2017 0622AV00CAB 1			
Start File	AD000001	BD012001			
Finish File	AD018802	BD013802			
Post-Verification	C9713ALD2017 0622BV00CAA 1	C9713ALD2017 0622BV00CAA 1			
Depth Return Error (in.)	N/A	1.0 high			
Comments	No fine gain adjustments made	No fine gain adjustments made			

NMLS Log Run Information

Log Run	1	2 Repeat			
HEIS Number	1019934	1019935			
Date	06/23/17	06/23/17			
Logging Engineer	Felt/Meisner	Felt/Meisner			
Start Depth (ft)	0.0	76.0			
Finish Depth (ft)	85.51	85.0			
Count Time (sec)	15	15			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.25	0.25			
Log Speed (ft/min)	N/A	N/A			
Pre-Verification	C9713AHD2017 0623AV00CAB 1	C9713AHD2017 0623AV00CAB 1			
Start File	AD000000	BD007600			
Finish File	AD008551	BD008500			
Post-Verification	C9713AHD2017 0623BV00CAA 1	C9713AHD2017 0623BV00CAA 1			
Depth Return Error (in.)	N/A	0.0			
Comments	None	None			

Logging Operation Notes

A centralizer was installed on the SGLS and NMLS sondes.

Pre- and post-survey verification measurements met the acceptance criteria for the established systems.

Analysis Notes

Analyst	P.D. Henwood	Date	07/11/17
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated in an EXCEL template identified as ALD20170126_CC-150 for the SGLS, using an efficiency function and corrections for casing and dead time as determined during annual response checks.

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The HGU⁴ 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 Model 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).

A water correction was applied below 88.7 ft.

Results and Interpretations

No manmade radionuclides were detected.

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

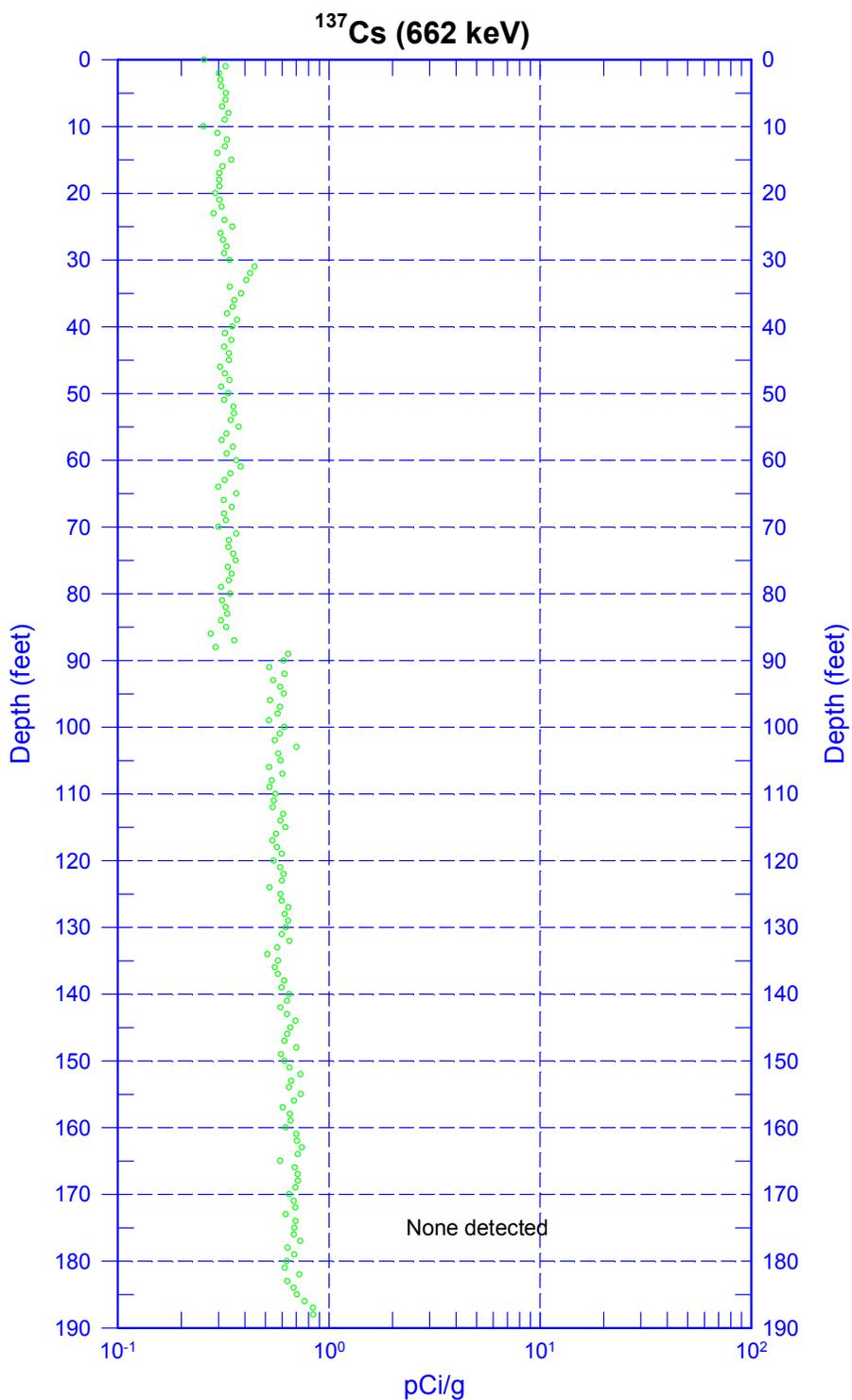
Depth Reference is ground surface.

Manmade Radionuclides (0-190 ft)
 Natural Gamma Logs (0-190 ft)
 Combination Plot (0-120 ft)
 Combination Plot (110-230 ft)
 Combination Plot (0-190 ft)
 Total Gamma & Moisture (0-190 ft)
 Total Gamma & Hanford Gamma Unit (0-190 ft)
 Repeat Section of Natural Gamma Logs (120-139 ft)
 Moisture Repeat Section (76-85 ft)

⁴ Hanford Gamma Unit



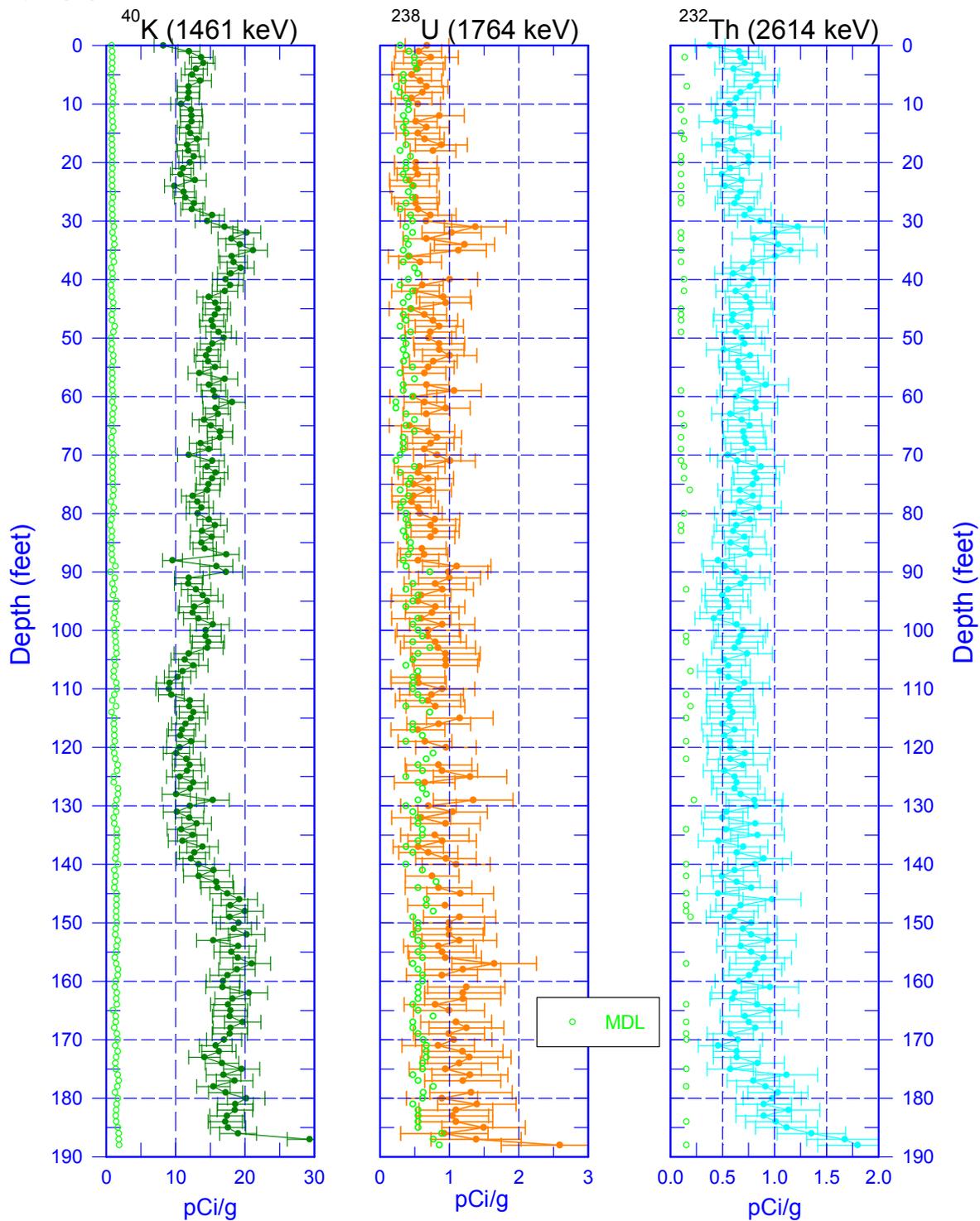
199-K-229 (C9713) Manmade Radionuclides



Zero Reference - Ground Surface

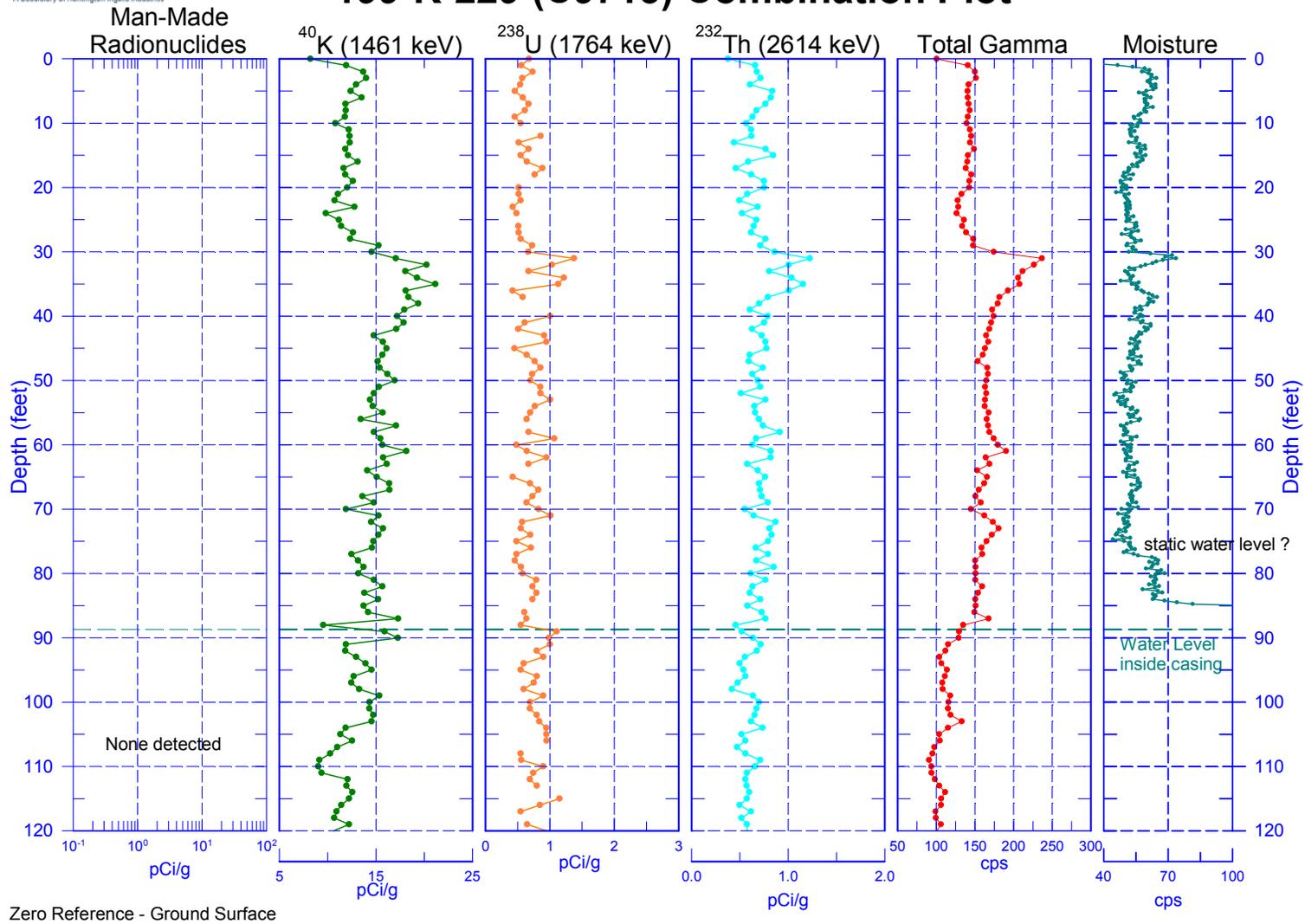


199-K-229 (C9713) Natural Gamma Logs



Zero Reference - Ground Surface

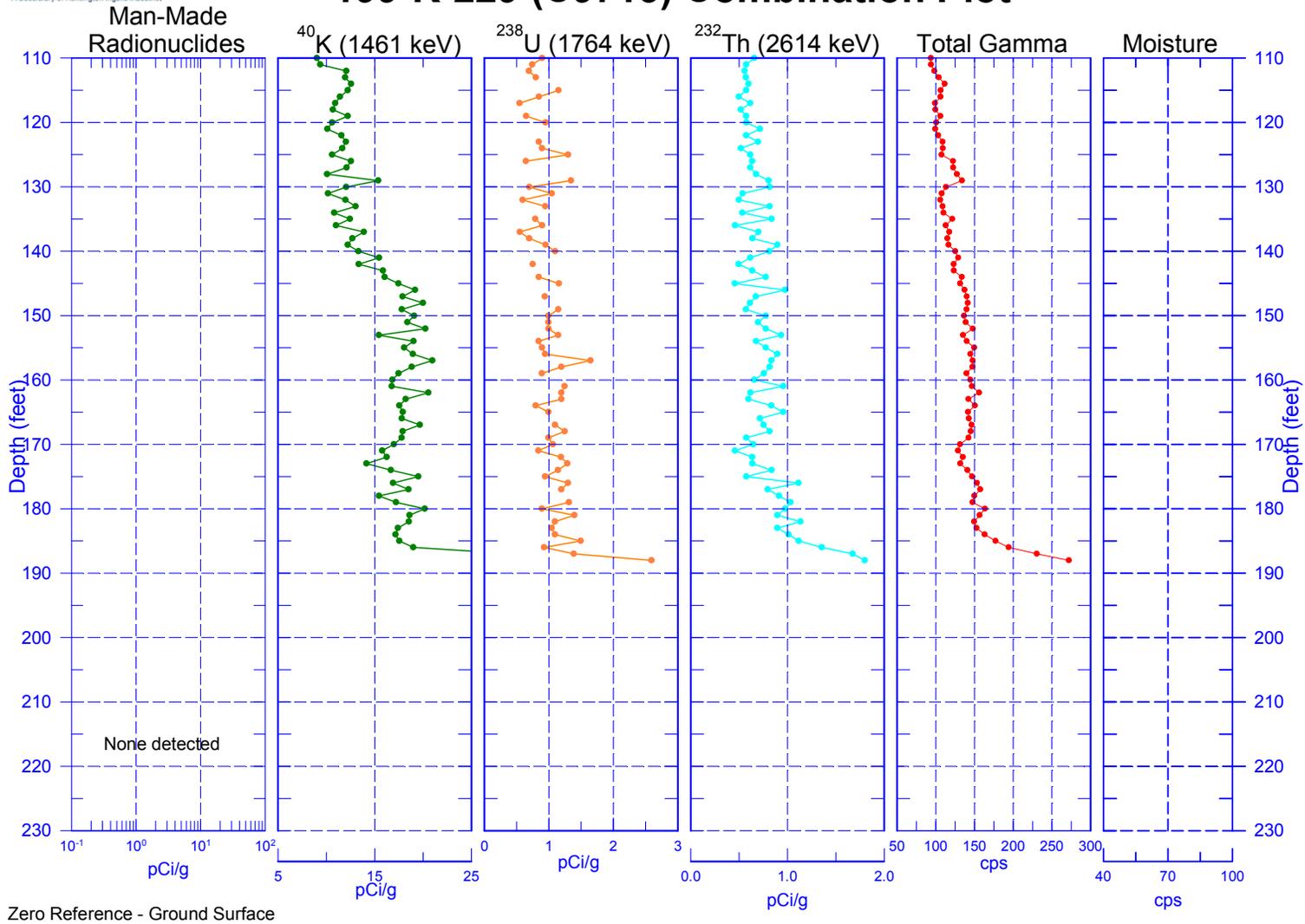
199-K-229 (C9713) Combination Plot



C-20

SGW-61094, REV. 0

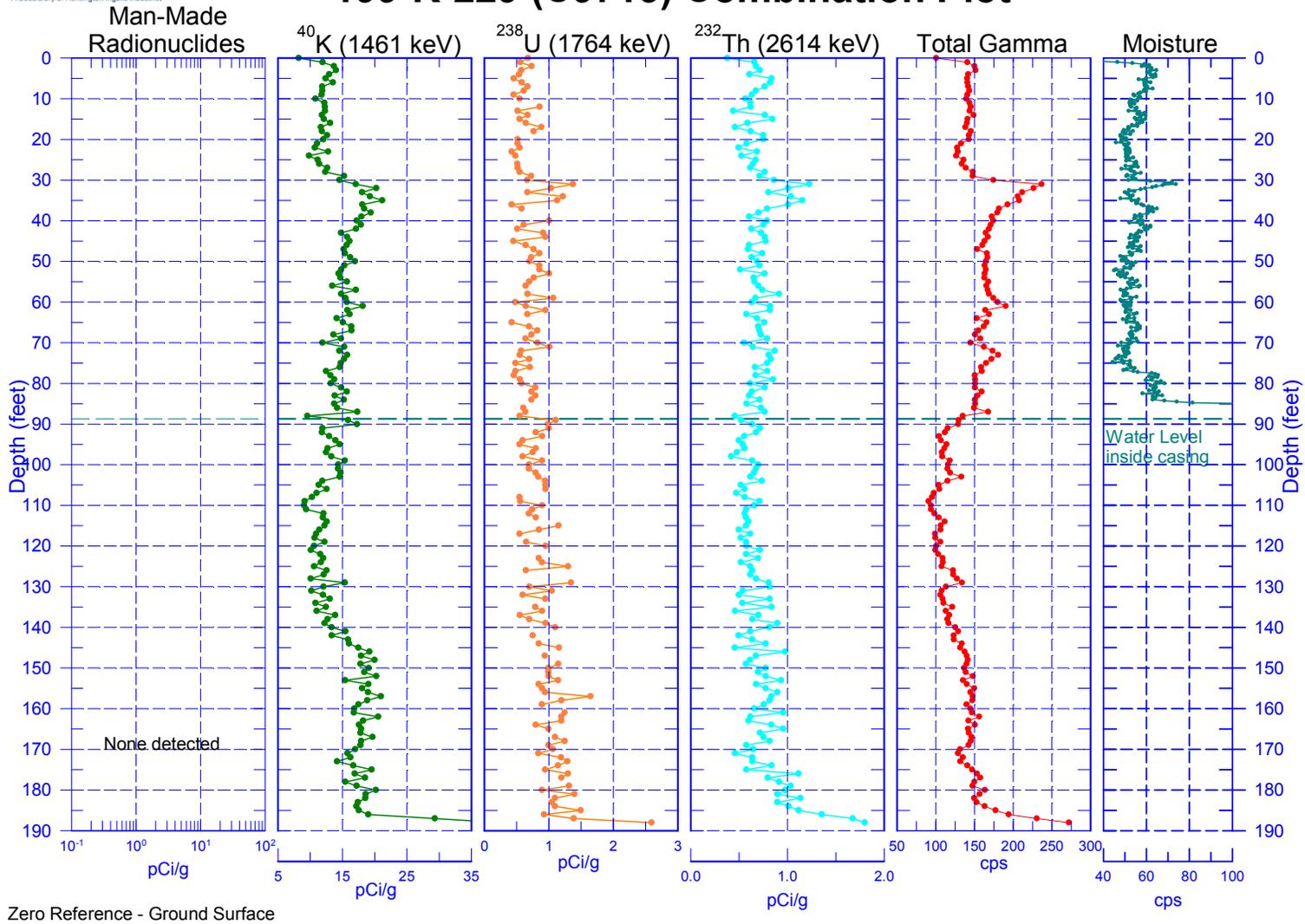
199-K-229 (C9713) Combination Plot



C-21

SGW-61094, REV. 0

199-K-229 (C9713) Combination Plot

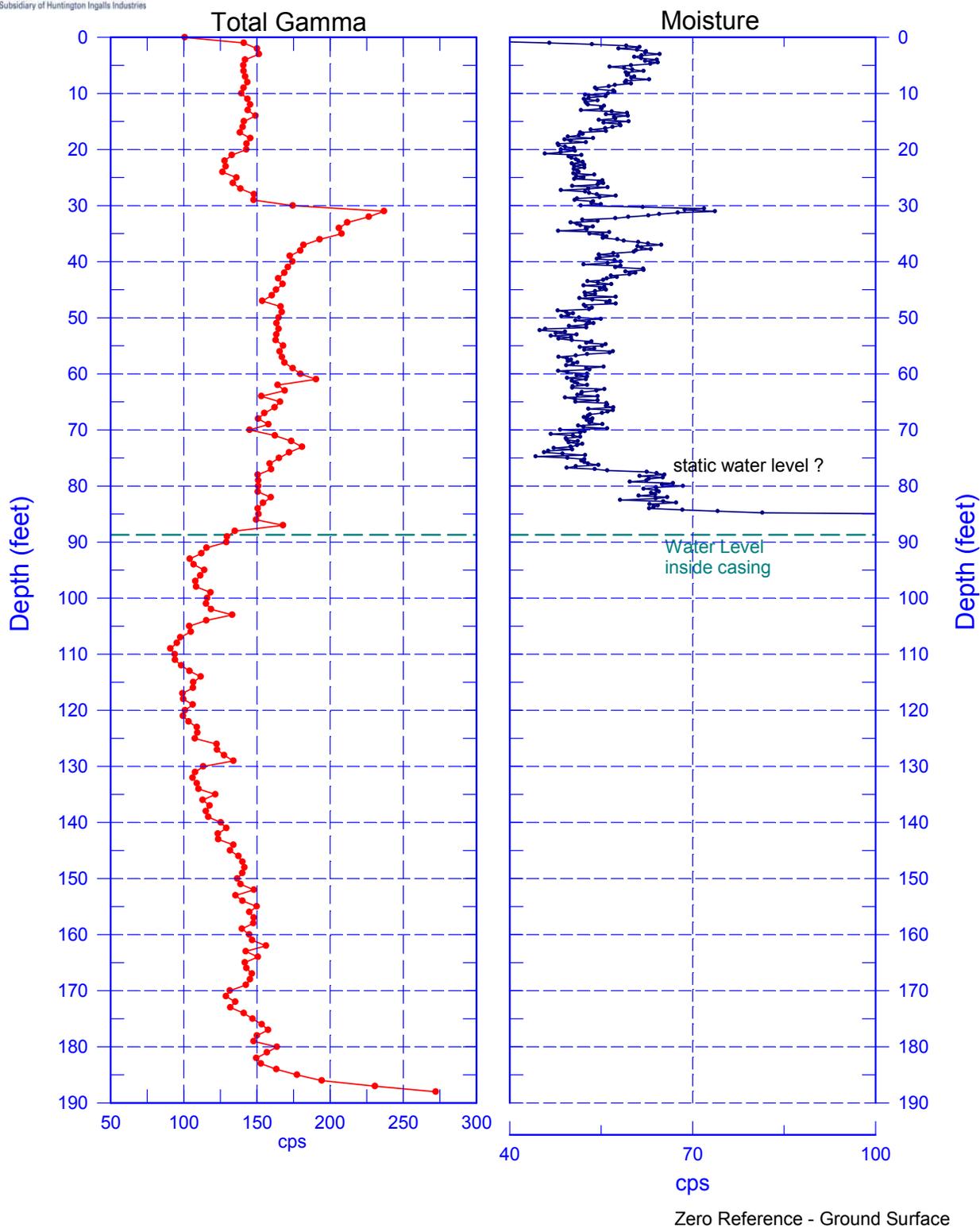


C-22

SGW-61094, REV. 0

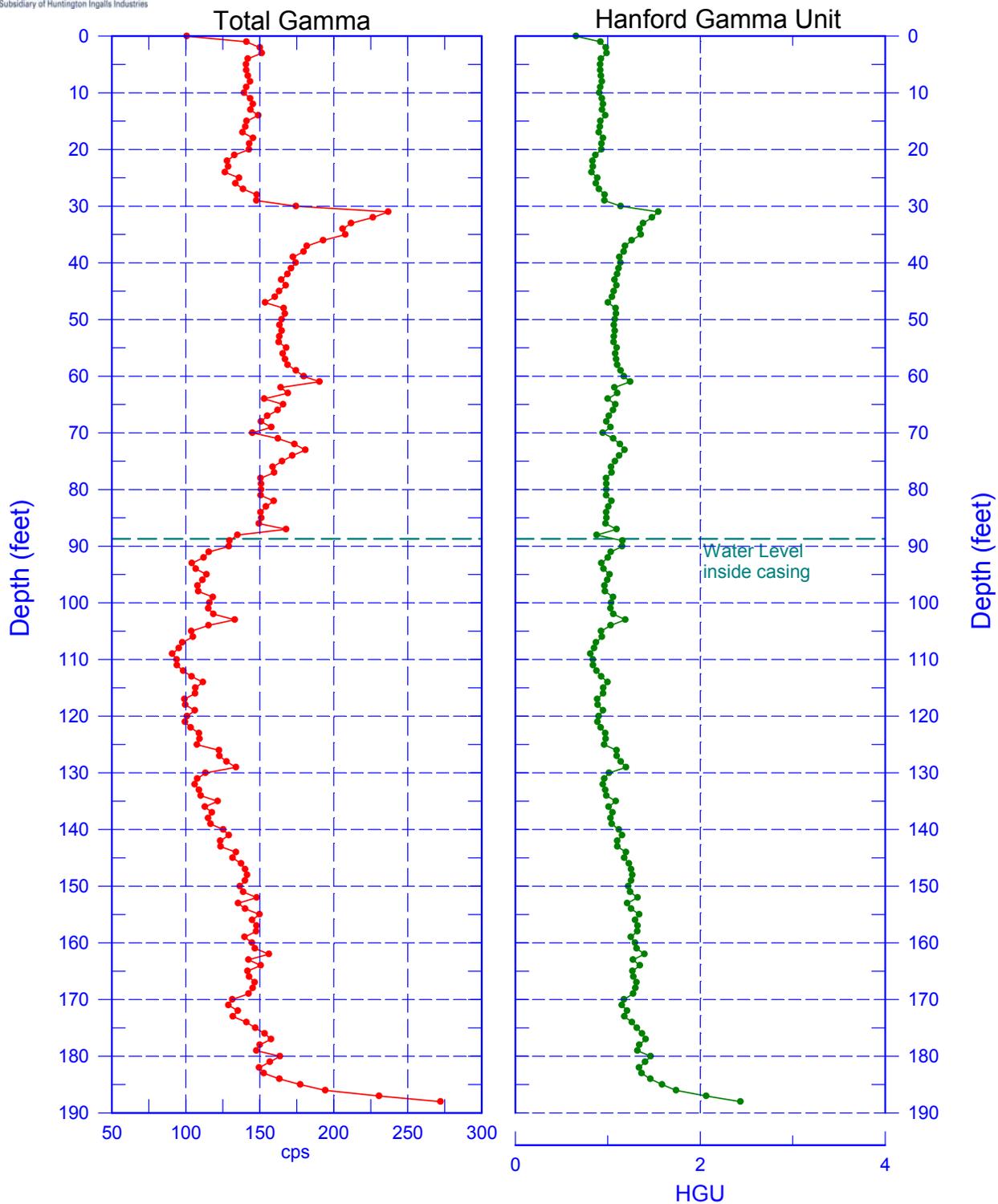


199-K-229 (C9713) Total Gamma & Moisture





199-K-229 (C9713) Total Gamma & Hanford Gamma Unit

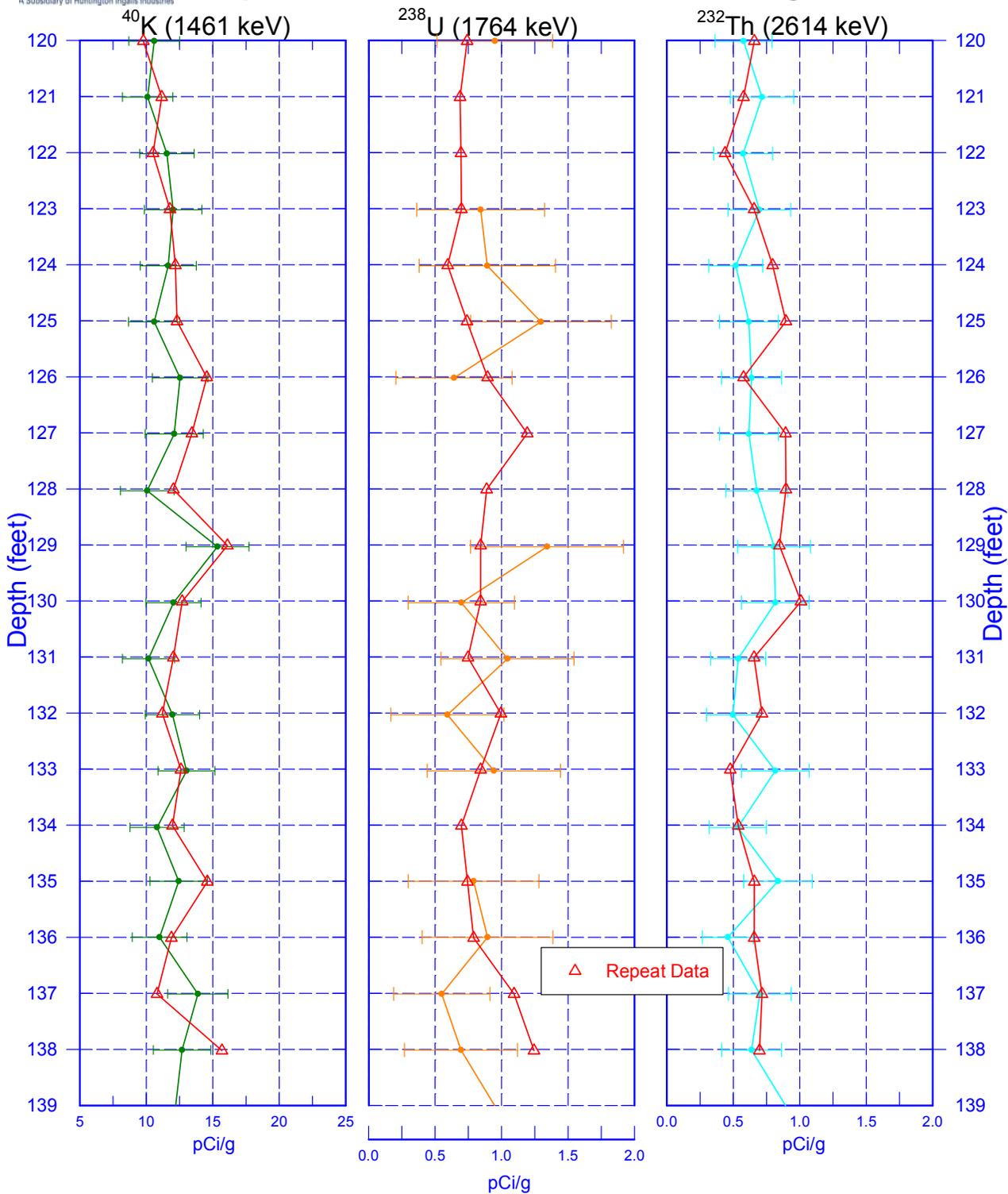


Zero Reference - Ground Surface



199-K-229 (C9713)

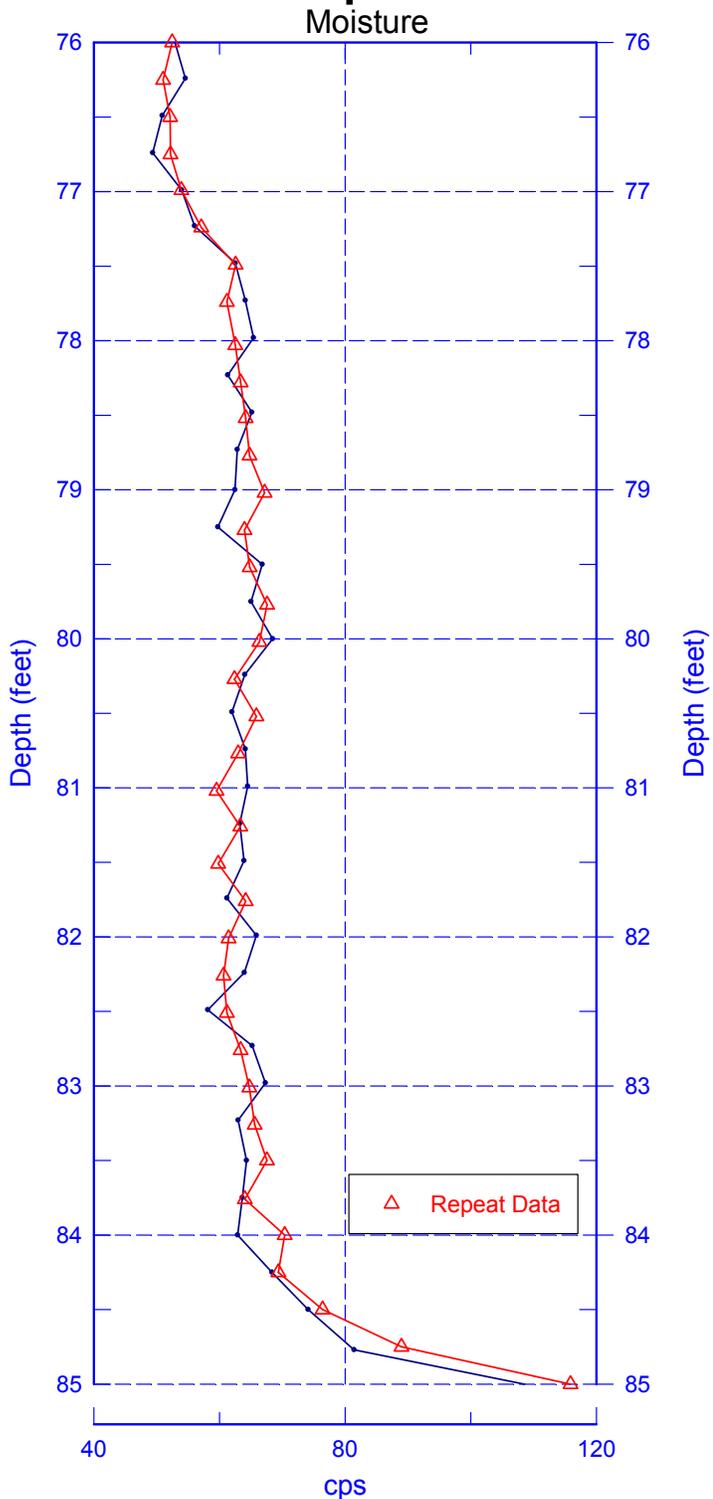
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



199-K-229 (C9713) Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

Project:	Prepared By: Neil P. Fastabend
	Company: CHPRC
Date Requested: 08/31/17	Requestor: Steven E. Imhoff (CHPRC)
Date of Survey: 09/12/17	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9713 (199-K-229) located in 100K Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 100K
Coordinate System: Washington State Plane Coordinates (South Zone)	
Horizontal Control Monuments: Washington State Reference Network	
Vertical Control Monuments: HSWB-045 (COE) and 100K-3 (CHPRC)	

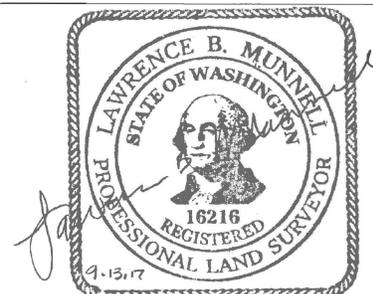
Well ID	Well Name	Easting	Northing	Elevation	
C9713	199-K-229	568867.99	146311.08		Center of Casing
				146.430	Top Outer Casing, N.Edge, Stamped X
				146.114	Top Inner 6"SS Casing, N.Edge
				145.662	Brass Survey Marker

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.

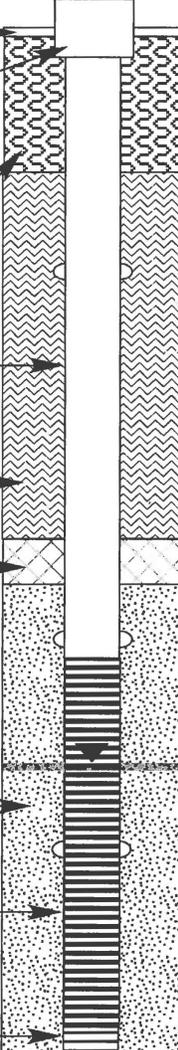


Appendix D

Well Documentation for C9714 (199-K-230)

Contents

Well Summary Sheet D-1
Borehole Log D-3
Drill Cutting Photographs D-7
Well Development and Testing Data D-11
Log Data Report D-12
Well Survey Data Report D-22

WELL SUMMARY SHEET			Page 1 of 2	
Well ID : C9714		Well Name: 199-K-230		Start Date: 4/3/2017
Project: Four 100-KR-4 OU Monitoring Wells		Location: 330m NE of 105-KW Reactor		Finish Date: 7/12/2017
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
Concrete Pad: 0.50 ft above ground surface (ags)		0		0.0 - 2.0 Crushed Gravel Drill Pad
8.64-in Protective Casing: 3.00 ft ags - 2.70 ft below ground surface (bgs)		2.0		2.0 - 7.0 Sand (S)
Type I/II Portland Cement Grout: 0.0 - 9.9 ft bgs		7.0		7.0 - 52.0 Sandy Gravel (sG)
6-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 43.00 ft bgs		10		
8-20 mesh Bentonite Crumbles: 9.9 - 34.7 ft bgs		20		
3/8-in Coated Bentonite Pellet Seal: 34.7 - 38.7 ft bgs		30		
10-20 mesh Premier Colorado Silica Filter Pack Sand: 38.7 - 145.1 ft bgs		40		
6-in I.D. Schedule 10, Type 304/304L, 30-slot (0.030 in.) Stainless Steel Screen: 43.00 - 68.01 ft bgs		50		Static Water Level: 50.75 ft bgs (7/12/2017)
6-in I.D. Schedule 10, Type 304/304L, 40-slot (0.040 in.) Stainless Steel Screen: 68.01 - 138.04 ft bgs		52.0		52.0 - 54.0 Sandy Silt (sM)
				60
Reported By: Caleb Grant Geologist  8/30/17				
Print Name Title Signature Date				
Reviewed By: Kelly Whitley Well Coordinator  9/5/17				
Print Name Title Signature Date				
For Office Use Only				
OR Doc Type:	WMU Code(s):			

WELL SUMMARY CONTINUATION SHEET			Page 2 of 2	
Well ID: C9714	Well Name: 199-K-230	Project: Four 100-KR-4 OU Monitoring Wells		
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
<p>10-20 mesh Premier Colorado Silica Filter Pack Sand: 38.7 - 145.1 ft bgs</p> <p>6-in I.D. Schedule 10, Type 304/304L, 40-slot (0.040 in.) Stainless Steel Screen: 68.01 - 138.04 ft bgs</p> <p>Stainless steel centralizer installed above and below screen and every 40 ft</p> <p>6-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 138.04 - 143.04 ft bgs</p> <p>Straightness Test: Pass, 05/2/2017 Total Depth: 145.1 ft bgs</p> <p>Depths are in ft below ground surface. Borehole drilled with 10 3/4-in O.D. casing from 0.0 - 143.0 ft bgs All temporary drill casing was removed from the ground.</p>		<p>70</p> <p>80</p> <p>90</p> <p>100</p> <p>110</p> <p>120</p> <p>130</p> <p>140</p> <p>150</p> <p>160</p>		<p>54.0 - 73.0 Sandy Gravel (sG)</p> <p>73.0 - 78.0 Sand (S)</p> <p>78.0 - 92.0 Sandy Gravel (sG)</p> <p>92.0 - 94.0 Sand (S)</p> <p>94.0 - 126.5 Sandy Gravel (sG)</p> <p>126.5 - 132.0 Sand (S)</p> <p>132 - 137.2 Sandy Gravel (sG)</p> <p>137.2 - 145.1 Mud (M)</p>

BOREHOLE LOG				Page 1 of 4
Well ID: C9714		Well Name: 199-E-230		Date: 4/3 to 4/5/17
Project: 4 GW MONITORING WELLS FY 2017		Location: 700-KR4		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			0-2' CRUSHED GRAVEL PAD BASE	CABLE TOOL DRILL 103/4" CASING-THREADED
5	G		2-7' SAND (S) 100% S, VFs-VCs 75% CS (average from 40) 95% FELSIC-5% MAFIC, A-SA, MOIST, 2.5 YR 5/2 GRAY, WELL SORTED, NO HCl RXN.	G-GRAB SAMPLE FOR 1 PINT JAR, FERTILIZER ARCHIVE PHOTO
			7-7.5' SANDY GRAVEL (SG)	
10	G		7' 65% G, 35% S, G-VF to CoD 35% COBBLES TO 80 MM STD-RND, 80% FELS 20% MAF, SAND VFs → VCs, 25% Cs + VCs, 75% VF-Ms sand 90% FELS 10% MAF, SAND, WELL SORTED	
15	G		2.5 YR 5/2 GRAY BRN, MOIST, NO HCl RXN @ 15' 75% G Above 75% Grav. 25% Sand	
20	G		@ 20' LARGER COBBLES TO 120 MM, As Above Gr 5/0	
25	G		24 to 26' COBBLES ↑ TO 160 MM @ 25' SAND FINING TO TRACE VCS 20% Ms 10% FS TR SILT 70% L sand	HARD DRILLING 24'-28'
30	G		28' COBBLES ↓ < 80 MM @ 30' S ₁ -SAND COARSER THAN ABOVE, avg = VC sand	
35				
Reported By: GREG L. KASZAK GEOLOGIST Print Name Title Signature Date 5/10/2017				
Reviewed By: Sarah Springer geologist Print Name Title Signature Date 09-05-17				
For Office Use Only				
OR Doc Type:		WMU Code(s):		

BOREHOLE LOG (Cont.)			Page 2 of 4
			Date: 4/5/17 - 4/13/17
Well ID:	Well Name:	Location:	
C9714	199-K-230	100-KR4 0U 4/5/17 330m NE of 105-KW Reactor	
Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other
35	G		7-73 sandy gravel (SG) @ 35' SANDY GRAVEL (SG) 70% G, 30% S G-VFP-COB, COB TO 110 MM, MOD SORT SR+R, 70% FEL 30% MAE, S-VF, VC-VF 15% VES, WELL SORT, SAND-ANG, 70% FEL 30% MAE NO HCl RXN DRY 5 YR 9/1 GRAY
40	G		@ 40' G AS ABOVE S AS ABOVE TR MICA & MINOR FeOx STAIN
45	GSC1		@ 45' G AS ABOVE S AS ABOVE 4/5/17 STRONG HCl RXN.
50	GSG1 I001		@ 50' G-COB TO MAX 80 MM S- AS ABOVE WET, STRONG HCl RXN 52-54 (5M) SANDY SILT, MED HCl RXN. 2.5T 7/1 LT GRAY, 60% SILT, 40% SAND (100% Very fine)
55	GSC1		54-56 AS BEFORE 54-73 SANDY GRAVEL (SG) @ 55' G AS ABOVE MAX COB M TO 110, 70% gravel, 30% sand MM S-AS ABOVE, WET, MOD HCl RXN. TR MICA NO FeOx STAIN Gravel: VFP-Cobble, mod sort, max=80mm, sub. end=20mm Sand: VC-VF sand well sorted, sub ang=ang, 70% FeSic
60	I002 GSC1		@ 60' SAME AS ABOVE 4/5/17 I002 GW SAMPLE 59.4' BGS
65	GSC2		@ 65' SAME AS ABOVE COBBLES M MAX 180 MM 4/5/17
70	GSC2		@ 70' SANDY GRAVEL (SG) 65% G 33% S 2% MAE G-VFP-COB, MAX COB=160 MM, MOD SORTING, R-SR, 70% FEL, 20% MAE, S-VF, VC 20% SAND @ 73' BGS MS-VCS, WELL SORTED, ANG, 80% FEL
75			
Reported By: <u>GRETA KASZA</u> GEOLOGIST <u>[Signature]</u> 5/10/2017			
Print Name		Title	Signature Date

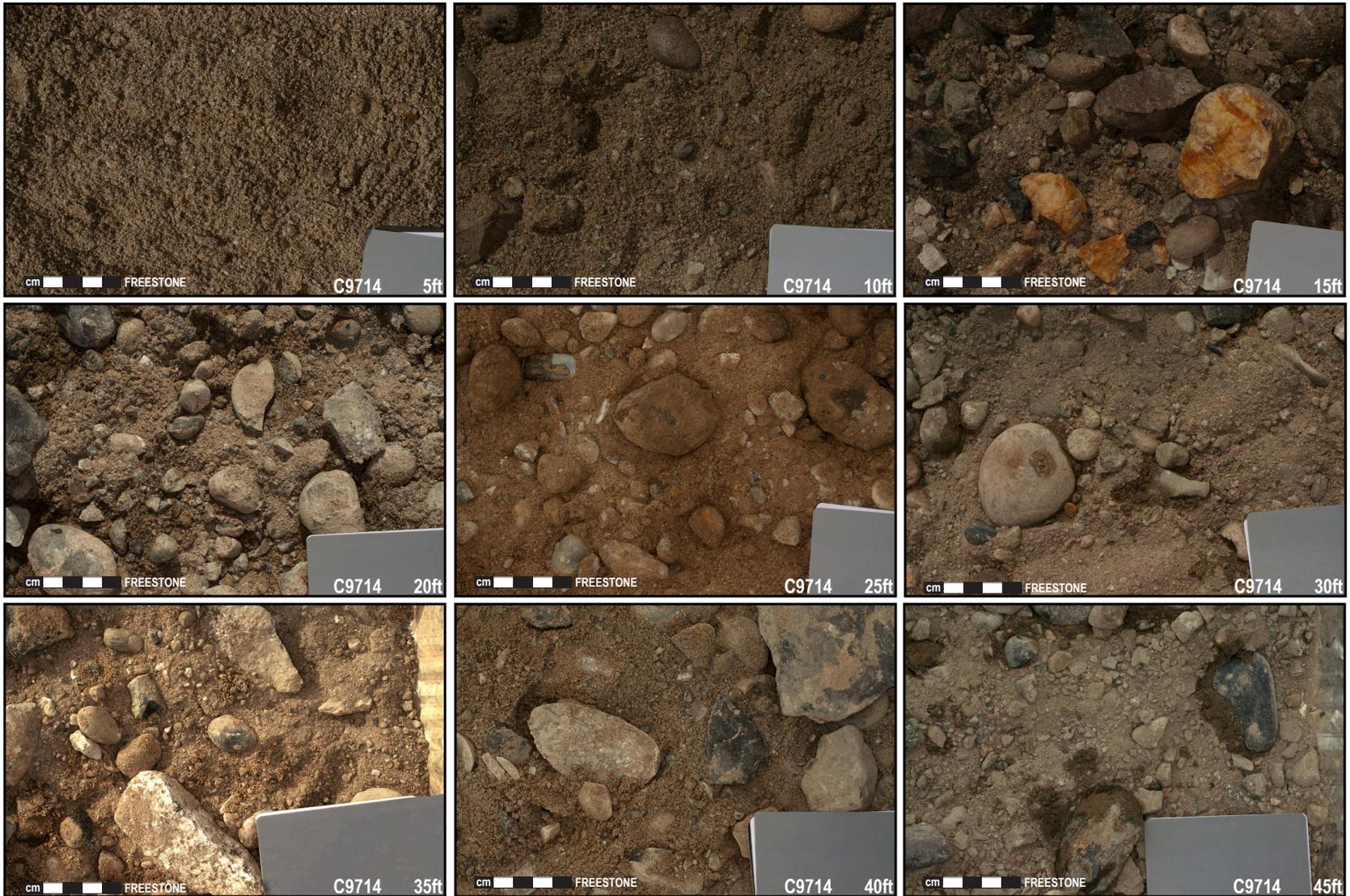
BOREHOLE LOG (Cont.)			Page 3 of 4	
Well ID: C 9714		Well Name: 199-K-230	Date: 4/13 TO 4/24/17	
		Location: 406 K 74 02 330 m NE of 105-KW Reader		
Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	
			Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other	
75	G 5 C 2		20% MAF. TR MICA 10YR 5/2 GRAYISH BRN, TR FeOx STAIN, WET NO HCl RXN. Gr 5/10/17 73-78' (S) SAND (S) @ 73' SAND (S) 8% G, 90% S, 2% M. G-VFP-MP MAX 10MM WELL SORTED, SA-SR, 75% FELSR - 25% MAF. Sand: VFs - Cs 50% Ms ^(low ang size) WELL SORTED, 95% FEL, ANG. TR MICA 10YR 5/2 GRAYISH BRN ^(no rxn) 78-92' (SG) SANDY GRAVEL @ 78' SANDY GRAVEL (SG) ^(vs 6/22/17) TO FM ABOVE SAND (73-78') sand: VFs - Cs, avg = Ms, well sorted, sub ang 75% G, 22% S, 3% M. TR MICA TR FeOx STAIN NO HCl RXN (gravel: VFP - Cobble, mod sort, R-SR, 75% felsic @ 85' SG AS ABOVE ^(vs 5/10/17) TR MICA NO FeOx STAIN @ 90' SG AS ABOVE ^(vs 5/10/17) TR MICA NO FeOx STAIN 92-94' SAND (S) ^(vs 5/10/17) 100% sand FS → Cs 70% Ms ^(vs 5/10/17) well sorted, sub round 95% FEL 10% MAF TR MICA NO HCl/RXN 10YR 5/2 GRAYISH BRN 94-126.5 SANDY GRAVEL (SG) @ 94' SG AS BEFORE ^(vs 5/10/17) 7.5' 5/2 BRN MAX COB STILL 140 MM NO RXN W/HCl, ^(vs 5/10/17) gravel: VFP - Cobble, R-SR, 75% felsic @ 100' SANDY GRAVEL (SG) ^(vs 5/10/17) 3% silt 75% G, 23% S, 2% M, G - VFP - Cob - NO DOMINANT SIZE RANGE MAX ↓↓ 80 MM MOD SORTING SR, 75% FEL - 25% MAF. Sand: VFs - Cs, 50% Ms ^(low ang size) WELL SORTED 95% FEL - 5% MAF TR MICA TR FeOx AVE 10YR 5/2 BRN ^(no rxn) W/HCl @ 105 AS ABOVE ^(vs 5/10/17) @ 110 SANDY GRAVEL (SG) 65% G ^(vs 5/10/17) AS ABOVE 30% S, 5% M G-AS ABOVE, Sand: 70% Fs & Ms, 30% VF sand Low % (TR) Cs & VCs, WELL SORTED	G-GRAB SAMPLE FOR ARCHIVE - PINT JAR CHND TRAY, PHOTO. SC SIEVE COMPOSITE OVER 20' INTERVALS 4 SAMPLES @ 5' HEAVED 5' INTO CASING USED SAND PUMP X 2 I-004 GWSAMPLE 93-0' BGS. I-003 SPLIT SPAD 95.0 - 97.5' BGS SAND PUMP NUMEROUS TIMES 75% gravel, 22% sand 3% silt SAND POMP USED 4X
80	G 5 C 2			
85	G 5 C 3			
90	G 5 C 3			
95	G 5 C 3			
100	G 5 C 3			
105	G 5 C 4			
110	G 5 C 4			

Reported By: GREG L. KASZA GEODOLOGIST [Signature] 5/10/2017
 Print Name Title Signature Date

BOREHOLE LOG (Cont.)				Page 4 of 4
				Date: 4/24 - 5/2/17
Well ID: C9714	Well Name: 199-K-230	Location: 100-KR4 OKS 8120117 330m NE of 105-KW		
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
110 (RPT)	G15C4		A → SA 75% FELSIC-25% MAFIC TR FeOx STAIN ↑↑ MICA 7.5YR 5/2 BROWN	CABLE TOOL DRIVE BARREL BELOW 112'
112'			@ 112' Cs & VC ^{sand amount} INCREASE G ALSO INCREASES ^{ALLS GREAT}	
115	G7SC4		@ 115' ^{120'} S G SANDY GRAVEL 80% G 20% S, TR M. G - VFP → COBBLE MAX COB = 85mm, MOD SORTING 75% FELSIC - 25% MAFIC TR → SR. ^{sand} VFS → VCS. OCCASIONALLY -	USING SAND PUMP 1x PER 5x DRIVE BARREL
120	G9SC4		DOMINANT Ms & Cs, WELL SORTED ANG. 80% FELSIC 20% MAFIC ↑↑ MICA TR FeOx STAIN. 7.5YR 5/2 BROWN WET, NO HCl/Rxn	
			@ 120' SAME AS ABOVE & 5/10/17 SAND FRACTION ↑ SLIGHT INCREASE	121' - 2x SAND PUMP
125	G SC5		@ 125' SAME AS ABOVE & 5/10/17 SAND ↑, GRAVEL ↓	
			@ 126.5 - 132' S-SAND 39% G, 95% S, 2% M, G-dom VFP & Fp ^{medium sand} S-VFS TO Ms DOMINATE, WELL SORTED 80% MAFIC 20% F TR MICA, TR FeOx, 10YR 5/2 GRAYISH BROWN OR 10YR 4/3 BROWN 95% FELSIC, NO MICA W/HCl	7' HEAVE INTO CASING AFTER COLLECTING 10Y GRAB SAMPLE
130	G, SC5		132 - 137.2 (S G) SANDY GRAVEL @ 132' S G, 70% G, 28% S, 2% M SAME AS PREVIOUS 6' INTERVAL ABOVE GRAVEL CLASTS VFP - C AVE 25mm MAX 80mm 75% FELSIC, 25% MAFIC RND EXCEPT WHEN CRUSHED BY DRILLING	5x SAND PUMP - 132-134' I 005 SPLIT SPOON 132.2 - 135.7' AGS I 006 G/W SAMPLE 133.2' BGS
135	G SC5		SAND VFS - VCS. Ms & Fs DOMINATE, WELL SORTED 80% FELSIC, 20% MAFIC ANG → SA 10YR 5/2 GRAYISH BRN, NO rxn w/HCl	
137.0	G SC5		137.2 - 143.0' M SILT-CLAY @ 138.3 M - 10% SAND 90% SILT-CLAY S-DOM VFS & MAFIC FS 100% FELSIC, ANG. M - NOT BEDDED, LOW PLASTICITY 2.5Y 6/2 LT BROWNISH GRAY, DRY VSET HCl/Rxn	137.2' RUM CONTACT Water level 48.6' (4/27/17) BOTTOM CASING @ 143.0 BOTTOM BOREHOLE TAGGED @ 145.1 5/2/17
140	G	139-143' HARD TOOL & BAILEY SLURRY - NO CHANGE		
145				

Reported By: Gregory L. Kasza Geologist [Signature] 5/10/17
 Print Name Title Signature Date

D-7



SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9714 (199-K-230)

D-8

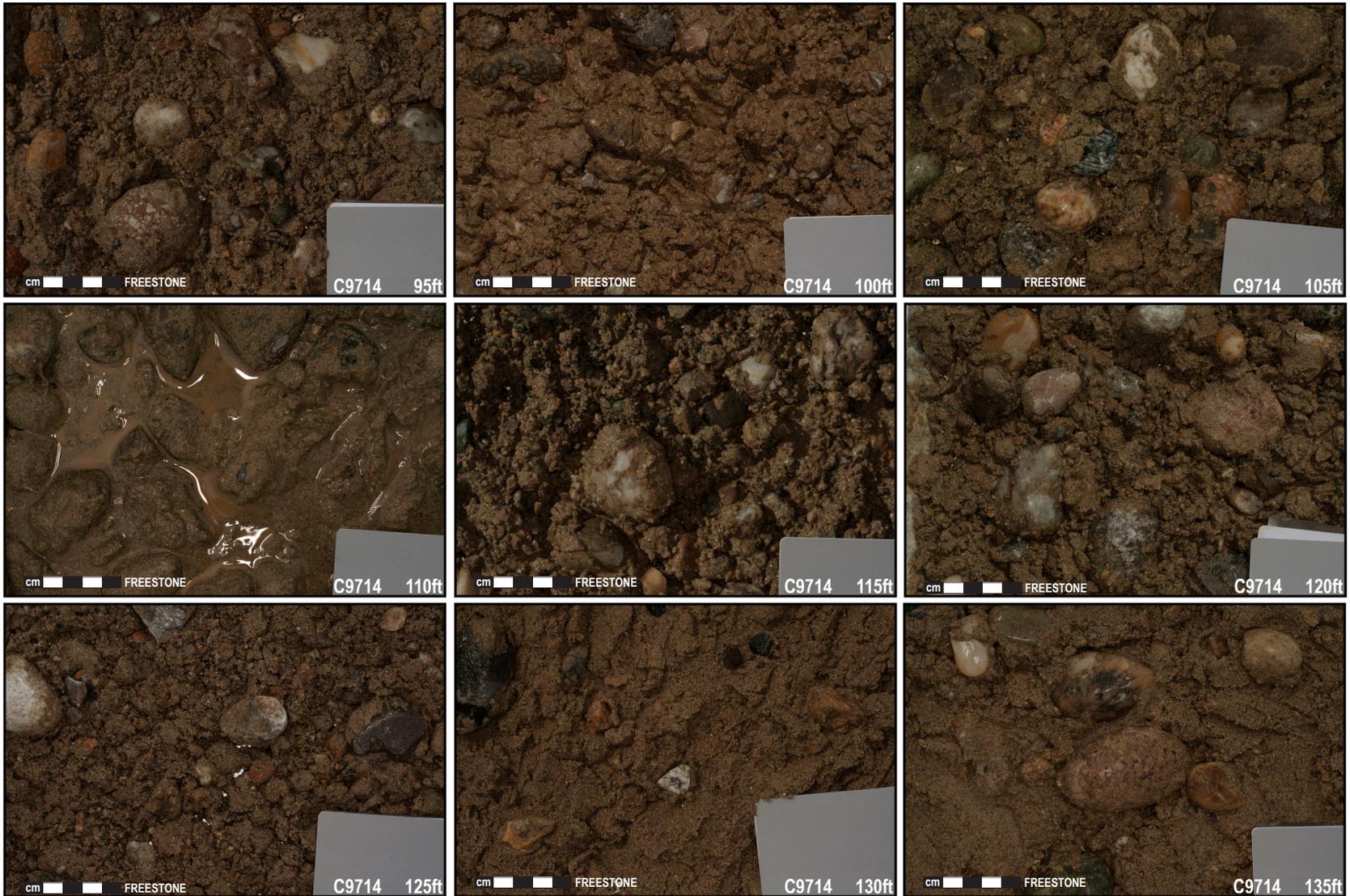


SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9714 (199-K-230)

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SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9714 (199-K-230)

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SGW-61094, REV. 0



Drill Cutting Photographs for Borehole C9714 (199-K-230)

WELL DEVELOPMENT AND TESTING DATA									
Well ID: C9714			Well Name: 199-K-230			Date: 8/15/2017			
Location: 330m NE of 105-KW Reactor									
Reference Measuring Point (unless otherwise noted): TOP OF OUTER CASING (TOC)									
Has the well been surveyed? <input type="radio"/> Yes <input checked="" type="radio"/> No			Does the well have a cement pad? <input type="radio"/> Yes <input checked="" type="radio"/> No						
Initial Conditions			<p style="margin-left: 20px;">A = 3.00' B = 2.00' C = 1.00'</p>						
Start of Job		End of Job							
STATIC WATER LEVEL:									
Date: 7-17-17	51.20' bgs	NA							
Date: 7-18-17	NA	51.30' bgs							
DEPTH TO BOTTOM:									
Date: 7-17-17	142.3' bgs	NA							
Date: 7-18-17	NA	143.1' bgs							
Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbidity (NTU)		Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)	
			Initial	Final					
130.2	13	73.23	62.5	17.2	1440	1504	72	5.51	
130.2	NA	73.21	223	1.16	0701	1015	**	23.87	
109	14	51.94	51.1	1.21	1120	1139	120	7.99	
84.7	49	30.82	49.4	3.58	1226	1249	150	3.06	
Total Pumped: 19,000 gal									
Pump Model: 25 hP 6" Volt-X Motor Subtroll, Model #: 236 3158 120									
Troll Serial Number and Pressure Range (PSI and depth): Serial #: 428494, 70m, 231 ft. vented									
Comments: ** 6 min @ 350gpm, 11 min @ 165 gpm, 5 min @ 250gpm, 16 min @ 125 gpm, 29 min @ 158.6 gpm									
Prepared By: Caleb Grant _____ 8/15/2017 Print Name Signature Date									
Reviewed By: Kelly Whitley _____ 9/5/17 Print Name Signature Date									
For Office Use Only									
OR Doc Type:			WMU Code(s):						



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199-K-230 (C9714) Log Data Report

Borehole Information

Log Date	2017-05-04	Filename	C9714_HG-NM_2017-05-04	Site	100-KR-4
DTW ¹ (ft)		DTW Date		Total Depth (ft)	Depth Datum
48.7		05/03/2017	SN3	145.1	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.)		Thickness (in.)	Top (ft)	Bottom (ft)
			Outer	Inside			
Threaded Steel	Cable Tool	2.0	10 3/4	9 3/8	11/16	-2.0	143.0

Borehole Notes

The logging engineer measured casing thickness. Drill depth and casing depth were provided by the wellsite geologist. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 1 ALd	Type	60% HPGe SGLS ²
Effective Calibration Date	01/26/17	Serial No.	47-TP-32211A
Calibration Reference	HGLP-CC-150, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0

Logging System	Gamma 1 AHd	Type	NMLS ³ He-3
Effective Calibration Date	02/23/17	Serial No.	H310700352
Calibration Reference	HGLP-CC-151, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0

SGLS Log Run Information

Log Run	1	2		
HEIS Number	1019884	1019885		
Date	05/03/17	05/03/17		
Logging Engineer	Spatz	Spatz		
Start Depth (ft)	0.0	129.0		
Finish Depth (ft)	144.0	144.0		
Count Time (sec)	100	100		
Live/Real	R	R		
Shield (Y/N)	N	N		
MSA Interval (ft)	1.0	1.0		
Log Speed (ft/min)	N/A	N/A		
Pre-Verification	C9714ALD2017 0503AV00CAB 1	C9714ALD2017 0503AV00CAB 1		

¹ depth to water inside casing

² Spectral Gamma Logging System

³ Neutron Moisture Logging System

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Log Run	1	2			
Start File	AD000000	BD012900			
Finish File	AD014400	BD014400			
Post-Verification	C9714ALD2017 0503BV00CAA 1	C9714ALD2017 0503BV00CAA 1			
Depth Return Error (in.)	N/A	4.0 high			
Comments	No fine gain adjustments made	No fine gain adjustments made			

NMLS Log Run Information

Log Run	3	4 Repeat			
HEIS Number	1019886	1019887			
Date	05/04/17	05/04/17			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	40.0			
Finish Depth (ft)	48.76	48.5			
Count Time (sec)	15	15			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.25	0.25			
Log Speed (ft/min)	N/A	N/A			
Pre-Verification	C9714AHD2017 0504AV00CAB 1	C9714AHD2017 0504AV00CAB 1			
Start File	AD000000	BD004000			
Finish File	AD004876	BD004850			
Post-Verification	C9714AHD2017 0504BV00CAA 1	C9714AHD2017 0504BV00CAA 1			
Depth Return Error (in.)	N/A	0.5 high			
Comments	None	None			

Logging Operation Notes

A centralizer was installed on the SGLS and NMLS sondes.

Pre- and post-survey verification measurements met the acceptance criteria for the established systems.

Analysis Notes

Analyst	P.D. Henwood	Date	06/01/17
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated in an EXCEL template identified as ALD20170126_CC-150 for the SGLS, using an efficiency function and corrections for casing and dead time as determined during annual response checks.

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The HGU⁴ 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 Model 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).

A water correction was applied below 48.7 ft.

Results and Interpretations

No manmade radionuclides were detected.

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

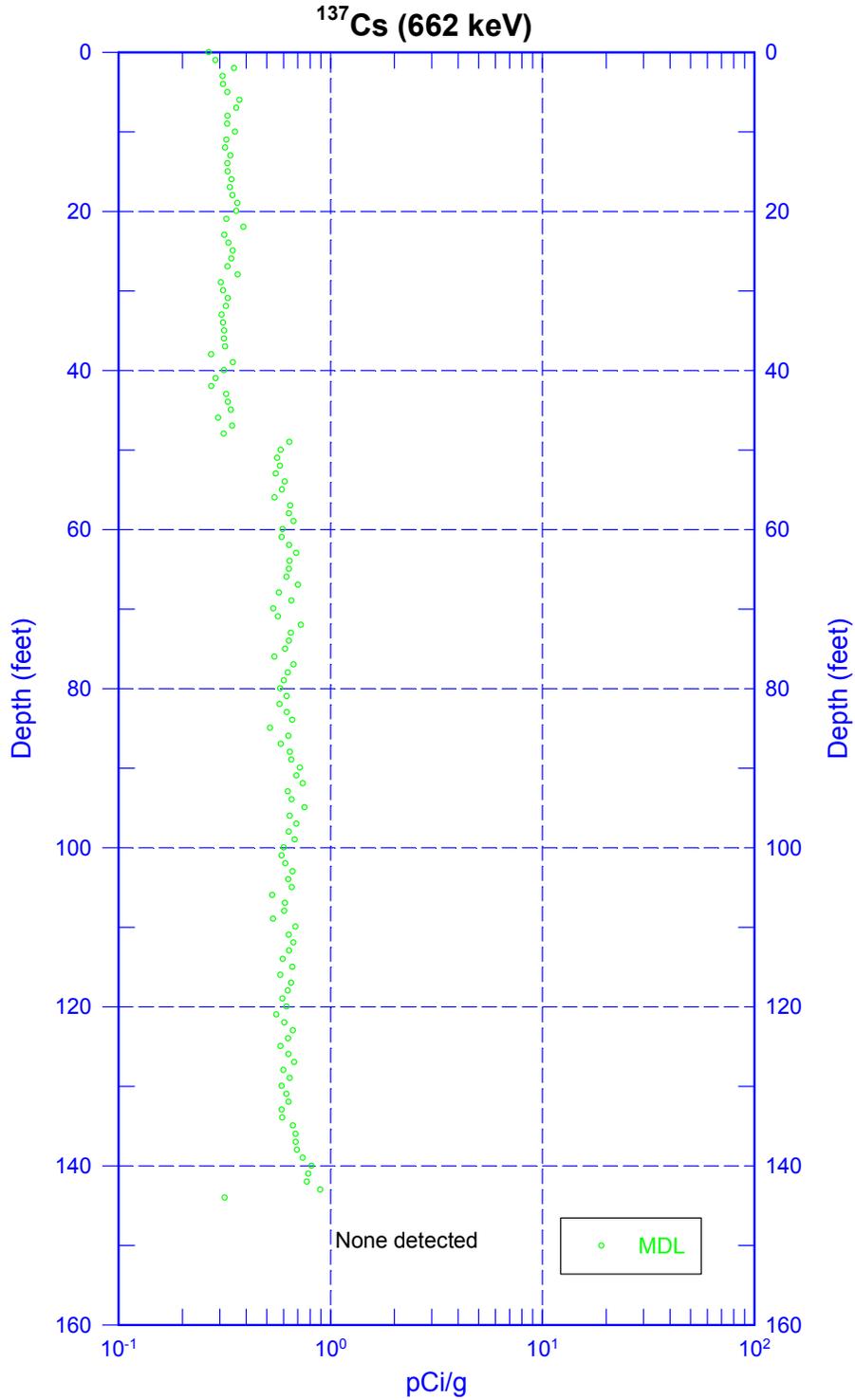
Depth Reference is ground surface.

Manmade Radionuclides (0-160 ft)
 Natural Gamma Logs (0-160 ft)
 Combination Plot (0-160 ft)
 Total Gamma & Moisture (0-160 ft)
 Total Gamma & Hanford Gamma Unit (0-160 ft)
 Repeat Section of Natural Gamma Logs (129-144 ft)
 Moisture Repeat Section (40-49 ft)

⁴ Hanford Gamma Unit



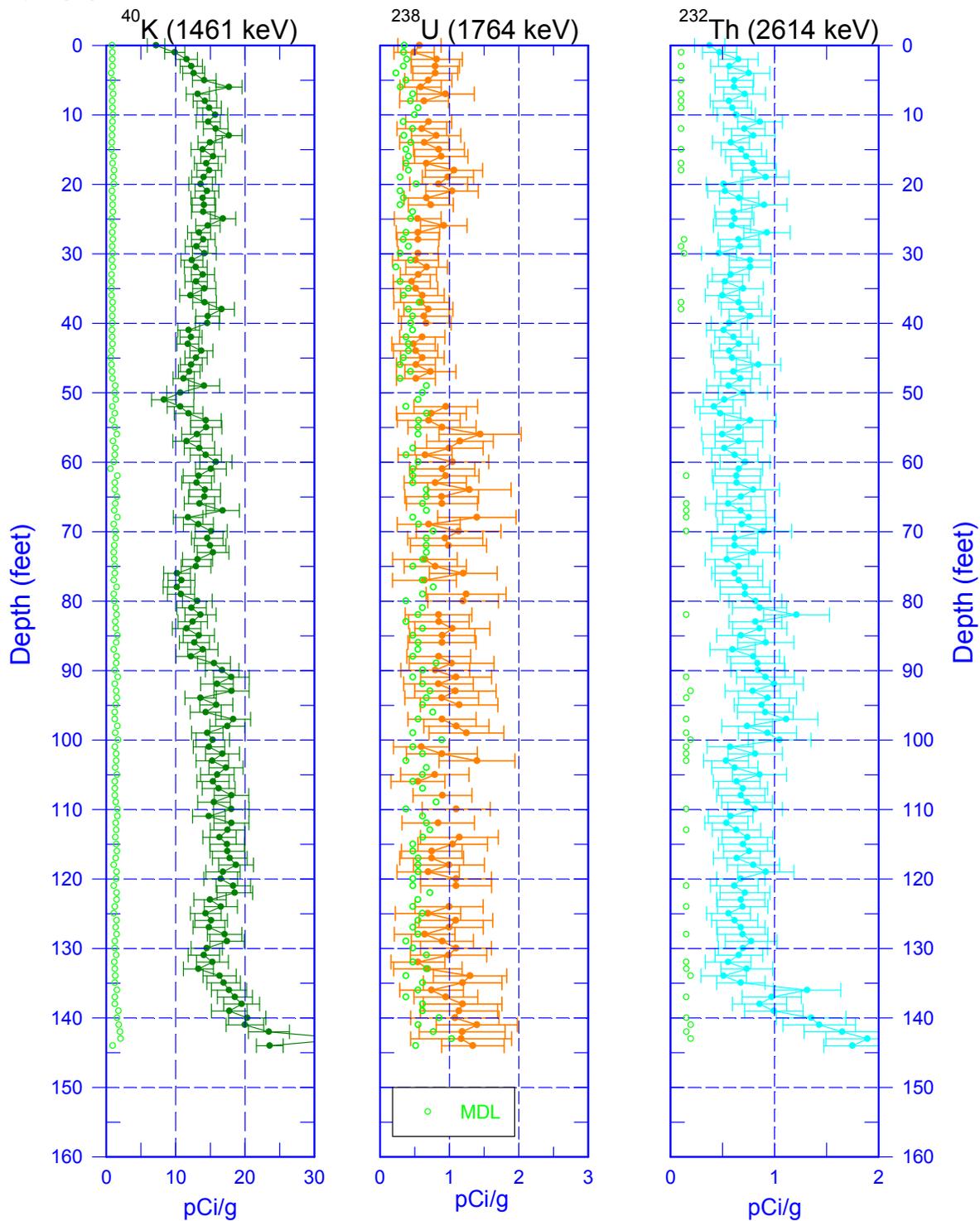
199-K-230 (C9714) Manmade Radionuclides



Zero Reference - Ground Surface

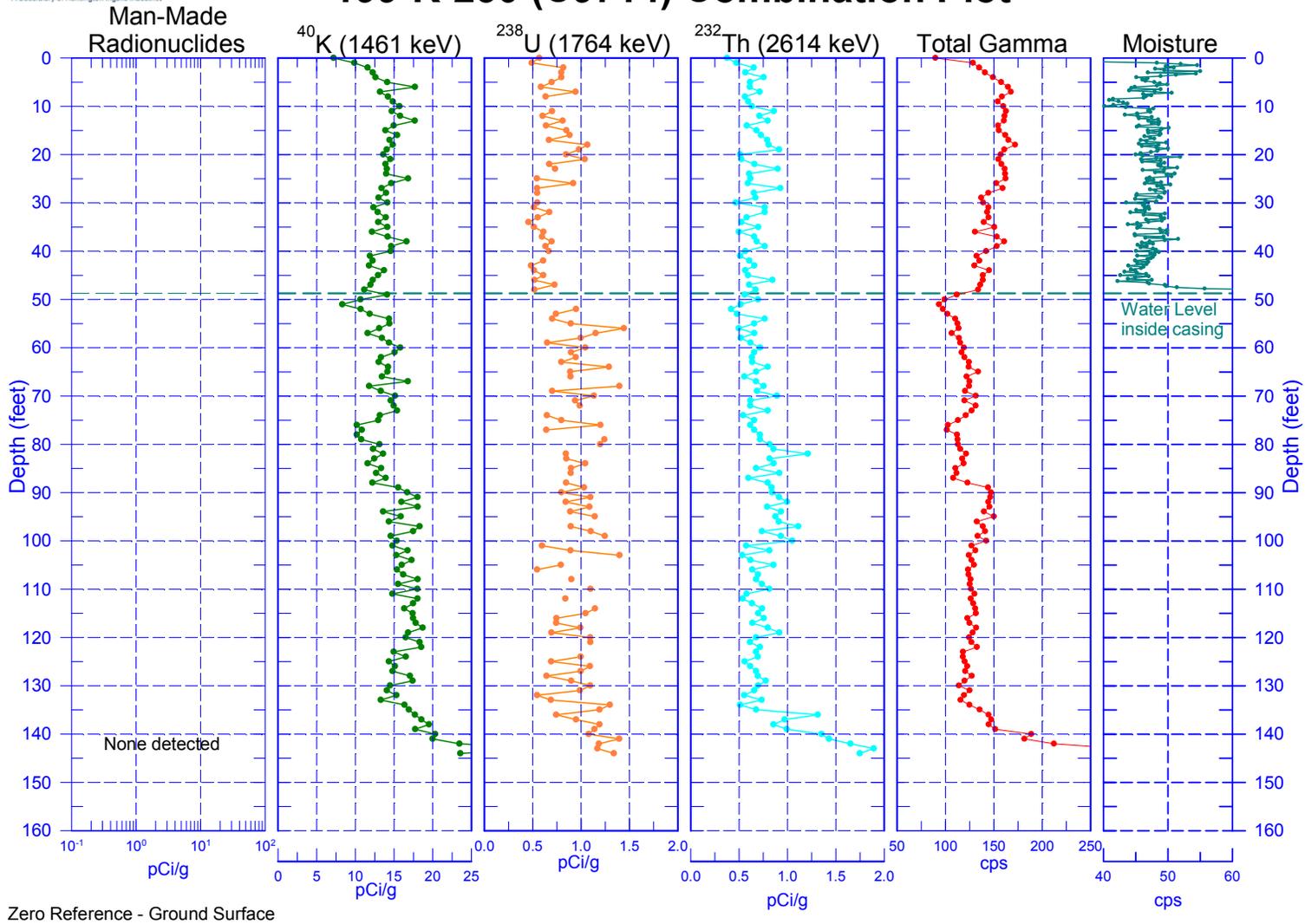


199-K-230 (C9714) Natural Gamma Logs



Zero Reference - Ground Surface

199-K-230 (C9714) Combination Plot

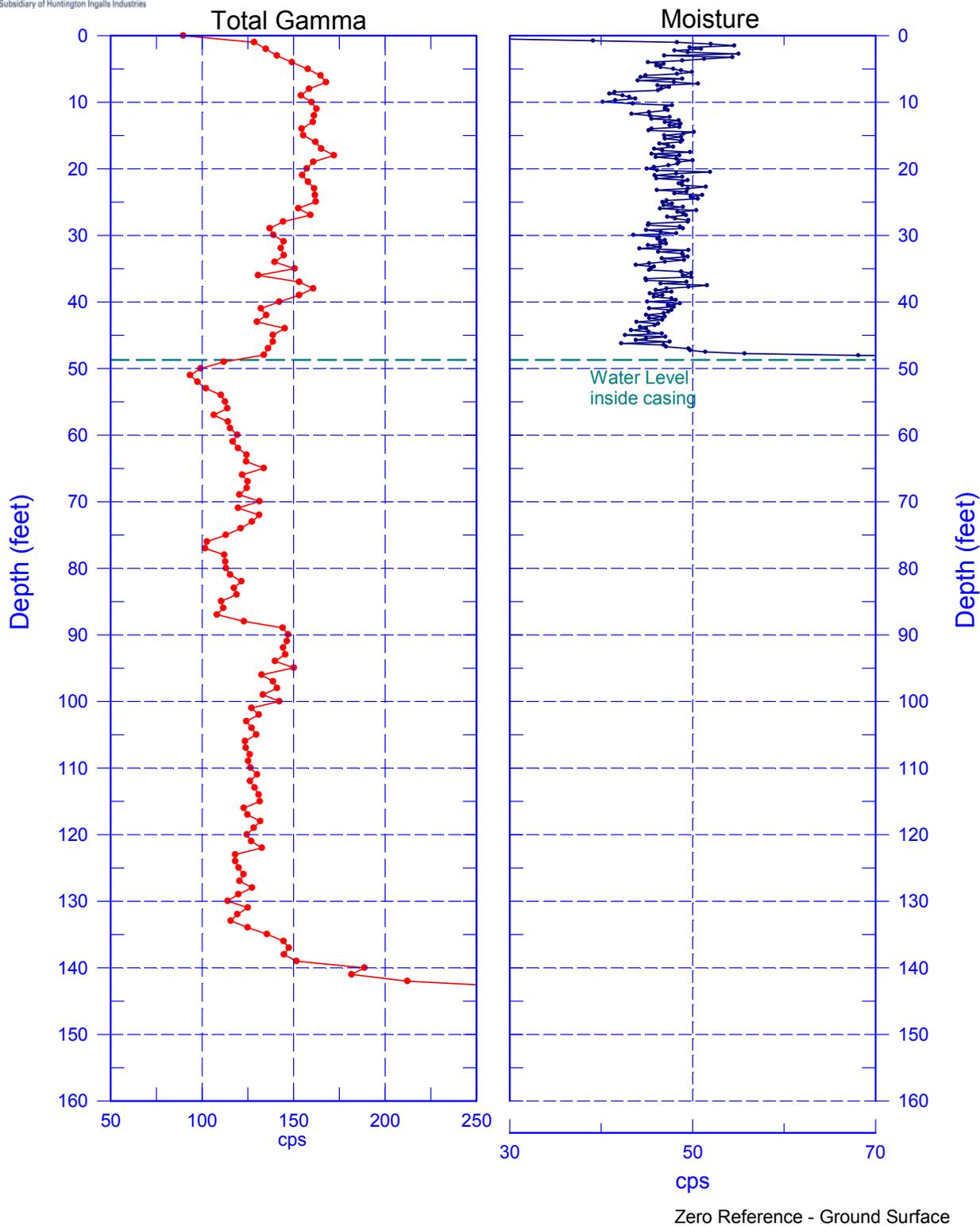


D-17

SGW-61094, REV. 0

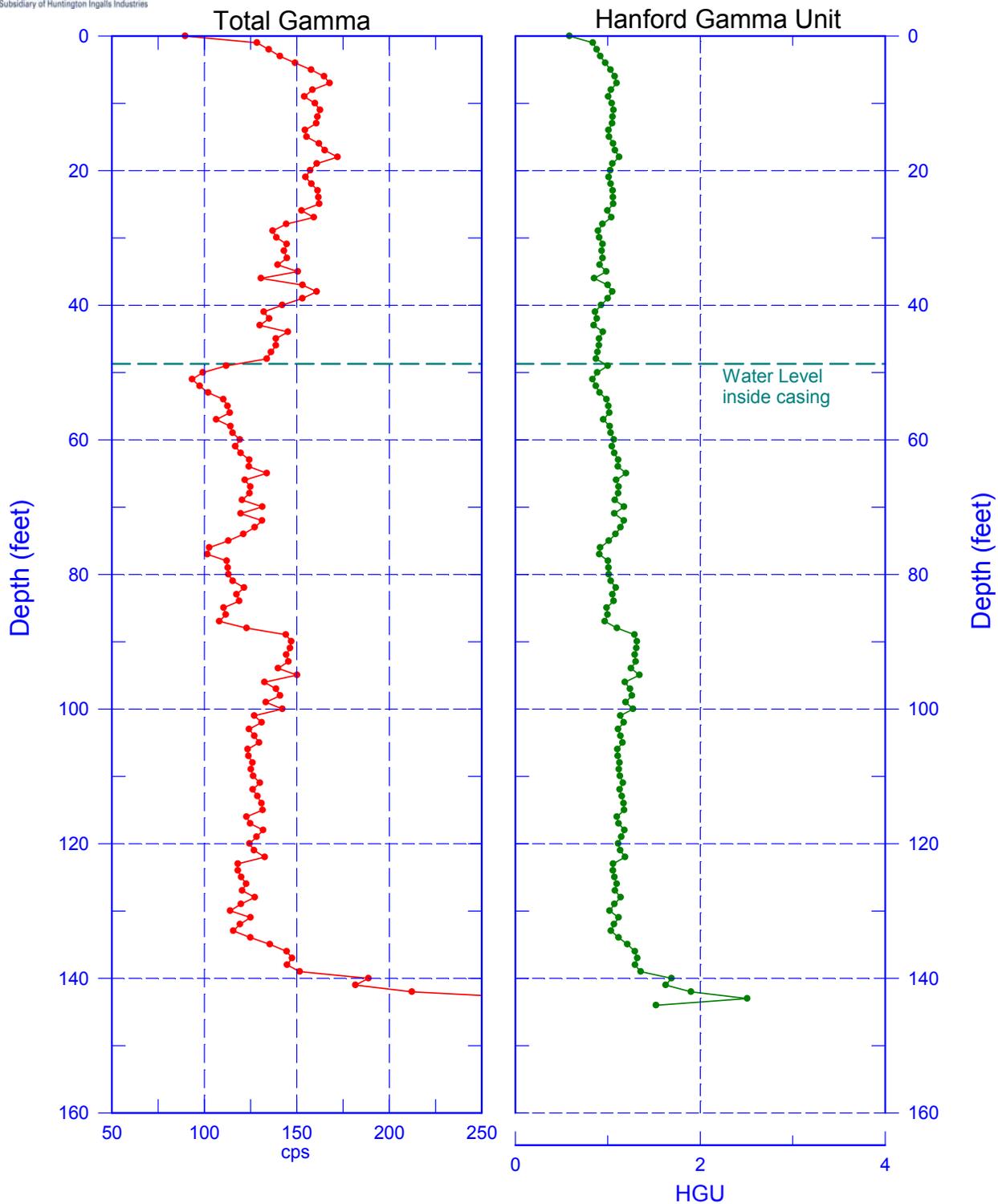


199-K-230 (C9714) Total Gamma & Moisture





199-K-230 (C9714) Total Gamma & Hanford Gamma Unit

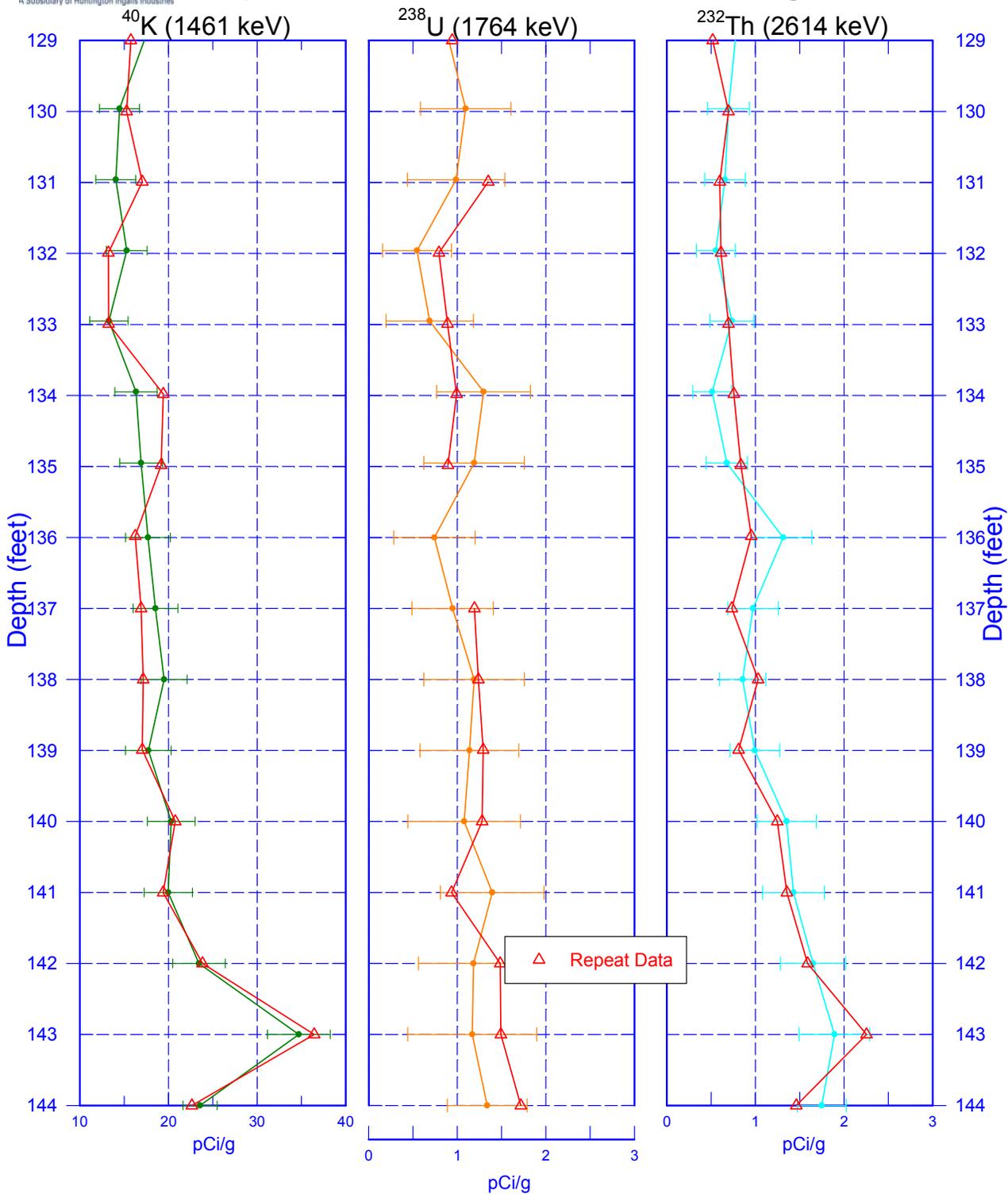


Zero Reference - Ground Surface



199-K-230 (C9714)

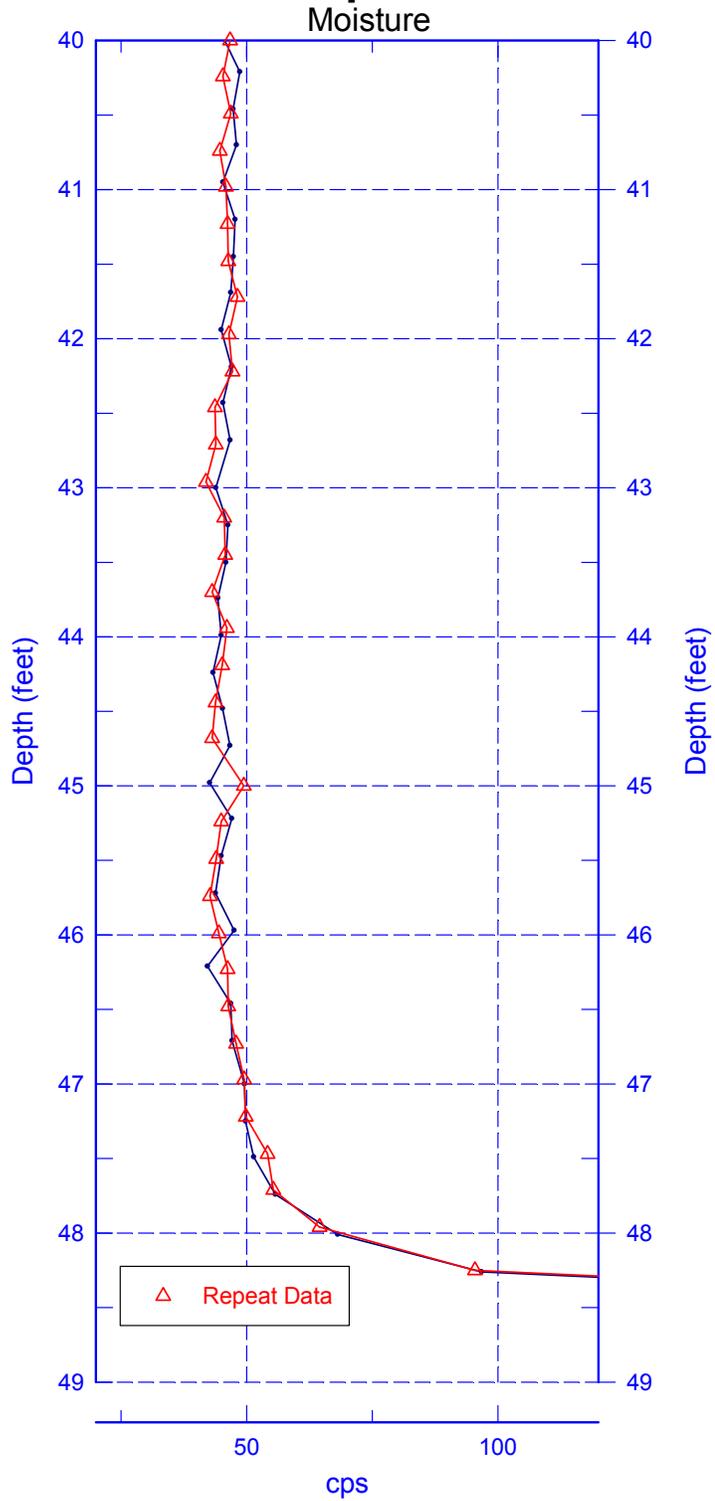
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



199-K-230 (C9714) Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

Project:	Prepared By: Neil P. Fastabend
	Company: CHPRC
Date Requested: 08/08/17	Requestor: Steven E. Imhoff (CHPRC)
Date of Survey: 09/12/17	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9714 (199-K-230) located in 100K Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 100K

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
M49 (COE) and 100K-8 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9714	199-K-230	568738.15	146759.31		Center of Casing
				136.472	Top Outer Casing, N.Edge, Stamped X
				136.164	Top Inner 6"SS Casing, N.Edge
				135.685	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.

