SGW-62438
Revision 0

Borehole Summary Report for the Installation of Wells 699-39-68 (C9607) and 699-38-64B (C9608) in the 200-UP-1 Groundwater Operable Unit, FY 2018

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

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

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Contents

1 Introduction 1

2 Drilling, Sampling, and Well Construction Activities 1

2.1 General Information 1

2.1.1 Drilling, Sampling, and Borehole Logging 3

2.1.2 Health and Safety Screening 4

2.1.3 Well Construction and Development 5

2.2 Well-Specific Information 6

2.2.1 Well 699-39-68 (C9607) 6

2.2.2 Well 699-38-64B (C9608) 9

3 Geologic Observations 11

3.1 Geology of the 200-UP-1 Operable Unit 11

3.2 Borehole Geology 12

3.2.1 Well 699-39-68 (C9607) 13

3.2.2 Well 699-38-64B (C9608) 13

4 Waste Management 14

4.1 Drill Cuttings 14

4.2 Purgewater 15

5 Civil Survey 15

6 Well Acceptance 15

7 References 16

Appendices

A Well Documentation for 699-39-68 (C9607) ..... A-i

B Well Documentation for 699-38-64B (C9608) ..... B-i

Figures

Figure 1. Hanford Site Map 2
Figure 2. Locations of the Five Planned 200-UP-1 OU Multipurpose Wells 3

Tables

Table 1. Project Well Identification and Drilling Date Summary 3
Table 2. Well Development Data Summary 7
Table 3. Sample Summary for Well 699-39-68 (C9607) 8
Table 4. Construction Summary for Well 699-39-68 (C9607) 9
Table 5. Sample Summary for Well 699-38-64B (C9608) 10
Table 6. Construction Summary for Well 699-38-64B (C9608) 11
Table 7. Civil Survey Summary 15

Terms

bgs	below ground surface
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
DOW	description of work
dpm	disintegrations per minute
Ecology	Washington State Department of Ecology
ERDF	Environmental Restoration Disposal Facility
HCl	hydrochloric acid
Holt	Holt Services, Inc.
hp	horsepower
LEL	lower explosive limit
NMLS	neutron moisture logging system
NTU	nephelometric turbidity unit
OD	outer diameter
OU	operable unit
PFP	Plutonium Finishing Plant
RCT	radiological control technician
Rlm	Ringold Formation member of Wooded Island – lower mud unit
SAP	sampling and analysis plan
SGLS	spectral gamma logging system
TD	total depth
VOC	volatile organic compound

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1 Introduction

This borehole summary report provides an overview of the well drilling and construction activities performed during installation of two multipurpose wells in the 200-UP-1 Groundwater Operable Unit (OU) in the Central Plateau region of the Hanford Site (Figure 1). SGW-60822, Rev. 1, *Description of Work for the Installation of Five Multipurpose Wells in the 200-UP-1 Operable Unit, FY 2018* (hereinafter referred to as the description of work [DOW]), is the controlling document for installation of five new wells, but only two of the five wells were installed at the time this report was prepared. The three remaining wells were postponed due to the extended work control area posted within the 200 West Area associated with the Plutonium Finishing Plant (PFP) demolition activities. Drilling of wells in the PFP work control area has been postponed until PFP demolition activities are complete.

The two multipurpose wells were drilled, constructed, and developed between January 9 and June 25, 2018, by Holt Services, Inc. (Holt) for CH2M HILL Plateau Remediation Company (CHPRC). Well site geology, well drilling documentation, and construction documentation services were provided by GRAM Northwest, LLC. Geophysical logging services were provided by Huntington Ingalls Industries.

The new wells were installed to monitor the northern extent of the iodine-129 plume and were constructed to support future injection or extraction use. Contaminants of concern for the 200-UP-1 OU include carbon tetrachloride, uranium, nitrate, chromium (total and hexavalent), iodine-129, technetium-99, and tritium. Installation of the new wells supports Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*. The wells were installed in compliance with the *Resource Conservation and Recovery Act of 1976* and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

Table 1 lists the well names, well identification numbers, Washington State Department of Ecology (Ecology) unique well tag numbers, and installation dates for the two new wells. Well summary sheets, borehole logs, geophysical log data reports, final civil survey reports, photo logs, and the well development and testing data sheets are presented in Appendix A for well 699-39-68 (C9607) and Appendix B for well 699-38-64B (C9608). Figure 2 shows the well locations.

2 Drilling, Sampling, and Well Construction Activities

This chapter summarizes the field activities associated with installing multipurpose wells 699-39-68 (C9607) and 699-38-64B (C9608).

2.1 General Information

The two new wells were constructed in accordance with WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells,” and the CHPRC construction specifications identified in the DOW (SGW-60822). All well drilling and construction activities were documented in daily field activity reports, and borehole geology was logged. The sampling activities are outlined in DOE/RL-2014-27, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit* (hereinafter referred to as the sampling and analysis plan [SAP]).

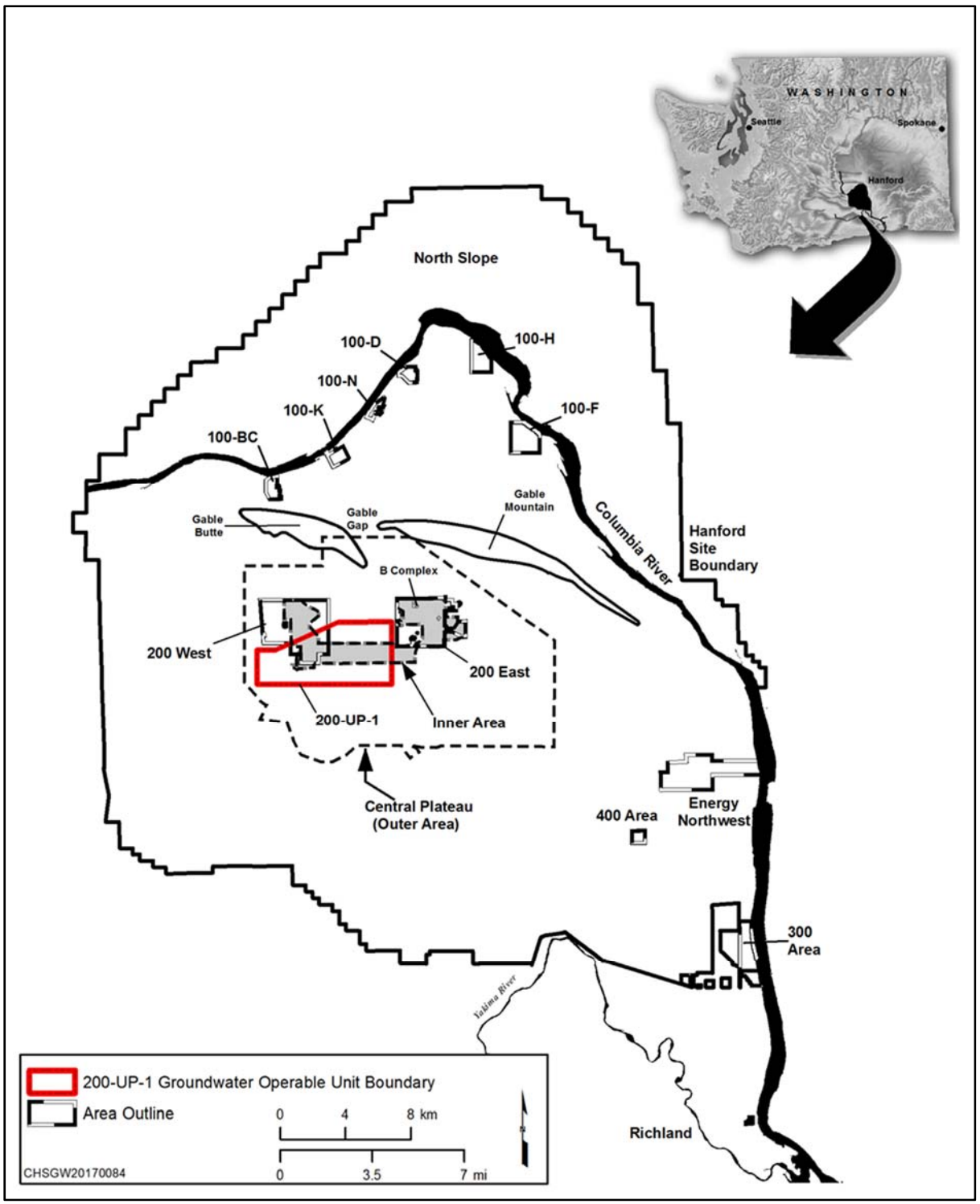

Figure 1. Hanford Site Map

Table 1. Project Well Identification and Drilling Date Summary

Well ID	Well Name	Well Installation Date		Ecology Well Tag Number
		Start	Finish	
C9607	699-39-68	1/22/2018	6/25/2018	BKG 076
C9608	699-38-64B	1/9/2018	4/3/2018	BKG 075

Ecology = Washington State Department of Ecology
ID = identification

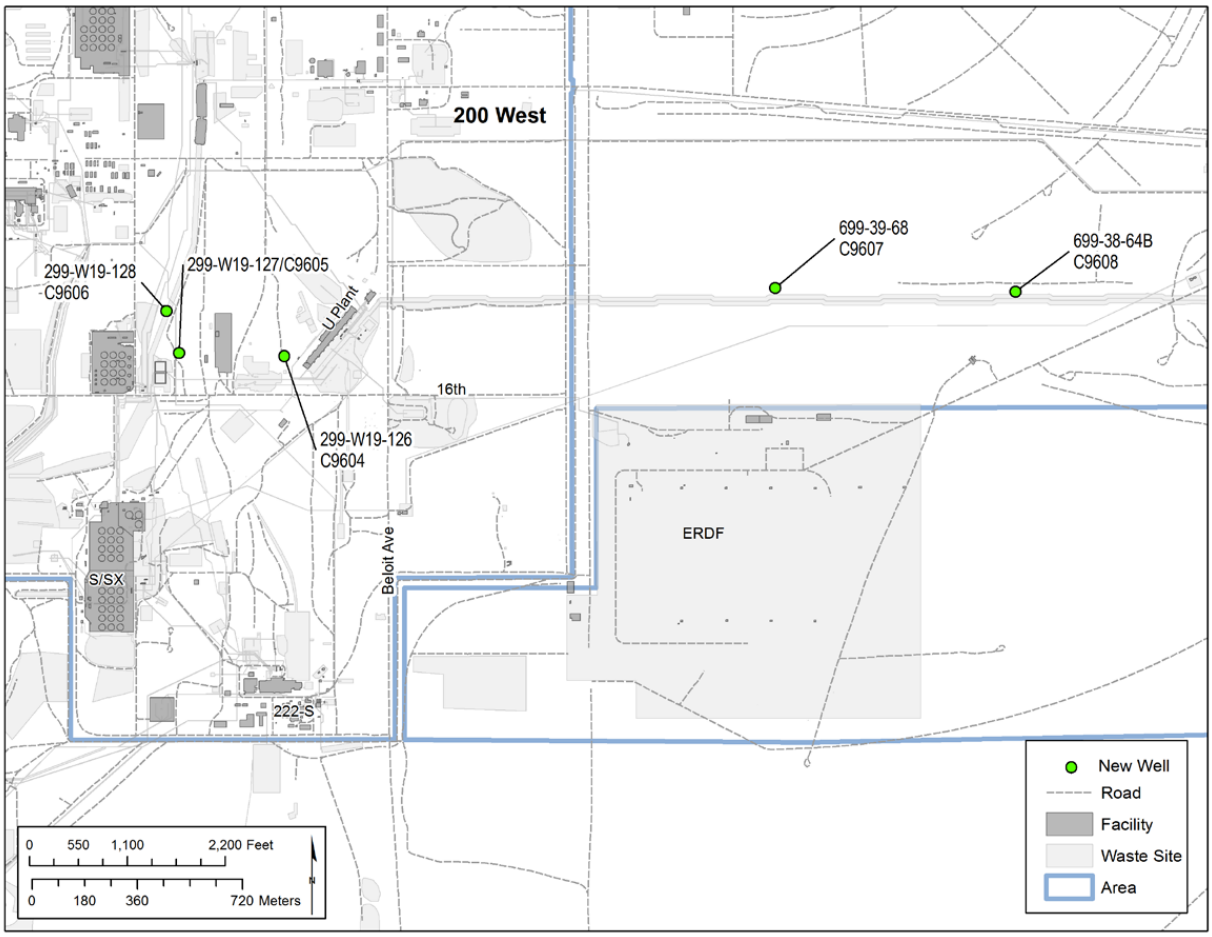

Figure 2. Locations of the Five Planned 200-UP-1 OU Multipurpose Wells

2.1.1 Drilling, Sampling, and Borehole Logging

The drilling, sampling, and borehole logging activities for installing the two new multipurpose wells are summarized in the following sections.

2.1.1.1 Drilling

Boreholes C9607 and C9608 were drilled with a Foremost DR-24[1] and a Foremost DR-24HD[1] dual rotary drill rig, respectively, operated by Holt. Each was drilled with a 16 in. outer-diameter (OD) carbon steel starter casing, and then downsized and drilled to total depth (TD) with 12 in. OD carbon steel casing. The boreholes were drilled using a combination of a 15 in. tricone bit, a 15 in. under-reamer bit, an 11 in. tricone bit, and an 11 in. under-reamer bit. All temporary casing was advanced as close as possible to TD with a 12 in. OD and 11.5 in. inner-diameter shoe. The boreholes were drilled approximately 3.0 m (10 ft) into the Ringold Formation member of Wooded Island – lower mud unit (Rlm).

2.1.1.2 Sampling

Sampling was conducted in accordance with the DOW (SGW-60822) and the SAP (DOE/RL-2014-27). Geologic grab samples were collected and archived at 1.5 m (5 ft) intervals and at major lithologic changes during the drilling of each borehole. Archive grab samples were placed in labeled pint-size glass mason jars and in labeled chip tray compartments for storage. Additional grab samples were collected every 1.5 m (5 ft) once water was encountered and then composited into 6.1 m (20 ft) sieve analysis samples. Sieve analyses of the composited samples were performed to determine particle-size distribution, and the results were used to help select the final filter pack and well screen slot size.

Three split-spoon soil samples were collected at each borehole within the saturated zone for chemical analysis. During drilling, six groundwater samples were collected at C9607 and four groundwater samples were collected at C9608. The groundwater samples were collected to identify the vertical distribution of contamination in the aquifer. A post-development groundwater sample also was collected during final development of each well. All samples collected for chemical analysis were collected by CHPRC nuclear chemical operators. Section 2.2 provides additional well-specific sampling information.

2.1.1.3 Geophysical Logging

The two boreholes were logged using a spectral gamma logging system (SGLS) to detect natural and manmade gamma-emitting radionuclides and a neutron moisture logging system (NMLS) to detect the soil moisture in the vadose zone. Each borehole was drilled using 16 in. and 12 in. temporary casing. The 16 in. temporary casing was logged prior to downsizing, and the 12 in. casing was logged after drilling was completed.

2.1.2 Health and Safety Screening

The health and safety screening included radiological field screening and air monitoring for volatile organic compounds (VOCs) and lower explosive limit (LEL), as discussed in the following sections.

2.1.2.1 Radiological Field Screening

A radiological control technician (RCT) performed radiological surveys twice daily (once in the morning and once in the afternoon) during drilling, construction, and development activities. The RCT conducted the surveys using standard radiological field screening instruments to detect any contaminants with alpha, beta, or gamma radiation on drill cuttings, geologic samples, temporary casings, and any other equipment that was used downhole. Radiological contamination was typically not detected during drilling activities at either borehole, except while constructing C9607. During construction at C9607, the last three pieces of 16 in. temporary casing pulled out of the ground had readings of 6,000 disintegrations per minute (dpm), and the drill stem had readings of 3,500 dpm. The three pieces of casing and drill stem

[1] DR-24 and DR-24HD are tradenames of Foremost Industries LP, Calgary, Alberta, Canada.

were placed in the radiological materials area at the end of the project for later disposal, as advised by the RCT.

2.1.2.2 Air Monitoring for Volatile Chemicals

Atmospheric monitoring was performed twice daily by an industrial hygiene technician during drilling activities (once in the morning and once in the afternoon). The industrial hygiene technician used a photoionization detector and a multi-gas meter to confirm acceptable atmospheric conditions during drilling. Conditions monitored using the photoionization detector included total VOCs; and conditions monitored using the multi-gas meter included carbon monoxide, hydrogen sulfide, LELs, ammonia, and oxygen. LEL wellhead monitoring was required prior to welding activities. Areas monitored for VOCs included the driller's breathing zone near the wellhead, the wellhead or source, any fresh drill cuttings and geologic samples, and any other areas of potential concern.

Very low to nonexistent levels of the monitored agents were detected downhole during drilling activities. VOCs were not detected in the breathing zone at either borehole location. Additionally, the LEL was never above 0% at either of the borehole locations.

2.1.3 Well Construction and Development

This section provides additional details on the well construction and development activities.

2.1.3.1 Screen and Casing Materials

Each well was constructed using 8-1/16 in. OD, 8 in. inner-diameter, Schedule 10S Type 304/304L stainless-steel blanks, screens, and sumps. Screens used at both wells were continuous vee-wire wrap with 50-slot (0.050 in.) apertures, and each well used a 3.0 m (10 ft) sump (i.e., 3.0 m [10 ft] of blank with a welded endcap) located below the lowest screened interval. Section 2.2 provides further details on the construction materials used for each well.

2.1.3.2 Well Completion

A straightness test was conducted in each well with a tool that was 6.1 m (20 ft) in length with a 10-3/4 in. OD. The test was conducted prior to setting the permanent well in accordance with WAC 173-160 requirements.

The screen size and filter pack size used for construction were determined based on sieve analysis results, geologic borehole logs, and intended well use. The two wells were constructed with a filter pack consisting of 8-16 mesh Colorado silica sand. The filter pack was settled using a dual-flange surging method.

The annular seals for the two wells used 3/8 in. coated bentonite pellets immediately above the silica filter pack of the uppermost screened interval as an approximate 0.9 m (3 ft) seal, followed by granular bentonite 8-20 chips. The granular bentonite was placed from the top of the bentonite pellet seal to approximately 3 m (10 ft) below ground surface (bgs). Type I/II Portland neat cement was used for the surface seal and was placed from the top of the granular bentonite to the ground surface. Any remaining unfilled annular space was filled with high-strength concrete during well pad construction.

The permanent casing was then surrounded by a stainless-steel protective monument with a unique Ecology well tag number riveted to the monument. Each well had a 1.2 m by 1.2 m by 15.2 cm (4 ft by 4 ft by 6 in.) thick concrete pad constructed around the wellhead protective monument. The wells are located within the center of the concrete pad with a brass surveyor's marker (stamped with the well name, identification number, and date of final construction) imbedded on the northern side of the pad. The monuments have a lockable cap, and the lock hasps were positioned to face northward. Four steel

posts (1.8 m [6 ft] long and 7.6 cm [3 in.] diameter, all of which are removable) were placed at the four corners of each concrete pad with 0.9 m (3 ft) stickup for wellhead protection. The posts for each well were painted yellow in accordance with ANSI Z535.1-1991, *Safety Color Code*, for increased visibility of physical hazards. Section 2.2 provides further details on well construction.

2.1.3.3 Final Well Development

Final well development for the two wells was conducted during construction activities, after the filter pack was added and settled and before the bentonite seal was placed. Each well was developed using multiple 6.1 m (20 ft) development intervals with an electric submersible pump. The groundwater was pumped while water quality parameters (turbidity, conductivity, dissolved oxygen, pH, and temperature) were monitored. Each development interval was completed when the turbidity read <5 nephelometric turbidity units (NTUs) and the remaining water quality parameters stabilized. A LevelTROLL® 700 data logger was used to record the drawdown and recovery data during development activities. Table 2 provides the final water quality data for each well interval. Appendices A and B, respectively, provide the well development and testing data sheets for each well.

2.1.3.4 Washington State Department of Ecology Well Identification

Each well received a unique Ecology well identification number that was embossed onto a stainless-steel tag and riveted to the protective monument. When the monuments were set, all identification tags were set to face toward the north. Table 1 lists the Ecology tag numbers and their associated wells.

2.2 Well-Specific Information

This section summarizes the drilling, air monitoring, sampling, geophysical logging, construction, and development activities specific to each well.

2.2.1 Well 699-39-68 (C9607)

Well 699-39-68 (C9607) was installed between January 22 and June 25, 2018. The borehole was drilled to a TD of 140.71 m (461.65 ft) bgs on February 26. Drilling began on January 22 using a Foremost DR-24 dual rotary rig. The temporary casing used was 16 in. OD and 12 in. OD carbon steel with welded joints. The 16 in. casing was advanced to a depth of 61.49 m (201.74 ft) bgs on January 24. The 12 in. casing was advanced to a depth of 140.14 m (459.79 ft) bgs on February 26.

Sampling at C9607 included collecting soil samples for geologic archival purposes, composited soil sieve samples for determining particle-size distribution (sieve analysis), three split-spoon samples for chemical analysis, and six groundwater samples for chemical analysis. Geologic archive soil samples were collected by the field geologist at 1.5 m (5 ft) intervals and at lithology changes throughout the borehole. Samples for sieve analysis were collected as 6.1 m (20 ft) composites of each 1.5 m (5 ft) soil grab sample from the top of the water table to the top of the Rlm. Split-spoon samples were collected approximately 3.0 m (10 ft) below the water table and at every other water sample depth (approximately every 6.1 m [20 ft]) to TD. Groundwater samples were collected at approximately 6.1 m (20 ft) below the water table and at approximately every 6.1 m (20 ft) thereafter to TD. Static water was tagged at 96.80 m (317.60 ft) bgs on June 11. Table 3 provides summary information for the samples collected for chemical analysis.

LevelTROLL® is a registered trademark of In-Situ, Inc., Fort Collins, Colorado.

Table 2. Well Development Data Summary

Well ID	Well Name	Date Developed	Initial Water Level (ft bgs)	Pump Intake Depth (ft bgs)	Duration Pumped (minutes)	Average Flow Rate (gpm)	Maximum Drawdown (ft)	Final Turbidity (NTU)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	pH	Temperature (°C)	Total Gallons Pumped
C9607	699-39-68	6/5/2018 through 6/6/2018	317.30	448.74	174	200	20.08	7.50*	675	9.48	7.48	21.8	34,800
		6/6/2018		407.74	82	210	20.60	4.13	686	11.12	7.54	22.8	17,220
		6/7/2018		365.74	29	210	18.97	4.16	692	9.95	7.50	21.3	6,090
C9608	699-38-64B	3/19/2018 through 3/22/2018	327.95	394.83	428	75	32.10	4.77	773	9.05	7.72	18.9	33,790
		3/22/2018		384.47	77	75	31.91	4.86	756	9.89	7.50	16.2	5,775

* The CH2M HILL Plateau Remediation Company buyer's technical representative and hydrogeologist approved the >5 NTU parameter for the first development interval.

bgs = below ground surface
gpm = gallons per minute
ID = identification
NTU = nephelometric turbidity unit

Table 3. Sample Summary for Well 699-39-68 (C9607)

Sample Date	Sample Interval	Sample Depth (ft bgs)	Sample Medium	Sample Method	HEIS Number
2/8/2018	I-001	333.97	Water	Pumped	B3H7W5, B3H7W6, B3H7W7, B3H7W8, B3H7W9, B3H913
2/8/2018	I-002	334.01 – 335.81	Soil	Split spoon	B3H7W1
2/12/2018	I-003	343.71	Water	Pumped	B3H7X0, B3H7X1, B3H7X2, B3H7X3, B3H7X4, B3H914
2/12/2018	I-004	344.60 – 345.10	Soil	Split spoon	B3H7W2
2/14/2018	I-005	365.70	Water	Pumped	B3H7X5, B3H7X6, B3H7X7, B3H7X8, B3H7X9, B3H915
2/13/2018	I-006	365.10 – 365.60	Soil	Split spoon	B3H7W3
2/14/2018	I-007	382.52	Water	Pumped	B3H7Y0, B3H7Y1, B3H7Y2, B3H7Y3, B3H7Y4, B3H916
2/15/2018	I-008	403.41	Water	Pumped	B3H7Y5, B3H7Y6, B3H7Y7, B3H7Y8, B3H7Y9, B3H917
2/21/2018	Contingency 1	421.53	Water	Pumped	B3H808, B3H919, B3H806, B3H807, B3H805, B3H809
6/6/2018	Post-development	449.74	Water	Pumped	B3H800, B3H801, B3H802, B3H803, B3H804, B3H918

bgs = below ground surface
HEIS = Hanford Environmental Information System

A borehole geophysical survey using the NMLS and the SGLS was conducted at the borehole prior to well construction. NMLS was performed from the surface to 60.4 m (198.0 ft) bgs through the 16 in. OD temporary casing on January 25 and from 60.1 to 96.8 m (197.0 to 317.5 ft) bgs through the 12 in. OD temporary casing on February 28. SGLS was performed from the surface to 60.4 m (198.0 ft) bgs on January 25 through the 16 in. OD temporary casing and from 60.7 to 140.5 m (199.0 to 461.0 ft) bgs on February 26 and 27 through the 12 in. OD temporary casing. Manmade radionuclides were not detected in the borehole. Appendix A provides the geophysical logging report for C9607 (HGLP-LDR-1047).

Well completion activities began on April 9. Holt performed a straightness test with a 6.1 m (20 ft) long, 10-3/4 in. OD tester. The tester passed through the 12 in. temporary casing without binding. Well installation began on April 9 using 8 in. inner-diameter, Schedule 10S Type 304/304L stainless-steel blank casing, screen, and sump. A total of 45.7 m (150.0 ft) of continuous vee-wire wrap, stainless-steel screen with 0.050 in. apertures was used. Stainless-steel centralizers were placed at the bottom and top of the screen intervals and at 12.2 m (40 ft) intervals within and above all subsequent screens. Table 4 provides information on the well construction materials and associated depths for C9607, and Appendix A provides the well summary sheet.

Table 4. Construction Summary for Well 699-39-68 (C9607)

Borehole Total Depth (ft bgs)	Static Water Level (ft bgs)	8 in. Diameter, Stainless-Steel Well Materials			Annular Materials		
		Material	Interval (ft bgs)	Screen Slot Size (in.)	Material	Interval (ft bgs)	Mesh Size
461.65	317.60	Stainless-steel monument	+3.30 – 1.70	N/A	Portland cement	0.00 – 9.50	Type I/II
		Stainless-steel blank casing	+2.25 – 298.72	N/A	Bentonite chips	9.50 – 293.73	8-20
		Stainless-steel screen	298.72 – 448.72	0.050	Bentonite pellets	293.73 – 295.98	3/8 in.
		Stainless-steel sump	448.72 – 458.72	N/A	Filter pack sand	295.98 – 461.65	8-16

bgs = below ground surface
N/A = not applicable

Well development at C9607 was performed during construction, prior to adding the final bentonite seal. Development operations were conducted from June 5 to June 7. A total of three intervals at 12.1 m (40 ft) increments were needed to complete development using a 30-horsepower (hp) submersible pump. The average purge rate for all intervals was 757.1 L/min (200 gal/min). For all development intervals, the requirement was to pump until the turbidity decreased to <5 NTUs and until other key parameters (specific conductance, pH, and temperature) stabilized. A total of 219,970.3 L (58,110 gal) of water was purged during development. Table 2 presents the results for all three stages of development for this well, and Appendix A provides the well development and testing data sheet.

2.2.2 Well 699-38-64B (C9608)

Well 699-38-64B (C9608) was installed between January 9 and April 3, 2018. The borehole was drilled to a TD of 124.89 m (409.77 ft) bgs. Drilling began on January 9 using a Foremost DR-24HD dual rotary rig. The temporary casings used were 16 in. and 12 in. OD carbon steel with welded joints. The 16 in. casing was advanced to a depth of 59.73 m (195.96 ft) bgs on January 11, and the 12 in. casing was advanced to a depth of 124.89 m (409.77 ft) bgs on February 5.

Sampling at C9608 included collecting soil samples for geologic archival purposes, composited soil sieve samples for determining particle-size distribution (sieve analysis), three split-spoon samples for chemical analysis, and four groundwater samples for chemical analysis. Geologic archive soil samples were collected by the field geologist at 1.5 m (5 ft) intervals and at lithology changes throughout the borehole. Samples for sieve analysis were collected as 6.1 m (20 ft) composites of each 1.5 m (5 ft) soil grab sample from the top of the water table to the top of the Rlm. Split-spoon samples were collected approximately 6.1 m, 9.1 m, and 15.2 m (20 ft, 30 ft, and 50 ft) below the water table. Groundwater samples were collected at approximately 6.1 m, 9.1 m, and 15.2 m (20 ft, 30 ft, and 50 ft) below the water table during drilling; a single groundwater sample was also collected during well development. Static water was tagged at 99.91 m (327.79 ft) on April 3. Table 5 provides summary information for samples collected for chemical analysis.

Table 5. Sample Summary for Well 699-38-64B (C9608)

Sample Date	Sample Interval	Sample Depth (ft bgs)	Sample Medium	Sample Method	HEIS Number
1/30/2018	I-001	354.29	Water	Pumped	B3H6V5, B3H6V6, B3H6V7, B3H6V8, B3H6V9, B3H8W9
1/29/2018	I-002	353.25 – 355.75	Soil	Split spoon	B3H742
1/31/2018	I-003	364.33	Water	Pumped	B3H6W0, B3H6W1, B3H6W2, B3H6W3, B3H6W4 B3H8X0
1/31/2018	I-004	363.74 – 366.24	Water	Pumped	B3H743
2/1/2018	I-005	382.34	Soil	Split spoon	B3H6W5, B3H6W6, B3H6W7, B3H6W8, B3H6W9 B3H8X1
2/1/2018	I-006	382.48 – 384.98	Water	Pumped	B3H744
3/21/2018	Post-development	394.83	Water	Pumped	B3H 6X0, B3H6X1, B3H6X2, B3H6X3, B3H8X2, B3H6X4

bgs = below ground surface
HEIS = Hanford Environmental Information System

Geophysical logging using the NMLS was performed from the surface to 59.2 m (194.1 ft) bgs through the 16 in. OD temporary casing on January 15, and from 58.8 to 106.7 m (193.0 to 350.0 ft) bgs through the 12 in. OD temporary casing on February 7. SGLS was performed from the surface to 59.1 m (194.0 ft) bgs on January 15 through the 16 in. OD temporary casing. Logging with the SGLS also was performed through the 12 in. OD temporary casing over the course of 2 days: from 59.4 to 76.2 m (195.0 to 250.0 ft) bgs on February 7, and then from 76.5 to 124.4 m (251.0 to 408.0 ft) bgs on February 8. Manmade radionuclides were not detected in the borehole. Appendix B provides the geophysical logging report for C9608 (HGLP-LDR-1046).

Well completion activities began on February 21. Holt performed a straightness test with a 6.1 m (20 ft) long, 10-3/4 in. OD tester. The tester passed through the 12 in. temporary casing without binding. Well installation began on February 22 using 8 in. inner-diameter, Schedule 10S Type 304/304L stainless-steel blank casing, screen, and sump. A total of 30.5 m (100.0 ft) of continuous vee-wire wrap, stainless-steel screen with 0.050 in. apertures was used. Stainless-steel centralizers were placed at the bottom and top of the screen interval, every 12.2 m (40 ft) within the screened interval, and every 12.2 m (40 ft) thereafter. Table 6 provides information on the well construction materials and associated depths for C9608, and Appendix B provides the well summary sheet.

Well development at C9608 was performed during construction, prior to adding the final bentonite seal. Development operations were conducted from March 19 to March 22. A total of two intervals at 3.0 m (10 ft) increments were needed to complete development using a 30-hp submersible pump. The average purge rate for all intervals was 283.9 L/min (75 gal/min). For all development intervals, the requirement was to pump until the turbidity decreased to <5 NTUs and until other key parameters (specific conductance, pH, and temperature) stabilized. A total of 179,996.3 L (47,550 gal) of water was purged during development. Table 2 presents the results for the two stages of development for this well, and Appendix B provides the well development and testing data sheet.

Table 6. Construction Summary for Well 699-38-64B (C9608)

Borehole Total Depth (ft bgs)	Static Water Level (ft bgs)	8 in. Diameter, Stainless-Steel Well Materials			Annular Materials		
		Material	Interval (ft bgs)	Screen Slot Size (in.)	Material	Interval (ft bgs)	Mesh Size
409.77	327.79	Stainless-steel monument	+3.13 – 1.87	N/A	Portland cement	0.00 – 10.50	Type I/II
		Stainless-steel blank casing	+2.30 – 295.61	N/A	Bentonite chips	10.50 – 288.23	8-20
		Stainless-steel screen	295.61 – 395.62	0.050	Bentonite pellets	288.23 – 291.80	3/8 in.
		Stainless-steel sump	395.62 – 405.61	N/A	Filter pack sand	291.80 – 405.20	8-16
					Bentonite pellets	405.20 – 408.53	3/8 in.
					Natural fill	408.53 – 409.77	N/A

bgs = below ground surface
N/A = not applicable

3 Geologic Observations

This chapter summarizes the general geology of the 200-UP-1 OU and the geology encountered at each of the well sites during drilling.

3.1 Geology of the 200-UP-1 Operable Unit

The 200-UP-1 OU underlies the southern portion of the 200 West Area and includes the Environmental Restoration Disposal Facility (ERDF). The stratigraphy of this area is comprised of several different sedimentary deposits that lie above the Columbia River Basalt Group. The major units that are found in the 200 West Area include the following (from youngest to oldest):

- Holocene eolian deposits, disturbed sediments, and recent sand and gravel backfill
- Pleistocene sand and gravel sediments of the Hanford formation
- Post-Ringold/pre-Hanford fine-grained calcareous sediments of the Cold Creek unit (CCU)
- Miocene-Pliocene Ringold Formation sediments:
  - Sand and gravel sediments of the Ringold Formation member of Wooded Island – unit E (hereinafter referred to as Ringold unit E)
  - Fine-grained sediments of the Rlm
  - Sand and gravel of the Ringold Formation member of Wooded Island – unit A (hereinafter referred to as Ringold unit A)
- Miocene Elephant Mountain Member of the Saddle Mountains Basalt of the Columbia River Basalt Group

The Pleistocene Hanford formation is divided into three facies including gravel-dominated, sand-dominated, and slackwater cataclysmic flood and interflood deposits that resulted from the Missoula floods that occurred 15,000 to 12,000 years ago (SGW-60822). The gravel-dominated facies are highly mafic due to a basaltic composition, ranging from approximately 50% to 80%.
The sand-dominated facies consists of approximately 50% mafic and 50% quartz-feldspar that is relatively thicker than the gravel-dominated facies and predominantly horizontally laminated of fine- to coarse-grained sand. Below the Hanford formation is the CCU, which consists of fine-grained calcareous sediments and represents mainstream alluvial, calcic paleosol, side stream alluvial, colluvial, and overbank-aeolian environments marginal to the ancestral Columbia River. The Ringold Formation is below the CCU and consists of semiconsolidated fluvial silt, sand, and mostly gravels of Ringold unit E, along with paleosol and lacustrine clay and silt of the Rlm below Ringold unit E (SGW-60822). For this project, drilling did not continue below the Rlm; therefore, the underlying Ringold unit A and Columbia River Basalt Group were not encountered.

Additional information regarding the geology of the 200 West Area is presented in the following:

- BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*
- BHI-01203, *Nature and Variability of the Plio-Pleistocene Unit in the 200 West Area of the Hanford Site*
- DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for the Post-Ringold-Formation Sediments Within the Central Pasco Basin*
- PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*
- WHC-SD-EN-TI-014, *Hydrogeologic Model for the 200 West Groundwater Aggregate Area*

Summaries of geologic units encountered throughout each borehole are presented in the following discussion.

3.2 Borehole Geology

This section describes the geologic characteristics and stratigraphic units that were observed from grab samples during drilling of the two new boreholes (C9607 and C9608). Appendices A and B provide the respective borehole logs.

The interpretations included in this report regarding the stratigraphy of each drill site are based on field observations from drill cuttings collected every 1.5 m (5 ft) or where major lithologic changes occurred; therefore, the depths of contacts included should be viewed as approximations. Final stratigraphic unit contacts will be determined during the remedial investigation data review and will incorporate the field observations, borehole geophysical logging data, and regional stratigraphic interpretations.

Due to the drilling method used, grab samples may appear more angular than the actual formation. Samples also could consist of less fine-grained sediments due to a graded effect when being lifted out of the ground, along with fines being washed away with the water used to aid in cuttings removal and/or within the water table (which cause the sample to appear coarser). Samples may also have a weaker reaction to 10% diluted hydrochloric acid (HCl) in the presence of water. The following sections discuss the determination of estimated stratigraphic unit contacts for each of the borehole summaries.

3.2.1 Well 699-39-68 (C9607)

Well 699-39-68 (C9607) is located south of the 200 West Area, approximately 101.0 m (330 ft) north of ERDF. The major stratigraphic units encountered include the Hanford formation, lower CCU, Ringold unit E, and Rlm.

The Hanford formation was observed from just under the drill pad to a depth of 54.86 m (180 ft) bgs. The soil classifications for the formation include sand, gravelly silty sand, gravelly sand, and sandy gravel. The sand ranged from 60% to 70% felsic, and the gravel ranged from 40% to 50% felsic. No reaction to moderate reaction with HCl was observed throughout the Hanford formation. The gravel angularity observed was angular to round. Sand grain size ranged from very fine to very coarse (62.5 µm to 2 mm). Gravel size ranged from very fine to very coarse pebbles (2 to 64 mm). The maximum gravel size observed was 43 mm (very coarse pebble).

The lower CCU was observed from 54.9 to 93.0 m (180 to 305 ft) bgs, evidenced by strong reactions to acid when tested with HCl. Soil classifications observed within the lower CCU include silt, sandy gravel, slightly silty-gravelly sand, gravelly sand, sandy silt, gravelly silt, gravelly sandy silt, and silty gravel. The sand ranged from 40% to 70% felsic material. Caliche fragments 3 to 8 mm thick were observed between 76.2 and 77.7 m (250 and 255 ft) bgs. The gravel ranged from 30% to 70% felsic material. The sediment angularity ranged from angular to subrounded. Sand grain size ranged from very fine to very coarse (62.5 µm to 64 mm). The gravel ranged from very fine to coarse pebbles (2 to 32 mm). The maximum gravel size observed was 25 mm (coarse pebble).

The contact between the lower CCU and Ringold unit E was at approximately 93.0 m (305 ft) bgs, evidenced by weak to no reaction to acid when tested with HCl. The soil classifications for Ringold unit E include sandy gravel and gravel. Sand composition ranged from 40% to 80% felsic material. The gravel composition ranged from 40% to 60% felsic material. There was weak to no HCl reaction throughout the formation. Gravel angularity ranged from angular to round. Sand grain size ranged from very fine to very coarse grain (62.5 µm to 2 mm). Gravel ranged from very fine pebbles to small cobbles (2 to 128 mm). The maximum gravel size was 76 mm (small cobble).

The contact between Ringold unit E and the Rlm was at approximately 136.9 m (449 ft) bgs, and the Rlm was observed to a TD of 140.71 m (461.65 ft) bgs. The soil classification for the Rlm was mud. At 136.9 m (449 ft) bgs and below, there was rigid clay and clay in suspension in the drilling water with sand and gravel. The Rlm did not have a reaction when tested with HCl and was yellowish-brown in color. Sand grain size ranged from very fine to very coarse (62.5 µm to 2 mm). Gravel ranged from very fine to very coarse pebbles (2 to 64 mm). The maximum gravel size was 40 mm (very coarse pebble).

The final static water level was measured at 96.80 m (317.60 ft) bgs on June 11, 2018. Appendix A provides the borehole log for C9607.

3.2.2 Well 699-38-64B (C9608)

Well 699-38-64B (C9608) is located south of the 200 West Area, approximately 0.8 km (0.5 mi) northeast of ERDF. The major stratigraphic units encountered while drilling included the Hanford formation, Ringold unit E, and Rlm.

The Hanford formation was observed from just under the drill pad to approximately 91.4 m (300 ft) bgs. The soil classifications for the Hanford formation include sand, gravelly sand, and gravelly silty sand. The overall sand composition was predominantly felsic, ranging from 50% to 70%. The overall gravel composition was also predominantly felsic, ranging from 40% to 65% when gravel was present. Sediment reactions to HCl ranged from strong to no reaction but were mostly moderate to weak. The sediment

angularity ranged from angular to subround. Sand grains ranged from very fine to very coarse (62.5 µm to 2 mm). Gravel ranged from very fine to coarse pebbles (2 to 32 mm). The maximum gravel size was 25 mm (coarse pebble).

The contact between the Hanford formation and the underlying Ringold unit E was observed by a change from sand-dominated to gravel-dominated sediment. Ringold unit E was encountered from approximately 91.4 to 121.0 m (300 to 397 ft) bgs. The Ringold unit E soil classifications include gravelly sand, sandy gravel, silty gravel, and silty-sandy gravel. Sands were angular to subangular, fine to very coarse (125 µm to 2 mm), and 50% to 55% felsic. Gravels were angular to subround, 50% to 55% felsic, and very fine to very coarse (2 to 64 mm), with a maximum gravel size of 50 mm (very coarse pebble). Reactions to HCl within Ringold unit E ranged from strong to no reaction but were mostly nonreactive.

From 91.4 to 96.0 m (300 to 315 ft) bgs, the gravelly sand was composed of 90% fine to coarse sand and 10% very fine to fine gravels, was moist, and exhibited a strong reaction to HCl and an overall color of dark yellowish-brown. From 96.0 to 100.6 m (315 to 330 ft) bgs, the soil (sandy gravel) was composed of 50% to 60% medium to very coarse sand, 30% to 40% very fine to coarse gravels, and 10% silt; was wet; and exhibited no reaction to HCl with an overall color of dark yellowish-brown. From 100.6 to 108.2 m (330 to 355 ft) bgs, the soil (silty-sandy gravel) was composed of 70% to 75% very fine to very coarse gravels, 15% to 20% silt, and 10% coarse to very coarse sand; was wet; exhibited no reaction to HCl; and had an overall color of dark yellowish-brown. From 108.2 to 120.4 m (355 to 395 ft) bgs, the soil (silty-sandy gravel) was composed of 50% to 60% very fine to coarse gravels, 20% medium to very coarse sand, and 20 to 30% silt; was wet; exhibited no reaction to HCl; and had an overall color of dark yellowish-brown.

The contact with the underlying Rlm was gradational, indicated by a change in lithology from gravel-dominated to silt-dominated. The Rlm was encountered from 120.4 m (395 ft) bgs to the TD of 124.89 m (409.77 ft) bgs. The soil classification was mud that was moist with high plasticity, exhibited no reaction to HCl, and was light olive-brown in color.

A final static water level was measured at 99.91 m (327.79 ft) bgs on April 3, 2018. Appendix B provides the borehole log for C9608.

4 Waste Management

Waste generated during installation of the two monitoring wells included drill cuttings, purgewater, and miscellaneous solid waste. Waste was managed in accordance with CERCLA and DOE/RL-2016-13, *Waste Management Plan for the 200-UP-1 Groundwater Operable Unit*.

4.1 Drill Cuttings

All drill cuttings from boreholes C9607 and C9608 were collected in catch tanks and troughs, with water removed when necessary. The drill cuttings were then placed into designated ERDF roll-off boxes. Miscellaneous solid waste associated with sampling activities was contained in clear plastic bags and was also disposed in the roll-off boxes. The roll-off boxes were then transported to ERDF for disposal at the completion of the project.

4.2 Purgewater

Purgewater was generated during well drilling, sampling, and development activities. All purgewater was collected and contained at the wellhead until it was transported to the purgewater modular storage units using regulated purge trucks in accordance with DOE/RL-2009-39, *Investigation-Derived Waste Purgewater Management Action Memorandum*; DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*; and DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*.

5 Civil Survey

The well locations for 699-39-68 (C9607) and 699-38-64B (C9608) were surveyed using a Trimble® R8 RTK global positioning system and a Trimble DiNi 12 level to collect coordinates. Washington State Plane (south zone) *North American Datum of 1983* (NAD83) (with the 1991 adjustment) was used to record the horizontal coordinates; *North American Vertical Datum of 1988* (NAVD88) was used to record the vertical survey data. Wells 699-39-68 and 699-38-64B were surveyed on July 19, 2018, and May 24, 2018, respectively. Table 7 identifies the locations of the surveyed wells. Survey reports for each well are provided in Appendices A and B, respectively.

Table 7. Civil Survey Summary

Well ID	Well Name	Northing[a] (m)	Easting[a] (m)	Brass Survey Marker Elevation[b] (m)	Top of Casing[b,c] Elevation (m)
C9607	699-39-68	135332.77	569077.90	225.860	226.745
C9608	699-38-64B	135319.93	569900.22	229.157	229.996

a. Northing and easting coordinates are based on Washington State Plane coordinates (*North American Datum of 1983* [NAD83]).

b. *North American Vertical Datum of 1988* (NAVD88) values rounded to 0.001 m.

c. Protective casing.

ID = identification

6 Well Acceptance

The final step of the installation process is well acceptance. Well acceptance represents confirmation that the wells meet the requirements outlined in the scope of work. Well acceptance also indicates the contractual completion of the finished wells.

After the wells were completed, representatives from CHPRC and Holt performed inspections for both wells. Work site assessments were conducted for well 699-39-68 on June 26, 2018, and for well 699-38-64B on April 24, 2018. Both wells were accepted by CHPRC.

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Appendix A

Well Documentation for 699-39-68 (C9607)

- Well Summary Sheet for C9607
- Borehole Log for C9607
- Geophysical Log Data Report for C9607
- Final Survey Report for C9607
- Well Development and Testing Data Sheet C9607
- Photo Log for C9607

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WELL SUMMARY SHEET

Well ID: C9607	Well Name: 699-39-68	Start Date: 1/17/2018
Project: 200 UP-1	Location: ~100m N of ERDF	End Date: 6/25/2018

CONSTRUCTION DATA

Description

WA Dept. of Ecology Tag: BKG 076

Surface Construction:
4' x 4' x 6" Concrete Pad with brass survey marker and protective monument

Temporary Casing Depth:
12" C.S. Wld. Joints = 459.79 ft bgs
16" C.S. Wld. Joints = 201.74 ft bgs

Permanent Well Materials:
8" ID SS Riser
2.25 ft ags - 298.72 ft bgs
(Continued on page 2)

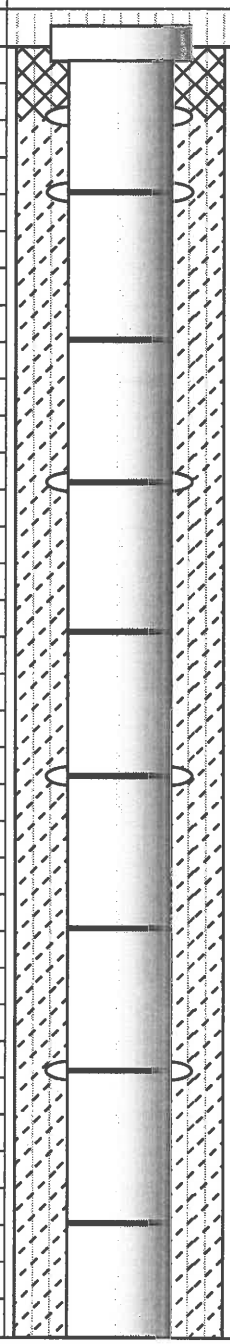
Well Completion Materials:
Cement Grout
0.00 ft bgs - 9.50 ft bgs
Bentonite Crumbles
9.50 ft bgs - 293.73 ft bgs
(Continued on page 2)

Centralizers are located at 40 ft increments from the top of the sump to the top of the well.

All 12" and 16" temporary casing completely removed from ground

ags - above ground surface
bgs - below ground surface

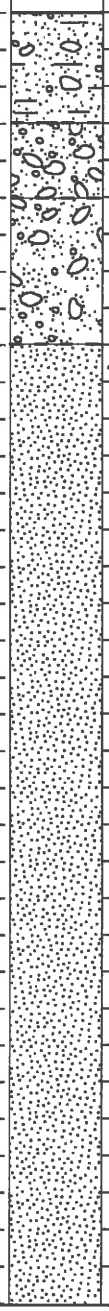
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 25, 50, 75, 100, 125, 150, 175

Graphic Log



Lithologic Description (ft bgs)

0 - 15 ft: Gravelly Silty Sand [gmS]

15 - 25 ft: Sandy Gravel [sG]

25 - 45 ft: Gravelly Sand [gS]

45 - 180 ft: Sand [S]

Reported By: Andrew Raulerson (Print Name)	Staff Geologist (Title)	(Signature)	6/26/2018 (Date)
Reviewed By: Jennifer Richart (Print Name)	Well Coordinator (Title)	(Signature)	7/3/18 (Date)

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9607 | Well Name: 699-39-68 | Project: 200 UP-1

CONSTRUCTION DATA

WA Dept. of Ecology Tag: BKG 076

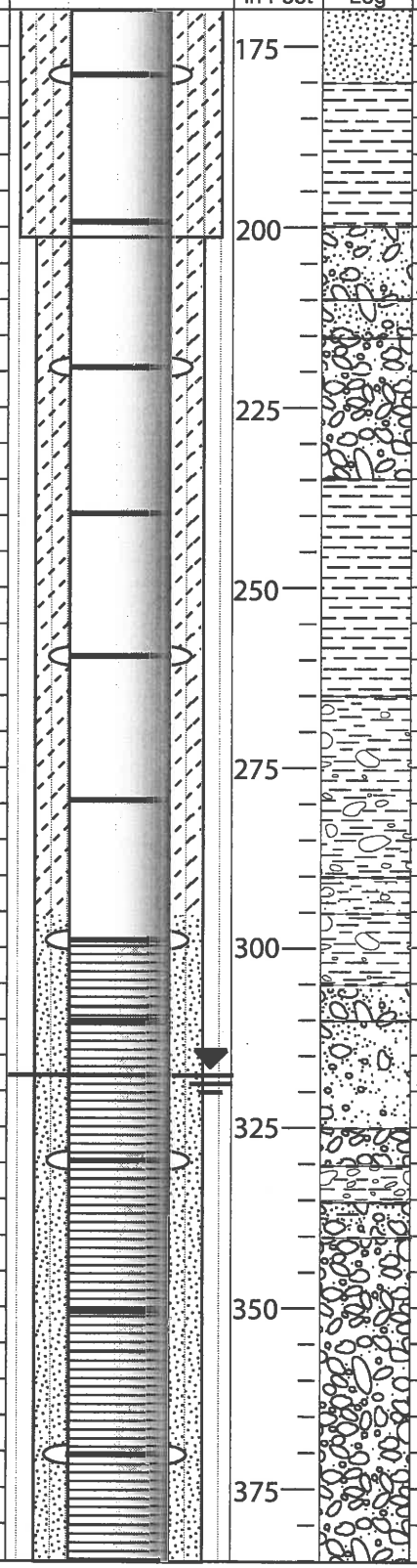
Permanent Well Materials:
(continued from page 1)
8" ID SS Riser
2.25 ft ags - 298.72 ft bgs
8" ID Stainless Steel 50-slot screen
298.72 ft bgs - 448.72 ft bgs
(Continued on page 3)

Well Completion Materials:
(Continued from page 1)
Bentonite Crumbles
9.50 ft bgs - 293.73 ft bgs
Bentonite Pellets
293.73 ft bgs - 295.98 ft bgs
8-16 Mesh Silica Sand
295.98 ft bgs - 461.65 ft bgs
(Continued on page 3)

Centralizers are located at 40 ft increments from the top of the sump to the top of the well.

All 12" and 16" temporary casing completely removed from ground

ags - above ground surface
bgs - below ground surface



GEOLOGIC/HYDROLOGIC DATA

Graphic Log

Lithologic Description (ft bgs)

45 - 180 ft: Sand [S]
180 - 200 ft: Silt [M]
200 - 210 ft: Sandy Gravel [sG]
210 - 215 ft: Slightly Silty Gravelly Sand [(m)gS]
235 - 265 ft: Silt [M]
265 - 290 ft: Gravelly Silt [gM]
290 - 295 ft: Gravelly Sandy Silt [gsM]
295 - 305 ft: Silty Gravel [mG]
305 - 310 ft: Sandy Gravel [sG]
310 - 325 ft: Gravelly Sand [gS]
Static water level at 317.60 ft (6/11/2018)
325 - 330 ft: Gravel [G]
330 - 335 ft: Silty Gravel [mG]
335 - 340 ft: Silty Sandy Gravel [msG]
340 - 440 ft: Gravel [G]

A-6006-992 (REV 0)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9607 | Well Name: 699-39-68 | Project: 200 UP-1

CONSTRUCTION DATA

Description

WA Dept. of Ecology Tag: BKG 076

Permanent Well Materials:
(continued from page 2)
8" ID Stainless Steel 50-slot screen
298.72 ft bgs - 448.72 ft bgs
8" ID Stainless Steel sump
448.72 ft bgs - 458.72 ft bgs

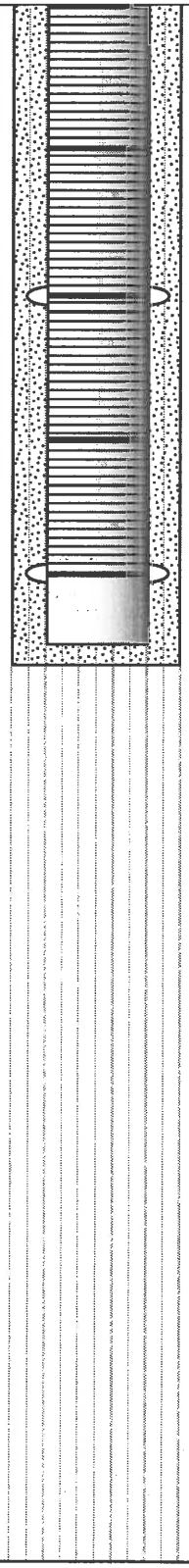
Well Completion Materials:
(Continued from page 2)
8-16 Mesh Silica Sand
295.98 ft bgs - 461.65 ft bgs

Centralizers are located at 40 ft increments from the top of the sump to the top of the well.

All 12" and 16" temporary casing completely removed from ground

bgs - below ground surface

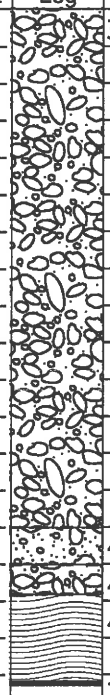
Diagram



Depth in Feet: 375, 400, 425, 450

GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Lithologic Description (ft bgs)

340 - 440 ft: Gravel [G]
440 - 445 ft: Sandy Gravel [sG]
445 - 449 ft: Gravel [G]
449 - 461.65 ft: Clay [M]

TD = 461.65 ft bgs

A-6006-992 (REV 0)

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BOREHOLE LOG

Page 1 of 12
Date: 1·22·18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100m N of ERDF
Project: 200-UP-1 | 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'- 15' : Gravelly Silty Sand (gmS)	Dual Air Rotary Rig w/16" casing & 14" tricone bit
			0'-5': 15% silt, 65% v.fn.- med. sand, 20% med.- crs. pebbles (max 28mm); sand: 60% f / 40% m, mod. sorted, sub.ang.-sub.rnd.; gravel: 50% f/50% m, mod. sorted, angular; wet, weak HCl rxn, 10YR 4/2 dark grayish brown.	wet dug toadded water ~75 gallons
5	G.S.			
			5'-10': 12% silt, 78% v.fn.- med. sand, 10% med.- crs. pebbles (max 22mm); no HCl rxn, 10YR 5/2 grayish brown, rest same as above	Archived @ 5'
				Hanford formation (0'-180')
10	G.S.		10'-15': 11% silt, 69% v.fn.- med. sand, 20% med.-crs. pebbles (max 16mm); sand: same; gravel: sub.rnd-ang.; same as above	Archived @ 10'
15	G.S.		15' - 25' : Sandy Gravel (sG)	Archived @ 15'
			15'-20': 5% silt, 40% v.fn.- v.crs sand (med.), 55% v.fn.- v.crs pebbles (max 43mm); sand: 60% f/40% m, poorly sorted, sub.ang.-sub.rnd; Gravel: 40% f/60% m, poorly sorted, angular-rnd.; wet, no HCl rxn, 10YR 5/2 grayish brown.	
20	G.S.			Archived @ 20'
			20'-25': 2% silt, 48% v.fn.-v.crs. sand (crs.), 50% v.fn.-crs pebbles (max 30mm); 10YR 4/2 dark grayish brown, rest same as above	
25	G.S.		25' - 45' : Gravelly Sand (gS)	Archived @ 25'
			25'-30': 1% silt, 79% v.fn.-v.crs. sand (v.crs), 20% v.fn.-v.crs. pebbles (max 33mm); sand: sub.ang.-sub.rnd, 70% f/30% m, mod. sorted; gravel: 50% f/50% m, ang.-rnd., poorly sorted; wet, no HCl rxn, 10YR 4/2 dark grayish brown.	~75 gallons H_2O added
30	G.S.			Archived @ 30'
			30'-35': 2% silt, 83% v.fn.-v.crs. sand (v.crs.), 15% v.fn.-crs. pebbles (max 30mm); sand: 65% f/35% m; gravel: 40% f/60% m; 10YR 4/3 brown, same as above	Parentheses next to sand grain size represents dominant grain size. G.S. = Grab Sample

Reported By: Andrew Rauterson (Print Name) | Staff Geologist (Title) | Adr (Signature) | 1.23.18 (Date)

Reviewed By: Sarah Springer (Print Name) | Sr. Geologist (Title) | (Signature) | 03-13-18 (Date)

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OR Doc Type: | WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 12

Date: 1.23.18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

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.S.		25' - 45' : Gravelly Sand (gS)	Dual Air Rotary Rig w/16"
			35'-40': 2% silt, 73% sand v.fn.-v.crs.(crs.), 25% v.fn.-crs. pebbles (max 31mm); sand: sub.ang.-sub.rnd., 70%f/30%m, mod. sorted; gravel: 40%f/60%m, sub.ang.-sub.rnd., poorly sorted; wet, no HCl rxn, 10YR 3/2 very dark grayish brown.	casing & 14" tricone bit Archived @ 35'
40	G.S.		40'-45': 75% fn.-v.crs. sand(v.crs.), 25% v.fn.-crs. pebbles (max. 20mm); sand: 70%f/30%m; gravel: 40%f/60%m; wet same as above.	Archived @ 40'
45	G.S.		45' - 180' : Sand (S)	
			45'-50': 2% silt, 93% v.fn.-v.crs. sand (med.-crs.), 5% v.fn.-med. pebbles (max 14mm); sand: 60%f/40%m, mod. sorted, sub.ang.-sub.rnd.; gravel: 40%f/60%m, mod. sorted, sub.ang.-sub.rnd.; damp, no HCl rxn, 10YR 4/3 brown	Archived @ 45'
50	G.S.		50'-55': 95% v.fn.-v.crs. sand(crs.), 5% v.fn. pebbles (max 6mm); sand: 60%f/40%m; gravel: 50%f/50%m; same as above.	Archived @ 50' ~75 gallons H_2O added
55	G.S.		55'-60': 91% v.fn.-v.crs. sand (med.), 9% v.fn.-med. pebbles (max 14mm); sand: 70%f/30%m; gravel: 50%f/50%m; dry, v. weak HCl rxn, same as above.	Archived @ 55'
60	G.S.		60'-65': 95% v.fn.-v.crs. sand (fn.), 5% v.fn.-med. pebbles (max 10mm); sand: 70%f/30%m; gravel: 50%f/50%m; no HCl rxn, same as above.	Archived @ 60'
65	G.S.		65'-70': 95% fn.-v.crs. sand (crs.), 5% v.fn.-crs. pebbles (max 10mm); sand: 60%f/40%m; gravel: 50%f/50%m; damp, same as above.	Archived @ 65'
70	G.S.		70'-75': 92% fn.-v.crs. sand (crs.), 8% v.fn.-crs. pebbles (max 9mm); sand: 70%f/30%m; gravel: 50%f/50%m; same as above	Archived @ 70' ~75 gal. H_2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Raulerson	Staff Geologist	[signature]	1.23.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 12

Date: 1.23.18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

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.S.		45'-180' : Sand (S)	Dual Air Rotary Rig w/ 16" casing + 14" tricone
			75'-80': 95% fn.-v.crs sand (crs.), 5% v.fn.-~~fn.~~ med. pebbles (max 7mm); sand: 60% f/40% m, sub. ang.-sub.rnd., mod.-well sorted; gravel: 40% f/60% m, ang.-sub.rnd., well sorted; damp, no HCl rxn, 10YR 4/3 brown. AR 1.23.18	Archived @ 75'
80	G.S.		80'-85': 9% silt, 82% fn.-v.crs. sand (crs.), 9% v.fn.-med. pebbles (max 10mm); silt: balls, some plastic, some brittle; sand: 60% f/40% m; gravel: 40% f/60% m; same as above.	Archived @ 80'
85	G.S.		85'-90': 9% silt, 85% v.fn.-v.crs. sand (~~fn.-med.~~), 6% fn. pebbles (max 7mm); sand: 70% f/30% m; gravel: 50% f/50% m; silt: plastic; same as above. AR 1.23.18	Archived @ 85'
90	G.S.		90'-95': 96% fn.-v.crs. sand (crs.), 4% v.fn.-med. pebbles (max 11mm); sand: 50% f/50% m; gravel: 50% f/50% m; weak HCl rxn, 10YR 5/3 brown.	~75 gal. H_2O added Archived @ 90'
95	G.S.		95'-100': 5% silt, 86% v.fn.-v.crs. sand (v.crs.), 9% v.fn.-crs. pebbles (max 30mm); sand: 60% f/40% m; gravel: mod. sorted, 40% f/60% m; no HCl rxn. Same as above.	Archived @ 95'
100	G.S.		100'-105': 10% silt, 90% v.fn.-v.crs. sand (med.); sand: 60% f/40% m; silt: plastic; same as above, 10YR 3/2 v. dark grayish brown.	Archived @ 100'
105	G.S.		105'-110': 10% silt, 86% v.fn.-crs. sand (fn.), 4% fn.-med. pebbles (max 10mm); silt: balls due to added water; sand: 60% f/40% m, mod.-well sorted; gravel: 50% f/50% m, mod. sorted; no HCl rxn, 10YR dark grayish brown.	Archived @ 105'
110	G.S.		110'-115': 10% silt, 81% v.fn.-crs. sand (med.), 9% v.fn.-v.crs. pebbles (max 33mm); silt: same; sand: same; gravel: same; same as above.	Archived @ 110' ~75 gal H_2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Raulerson	Staff Geologist	[signature]	1.24.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 12

Date: 1·24·18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N/NW ERDF

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.S.		45' – 180' : Sand (s)	Dual Air Rotary Rig w/16"
			115'-120': 91% v.fn.-v.crs. sand(crs.), 9% v.fn.-med. pebbles (max 11mm); sand: 60%f/40%m, sub.ang.-sub.rnd., poorly sorted; gravel: 50%f/50%m, sub.ang.-sub.rnd, mod. sorted; damp, no HCl rxn, 10YR 4/3 brown	casing + 14" tricone bit Archived @ 120' Archived @ 115'
120	G.S.		120'-125': 5% silt, 95% v.fn.-v.crs. sand(med.-crs.); sand: 60%f/40%m; rest same as above.	Archived @ 125'
125	G.S.		125'-130': 2% silt, 98% fn.-v.crs. sand(crs.); sand: 50%f/50%m; 10YR 4/2 dk. grayish brown, rest same as above.	Archived @ 130'
130	G.S.		130'-135': 2% silt, 98% v.fn.-v.crs. sand(med.); sand: 60%f/40%m; same as above, mod. HCl rxn only on silt balls.	~15 gal. H_2O added Archived @ 135'
135	G.S.		135'-140': 2% silt, 98% fn.-v.crs. sand(med./v.crs.); sand: 50%f/50%m; no HCl rxn, rest same as above.	Archived @ 140'
140	G.S.		140'-145': 2% silt, 98% v.fn.-crs. sand (med.); sand: 70%f/30%m; same as above, 10YR 4/3 brown	Archived @ 145'
145	G.S.		145'-150': 100% v.fn.-v.crs. sand(med.); sand: 70%f/30%m; same as above, 10YR 5/3 brown.	Archived @ 150'
150	G.S.		150'-155': 100% v.fn.-crs. sand(med.); sand: 70%f/30%m; same as above.	Archived @ 155' ~15 gal. H_2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Ramlerson	Staff Geologist	[signature]	1·24·18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 5 of 12

Date: 1.24.18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

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.S.		45' - 180' : Sand (S)	Dual Air Rotary Rig w/
			155'-160': 98% fn.-crs. sand (~~60~~ med.) ~~; sand~~ NR 1.24.18; 2% v.fn-fn pebbles (max 6mm); sand: 60%f/40%m, sub.ang.-sub.rnd, mod. sorted; no HCl rxn, slightly damp, 10YR 5/3 brown.	16" casing + 14" tricone bit; Archived @ 160'
160	G.S.		160'-165': 100% v.fn.-crs sand (med.); sand: 60%f/40%m; same as above.	Archived @ 165'
165	G.S.		165'-170': 100% v.fn.-v.crs. sand (med.); sand: 70%f/30%m; same as above.	Archived @ 170'
170	G.S.		170'-175': 100% v.fn.-v.crs. sand (med.); sand: 60%f/40%m; same as above.	~75 gal. H_2O added; Archived @ 175'
175	G.S.		175'-180': 100% v.fn.-v.crs. sand (med.); sand: 60% f/40%m; mild HCl rxn, same as above.	Archived @ 180'
180	G.S.		180' - 200' : Silt (M)	
			180'-185': 95% silt, 5% v.fn. sand; silt: not plastic; dry, mod. HCl rxn, 10YR 4/4 dark yellowish brown.	Archived @ 185'; Cold Creek Unit (180'-305')
185	G.S.		185'-190': 98% silt, 2% v.fn. sand; all same as above.	Archived @ 190'
190	G.S.		190'-195': 98% silt, 2% v.fn. sand; all same as above.	Archived @ 195'; ~75 gal. H_2O added

Reported By: Andrew Rankerson (Print Name) | Staff Geologist (Title) | [signature] (Signature) | 1.24.18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 6 of 12

Date: 1.24.18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
195	G.S.		180' – 200' : Silt (M)	Dual Air Rotary Rig w/16"
			195'-200': 85% silt, 15% v.fn.-v.crs. sand (v.fn/crs.); silt; notplastic, compressed due to drilling air pressure; sand: 60%f/40%m, sub.ang.-sub.rnd., poorly sorted; dry, mod. HCl rxn, 10YR 4/4 dark yellowish brown.	casing & tricone bit ~~Archived @ 200'~~ 195' *R 2.24.18
200	G.S.		200' – 210' : Sandy Gravel (GS)	*Downsize to 12" casing &
			200'-205': 5% silt, 35% v.fn.-v.crs. sand (crs.), 60% v.fn.-med. pebbles (max 8mm); sand: 60%f/40%m, sub.ang.-sub.rnd., poorly sorted; gravel: 60%f/40%m, ang.-sub.rnd., mod.-well sorted; dry, very violent HCl rxn, 10YR 5/4 yellowish brown	tricone bit Archived @ 200'
205	G.S.		205'-210': 10% silt, 60% v.fn.-v.crs. sand (med.), 30% v.fn.-med. pebbles (max 10mm); sand: 60%f/40%m; gravel: 50%f/50%m; 10YR 4/4 dark yellowish brown.	Archived @ 205'
210	G.S.		210' – 215' : Slightly Silty Gravel, Sand (*R 1.30.18 ~~(m)~~ G(m)gS)	
			210'-215': 15% silt, 70% v.fn.-med. sand (fn.), 15% v.fn.-med. pebbles (max 10mm); sand: 70%f/30%m, sub.ang.-sub.rnd., well sorted; gravel: 50%f/50%m, ang.-sub.rnd., poorly sorted; damp, very violent HCl rxn, 10YR 4/4 dark yellowish brown.	Archived @ 210' ~15 gal. H_2O added
215	G.S.		215' – 220' : ~~Gravelly~~ Sand (gS) *R 2.26.18 *R 2.26.18	Archived @ 215'
			215'-220': 2% silt, 91% v.fn.-v.crs. sand (v.crs.), 7% v.fn.-med. pebbles (max 9mm); sand: sub.ang.-sub.rnd., well sorted, 40%f/60%m; gravel: 30%f/70%m, mod. sorted, ang.-sub.rnd.; damp, very violent HCl rxn, 10YR 4/4 dark yellowish brown	
220	G.S.		220' – ~~225~~ 235': Sandy Silt (sM) *R 2.26.18	Archived @ 220'
			220'-225': 70% silt, 30% v.fn. sand; silt: loose; sand: sub.ang.-sub.rnd.; dry, very violent HCl rxn, 10YR 5/4 yellowish brown.	
225	G.S.			Archived @ 225'
			225'-230': 55% silt, 41% v.fn.-crs. sand (med.), 4% v.fn.-med. pebbles (max 14mm); silt; plastic, moldable; sand: same as above; pebbles: 50%f/50%m, sub.ang.-sub.rnd., mod. sorted; damp, very violent HCl rxn, 10YR 4/6 brown	
230	G.S.		230'-235': 80% silt, 20% v.fn. sand; slightly damp, same as above, 10YR 5/4 yellowish brown	Archived @ 230' ~15 gal. H_2O added

Reported By: Andrew Rauterson (Print Name) | Staff Geologist (Title) | [signature] (Signature) | 1.30.18 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 7 of 12

Date: 1.31.18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
235	G.S.		235' - 265' : ~~Sandy~~ Silt (sM) AR 1.31.18 AR 1.31.18	Dual air rotary ing w/12" casing + tricone bit
			235'-240': 90% silt, 20% v.fn. sand; sand: sub.ang.-sub.rnd, well sorted; silt; loose, not wet/plastic/moldable; dry, strong HCl rxn, 10YR 4/4 dark yellowish brown.	Archived @ 235'
240	G.S.		240-245': 95% silt, 5% v.fn. sand; slightly damp, very strong HCl rxn, rest same as above.	Archived @ 240'
245	G.S.		245'-250': 95% silt, 5% v.fn. sand; slightly damp, moldable, very strong HCl rxn, rest same as above.	Archived @ 245'
250	G.S.		250'-255': 85% silt, 15% v.fn.-v.crs. sand; damp, plastic, moldable, very strong HCl rxn, may be very thin caliche fragments included (~3-8mm thick) extremely reactive to HCl, same as above.	Archived @ 250' ~75 gal. H_2O added
255	G.S.		255'-260': 85% silt, 10% v.fn.-v.crs. sand, 5% v.fn.-med. pebbles (max 8mm); very reactive to HCl, same as above, no caliche included.	Archived @ 255'
260	G.S.		260'-265': 90% silt, 10% v.fn.-v.crs. sand; same as above.	Archived @ 260'
265	G.S.		AR 2.27.18 265' - 290' : Gravelly ~~Sandy~~ Silt (gM)	
			265'-270': 70% silt, 10% v.fn.-v.crs. sand, 20% v.fn.-med. pebbles (max 14mm); gravel: ang.-sub.ang., 70%f/30%m, mod. sorted; sand: sub.ang.-sub.rnd.; slightly damp, mod. HCl rxn, 10YR 4/4 dark yellowish brown.	Archived @ 265' Driller felt drilling get more rough @ ~265' bgs
270	G.S.		270'-275': 75% silt, 15% v.fn.-v.crs. sand, 10% fn.-med. pebbles (max 15mm); gravel: 60%f/30%m, ang.-sub.ang.; strong HCl rxn, 10YR 4/3 brown.	Archived @ 270' ~75 gal. H_2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Rawderson	Staff Geologist	[signature]	1-31-18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 8 of 12

Date: 1·31·18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
275		G.S.	265'-290' : Gravelly Sandy Silt ~~(gsM)~~ (gM) AR 2·27·18 AR 2·27·18	Dual air rotary rig w/12" casing + tricone bit
			275'-280': 70% silt, 10% v.fn.-v.crs. sand, 20% fn.-med. pebbles (max 14mm); silt: moldable; gravel: ang.-sub.ang., 70% f/30% m, mod. sorted; damp, v. strong HCl rxn, 10YR 4/4 dark yellowish brown	Archived @ 275'
280		G.S.	280'-285': 70% silt, 10% v.fn.-v.crs. sand, 20% fn.-crs. pebbles (max 18mm); all same as above.	Archived @ 280'
285		G.S.	285'-290': 70% silt, 10% v.fn.-med. sand, 20% fn.-crs. pebbles (max 16mm); all same as above.	Archived @ 285'
290		G.S.	290'-295': Gravelly Sandy Silt (gsM)	
			290'-295': 60% silt, 30% v.fn.-fn. sand, 10% fn.-crs. pebbles (max 24mm); 10YR 4/2 dark grayish brown; gravel: ang.-sub.rnd. mod. sorted, 50% f/50% m.	Archived @ 290' ~75 gal. H_2O added
295		G.S.	295'-305' : Silty Gravel (mG)	
			295'-300': 35% silt, 15% v.fn.-med. sand, 50% v.fn.-crs. pebbles (max 24mm); silt: moldable; gravel: 60% f/40% m, ang.-sub.rnd., mod. sorted; damp, v. strong HCl rxn, 10YR 3/2 v. dark grayish brown.	Archived @ 295'
300		G.S.	300'-305': 40% silt, 20% v.fn.-crs. sand, 40% v.fn.-crs. pebbles (max 25mm); all same as above.	Archived @ 300'
305		G.S.	305'-310' : Sandy Gravel (sG)	Archived @ 305'
			305'-310': 10% silt, 50% v.fn.-med. (fn) sand, 40% v.fn.-med pebbles (max 8mm); sand: 80% f/20% m, sub.ang.-sub.rnd., well sorted; gravel: ang.-sub.rnd., 60% f/40% m, well sorted; dry, no HCl rxn, 10YR 6/2 light brownish gray.	Ringold Formation, Unit E (305'-449')
310		G.S.	~~310-315~~ AR 2·5·18	Archived @ 310' @310' bgs, change to under reamer bit ~75 gal H_2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Rawlerson	Staff Geologist	[signature]	2·5·18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 9 of 12

Date: AR 2.5.18 ~~2.30.18~~ 2.5.18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
315	G.S.		310' – 325 : Gravelly Sand (gS)	g.s. = grab sample, s.s. = spoon,
			310'-315': 5% silt, 85% v.fn.-med. sand (med), 10% v.fn.-	w.s. = water sample
	316.21' bgs (2/8/18)		fn. pebbles (max 5mm); sand: 50%f/50%m, sub.ang.-sub-	Archived @ 315'
			rnd., mod.-well sorted; gravel: 50%f/50%m, ang.-sub.rnd.,	H2O tagged @316.21' bgs on 2/8/18
			well sorted; slightly damp, weak HCl rxn, 10YR 3/2	Dual Air Rotary Rig w/12" case
320	G.S.		v. dk. grayish brown.	+ under reamer bit
			315'-320': 5% silt, 85% v.fn.-med. sand (med.), 10% v.fn.-	Archived @ 320'
			fn. pebbles (max 6mm); no HCl rxn, rest same as	~75 gal. H2O added
			above.	
			320'-325': 5% silt 70% v.fn.-v.crs. sand (med.), 25%	
325	G.S.		v.fn.-fn. pebbles (max 7mm); sand: 60%f/40%m;	Archived @ 325'
			AR 2.5.18 gravel: 40%f/60%m; no HCl rxn, rest same	Archived @ 330'
			as above.	Archived @ 335'
			325-330: Gravel (G)	@ 325' change to tricone bit
			90% Gravel: 2mm-28mm (v.fn-crs. pebble), poorly sorted, subrounded	@ 325': while cleaning out bore-
330	G.S.		subangular, 60%F/40%M; 10% Sand: med.-v.crs., mod. sorted, subrnd	hole, med.-crs. pebbles were in
			to angular, 60%F/40%M; <1% silt, no plasticity, 2.5Y 4/3 olive brown;	cuttings; all returns were pebbles
			no rxn w/ HCl due to samples now being in the saturated zone	@ 325': H2O begins to appear
				and may cause fines to wash
	S.S. I-002		330-335 : Silty Gravel (mG)	through cone used to collect g.s.
335	W.S. I-001		75% Gravel: v.fn (2mm)-v.crs. (37mm) pebble, poorly sorted, rounded-	S.S. I-002: Actual depth: 334.01-335.81';
	G.S.		subangular, 55%F/45%M; 10% Sand: v.fn.-v.crs., mod. sorted, subrounded-	sample time @ 1005 on 2/8/18; 100% recovery
			subangular, 60%F/40%M; 15% Silt, 2.5Y 4/3 olive brown	of silty sandy gravel; HEIS #: B3H7W1
			335-340 : ~~Gravel (G)~~ BT 2/8/18 Silty Sandy Gravel (mSG)	W.S. I-001 (121) on 2/8/18) Actual Depth:
			55% MN 65% F 60% Gravel: v.fn (2mm)-v.crs. (36mm) pebble, poorly sorted, well rounded-	333.97' bgs; HEIS #s B3H7W6, B3H7W7, B3H7W8,
340	G.S.		subrounded; 25% Sand: v.fn.-v.crs., poorly sorted, subrounded-subangular, 60%F/	B3H9J3; 420 total gal pumped
			40%M, 15% Silt: 2.5Y 5/3 light olive brown; wet sample	@ 340' fines may have blown
			340-440' : Gravel (G)	out of the hole prior or washed
			100% Gravel: 55%F/45%M, v.fn.(2mm)-v.crs. (34mm) pebble, poorly sorted,	through the cone; @ 345' all gravels are
	I-003 W.S.		well rounded-subrounded; fines may not be present in sample due to drilling	being blown out while cleaning bore hole
	S.S. I-004		method	S.S. I-004, 2.12.18 Liner B 344.60'-345.10', 75%
345	G.S.		345'-350': 10% v.fn.-v.crs. sand, 90% v.fn.-v.crs. pebbles	recovery, sample time 1107, HEIS #: B3H7W2
			(max 42mm); sand: 50%f/50%m, poorly sorted, sub.ang.-subrnd,	2.12.18 W.S. I-003, sample time 1341, 343.71' bgs,
			gravel: 40%f/60%m, poorly sorted, ang.-rnd; wet, no HCl rxn,	HEIS #: B3H7X0, B3H7X1, B3H7X2,
			10YR 4/3 brown.	B3H7X3, B3H7X4, B3H9H; 1300 gals.
350	G.S.		350'-355': 5% v.fn.-v.crs. sand, 95% v.fn.-crs. pebbles (max 27mm);	pumped total.
			gravel: 60%f/40%m; same as above	Archived @ 340'
				Archived @ 345'
				Archived @ 350'
				~600 gal H2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Rauterson / Brandon Thurman	Staff Geologist / Geologist		2.13.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Date: ~~2-18-18~~ 2.13.18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
355	G.S.		340'-440': Gravel (G)	S.S.=Split Spoon, W.S.=water sample, g.s.=grab sample
			355'-360': 5% silt, 15% v.fn.-v.crs. sand, 80% v.fn.-crs. pebbles (max 31 mm); sand: 50%f/50%m, ang.-sub.rnd., poorly sorted; gravel: 40%f/60%m, ang.-rnd, poorly sorted; wet, no HCl rxn, 10YR 4/3 brown.	Archived @ 355'
				S.S. I-006: 2/13/18 @ 1347, actual sample depth: 365.10'-365.60' bgs from liner B, HEB# B3H7W3, 75% recovery
360	G.S.		360'-365': 10% v.fn.-v.crs. sand, 90% v.fn.-v.crs. pebbles (max 50 mm); gravel: 60%f/40%m; all same as above.	Archived @ 360'
				W.S. I-005: 2/14/18 @ 0846, actual depth: 364.70'; HEB#s B3H7W4, B3H7W5, B3H7W6, B3H7W7, B3H7W8, B3H7W9
	SS I-006			
365	W.S. I-005 G.S.		365-370': 95% Gravel v.fn.-v.crs. (49 mm) pebble, 55%F/45%M, poorly sorted, well rounded-subangular; 5% sand-v.fn.-v.crs., 55%F/45%M, poorly sorted; subrounded-sub angular; wet sample; no rxn w/ HCl	Archived @ 365'
				W.S. I-007; 2/14/18 @ 1406, actual depth: 382.52; HEB #s B3H7W0, B3H7W1, B3H7W2, B3H7W3, B3H9W6, B3H7W4
			370-375': similar to g.s. from 365'-370' except 45% sand	
370	G.S.			Archived @ 370'
				~300 gal. H_2O added
				Archived @ 375'
375	G.S.		375-380': same as g.s. from 365-370' except gravels are 60%F/40%M	@ 375' fines may be washed through cone used to collect sample
				Archived @ 380'
380	G.S.		380-385': same as g.s. from 375-380'	
	W.S. I-007			
				Archived @ 385'
385	G.S.		385-390: 90% Gravel: v.fn-v.crs. (54 mm) pebble, well rounded-sub rounded, poorly sorted, 60%F/40%M; 10% v.f-v.crs. sand, 60%F/40%M, poorly sorted, rounded-subrounded; wet sample; no rxn w/ HCl	
				Archived @ 390'
390	G.S.		390-395: similar to g.s. from 385-390	@ 395: more fines appear in cuttings bin after pumping out the H_2O; roughly 85% Gravel / 15% Sands and silts
				~300 gal. H_2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Rawlerson / Branton Thurman	Staff Geologist / Geologist	[signature] / [signature]	2.15.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 12

Date: 2/15/18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of BAOF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
395	G.S.		390-440': Gravel (G)	Dual Air Rotary Rig w/ 12"
			~~395'-400'~~	casing & tricone bit
			95% Gravel: u-fn-v.crs. (63 mm) pebble, 55%F/45%M, poorly sorted, well-subrounded; 5% Sand: v.fn.-crs. sand, poorly sorted, rounded-subrounded, 60%F/40%M; wet sample; no rxn w/ HCl	Archived @ 395'
				Archived @ 400'
400	G.S.		395-400 - same as g.s. from 395-400 except	@400', much more sands
			90% Gravel/10% sands and silts; Gravels are larger	and silts appear after removing
			(up to 76 mm - small cobble) and also are 55%F/45%M	H_2O from cuttings bin; better
	W.S. I-008		400'-405' - same as above	interpreted as silty sandy
			Silty Sandy Gravel (msG) @ 408' (~1' layer)	gravel instead of only gravel
405	G.S.		408': 15% silt, 40% v.fn.-med. sand, 45% v.fn.-v.crs.	being observed in the cone
			pebbles (35 mm max); sand: mod. sorted, sub.ang.-sub.rnd., 70%f/	used to collect g.s.
			30%m; gravel: mod. sorted, ang.-rnd., 50%m/50%f; wet, no HCl	Archived @ 405'
	G.S.		rxn, 10YR 5/3 brown.	W.S. I-008; 2/15/18 @ 1317, actual
				depth: 403.41; HEIS #s B3H7N5,
410			* Gravel Continues	B3H917, B3H7N6, B3H7N7, B3H7N8,
AR 2.26.18 ~~415~~	G.S.		405'-410': 10% v.fn.-crs. sand (med), 90% v.fn.-v.crs	B3H7N9
			pebbles (max 53 mm); sand: poorly sorted, same as above;	Archived @ 408'
			gravel: ang.-rnd., poorly sorted, same as above; same as	Archived @ 410'
			above.	~300 gal. H_2O added
415			410'-415': 15% v.fn.-v.crs. sand (med.), 85% v.fn.-	
AR 2.26.18 ~~420~~	G.S.		v.crs pebbles (max 55 mm); sand: same as above;	
	W.S. Cont. 1 AR 2.26.18		gravel: same as above; same as above	Archived @ 415'
				W.S. Contingency 1; 2.21.18,
			415'-420': 15% v.fn.-v.crs. sand (crs.), 85% v.fn.-v.crs.	depth 421.53' bgs, HEIS #:
420 AR 2.26.18 ~~425~~	G.S.		pebbles (max 50 mm); sand: same as above; gravel: same as above;	B3H809
			same as above.	
	W.S. Cont. 1		420-425': 15% v.fn.-v.crs. sand (med.), 85% v.fn.-v.crs.	Archived @ 420'; @ ~420'
			pebbles (max 46 mm); all same as above.	Water turned more brown
				w/ silt/fine sand washing
425 AR 2.26.18 ~~430~~	G.S.		425'-430': 10% sand (v.fn.-v.crs.), 90% v.fn.-crs. pebbles	through catching cone
			(max 30 mm); gravel: ang.-rnd., 60%f/40%m; same	Archived @ 425'
			as above.	
			430'-435': 20% v.fn.-v.crs. sand, 80% v.fn.-v.crs. pebbles (max 50 mm);	
430 AR 2.26.18 ~~435~~	G.S.		sand: 40%f/60%m; gravel: 60%f/40%m; same as above,	
			435'-440': 10% sand, 90% v.fn.-v.crs. pebbles (max 35 mm);	Archived @ 430'
			gravel: 60%f/40%m, ang.-rnd.; all same as above.	
				~300 gal. H_2O added

Reported By:

Print Name	Title	Signature	Date
Andrew Raulerson / Brandon Thurman	Staff Geologist / Geologist	[signature] / [signature]	2.22.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 12 of 12

Date: 2·22·18

Well ID: C9607 | Well Name: 699-39-68 | Location: ~100 m N of ERDF

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
AR 2·26·18 435 440	G.S.		440'- 445' : Sandy Gravel (SG)	Dual Air rotary rig w/12"
			~~440'-445': AR 2.22.18 435'-440': AR 2.22.18~~ 440'-445': 10% silt,	casing + tricone bit
			35% v.fn.- v.crs. sand (med.), 55% v.fn.- v.crs. pebbles	Archived @ 435'
			(max 60 mm); sand: 60%f/40%m, sub.ang.-sub.rnd., poorly	Water still more brown w/
			sorted; gravel: 60%f/40%m, poorly sorted, ang.-rnd;	silt/sand
AR 2·26·18 440 445	G.S.		wet, no HCl rxn.	
			445'-449': Gravel (G)	Archived @ 440'
			445'-449': 10% v.fn.-v.crs. sand, 90% v.fn.-v.crs. pebbles	
			(max 35mm); gravel: ang.-rnd., poorly sorted, 50%f/50%m;	
			sand: poorly sorted, ang-sub.rnd., 70%f/30%m; wet,	
AR 2·26·18 445 ~~455~~	G.S.		no HCl rxn.	Archived @ 445'
			449'-461.65' Mud (M)	~300 gal. H_2O added
			449'- : ~~72% silt, 9% v.fn.-v.crs. pebbles (max~~ AR 2.22.18	Ringold Formation, RLM
	G.S.		~~sand, 19~~ AR 2.22.18	(449'-461.65')
AR 2·26·18 450 455			72% silt/mud, 9% v.fn.-v.crs. pebbles (max	Archived @ 449'
	AR 2·26·18 Not used		40 mm), 19% v.fn.-v.crs. sand; silt; rigid chunks,	@449' was last sample able
			in suspension as well; sand: sub.ang.-sub.rnd., poorly	to be collected due to high
			sorted, 60%f/40%m; gravel: ang.-rnd., poorly sorted,	amounts of water
			50%f/50%m; wet, no HCl rxn, 10YR 5/4 yellowish	
AR 2·26·18 455 460	AR 2·26·18 Not Used		brown.	
			449'-461.65': 90% silt, 10% v.fn. sand; silt/mud	
			completely in suspension, washing through catching zone.	TD @ 461.65' bgs
			10YR 5/4 yellowish brown.	~125 gal. added
460				
				~3500 gal. Total H_2O added
	TD: 461.65' bgs			during drilling

Reported By:

Print Name	Title	Signature	Date
Andrew Raulerson	Staff Geologist	[signature]	2·26·18

A-6006-993 (REV 0)

699-39-68 (C9607)
Log Data Report

Borehole Information

Log Date	2018-02-28	Filename	C9607_HG-NM_2018-02-28	Site	200-UP-1

DTW[1] (ft)	DTW Date	DTW Source	Drill Date	Total Depth (ft)	Depth Datum
317.1	02/26/18	SN3	02/25/18	461.65	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Welded Steel	Air Rotary	1.4	16	15 1/4	3/8	-1.4	201.74
Welded Steel	Air Rotary	2.0	12 3/4	12	3/8	-2.0	459.79

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up and casing diameters. The maximum logging depth achieved was 461.01 ft. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 5TB	**Type**	60% Coaxial HPGe (SGLS)[2]
Effective Calibration Date	11/28/2017	**Serial No.**	54-TP-13441B
Calibration Reference	HGLP-CC-167, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53023, Rev. 0, Change 2

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

Logging System	Gamma 5PB	**Type**	He-3 (CPN 503DR) NMLS[3]
Effective Calibration Date	11/14/2017	**Serial No.**	H34055445
Calibration Reference	HGLP-CC-164, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

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

SGLS Log Run Information

Log Run	1	2 Repeat	5	6	7 Repeat
HEIS Number	1020165	1020166	1020167	1020168	1020169

[1] depth to water inside casing
[2] Spectral Gamma Logging System
[3] Neutron Moisture Logging System

Log Run	1	2 Repeat	5	6	7 Repeat
Date	01/25/18	01/25/18	02/26/18	02/27/18	02/27/18
Logging Engineer	McClellan/Spatz	Spatz	Spatz/McClellan	Spatz/McClellan	Spatz
Start Depth (ft)	0.01	170.0	199.02	241.02	434.0
Finish Depth (ft)	198.0	190.0	240.0	461.01	460.01
Count Time (sec)	100	100	100	100	100
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA	NA
Pre-Verification	C9607FTB20180 125AV00CAB1	C9607FTB20180 125AV00CAB1	C9607ALD2018 0226AV00CAB1	C9607ALD2018 0227BV00CAB1	C9607ALD2018 0227BV00CAB1
Start File	AD000001	BD017000	AD019902	BD024102	CD043400
Finish File	AD019800	AD019000	AD024000	BD046101	CD046001
Post-Verification	BV00CAA1	BV00CAA1	AV00CAA1	CV00CAA1	CV00CAA1
Depth Return Error (in.)	N/A	2.5 high	0.0	N/A	3.0 low
Comments	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made

NMLS Log Run Information

Log Run	3	4 Repeat	8	9 Repeat	
HEIS Number	1020170	1020171	1020172	1020173	
Date	01/25/18	01/25/18	02/28/18	02/28/18	
Logging Engineer	Felt	Felt	Spatz	Spatz	
Start Depth (ft)	0.0	85.0	197.0	285.0	
Finish Depth (ft)	198.01	105.0	317.51	300.01	
Count Time (sec)	15	15	15	15	
Live/Real	R	R	R	R	
Shield (Y/N)	N	N	N	N	
MSA Interval (ft)	0.25	0.25	0.25	0.25	
Log Speed (ft/min)	NA	NA	NA	NA	
Pre-Verification	C9607FPB20180 125AV00CAB1	C9607FPB20180 125AV00CAB1	C9607AHD2018 0228AV00CAB1	C9607AHD2018 0228AV00CAB1	
Start File	AD000000	BD008500	AD019700	BD028500	
Finish File	AD019801	BD010500	BD031751	BD030001	
Post-Verification	CV00CAA1	CV00CAA1	BV00CAA1	BV00CAA1	
Depth Return Error (in.)	N/A	1.0 high	N/A	0.0	
Comments	None	None	None	None	

Logging Operation Notes

A centralizer was installed on the sondes during logging of the second casing string. During logging of the first casing string, the sonde was positioned near the casing wall and no centralizer was used.

Analysis Notes

Analyst	P.D. Henwood	**Date**	03/05/18
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

A casing correction for a 3/8-in. thick casing was applied to the log data except from 199 to 202 ft where a combined casing correction for a 3/4-in. thick casing was applied.

A water correction was applied below 319 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in an EXCEL templates identified as ALD20171019 and FTB20171128 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

An interpreted data set was created for this borehole. Depth overlaps from consecutive log runs or where two casings existed were removed from 197 and 198 ft and 239 and 240 ft. This results in a data set where only one data point is presented for each depth.

NMLS data are reported in counts per second. HGU[4] is an empirical unit of gamma activity proposed as a means to standardize gamma log response across multiple logging systems with different response characteristics. The HGU is defined in terms of measurements in the Hanford Borehole Calibration Facility, and the magnitude is selected such that 1 HGU is approximately equivalent to typical Hanford background activity, based on data from background samples as reported in *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE/RL-96-12).

Results and Interpretations

No manmade radionuclides were detected in this borehole.

Radon appears to be in the water inside the casing from approximately 410 ft to the bottom of the borehole as evidenced by the enhanced concentrations of naturally occurring U-238.

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.

A borehole named C4256 is located approximately 20 ft from this borehole and was drilled and logged in February 2004. The total gamma profiles roughly correlate even though the 2004 log data were greatly influenced by casing joints in the Becker casing.

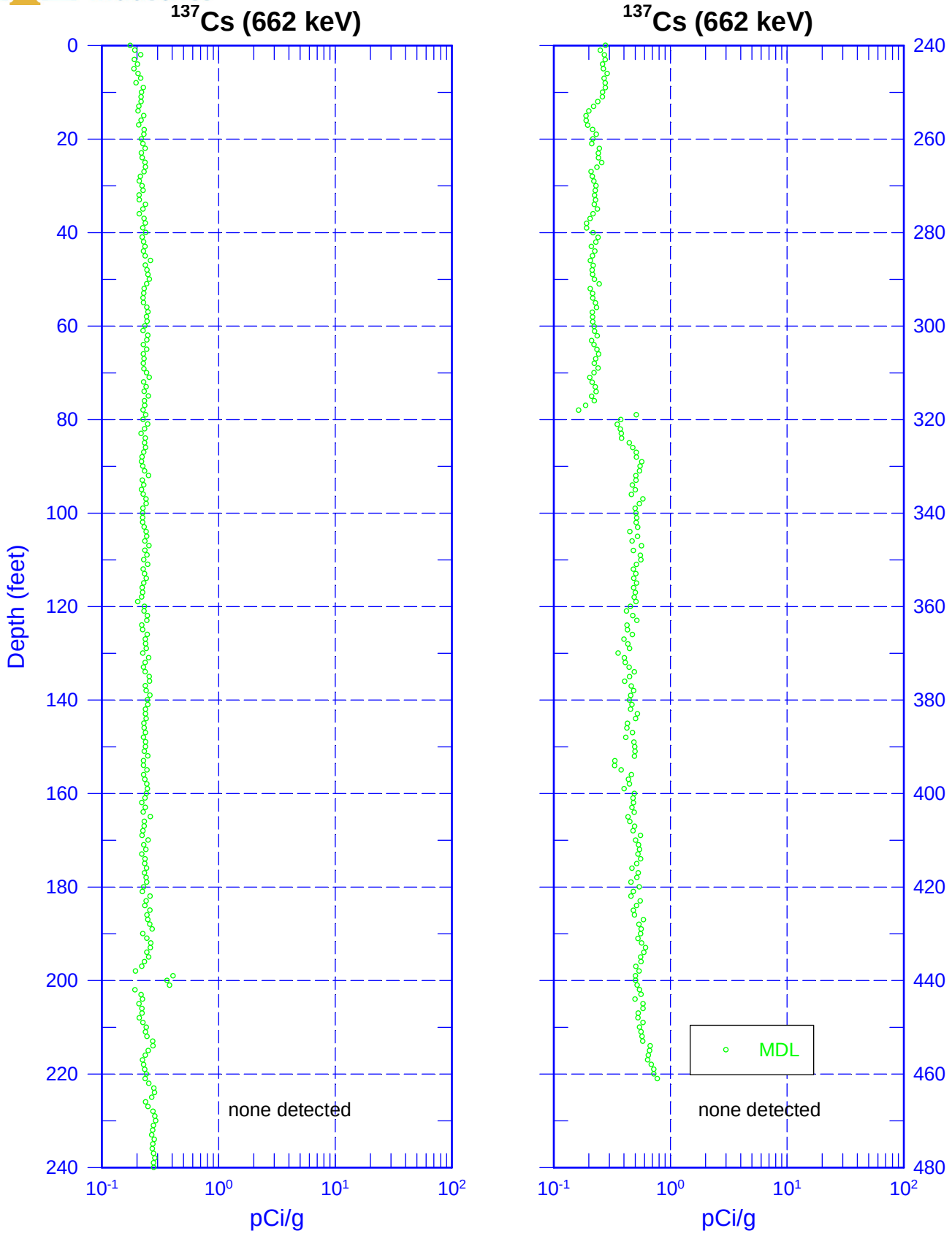
[4] Hanford Gamma Unit

List of Log Plots

Depth Reference is ground surface.

Manmade Radionuclides (0-480 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (150-310 ft)
Natural Gamma Logs (300-460 ft)
Combination Plot (0-120 ft)
Combination Plot (110-230 ft)
Combination Plot (220-340 ft)
Combination Plot (340-460 ft)
Combination Plot (0-480 ft)
Total Gamma & Moisture (0-160 ft)
Total Gamma & Moisture (150-310 ft)
Total Gamma & Moisture (300-460 ft)
Total Gamma & Hanford Gamma Unit (0-480 ft)
Repeat Section of Natural Gamma Logs (170-190 ft)
Repeat Section of Natural Gamma Logs (434-460 ft)
Moisture Repeat Section (85-105 ft)
Moisture Repeat Section (285-300 ft)

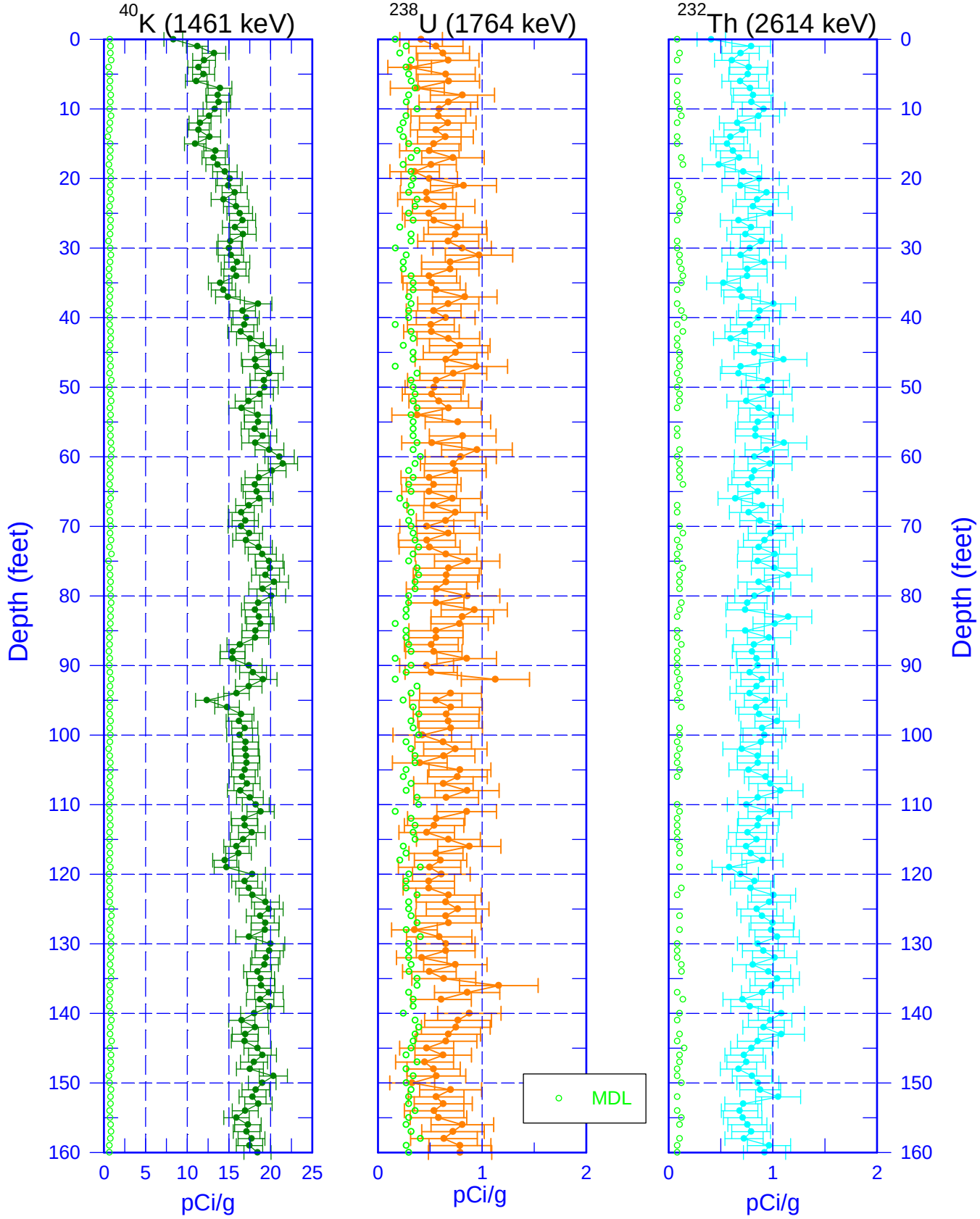
699-39-68 (C9607)
Manmade Radionuclides



Zero Reference - Ground Surface

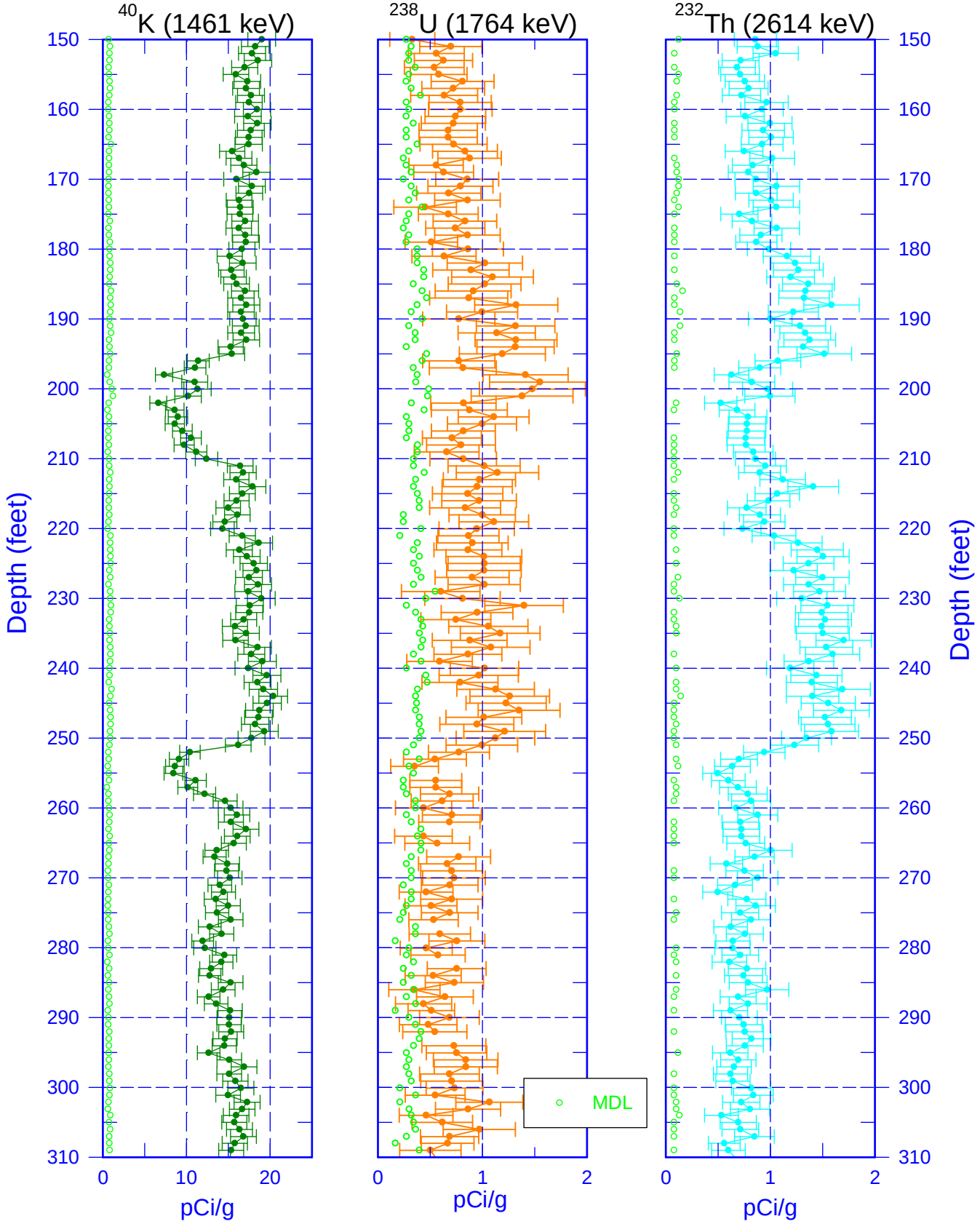
Huntington Ingalls Industries

699-39-68 (C9607)
Natural Gamma Logs



Zero Reference - Ground Surface

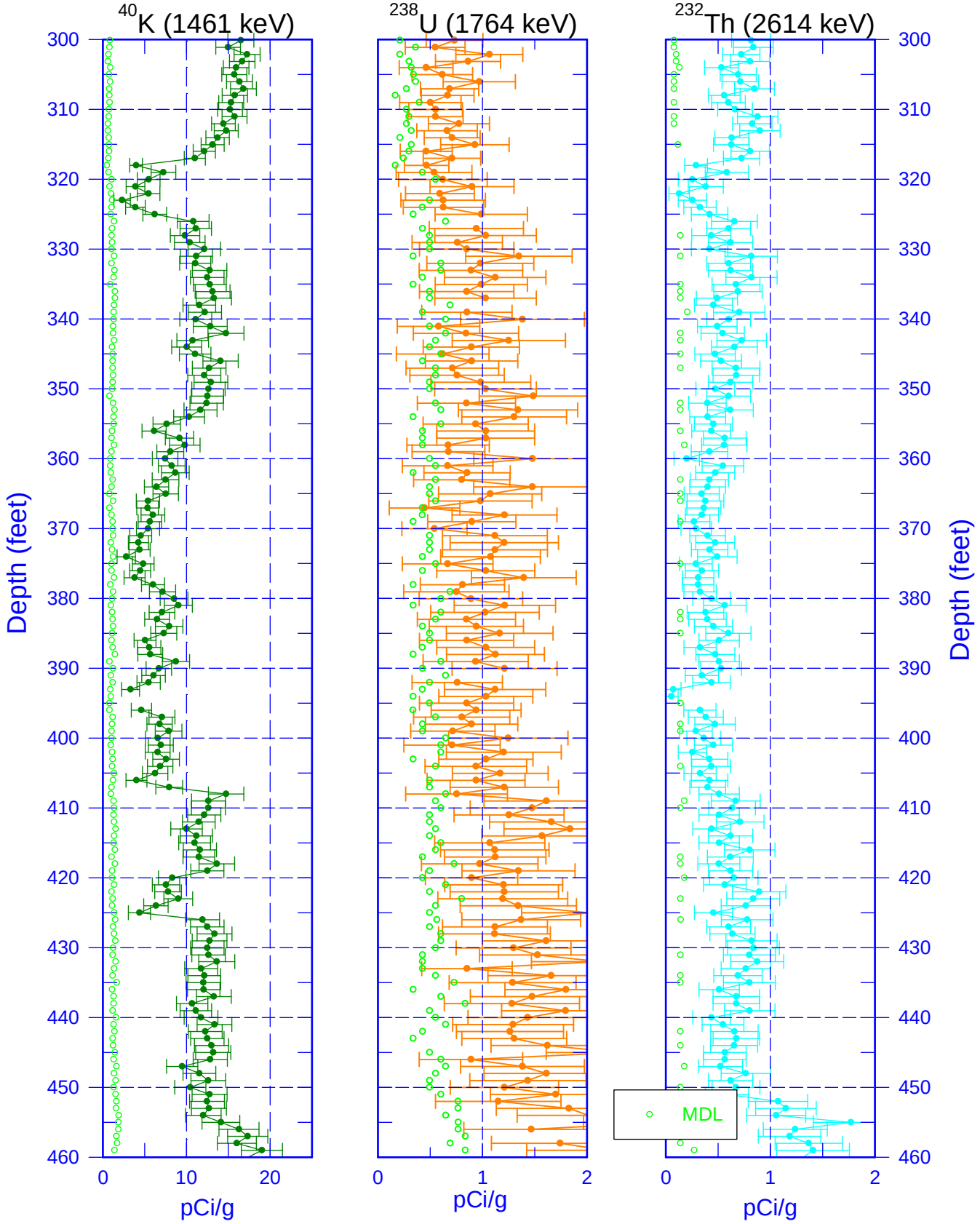
699-39-68 (C9607)
Natural Gamma Logs



Zero Reference - Ground Surface

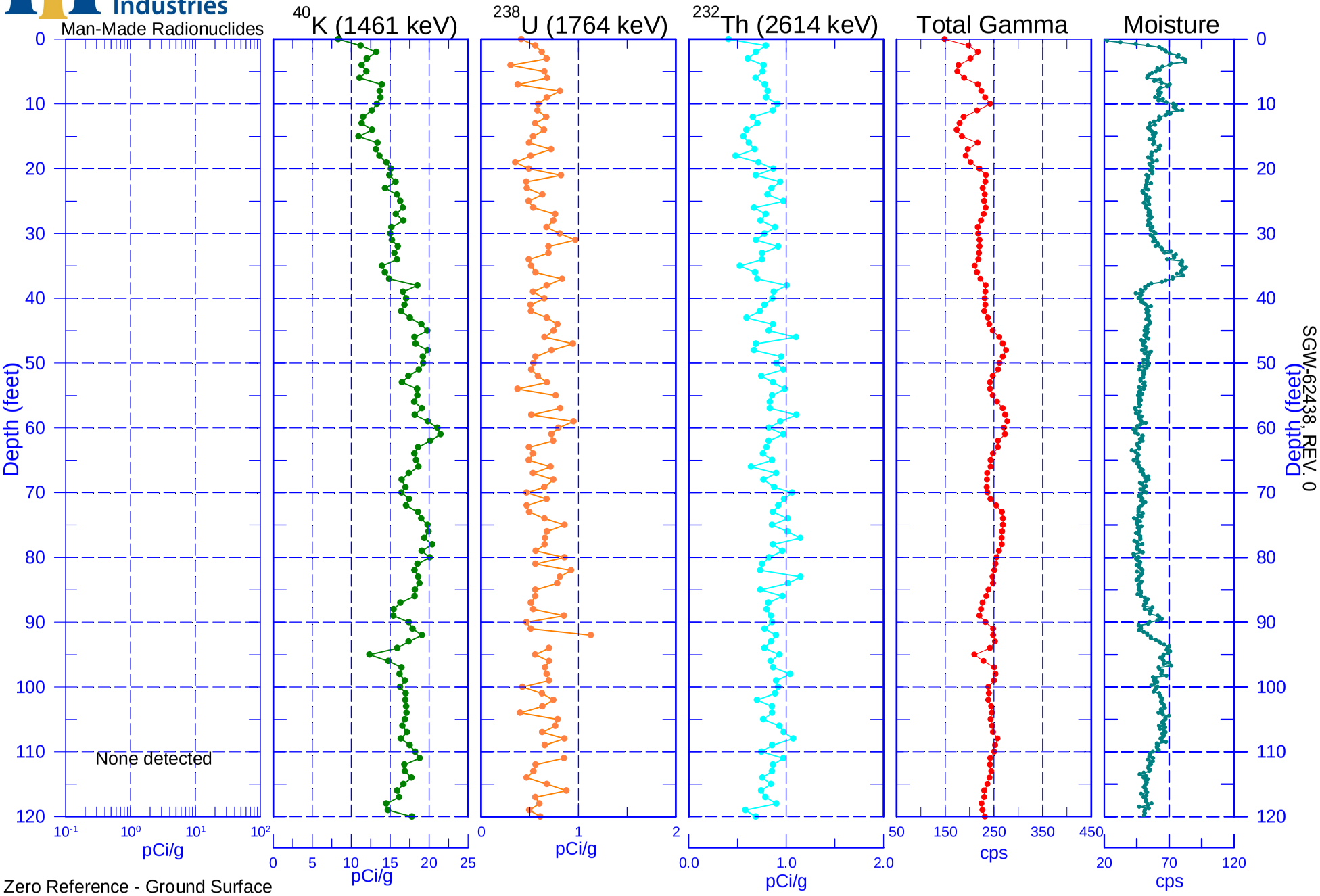
Huntington Ingalls Industries

699-39-68 (C9607)
Natural Gamma Logs



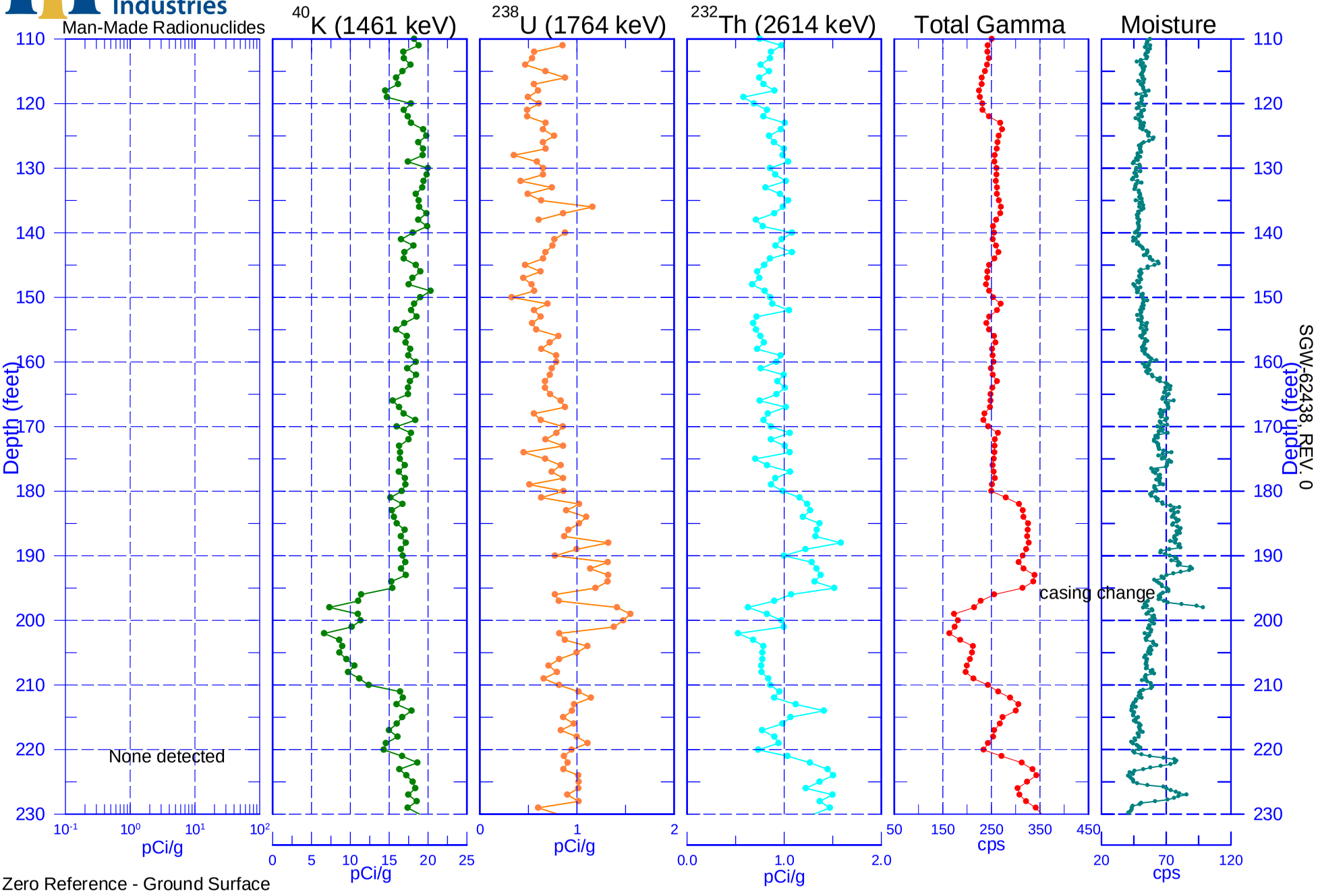
Zero Reference - Ground Surface

699-39-68 (C9607) Combination Plot



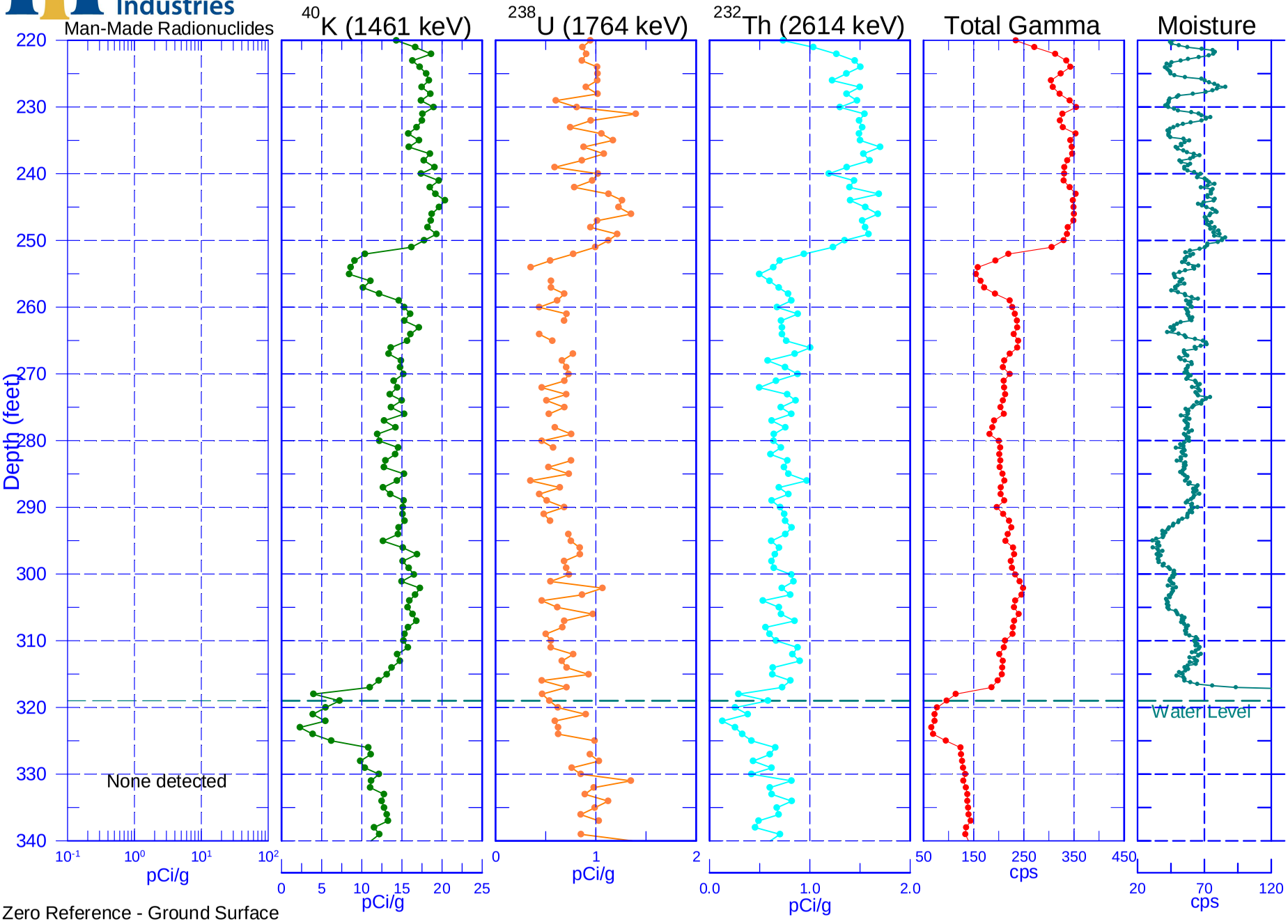
Zero Reference - Ground Surface

699-39-68 (C9607) Combination Plot



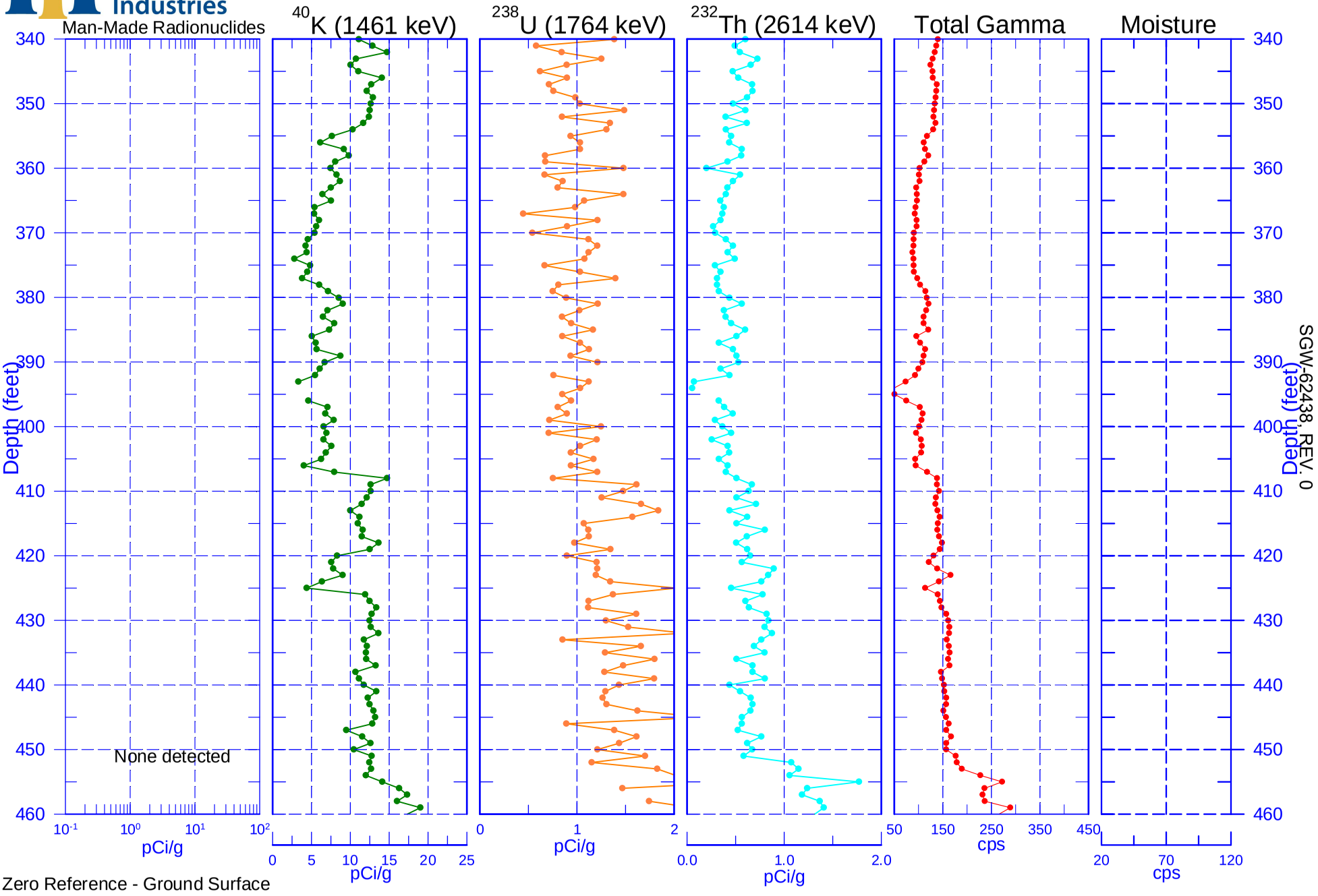
Zero Reference - Ground Surface

699-39-68 (C9607) Combination Plot



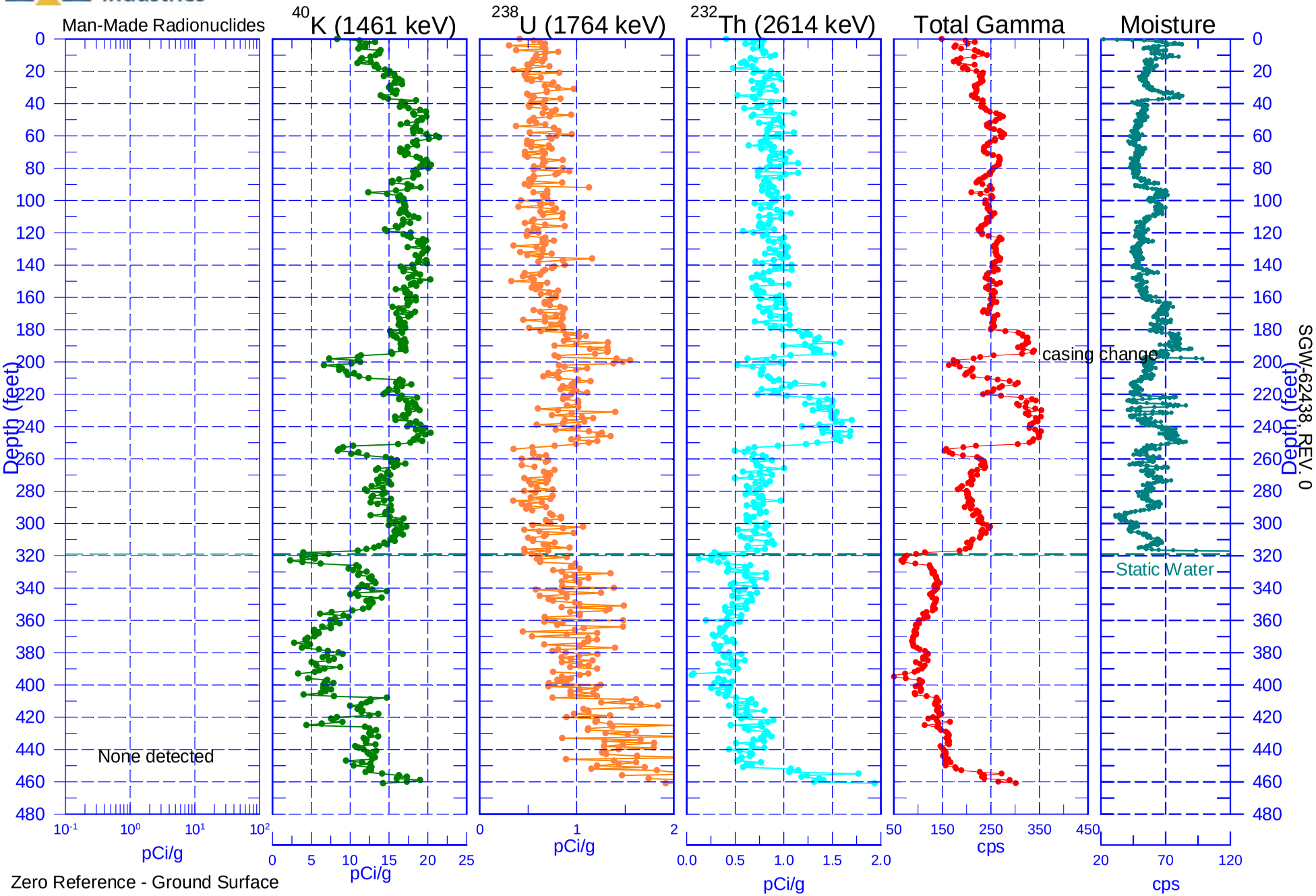
Zero Reference - Ground Surface

699-39-68 (C9607) Combination Plot

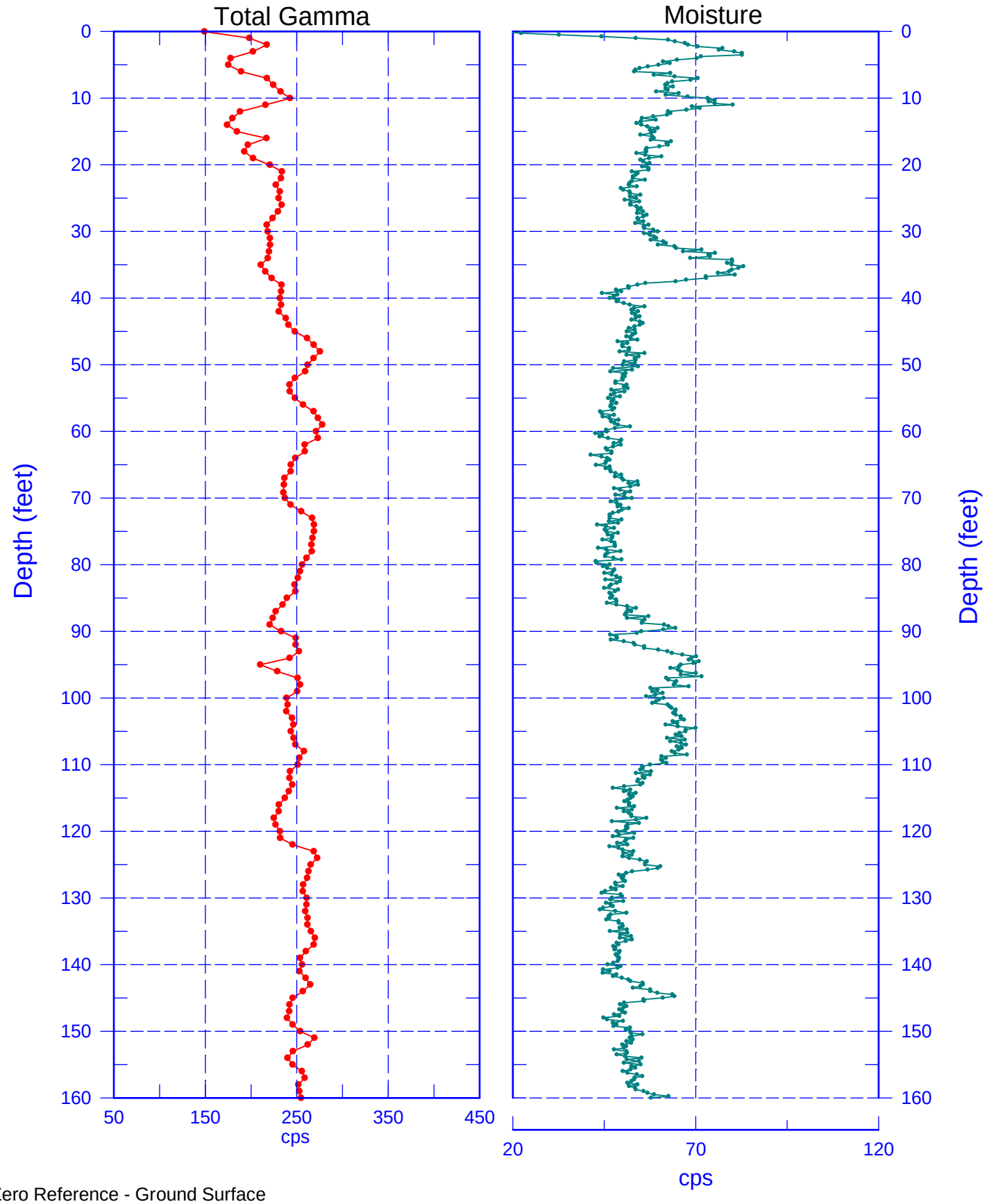


Zero Reference - Ground Surface

699-39-68 (C9607) Combination Plot



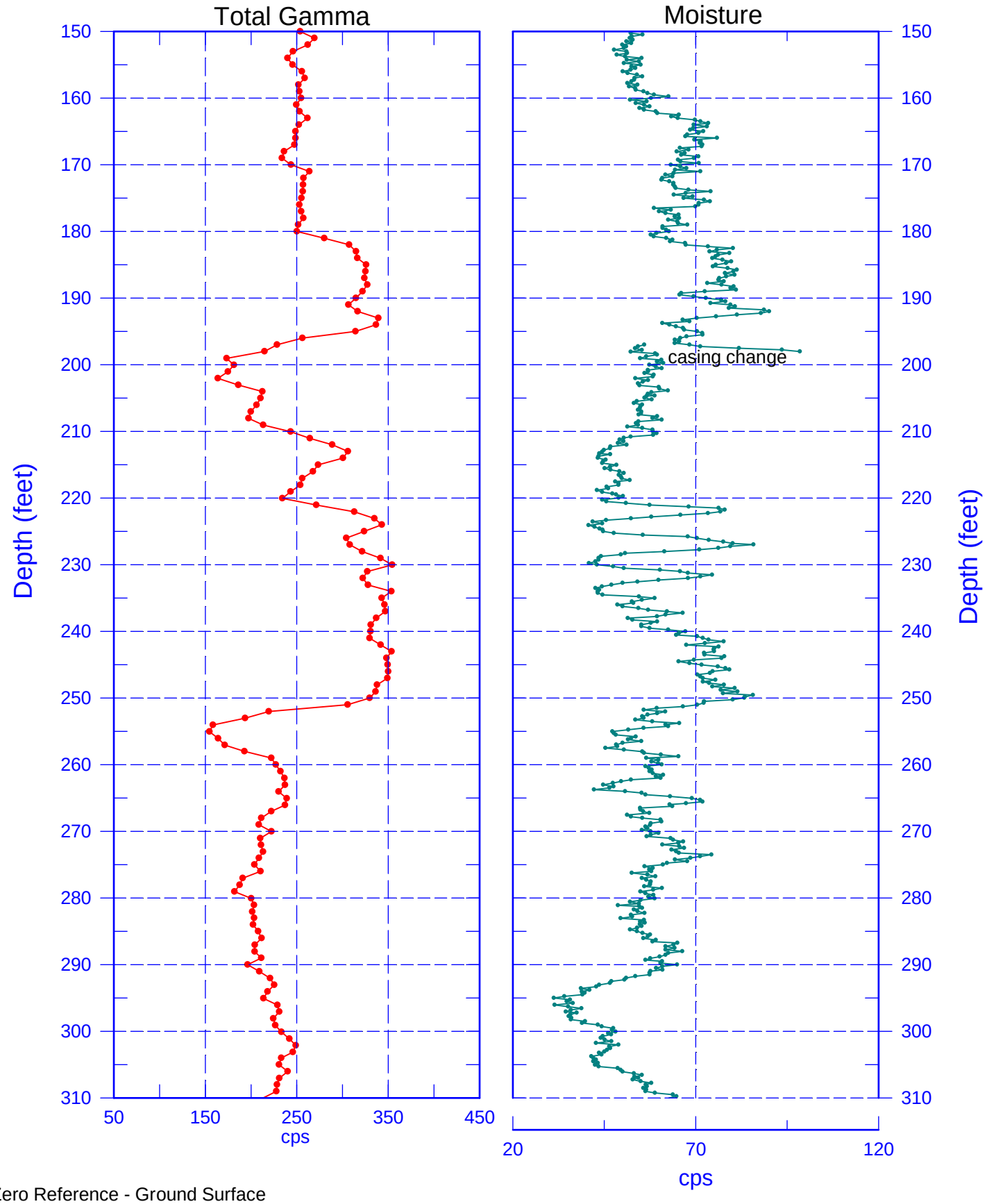
699-39-68 (C9607)
Total Gamma & Moisture



Zero Reference - Ground Surface

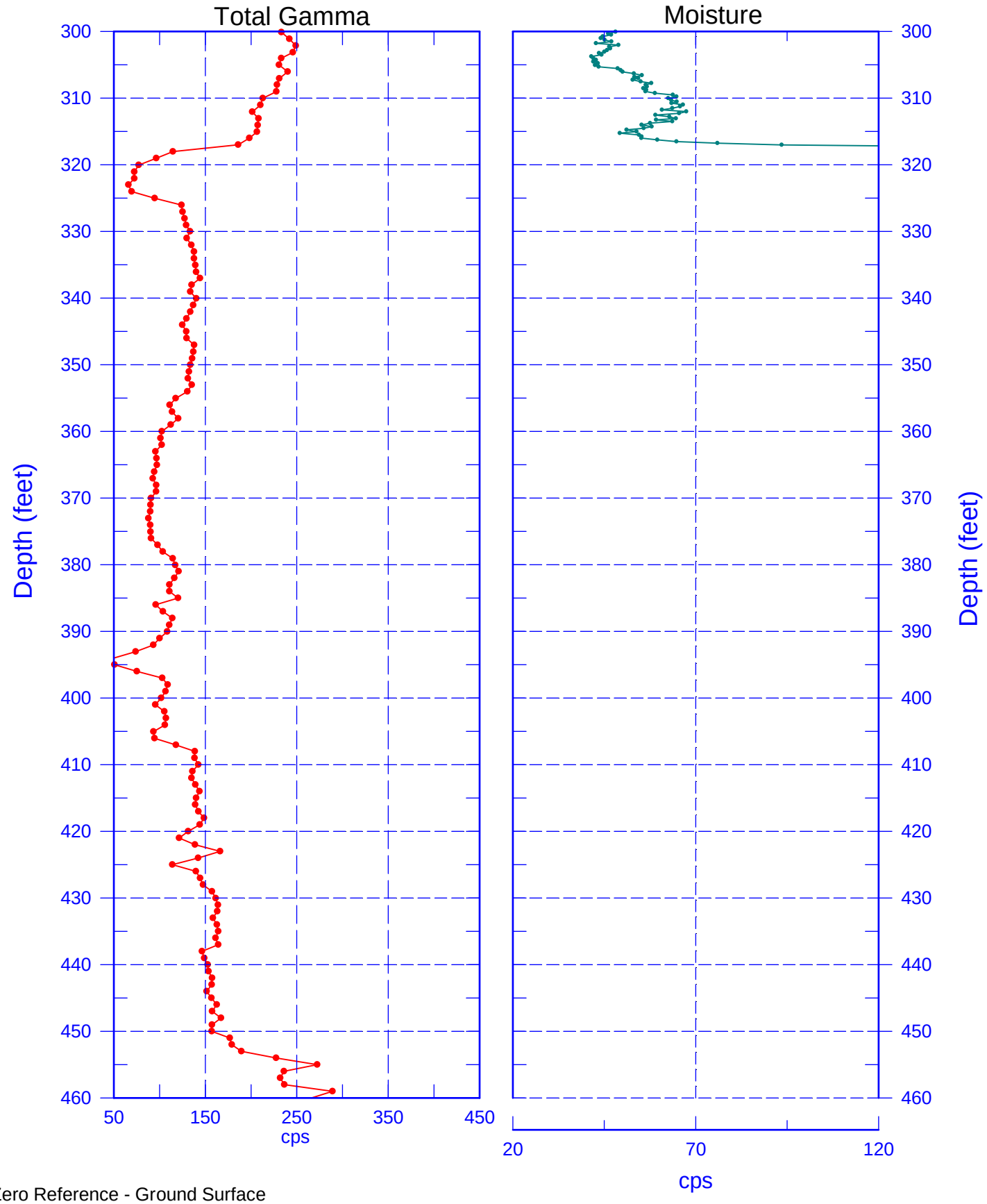
Huntington Ingalls Industries

699-39-68 (C9607)
Total Gamma & Moisture



Zero Reference - Ground Surface

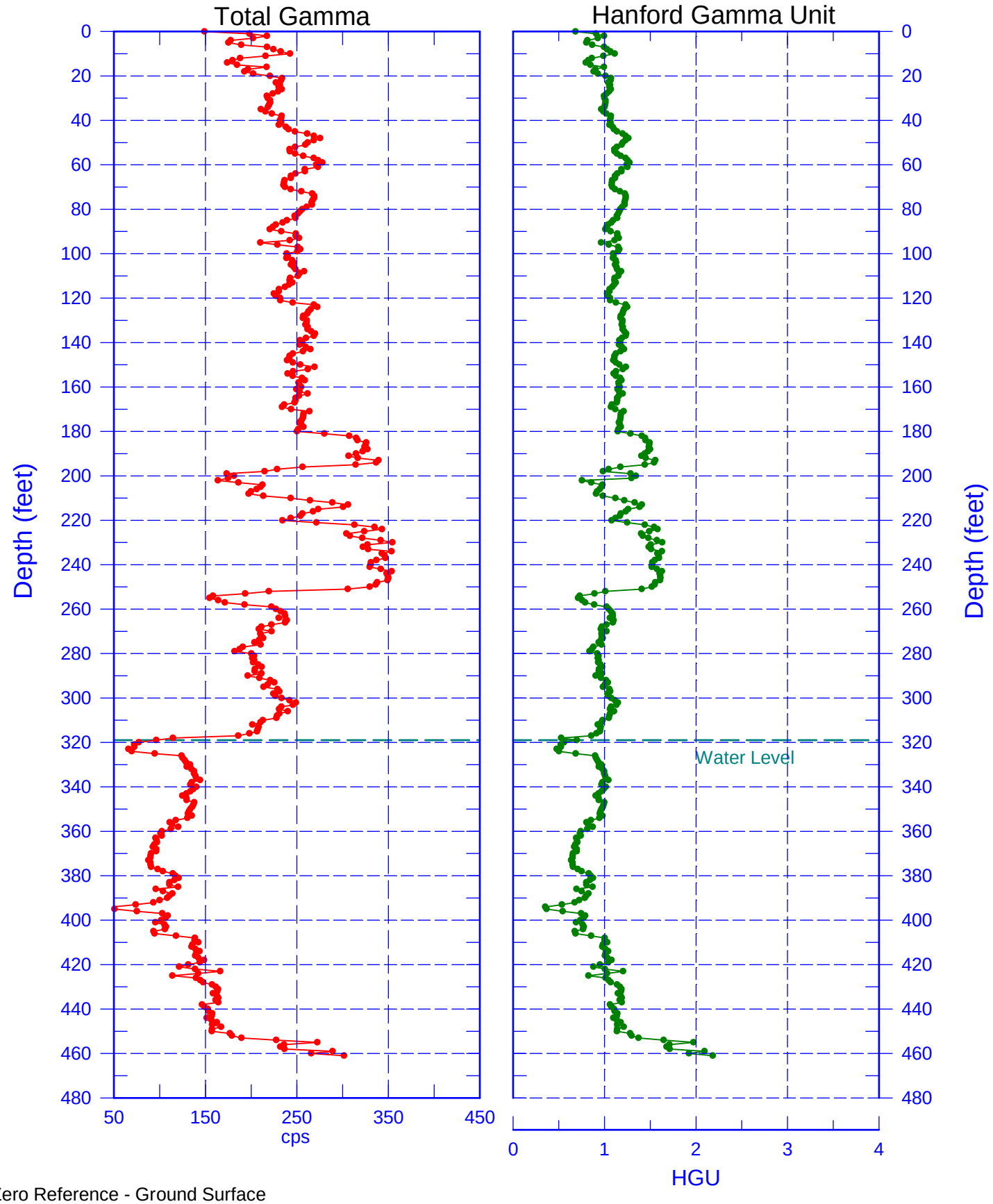
699-39-68 (C9607)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

699-39-68 (C9607)
Total Gamma & Hanford Gamma Unit

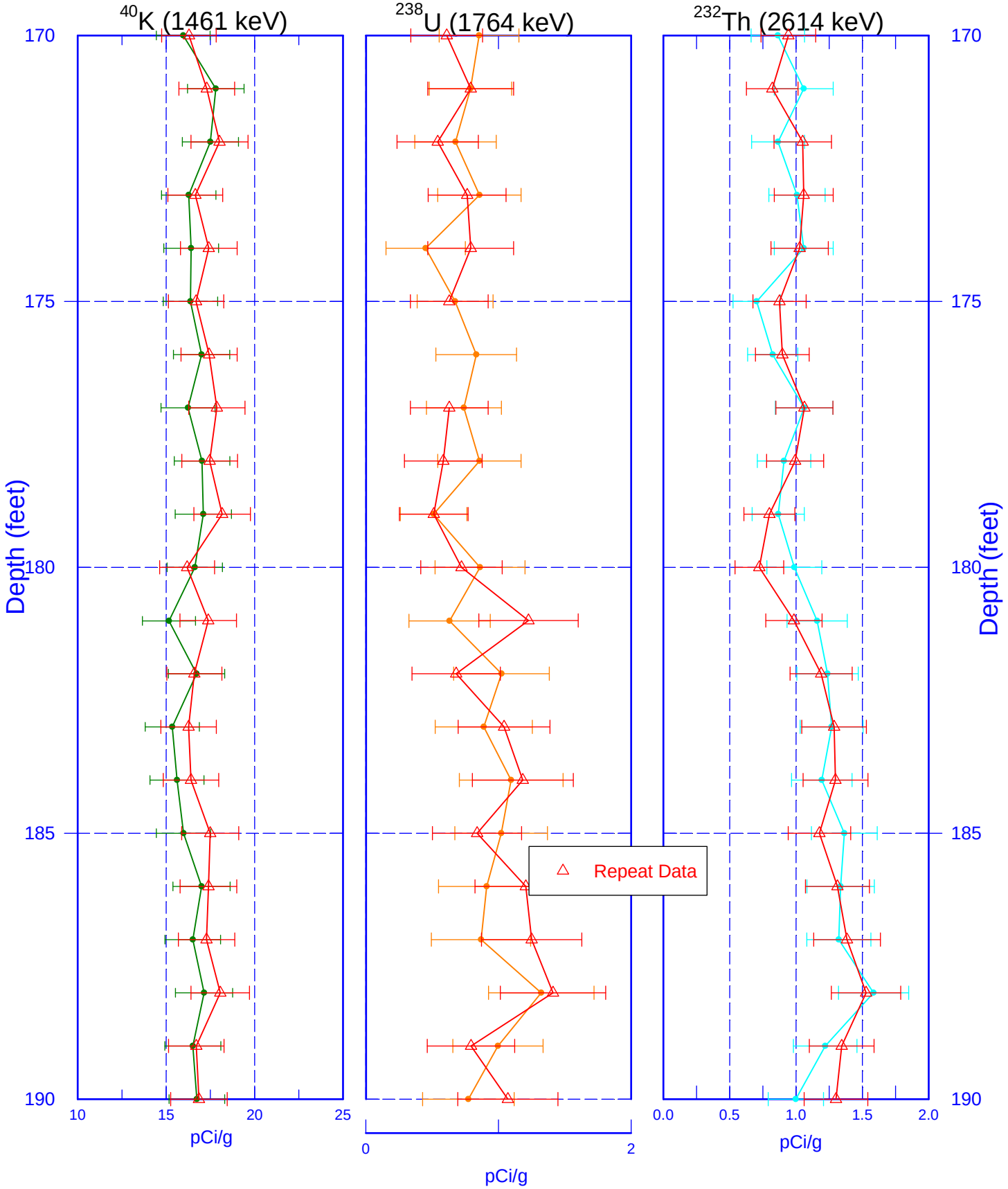


Zero Reference - Ground Surface

Huntington Ingalls Industries

699-39-68 (C9607)

Repeat Section of Natural Gamma Logs

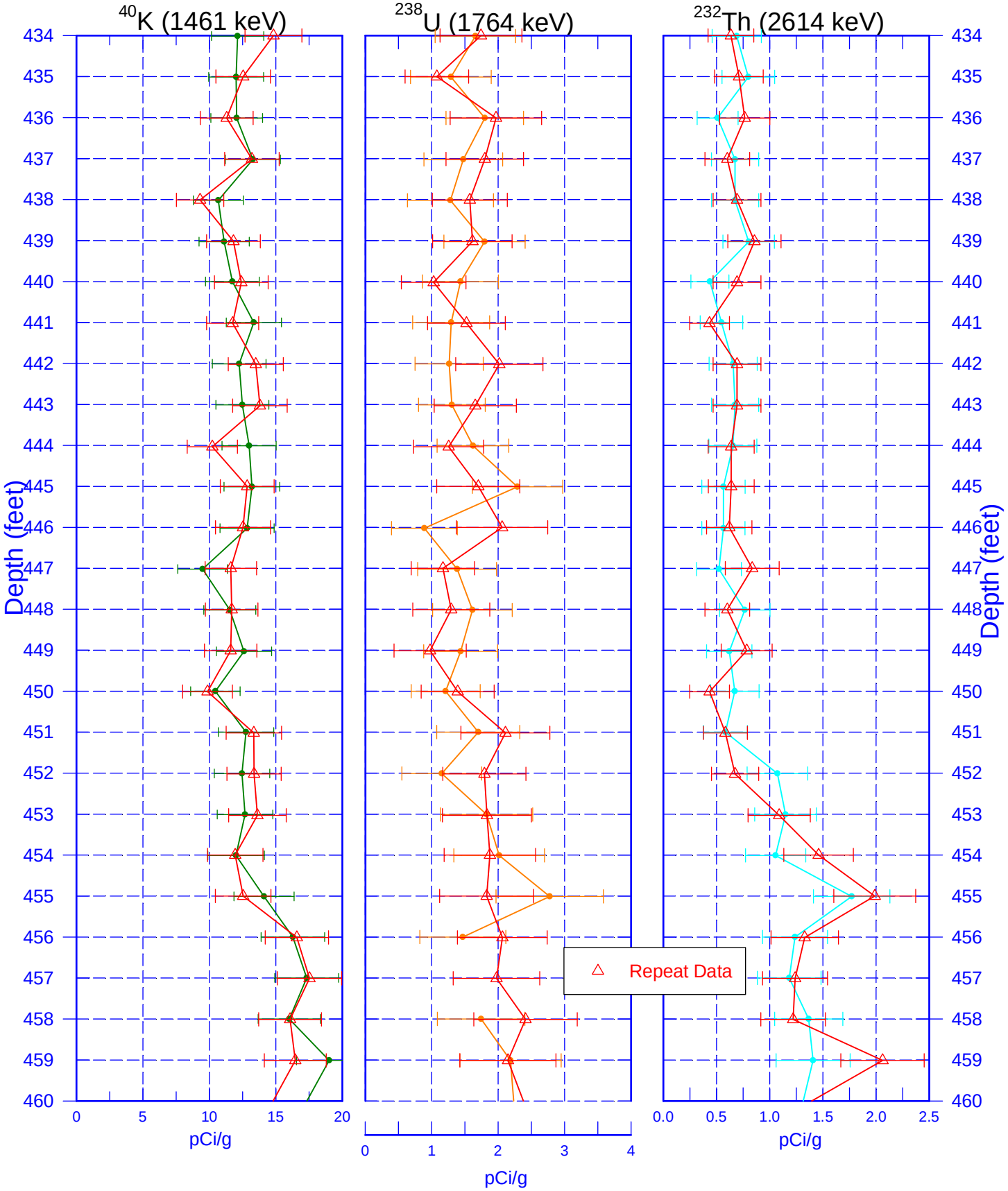


Zero Reference - Ground Surface

Huntington Ingalls Industries

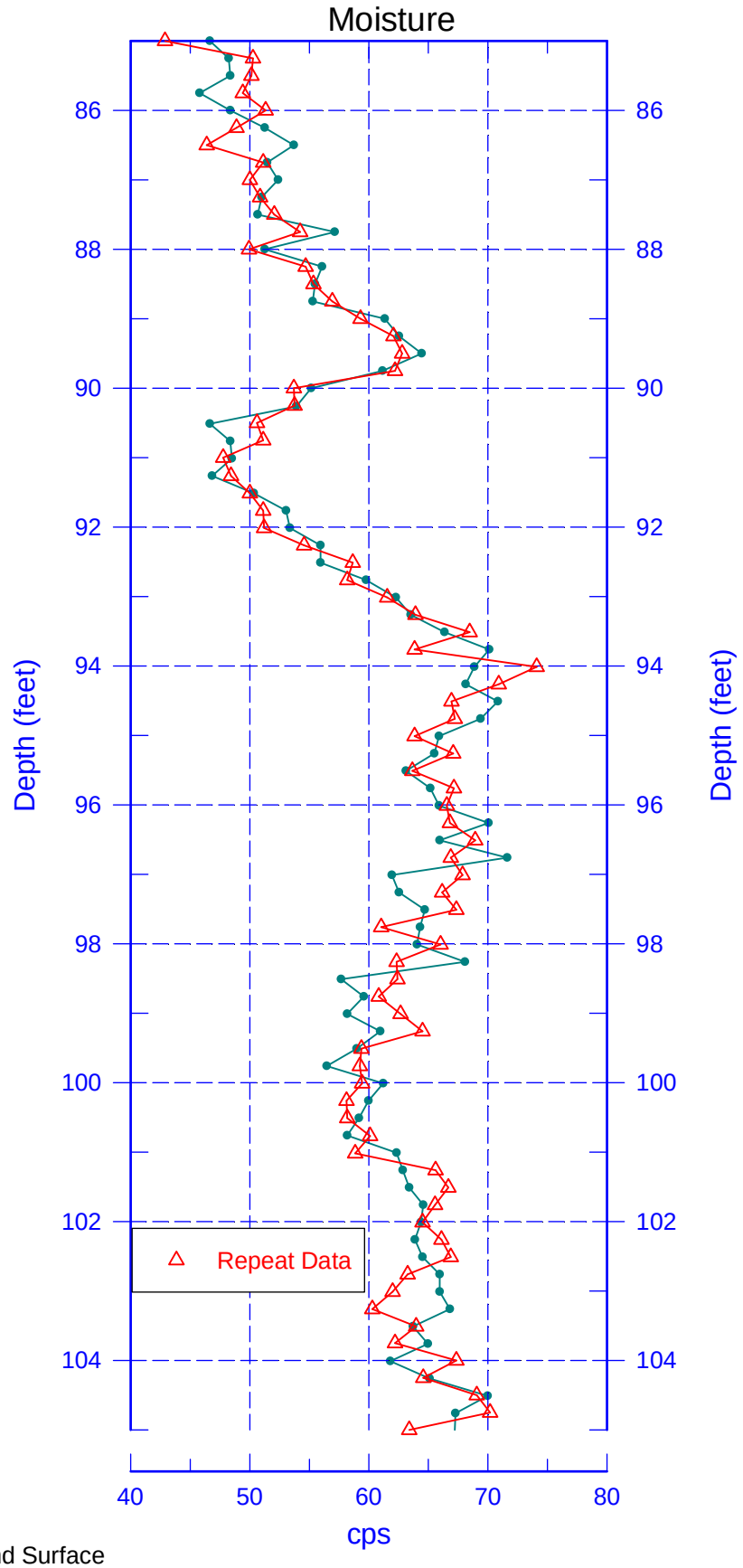
699-39-68 (C9607)

Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

699-39-68 (C9607)
Moisture Repeat Section



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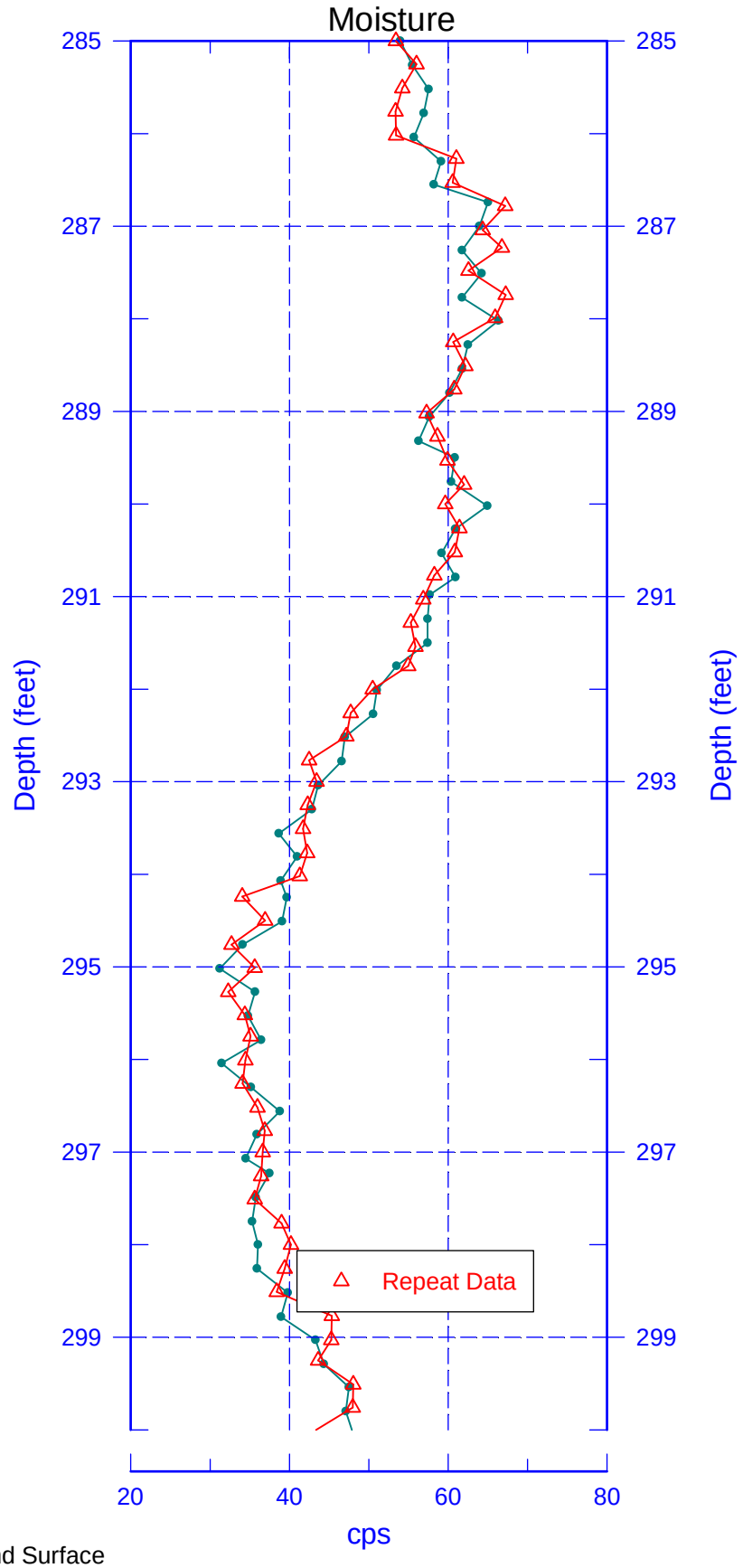
Moisture Repeat Section



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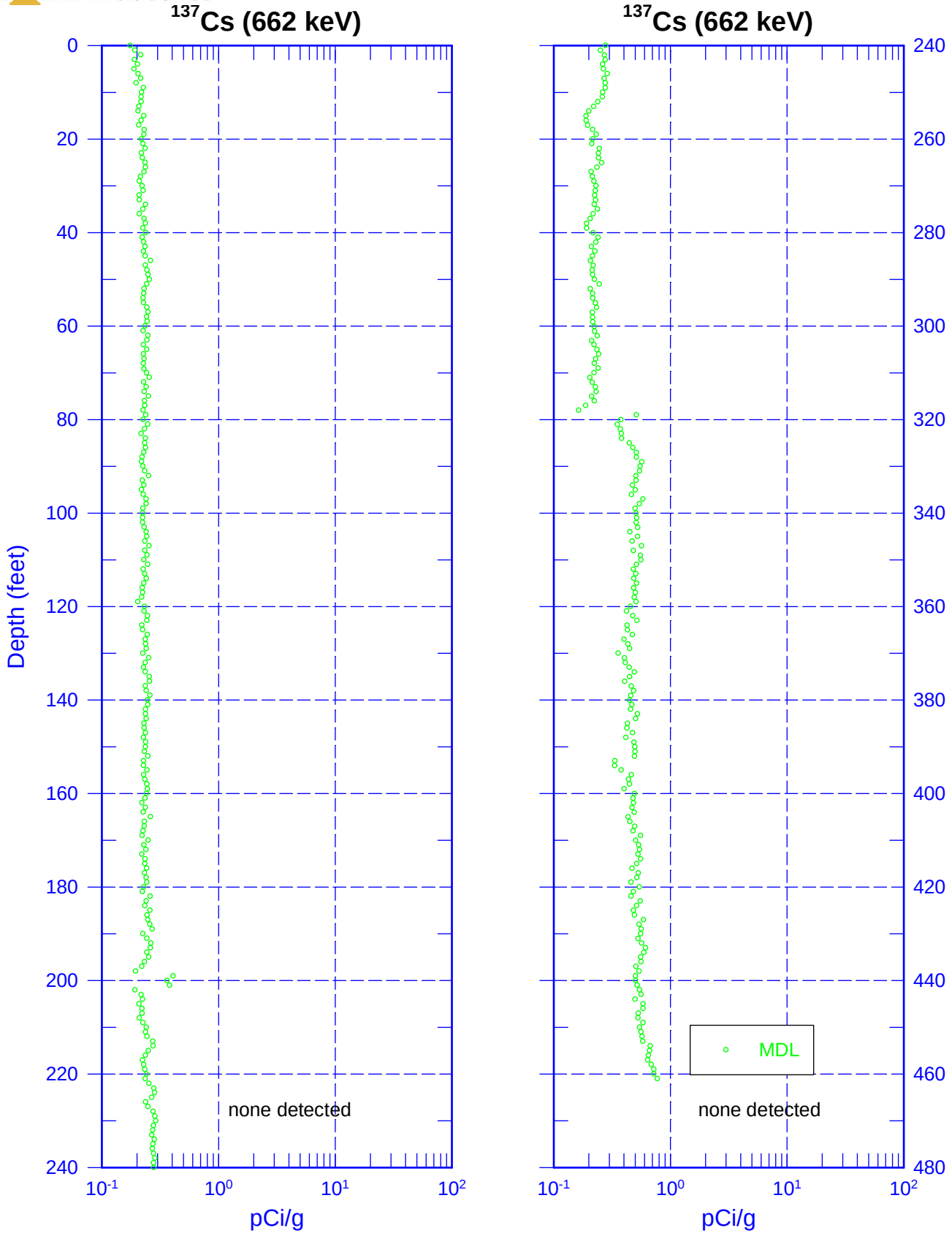
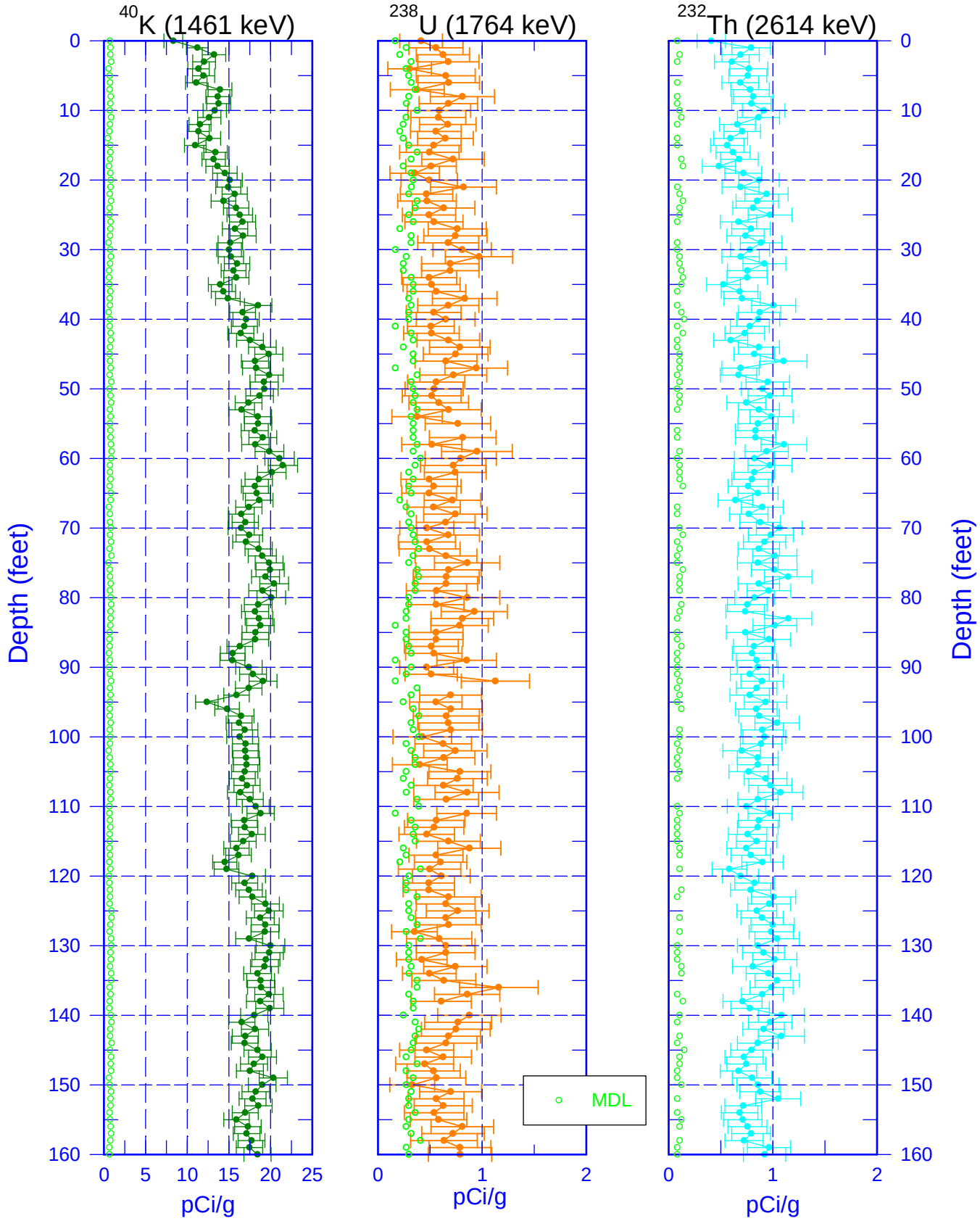
699-39-68 (C9607)
Manmade Radionuclides



Zero Reference - Ground Surface

Huntington Ingalls Industries

699-39-68 (C9607)
Natural Gamma Logs



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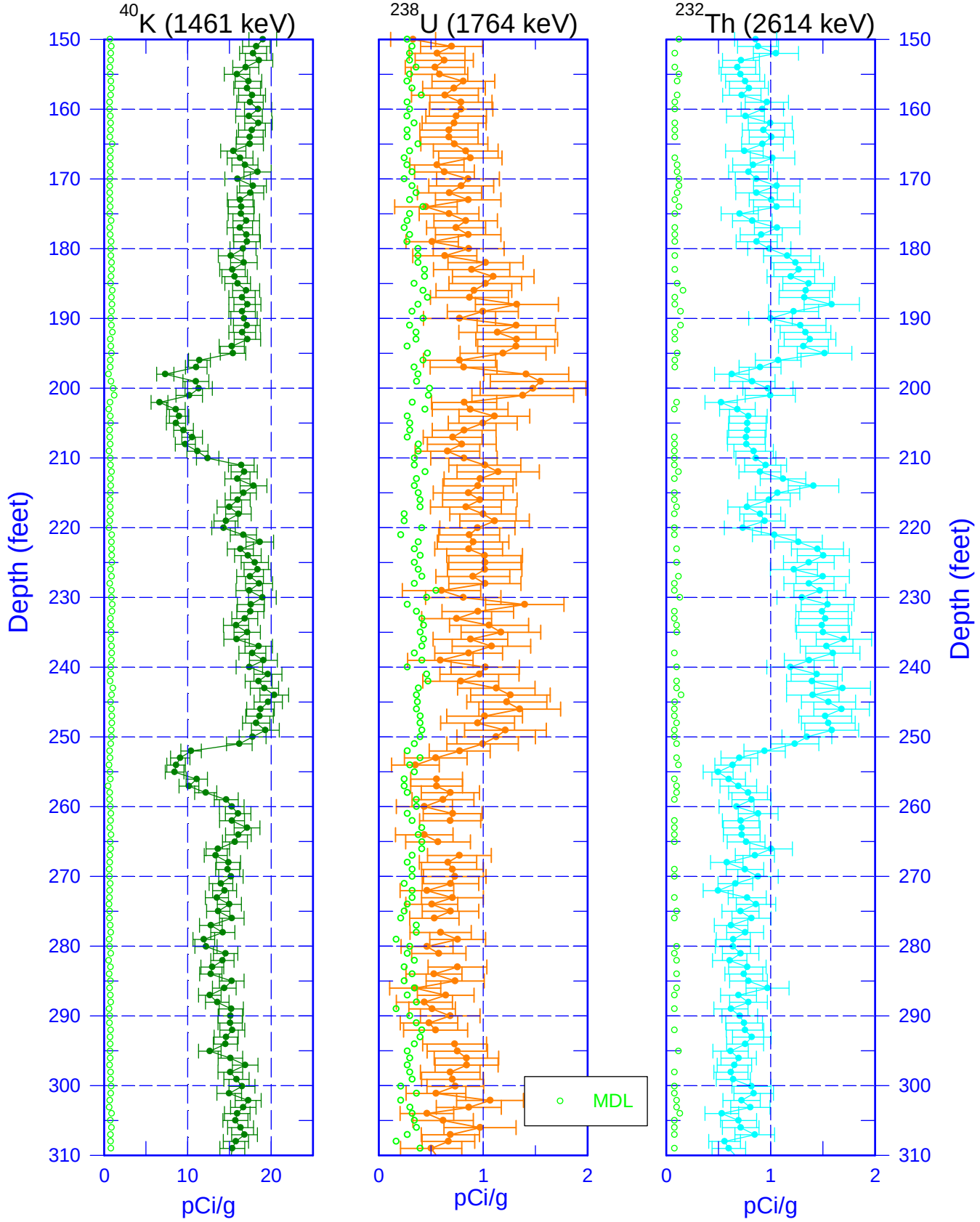
Natural Gamma Logs



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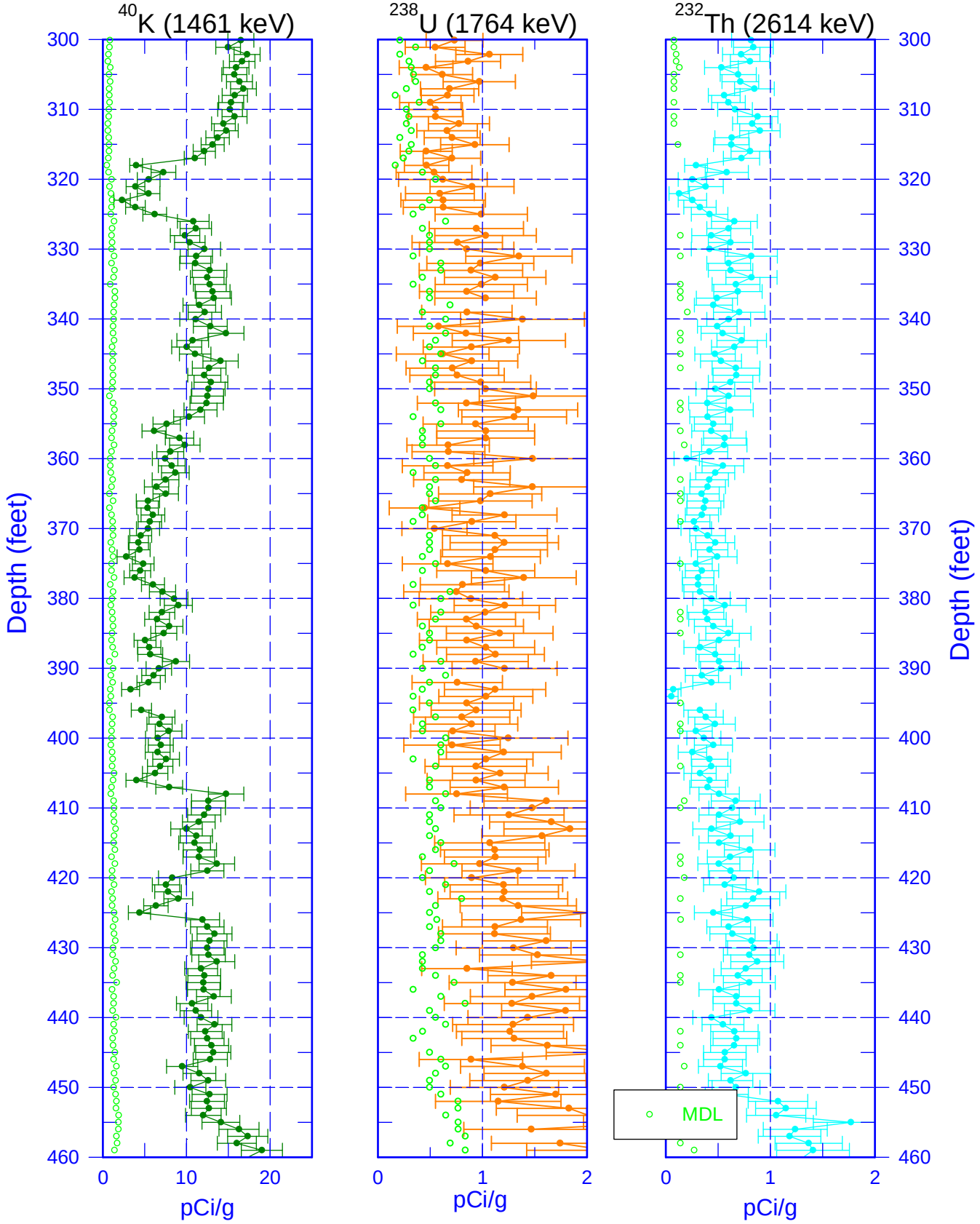
699-39-68 (C9607)
Natural Gamma Logs



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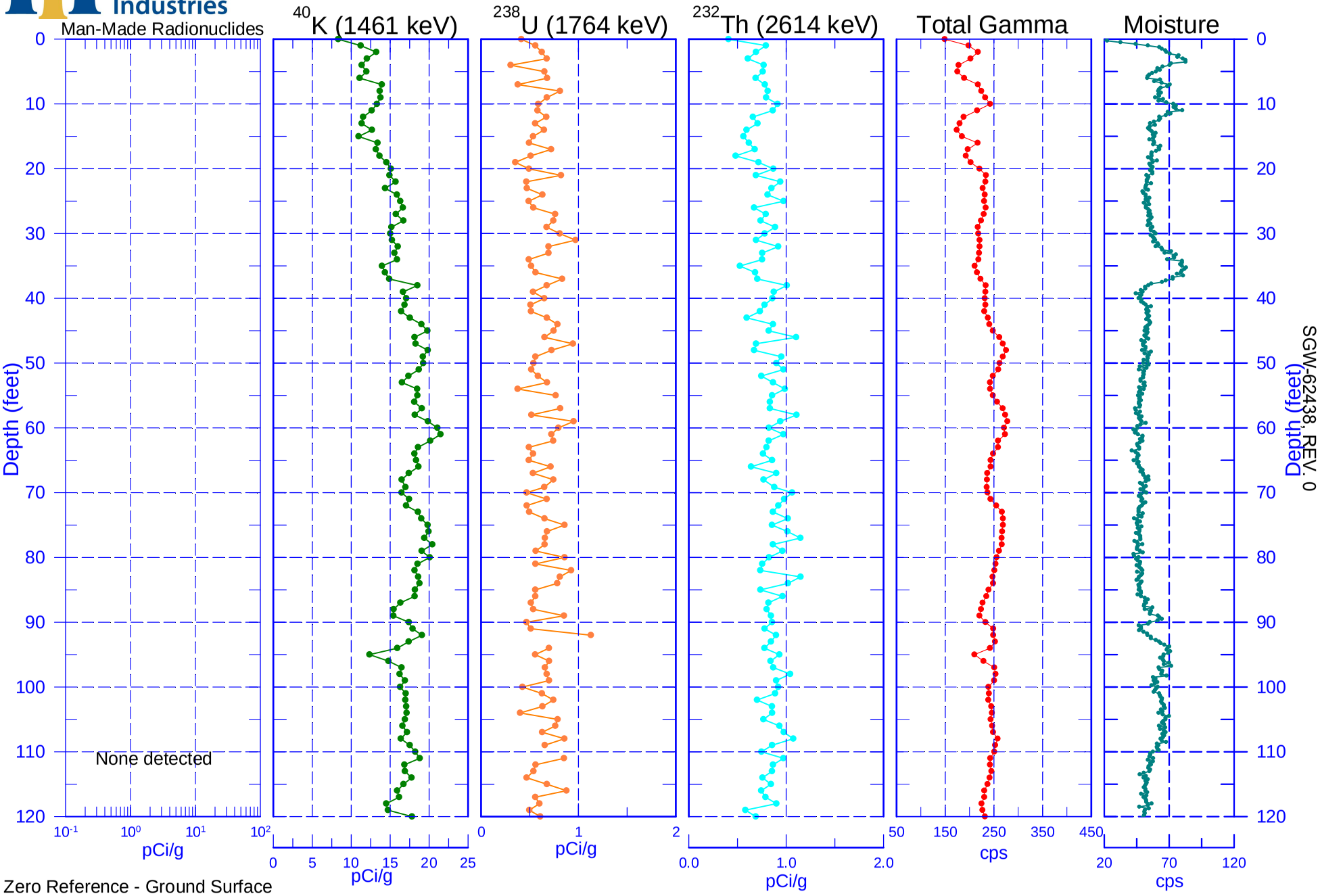
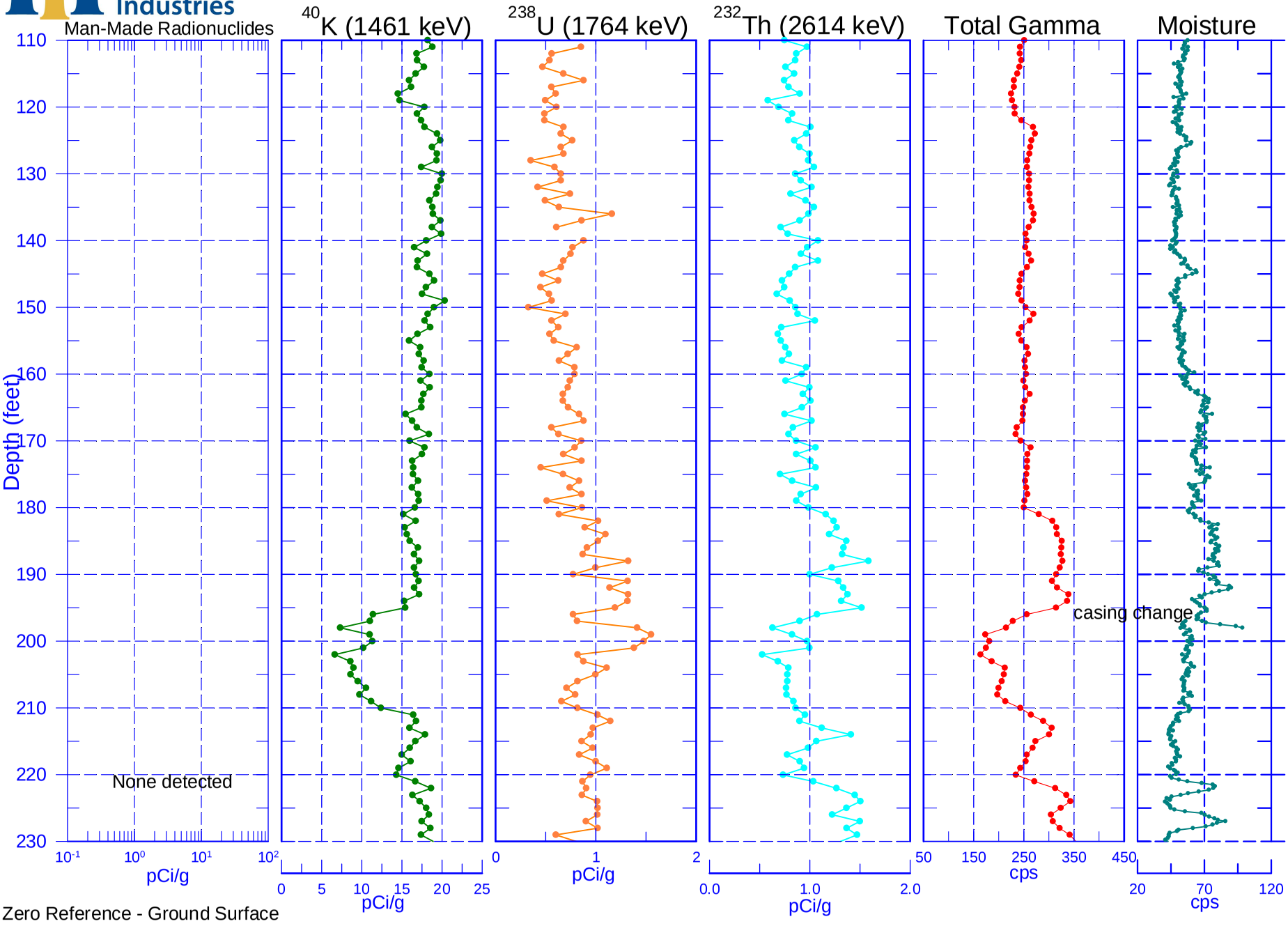
699-39-68 (C9607) Combination Plot



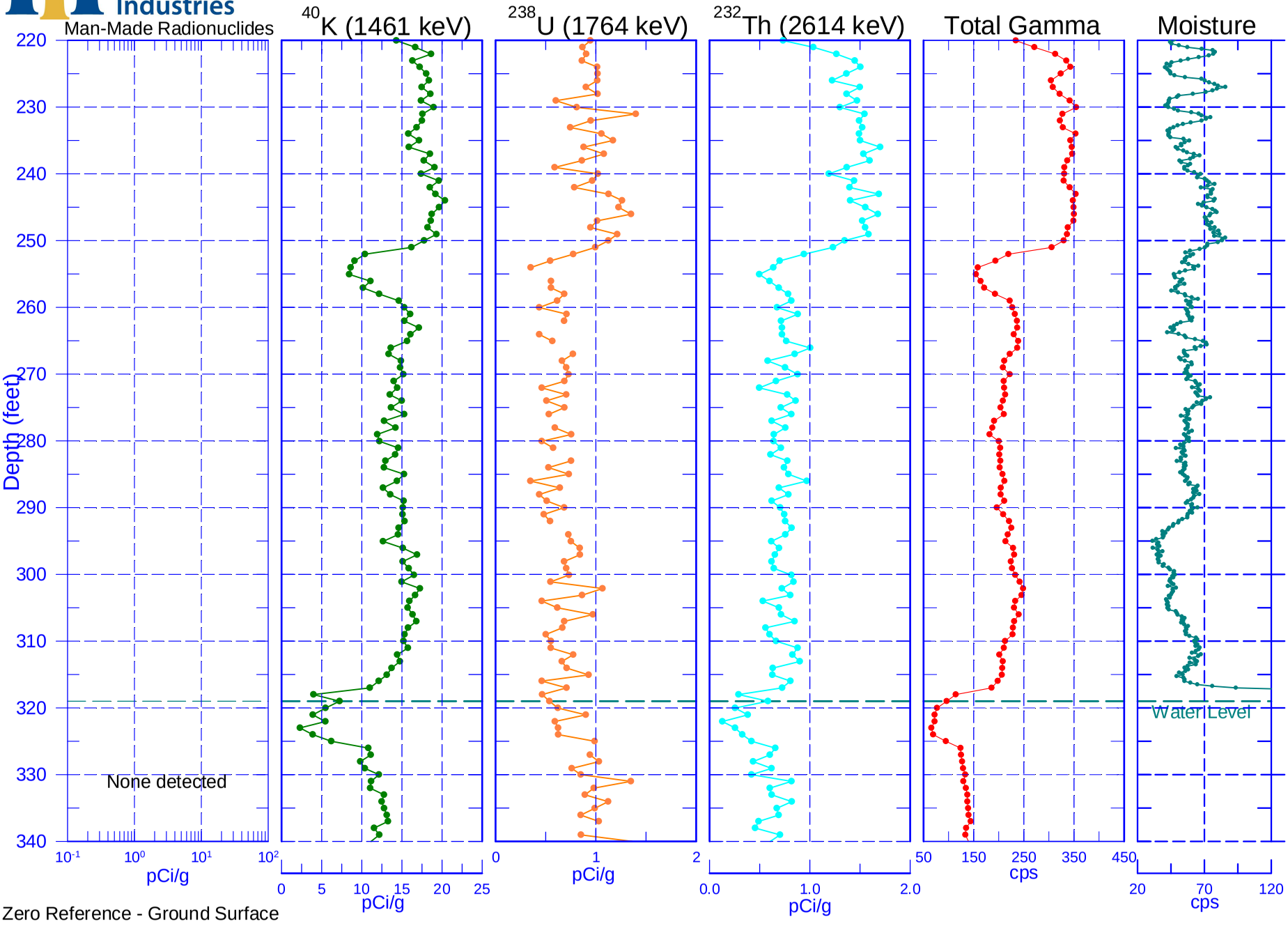
Zero Reference - Ground Surface

699-39-68 (C9607) Combination Plot



Zero Reference - Ground Surface

699-39-68 (C9607) Combination Plot



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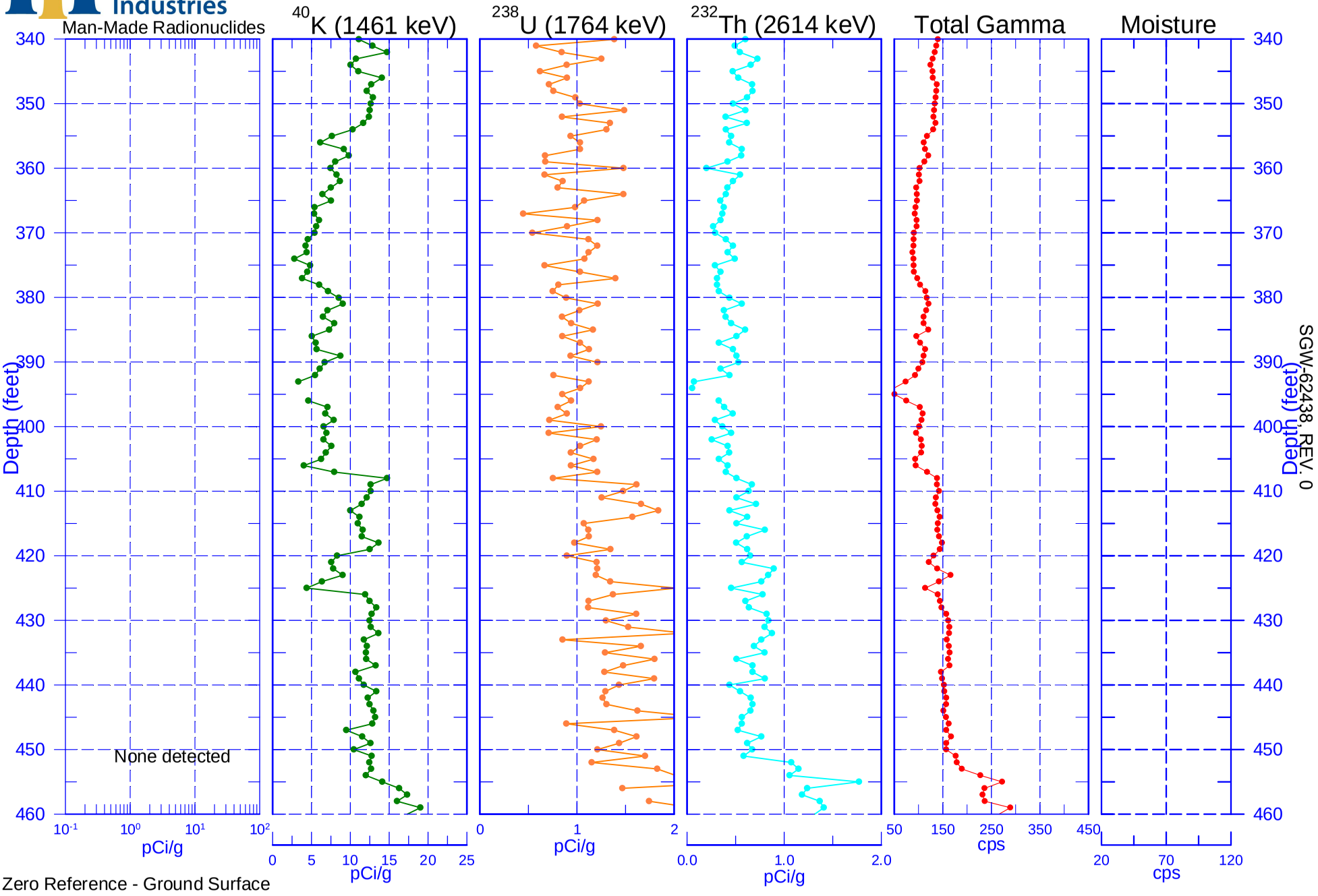
699-39-68 (C9607) Combination Plot



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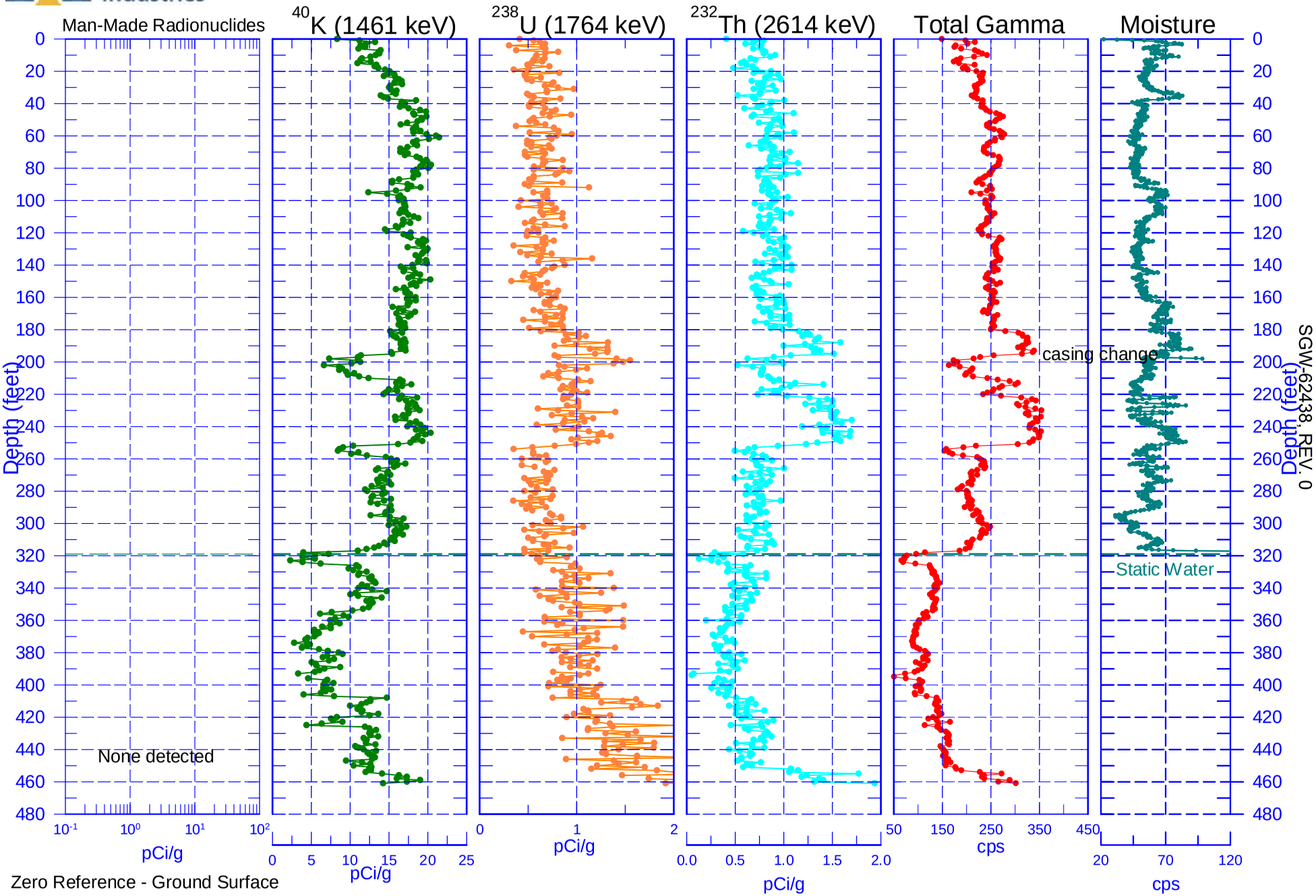
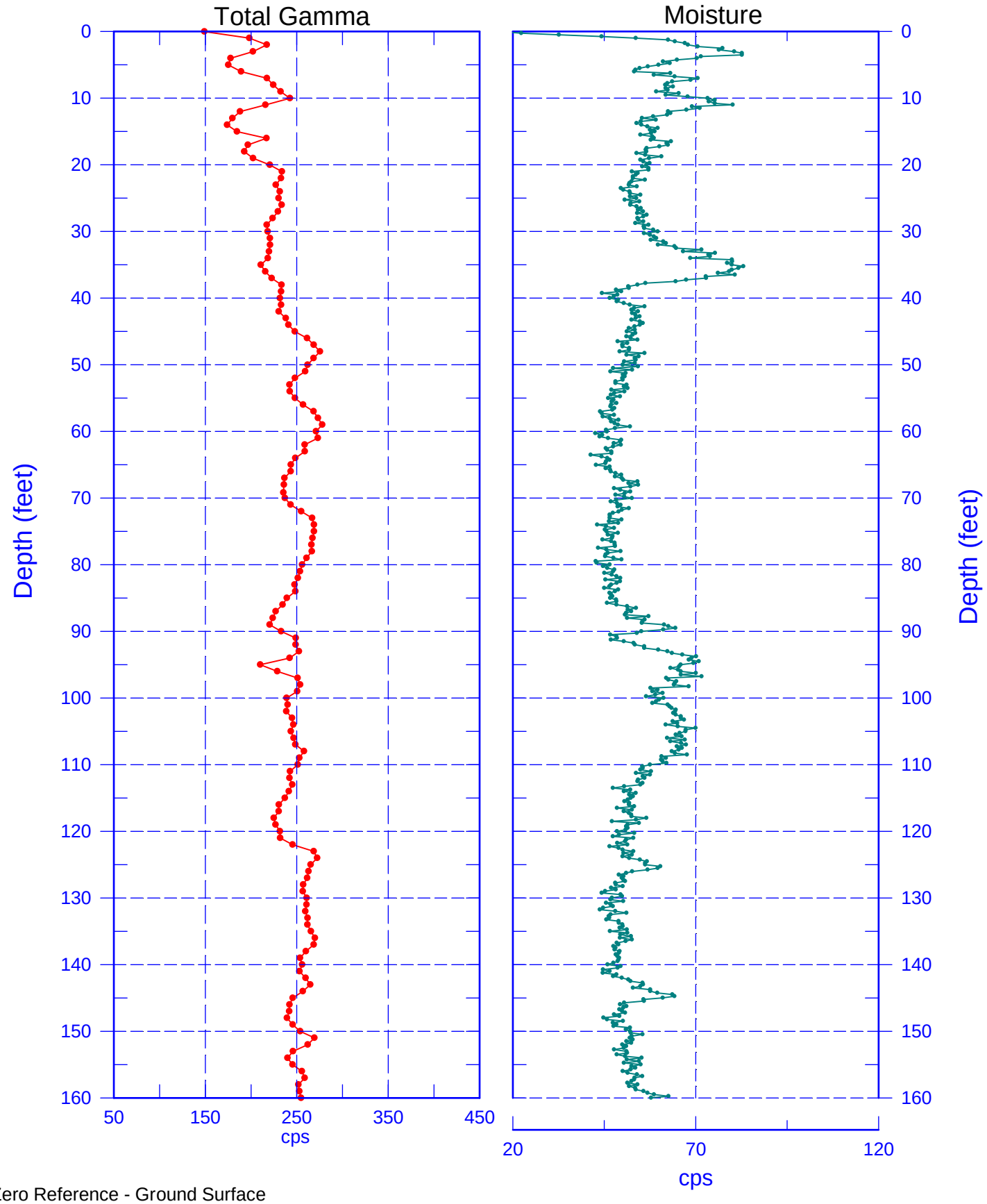
699-39-68 (C9607) Combination Plot



Zero Reference - Ground Surface

Huntington Ingalls Industries

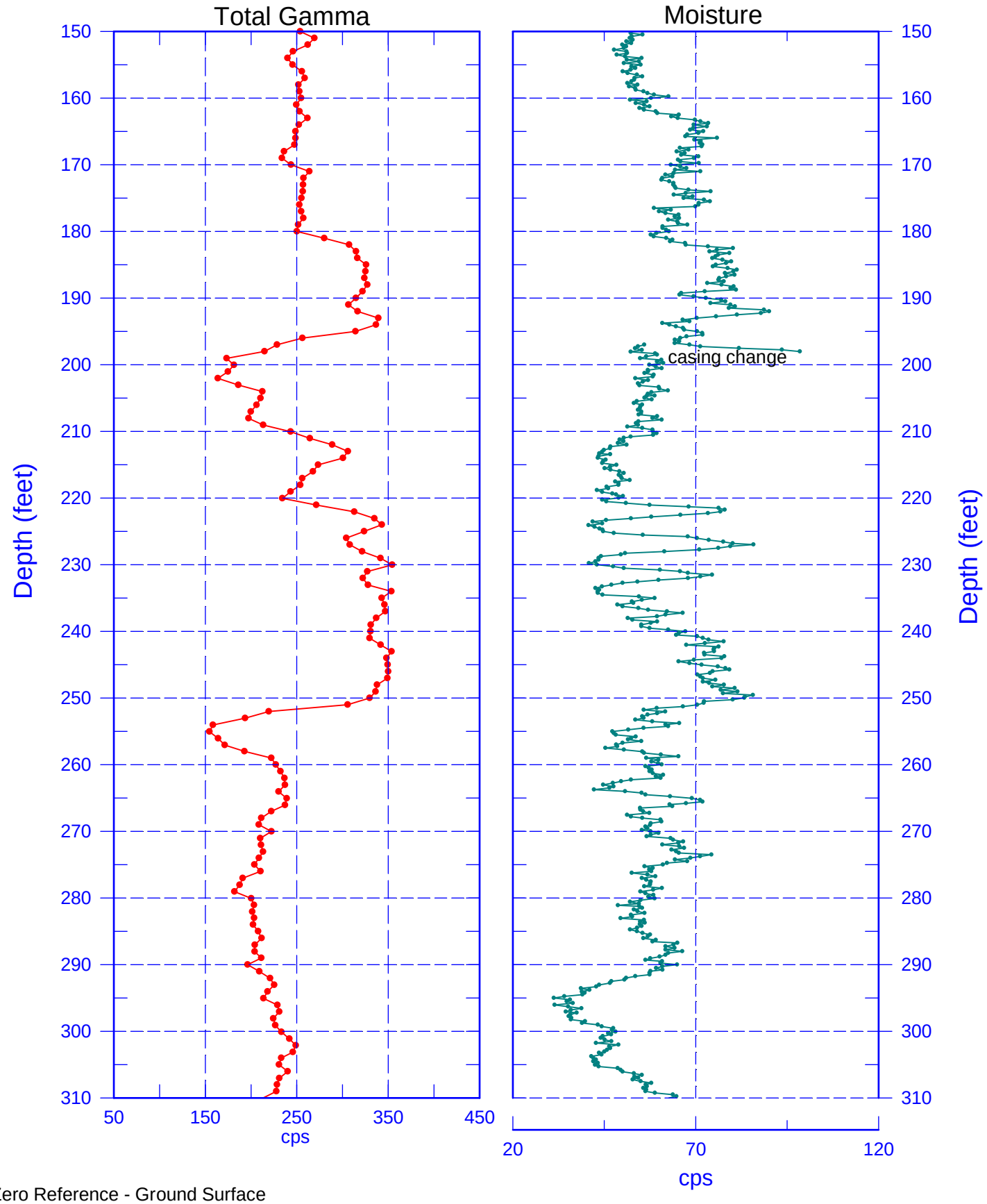
699-39-68 (C9607)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

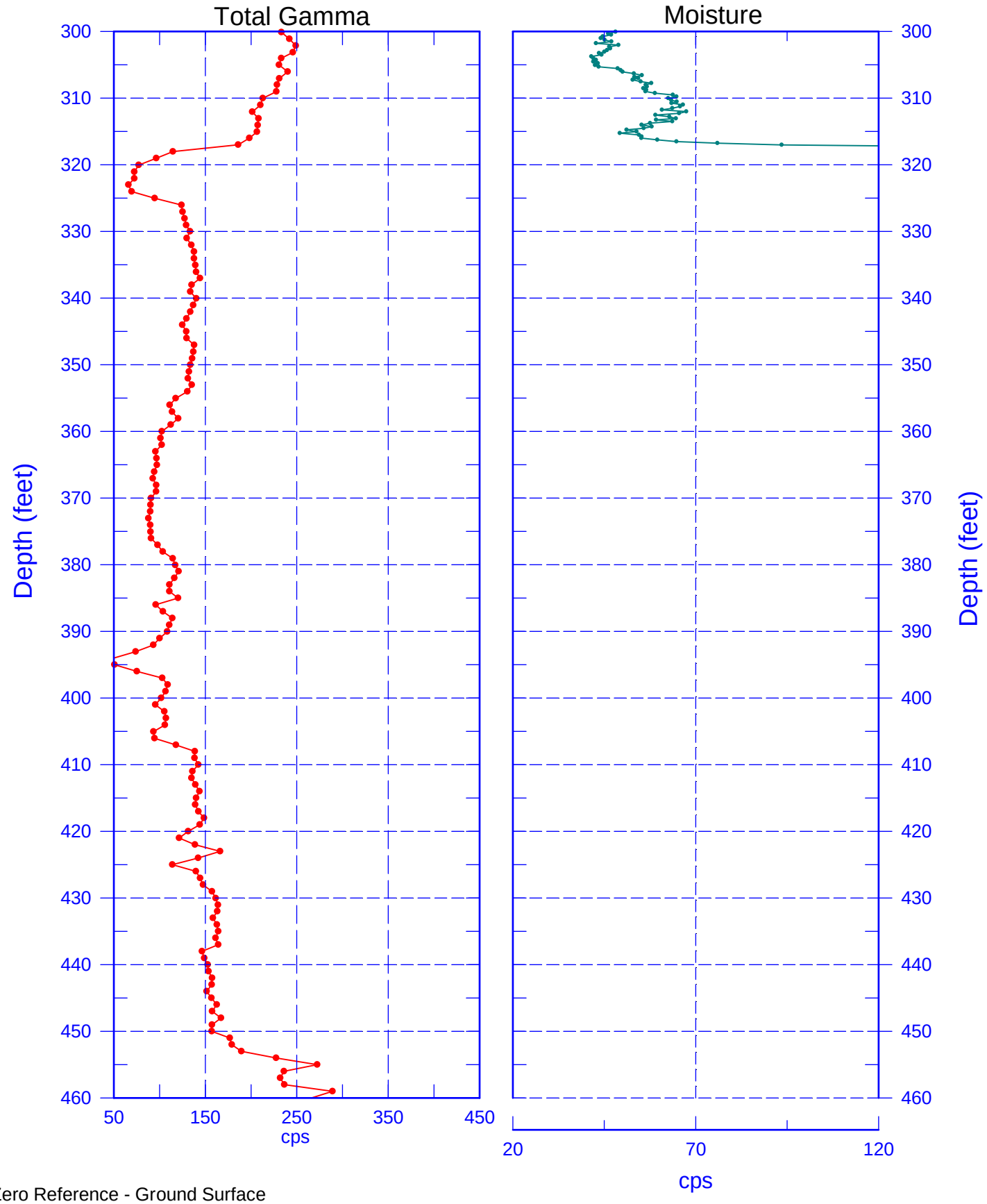
699-39-68 (C9607)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

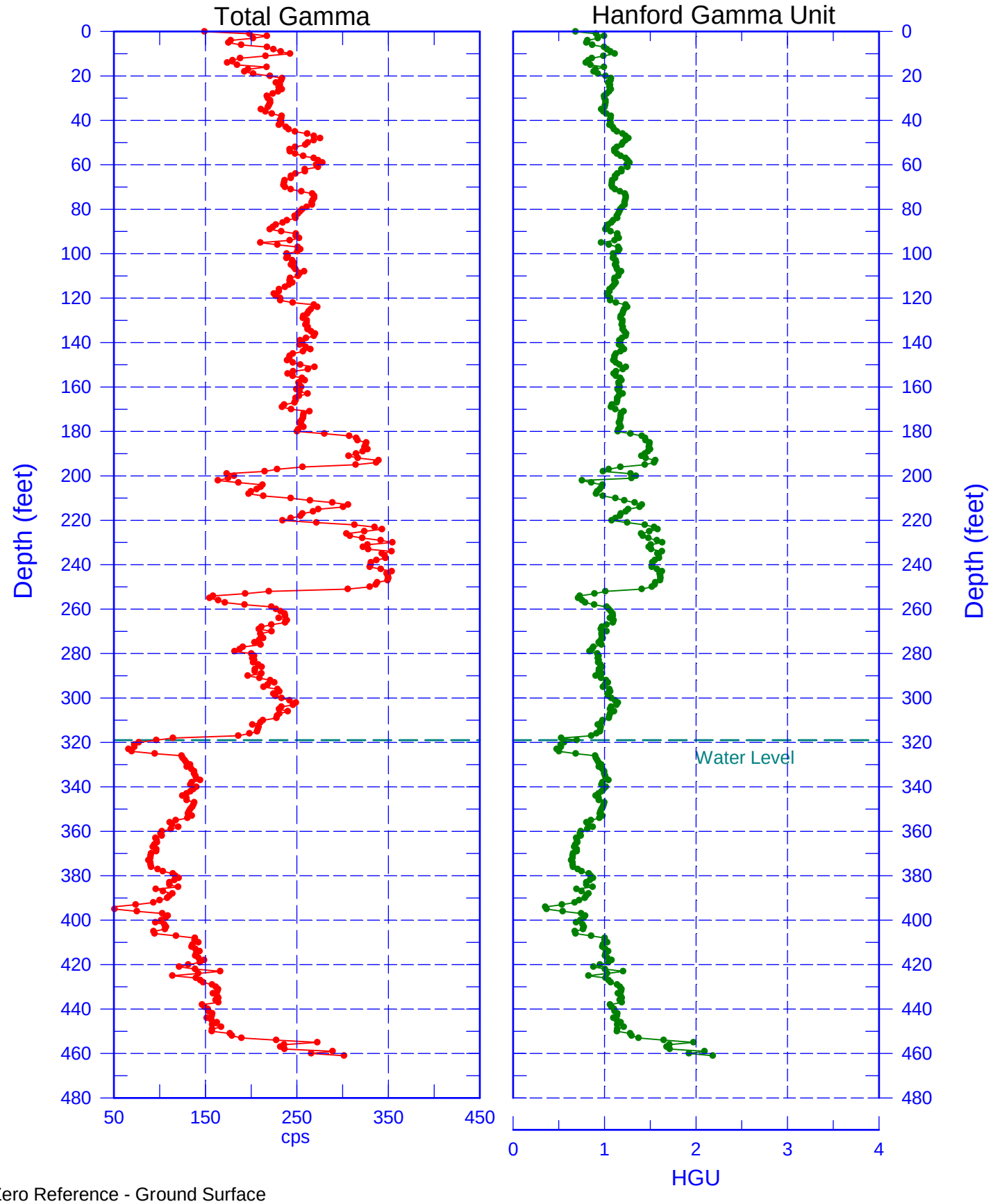
699-39-68 (C9607)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

699-39-68 (C9607)
Total Gamma & Hanford Gamma Unit



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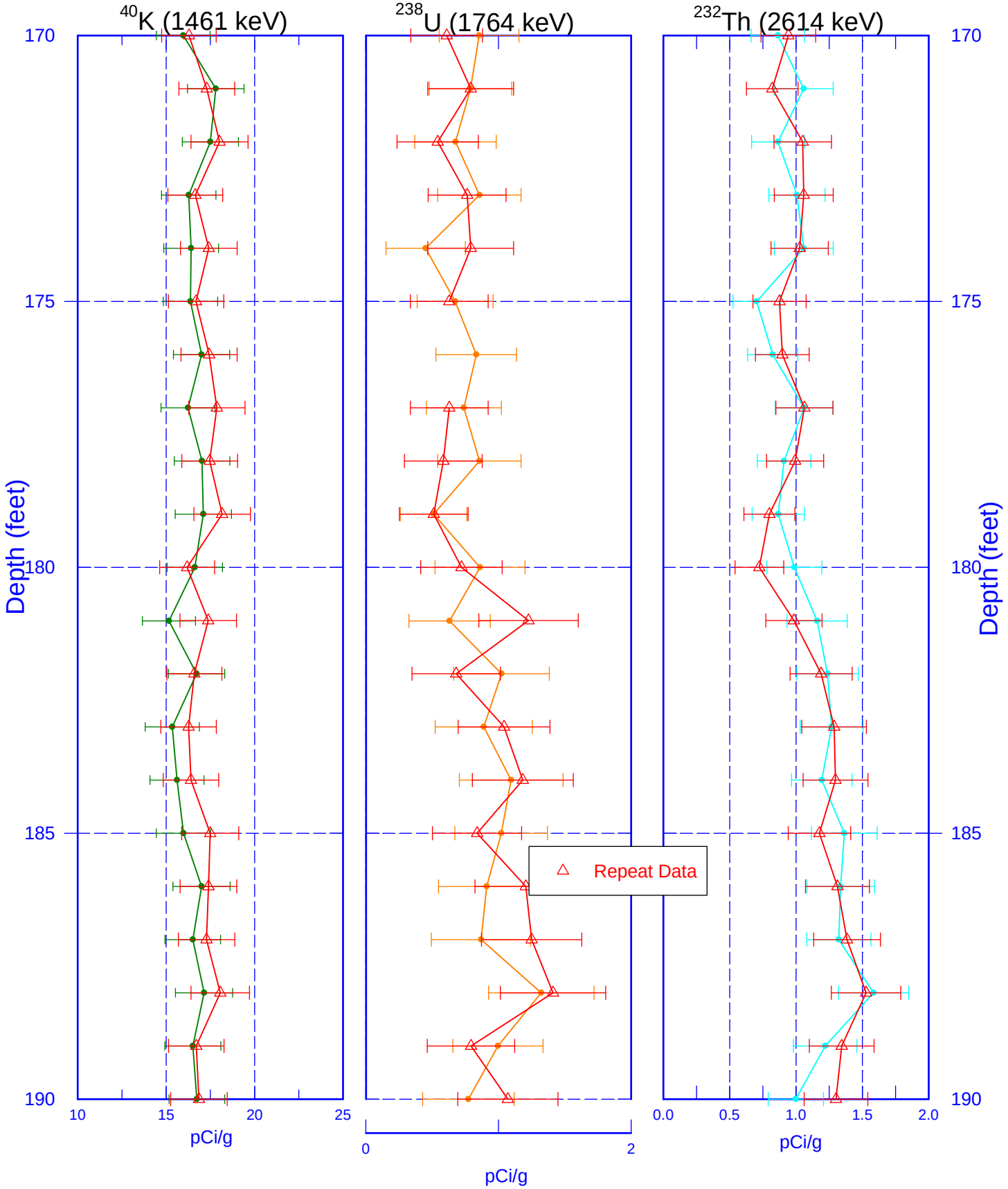
Huntington Ingalls Industries

699-39-68 (C9607)

Repeat Section of Natural Gamma Logs



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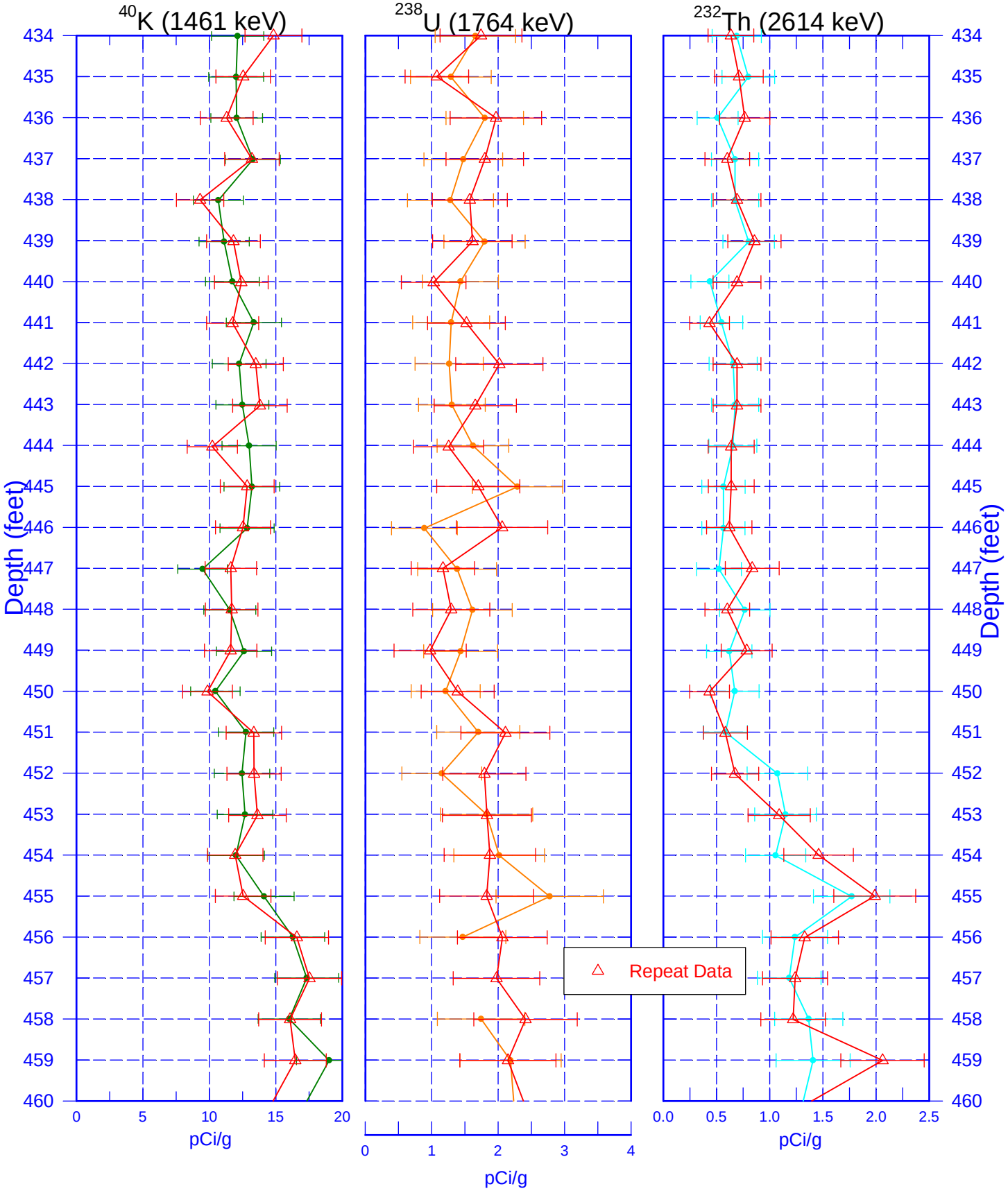
699-39-68 (C9607)

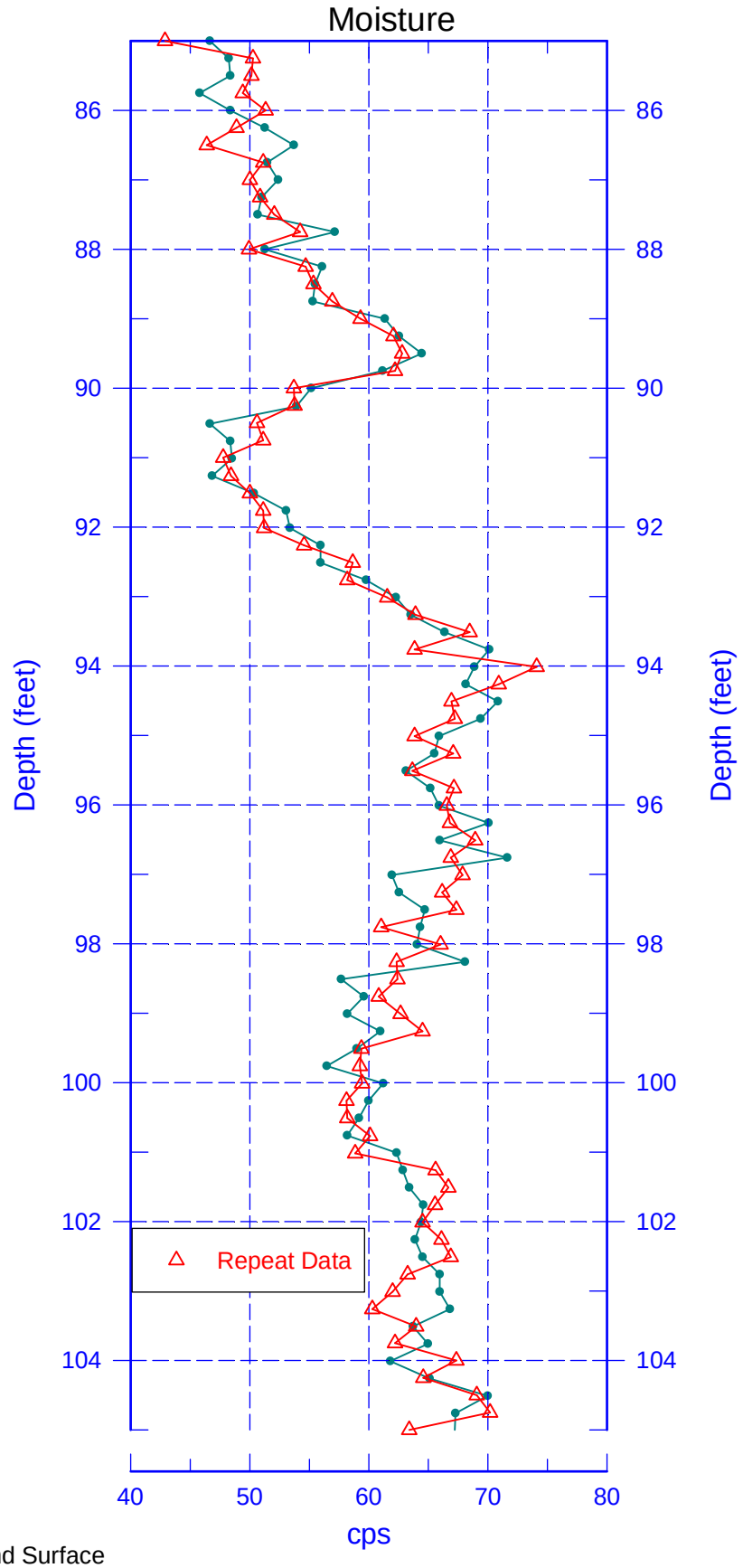
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

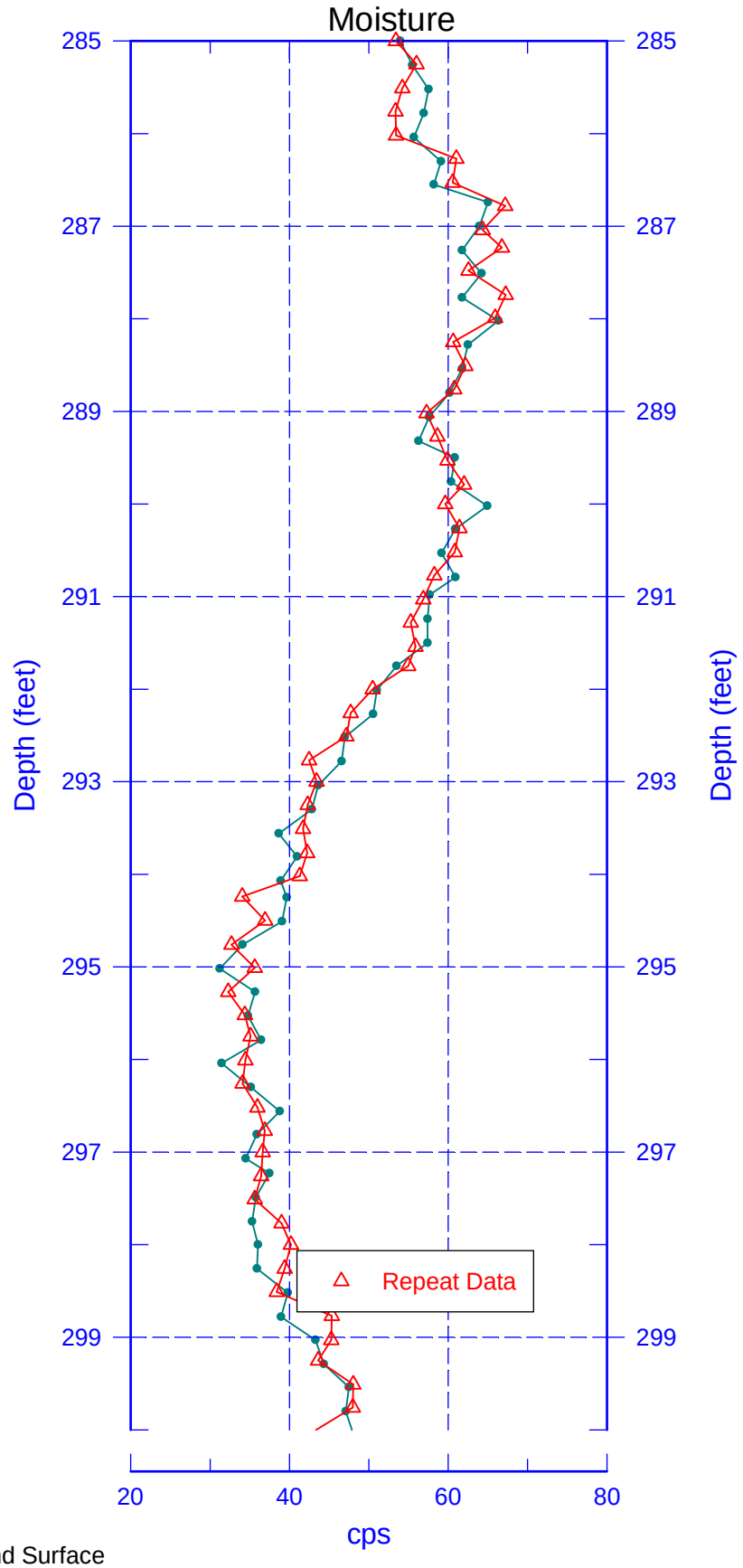
Huntington Ingalls Industries

699-39-68 (C9607)
Moisture Repeat Section



Zero Reference - Ground Surface

699-39-68 (C9607)
Moisture Repeat Section



Zero Reference - Ground Surface

SURVEY DATA REPORT

Request No. 184-102

Project No.	Title	File No.
	UP-1 Well C9607 (699-39-68) Final Survey	6AT12R26

Job. No.	Prepared By	Date	Reviewer
CACN: 304398-JPRC	N.P. Fastabend	7/19/18	LBM

DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Obtained final coordinates (C/L Casing) and elevations of UP-1 Well C9607 (699-39-68) located southwest of the 200 Area Fire Station (609A Building).	Survey File	OR		
	L.D. Bultena	1		
	J.L. Richart	1		
	J.L. Smoot	1		
	J.B. Geiger	1		
Horizontal Coordinate System: WCS83S/91 (Meters) Vertical Datum: NAVD88 (Meters)	B.J. Howard	1		
	A.J. Green	1		

SURVEY RESULTS AND COMMENTS

See Attached Well Survey Data Report Sheet

FOR OFFICE USE ONLY

OR Doc Type:	WMU Code(S):

A-6006-495 (REV 1)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 06/28/18	Requestor: Leonard D. Bultena (CHPRC)
Date of Survey: 07/19/18	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of UP-1 Well C9607 (699-39-68) located southwest of the 200 Area Fire Station (609A Building).	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 600A

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:

Washington State Reference Network

Vertical Control Monuments:

2W-145 (CHPRC) and 2W-146 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9607	699-39-68	569077.90	135332.77		Center of Casing
				226.745	Top Outer Casing,N.Edge Stamped "X"
				226.416	Top Inner 8"SS Casing, N.Edge
				225.860	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.

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9607 | Well Name: 699-39-68 | Date: 6·5·18

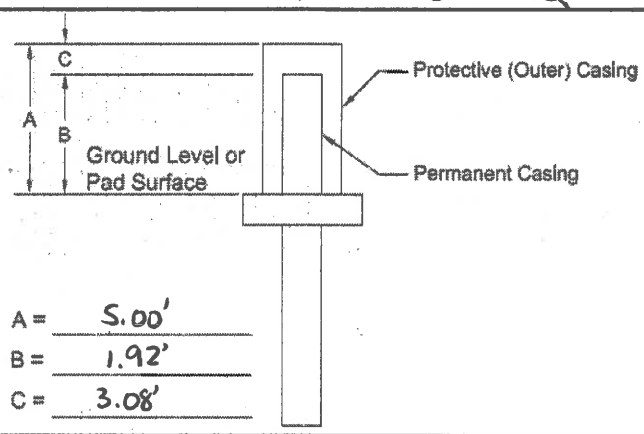
Location: ~100 m N of ERDF

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

Has the well been surveyed? ○ Yes ⊗ No | Does the well have a cement pad? ○ Yes ⊗ No

Initial Conditions

	Start of Job	End of Job
STATIC WATER LEVEL:		
Date: 6·4·18	317.30	N/A
Date: 6·11·18	N/A	317.60
DEPTH TO BOTTOM:		
Date: 6·4·18	458.5	N/A
Date: 6·11·18	N/A	458.5



A = 5.00'
B = 1.92'
C = 3.08'

Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbitidy (NTU) Initial	Turbitidy (NTU) Final	Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
448.74	9.6	128.7	71.2	7.5	0906	1102	200	20.08
407.74	10.2	86.7	106	4.13	1340	1502	210	20.6
365.74	11.1	44.7	19.3	4.16	0816	0845	210	18.97
	AR 6·5·18 Not Used							JLR 7/3/18

Total Pumped: ~55,800 gallons

Pump Model: Grundfos X 30HP Model #: 23661616020

Troll Serial Number and Pressure Range (PSI and depth): S/N: 546780 PSI: 300 PSIG

Comments:

interval 1 { C9607_dev_int1_6-5-2018
C9607_dev_int1_6-6-2018

interval 2 → C9607_dev_int 2_6-6-2018

interval 3 → C9607_dev_int 3_6-7-2018

Prepared By:

Andrew Raulerson (Print Name) | Signature | 6·7·18 (Date)

Reviewed By:

Jennifer Richart (Print Name) | Signature | 7/3/18 (Date)

For Office Use Only

OR Doc Type: | WMU Code(s):

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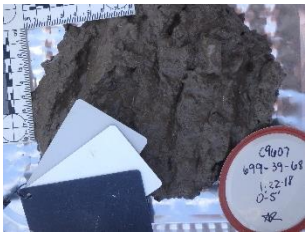
Photo Log


0-5 bgs

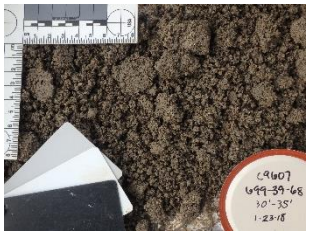
5-10 bgs

10-15 bgs

15-20 bgs

20-25 bgs

25-30 bgs


30-35 bgs

35-40 bgs

40-45 bgs

45-50 bgs

50-55 bgs

55-60 bgs

60-65 bgs

65-70 bgs

70-75 bgs

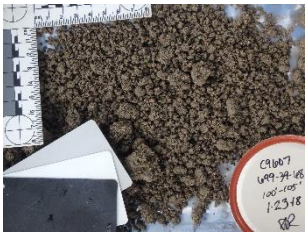
75-80 bgs

80-85 bgs

85-90 bgs

90-95 bgs

95-100 bgs


100-105 bgs

105-110 bgs

110-115 bgs

115-120 bgs

120-125 bgs

125-130 bgs

130-135 bgs

135-140 bgs

140-145 bgs

145-150 bgs

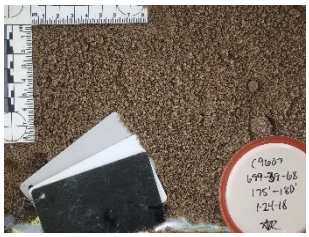
150-155 bgs

155-160 bgs

160-165 bgs

165-170 bgs

170-175 bgs


175-180 bgs

180-185 bgs

185-190 bgs

190-195 bgs

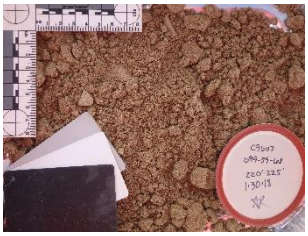
195-200 bgs

200-205 bgs

205-210 bgs

210-215 bgs

215-220 bgs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225-230 bgs

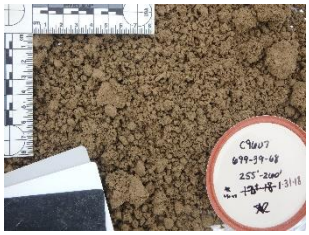
230-235 bgs

235-240 bgs

240-245 bgs

245-250 bgs

250-255 bgs


255-260 bgs

260-265 bgs

265-270 bgs

270-275 bgs

275-280 bgs

280-285 bgs

285-290 bgs

290-295 bgs

295-300 bgs

300-305 bgs

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310-315 bgs

315-320 bgs

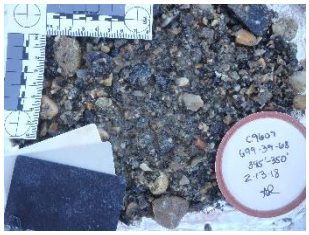
320-325 bgs

325-330 bgs

330-335 bgs

335-340 bgs

340-345 bgs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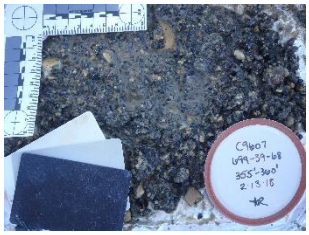
350-355 bgs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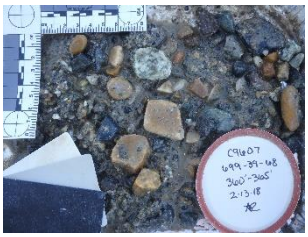

360-365 bgs

365-370 bgs

370-375 bgs

375-380 bgs

380-385 bgs

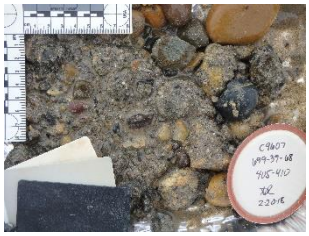
385-390 bgs

390-395 bgs

395-400 bgs

400-405 bgs

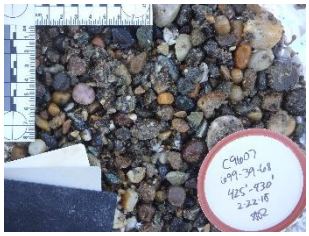
408 ft bgs


405-410 bgs

410-415 bgs

415-420 bgs

420-425 bgs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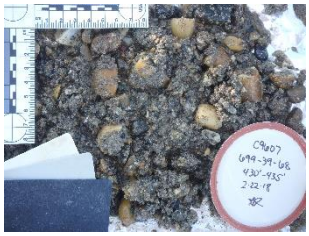
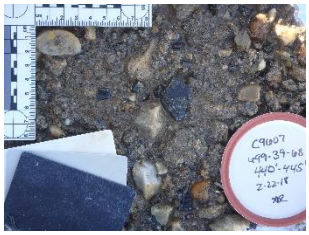

430-435 bgs

435-440 bgs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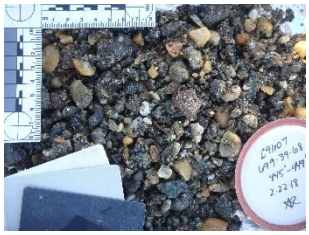
445-449 bgs

449 bgs

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Appendix B

Well Documentation for 699-38-64B (C9608)

- Well Summary Sheet for C9608
- Borehole Log for C9608
- Geophysical Log Data Report for C9608
- Final Survey Report for C9608
- Well Development and Testing Data Sheet C9608
- Photo Log for C9608

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WELL SUMMARY SHEET

Well ID: C9608	Well Name: 699-38-64B	Start Date: 1/9/18
Project: 200-UP-1 Injection Wells	Location: 0.5 mi NE of ERDF	End Date: 4/4/18

CONSTRUCTION DATA

Surface Completion:
4' x4' x 6" Concrete Pad with brass survey marker and protective monument (3.13' ags - 1.87' bgs)
Ecology Well # BKG-075

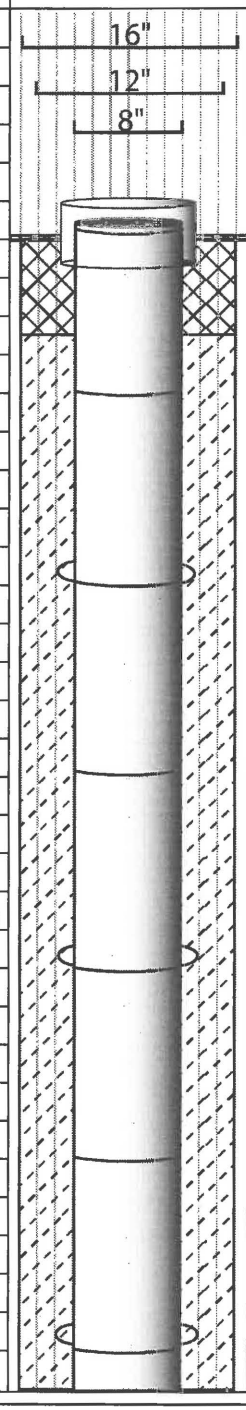
Well Completion Material:
Type I/II Portland Cement
0.00' bgs - 10.50' bgs
3/8" Bentonite Crumbles
10.50' bgs - 288.23' bgs
3/8" Bentonite Pellet Seal
288.23' bgs - 291.80' bgs
8-16 mesh Primary Filterpack
291.80' bgs - 405.20' bgs
3/8" Bentonite Pellet Seal
405.20' bgs - 408.53' bgs
Natural Fill
408.53' bgs - 409.77' bgs

Permanent Well:
8" ID Stainless Steel Blank
2.30' ags - 295.61' bgs
8" ID Stainless Steel 0.050-in Screen
295.61' bgs - 395.62' bgs
8" ID Stainless Steel Sump
395.62' bgs - 405.61' bgs

Hole Dimensions:
16" Temporary Casing: 195.96' bgs
12" Temporary Casing : 405.47' bgs
(all temporary casing removed)
Total Depth : 409.77' bgs

ags = above ground surface
bgs = below ground surface

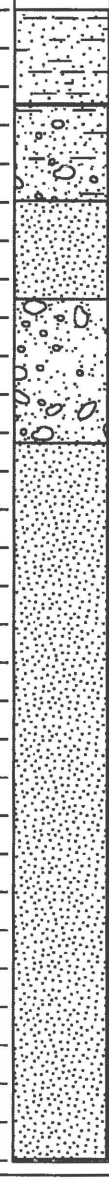
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 20, 40, 60, 80, 100, 120

Graphic Log



Lithologic Description (ft bgs)

0 - 10 : Silty Sand (mS)
10 - 20 : Gravelly Silty Sand (gmS)
20 - 30 : Sand (S)
30 - 45 : Gravelly Sand (gS)
45 - 300 : Sand (S)

Reported By:

Print Name	Title	Signature	Date
Brandon Thurnau	Project Geologist	Brandon Thurnau	4/24/18

Reviewed By:

Print Name	Title	Signature	Date
Jennifer Hammons	JLH 5/14/18 Well Coordinator	[signature]	5/14/18

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OR Doc Type:	WMU Code(s):

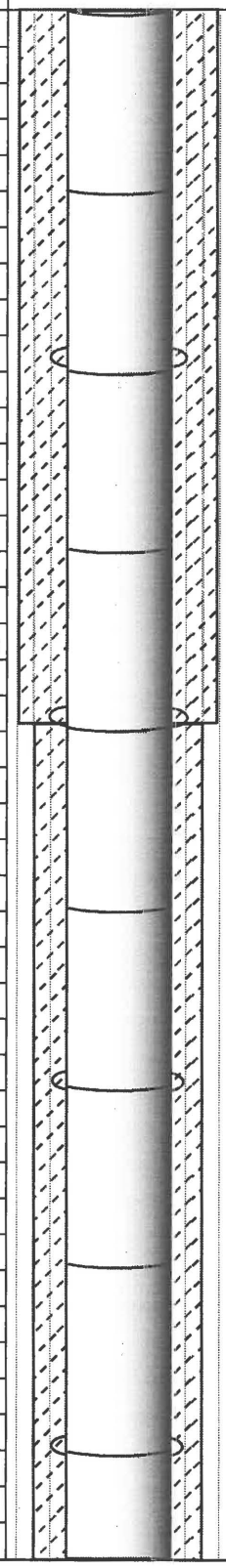
WELL SUMMARY CONTINUATION SHEET

Well ID: C9608 | Well Name: 699-38-64B | Project: 200-UP-1 Injection Wells

CONSTRUCTION DATA

Description
Well Completion Material:
Type I/II Portland Cement
0.00' bgs - 10.50' bgs
3/8" Bentonite Crumbles
10.50' bgs - 288.23' bgs
3/8" Bentonite Pellet Seal
288.23' bgs - 291.80' bgs
8-16 mesh Primary Filterpack
291.80' bgs - 405.20' bgs
3/8" Bentonite Pellet Seal
405.20' bgs - 408.53' bgs
Natural Fill
408.53' bgs - 409.77' bgs
Permanent Well:
8" ID Stainless Steel Blank
2.30' ags - 295.61' bgs
8" ID Stainless Steel 0.050-in Screen
295.61' bgs - 395.62' bgs
8" ID Stainless Steel Sump
395.62' bgs - 405.61' bgs
Hole Dimensions:
16" Temporary Casing: 195.96' bgs
12" Temporary Casing : 405.47' bgs
(all temporary casing removed)
Total Depth : 409.77' bgs
bgs = below ground surface

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
120		45 - 300: Sand (S)
140		
160		
180		
200		
220		
240		
260		
280		

A-6006-992 (REV 0)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9608 | Well Name: 699-38-64B | Project: 200-UP-1 Injection Wells

CONSTRUCTION DATA

Well Completion Material:

Type I/II Portland Cement
0.00' bgs - 10.50' bgs
3/8" Bentonite Crumbles
10.50' bgs - 288.23' bgs
3/8" Bentonite Pellet Seal
288.23' bgs - 291.80' bgs
8-16 mesh Primary Filterpack
291.80' bgs - 405.20' bgs
3/8" Bentonite Pellet Seal
405.20' bgs - 408.53' bgs
Natural Fill
408.53' bgs - 409.77' bgs

Permanent Well:

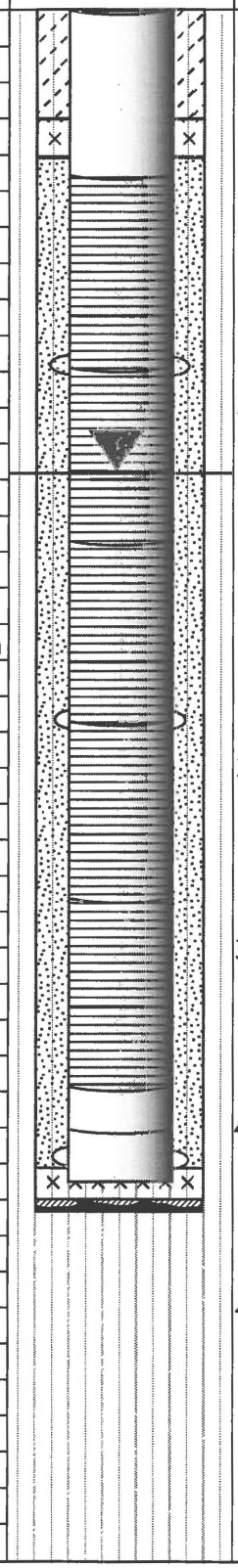
8" ID Stainless Steel Blank
2.30' ags - 295.61' bgs
8" ID Stainless Steel 0.050-in Screen
295.61' bgs - 395.62' bgs
8" ID Stainless Steel Sump
395.62' bgs - 405.61' bgs

Hole Dimensions:

16" Temporary Casing: 195.96' bgs
12" Temporary Casing : 405.47' bgs
(all temporary casing removed)
Total Depth : 409.77' bgs

bgs = below ground surface

Diagram



Depth in Feet: 280, 300, 320, 340, 360, 380, 400, 420

GEOLOGIC/HYDROLOGIC DATA

Graphic Log

Lithologic Description (ft bgs)

45 - 300: Sand (S)
300 - 315: Gravelly Sand (gS)
315 - 330: Sandy Gravel (sG)
Depth to water 327.79 (4-3-2018)
330 - 355: Silty Gravel (mG)
355 - 397: Silty Sandy Gravel (msG)
397 - 409.77: Silt (M)

A-6006-992 (REV 0)

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BOREHOLE LOG

Page 1 of 11
Date: 1/9/18

Well ID: C9608	Well Name: 699-38-64B	Location: 1/2 mi NE of ERDF	
Project:		Reference Measure Point: Ground Surface	

Depth (ft)	Sample 1.9.18CB	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	~~GS~~		0 - 10'bgs: Silty Sand (m S)	Air Rotary w/ 16" Temp.
			60% sand 40% silt	Casing & Tri-Cone Bit
			sand: v. fine to medium, 60% felsic,	
			well-sorted	Hanford fm.
			soil is moist, low plasticity, weak HCl	
5	GS		rxn, 2.5Y 4/3 olive brown	
			silty	
10	GS		10 - 20 'bgs: gravelly sand (gmS)	@10'bgs - driller adds
			50% sand 35% silt 15% gravel	H_2O to control dust
			sand: fine to coarse, moderately sorted,	approx 100 gal
			60% felsic	
			gravel: 2mm to 10mm, angular to subangular,	
15	GS		65% felsic	
			soil is moist, no plasticity, strong HCl	
			rxn, 2.5Y 4/3 olive brown	
			@15' bgs - silt content decreases, now	
20	GS		25% silt, 50% sand, 25% gravel	
			gravels are now 2mm to 30mm, poorly	
			sorted, 90% felsic	
			sands now fine to v. coarse, angular to	
			subangular, poorly sorted	
25	GS		color is now 2.5Y 4/2 dark grayish brown	
			20 - 30'bgs Sand (S)	
			96% sand 2% gravel 2% silt	
			sand is moderately sorted, fine to v.	
30	GS		coarse, angular to sub angular, 65%	
			felsic,	
			moist with no plasticity and a	
			moderate reaction to HCl, 2.5Y 4/2 dk greybrown	
			gravels 2mm to 5mm	

Reported By:			
C. Burns	Geologist	CB	1/9/18
Print Name	Title	Signature	Date
Reviewed By:			
Sarah Springer	Sr. Geologist	[signature]	03-13-18
Print Name	Title	Signature	Date

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 4

Date: 1/9/18

Well ID: C9608 | Well Name: 699-38-64B | Location: ~0.5 mi NE of GSDF

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	GS		20-30 'bgs Sand (S)	Air Rotary w/ 16" Temp Casing & Tri Cone Bit
			@25 'bgs - 92% sand 8% gravel	
			sand: medium to very coarse, moderately	
			sorted, angular to subangular, 65% felsic	
			gravels: 2mm to 15mm, angular to	
40	GS		subround, 55% felsic, poorly sorted	
			weak HCl rxn, no plasticity, 2.5Y 4/2	
			dark greyish brown	
			30-45 'bgs gravelly Sand (gS)	
45	GS		80% sand 20% gravel	
			sand: medium to very coarse, poorly	
			sorted, angular to subangular, 70%	
			felsic	
			gravel: 2mm to 25mm, angular to	
50	GS		subround, 55% felsic, poorly sorted	
			weak HCl rxn, dry, 5Y 5/2 olive	
			grey	
			@40' bgs - gravels smaller, now 2-5mm;	
55	GS		sands finer, now fine to very coarse;	
			2.5Y 5/3 light olive brown, weak HCl rxn	
			90% sand 10% gravel	
			45-300' bgs Sand (S)	
60	GS		95% sand 5% gravel	
			sand: fine to very coarse, 60% felsic,	
			well-sorted	
			gravel: 2mm to 4mm, poorly sorted, 50%	
65	GS		mafic	
			2.5Y 5/3 light olive brown, moist	
			w/ no plasticity & no HCl rxn	
			@50' bgs - gravels 8% sand 92%	
70	GS		sand is now very fine to coarse,	
			HCl rxn is weak, soil is dry,	
			color remains 2.5Y 5/3 light	
			olive brown	

Reported By:

Print Name	Title	Signature	Date
C. Burns	Geologist		1/9/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 11

Date: 1/9/18

Well ID: C9608 | Well Name: 699-38-64B | Location: 1/2 mi NE of ERDF

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	GS		45 - 300 'bgs Sand (s)	AR w/ 16" Temp
			(@55'bgs) sand 98% gravel 2%	Casing & Tri-Cone Bit
			sand is v. fine to v. coarse, well-sorted,	
			65% felsic,	
			gravels 55% felsic, 2-4mm, subround to	
80	GS		subangular,	
			HCl rxn weak, dry, no plasticity	
			@65' bgs - no significant changes	
85	GS		@70' bgs - no HCl rxn, no further changes	
			@75bgs - gravel content decreases, silt	
			content increases; now 98% sand 2% silt,	
			silt exhibits moderate HCl rxn,	
90	GS			
			@80'bgs - sand is now 55% felsic, soil	
			exhibits weak HCl rxn, no further	
			changes	
95	GS		@85' bgs - sand is now v. fine to coarse,	
			soil exhibits no HCl rxn, remains dry	
			w/ no plasticity	
			@95' bgs - sand is now 60% felsic, no further	
100	GS		changes	
			@100' bgs - sand is now v. fine to v.	
			coarse, moderately sorted. composition	
105 HB 1/9/18CB	GS		remains 60% felsic, HCl rxn is now	
			weak. dry w/ no plasticity.	
			@105'bgs - 96% sand 2% gravel 2% silt,	
			gravels range 2mm to 4mm, 55% felsic,	
			soil shows weak rxn w/ HCl	
110	GS			
			@110' bgs - no significant changes	

Reported By:

Print Name	Title	Signature	Date
C. Burns	Geologist		1/10/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 11

Date: 1/10/18

Well ID: C9608 | Well Name: 699-38-64B | Location: 1/2 mi NE of ERDF

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	GS		45 - 300 'bgs: sand (s)	AR w/ 16" Temp Casing & TriCone Bit
			(@115'bgs) sand 96% gravel 2% silt 2%	
			sands: v. fine to v. coarse, moderately sorted,	
			60% felsic	
			gravels: 2mm to 4mm, subangular to subround,	
120	GS		55% felsic, well-sorted	
			soils show weak HCl rxn, dry w/ no	
			plasticity, @ 2.5Y 5/3 light olive brown	
			@120'bgs: 95% v.fn.-v.crs sand, 3% v.fn	
125	GS		gravel, 2% silt; sand: mod. sorted, 70%f/	
130			30%m, sub.ang.-sub.rnd; pebbles: well sorted,	
1/9/1820			sub.ang.-subrnd., 50%f/50%m; dry, no	
			HCl rxn, 10YR 5/2 grayish brown	
130	GS		@125'bgs: 98% v.fn.-med. sand, 2% silt;	
			sand: mod.-well sorted, 70%f/30%m, same as	
			above; dry, very weak HCl rxn, 10YR 5/3 brown	
			@130'bgs: 98% v.fn.-crs. sand, 2% silt.	
135	GS		sand: same as above; 10YR 6/3 pale brown,	
			rest same as above	
			@135'bgs: 98% v.fn.-crs. sand, 2% silt;	
			same as above.	
140	GS		@140'bgs: 98% v.fn-v.crs. sand, 2% silt;	
			no HCl rxn, 10YR 5/2 grayish brown, rest	
			same as above.	
145	GS		@145'bgs: 98% v.fn.-v.crs. sand, 2% silt;	
			all same as above.	
150	GS		@150'bgs: 98% v.fn.-med. sand, 2% silt;	
			weak HCl rxn, same as above	

Reported By:

Print Name	Title	Signature	Date
C. Burns / Andrew Rawlerson	Geologist / Staff Geologist	[signature] / [signature]	1.11.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 5 of 11

Date: 1-11-18

Well ID: CG608 | Well Name: 699-38-64B | Location: ~0.5 mi NE of ERDF

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	GS		45' – 300' bgs: Sand (S)	Dual tin Rotary Rig w/ 16" temp. casing + tricone bit
			@155' bgs: 97% v.fn.- crs. sand, 1% v.fn. pebbles, 2% silt; sand: mod.-well sorted, sub.ang.-sub.rnd., 75%f/25%m; dry, 10YR 5/2 grayish brown, weak HCl rxn.	
160	GS		@160' bgs: 98% v.fn-crs. sand, 2% silt; sand: 60%f/40%m, rest same; same as above.	
165	GS		@165' bgs: 98% v.fn.-v.crs sand (crs.), 2% silt; 70%f/30%m sand, 10YR 6/3 pale brown, no HCl rxn, rest same as above.	* Grain size inside parenthesis () indicates dominant grain size. AR
170	GS		@170' bgs: 92% v.fn.-v.crs sand (crs.), 6% v.fn. pebbles, 2% silt; sand: 60%f/40%m, mod. sorted, same; pebbles: 40%f/60%m, sub.ang.-sub.rnd., well sorted; same as above 10YR 4/3 brown.	
175	GS		@175' bgs: 99% v.fn.-v.crs. sand (crs.), 1% silt; all same as above.	
180	GS		@180' bgs: 97% v.fn.-fn. sand, 3% silt; sand: well sorted, same as above; mild HCl rxn, same as above.	
185	GS		@185' bgs: 94% v.fn.-med. sand (fn.), 6% silt; same as above. 10YR 5/3 brown	
190	GS		@190' bgs: 96% v.fn.-v.crs sand (crs.), 4% silt; 10YR 4/3 brown, 60%f/40%m, same as above, mod. sorted.	

Reported By:

Print Name	Title	Signature	Date
Andrew Rauterson	Staff Geologist	[signature]	1-11-18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 6 of 11

Date: 1.11.18

Well ID: C9608 | Well Name: 699-38-64B | Location: ~0.5 mi NE of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
195	GS		45' – 300' bgs: Sand (S)	Air Rotary w/ 16" Temp
			@195' bgs: 97% v.fn. – v.crs. sand (med.),	Casing & TriCone Bit
			3% silt; sand: AR 1.11.18 60%f/40%m, mod.	
			sorted, sub.ang. – sub.rnd; no HCl rxn, dry,	@195' bgs – switch
			10YR 4/3 brown.	to 12" temp casing
200	GS			w/ under-reamer bit
			@200' bgs – no significant changes	
			@205' bgs – no significant changes	
205	GS		@210' bgs – 95% sand 5% silt,	
			no further changes	
			@215' bgs – 95% sand 5% silt,	
			S: v.fine to v. coarse, 60% felsic,	
210	GS		mod. sort, no HCl rxn, dry,	
			10YR 4/3 brown	
			@220' bgs – sand coarsens; now	
			med to v. coarse & poorly sorted.	
215	GS		no further differences.	
			@225' bgs – 97% sand 3% silt,	
			sand: very fine to coarse, 60%	
			felsic, moderately sorted, sub-ang.	
220	GS		to sub-round, weak HCl rxn, dry,	
			10YR 4/3 brown	
			@230' bgs – no significant changes	
225	GS			
230	GS			

Reported By:

Print Name	Title	Signature	Date
Andrew Raulerson / C. Burns	Staff Geologist / Geologist	[signature]	1.22.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 7 of 11

Date: 1.22.18

Well ID: C9608 | Well Name: 699-38-64B | Location: ~0.5mi NE of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
235	GS		45 - 300 Sand (S)	Air Rotary w/ 12" Temp Casing & Under-Reamer Bit
			@235' bgs - 97% sand 3% silt sand is fine to coarse, 65% felsic, well-sorted, subround to subangular, soil is dry with a weak reaction to HCl & an overall color of 2.5Y 5/3 light olive brown	
240	GS		@240' bgs - no significant changes	
245	GS		@245' bgs - 100% sand, composition remains 65% felsic, soil remains dry w/ weak HCl rxn, 2.5Y 5/3 light olive brown	
250	GS		@250' bgs - sand ranges from fine to v. coarse, remains well-sorted, no further changes	
			@255' bgs - no significant changes	
255	GS		@265' bgs - 90% sand, 5% silt, 5% gravel sands range from very fine to very coarse, 60% felsic, subangular to angular, moderately sorted gravels range 2mm to 5mm, 50% felsic, angular to subangular, moderately sorted. soil is dry with a weak HCl rxn & an overall color of 2.5Y 5/3 light olive brown	
260	GS			
265	GS		@270' bgs - no significant changes	
270	GS			

Reported By:

Print Name	Title	Signature	Date
C. Burns	Geologist		1.23.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 8 of 11

Date: 1·23·18

Well ID: C9608 | Well Name: 699-38-64B | Location: ~0.5m: NE of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
275	GS		45- 300' bgs Sand (S)	Air Rotary w/ 12" Temp Casing & Under Reamer
			90% sand 5% gravel 5% silt (@275' bgs)	
			sands range from very fine to very	
			coarse, are moderately sorted, and	
			60% felsic	
280	GS		gravels are 2mm to 5mm, moderately	
			sorted, and angular to subangular,	
			soil is dry w/ a very weak HCl	
			reaction and an overall color of 2.5Y	
			5/3 light olive brown	
285	GS			
			@280' bgs - 97% sand, 3% silt	
			sands range from very fine to coarse,	
			well-sorted, 65% felsic, no HCl rxn	
290	GS		@285' bgs - 95% sand 5% gravel	
			gravels range 2mm to 10mm,	
			angular, poorly sorted, no HCl rxn	
			1·23·18 CB	
			~~@295' bgs~~ @290' bgs - 100% sand,	
295	GS		sands range from v. fine to	
			coarse, 65% felsic, subangular to	
			angular, moderately sorted, no HCl	
			rxn.	
300	GS		@295' bgs - no significant changes	@approx 300' bgs - returns to tricone bit
			300 - 315' bgs Gravelly Sand (gS)	
			90% sand 10% gravel	Ringold Fm., Unit E @ 300' bgs
			sands are fine to coarse, well-sorted,	
305	GS		55% ~~mafic~~ felsic, subangular to angular	
			gravels are 2mm to 6mm, 50% mafic,	
			angular	
			soil is ~~damp~~ moist with low plasticity &	
			a strong rxn w/ HCl	
310	GS		overall color 10YR 4/4 dark yellowish	
			brown	
			@305' bgs - gravels now 2mm - 4mm	

Reported By:

Print Name	Title	Signature	Date
C. Burns	Geologist	[signature]	1/23/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 9 of 11

Date: 1.23.18

Well ID: C9608 | Well Name: 699-38-64B | Location: ~0.5 mi NE of ERDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
315	GS		315 – 330' bgs ~~silty~~ sandy gravel (sG) 1/23/18CB	AR w/ 12" Casing & tricone bit.
			30% gravel, 60% sand, 10% silt	
			sands are medium to very coarse,	
			55% felsic, poorly sorted	
			gravels range 2mm to 30mm,	
320	GS		subround to angular, 50% felsic, poorly	
			sorted	
			10YR 4/4 dark yellowish brown,	
			low plasticity, wet, no HCl rxn	
325	GS		@320' bgs – gravels increase in	
			size to ~40mm max, now 40% gravel,	
			50% sand, 10% silt	DTW (unconfined)
				327.38 ft bgs
			@325' bgs – no significant changes	(02/01/2018)
330	GS			
			@330 – 355 'bgs silty Gravel (gG)	
			75% gravel, 10% sand, 15% silt	
			gravels range 2mm to ~~80mm~~ 1.24.18CB 50mm,	
			round to angular, 50% felsic, poorly	
335	GS		sorted	
			sands are very coarse to coarse,	
			well-sorted, 50% felsic, angular to s. angular	
			soil is wet with no HCl rxn,	
			overall color of 10YR 4/4 drk. yellowish	
340	GS		brown	
			@340 'bgs – 70% gravel, 10% sand,	
			20% silt, remains wet w/ no	
			HCl rxn	I-001 (Water)
345	GS			1.30.18 @ 354.29' bgs
			@345' bgs – no significant changes	HELS# B3H6U5, B3H6U6
				B3H6U7, B3H6U8,
				B3H8W9
350	GS		@350' bgs – no significant changes	I-002 (Soil)
				1.29.18 @ 353.25 – 355.75' bgs
				HELS# B3H742
	GS			

Reported By:

Print Name	Title	Signature	Date
C. Burns	Geologist	[signature]	1.30.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Date: 1.30.18

Well ID: C9608 | Well Name: 699-38-64B | Location: ~0.5 mi NE of GRDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
355	WS/GS		355 1/30/18CB ~~330~~ – 397 'bgs silty sandy Gravel (GSG)	AR w/ 12" casing & TriCone Bit
	44		60% gravel, 20% sand, 20% silt sand is medium to very coarse, poorly sorted, angular to subangular, 55% felsic	
360	GS		gravels are angular to subround, 2mm to 20mm, poorly sorted, and 50% felsic	
			soil is wet w/ no HCl rxn, color 10 YR 4/4 dark yellowish brown	
365	WS/GS			I-003 (Water) 1.31.18 @ 364.33' bgs HEIS# B3H6W0, B3H6W1, B3H6W2, B3H6W3, B3H8X0
	44		@365' bgs – gravels range 2mm to 30mm, now angular to subround, remain poorly sorted. sands remain medium to v. coarse & poorly sorted, no HCl rxn, remains wet.	
370	GS			I-004 (Soil) 1.31.18 @ 363.74-366.24' bgs HEIS# B3H743
			@370' bgs – sands now fine to v. coarse, remain poorly sorted & 55% felsic. Gravels unchanged.	
375	GS			I-005 (water) 2.1.18 @ 382.34' bgs HEIS# B3H6W5, B3H6W6, B3H6W7, B3H6W8, B3H8X1
			@375' bgs – no significant changes	
380	GS		@380' bgs – 50% gravel, 20% sand, 30% silt,	I-006 (Soil) 2.1.18 @ 382.48-384.98' bgs HEIS# B3H744
	WS		sands are ~~medium~~ 2.1.18CB fine to very coarse, poorly sorted, 55% felsic	
	44		gravels are 2mm to 35mm, angular to subround, poorly sorted, 50% felsic,	
385	GS		soil is wet w/ no HCl rxn	
			@390' bgs – sands range very fine to very coarse; gravels decrease in size, now 2mm to 25mm	
390	GS			

Reported By:

Print Name	Title	Signature	Date
L. Burns	Geologist	[signature]	2.1.18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 11 of 11

Date: 2/1/18

Well ID: C9608 | Well Name: 699-38-64B | Location: ~0.5 mi NE of CRDF

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
395	GS		397-409.77 'bgs Silt (M)	AR w/ 12" casing & TriCone
			100% silt	
			soil is damp w/ high plasticity, no HCl rxn, overall color of 2.5Y 5/6 light olive brown	
				Ringold Fm., Lower Mud @ 397' bgs.
400	GS		@400' bgs - no significant changes	
405	GS		@405' bgs - soil is now moist, no HCl rxn, color remains 2.5Y 5/6 light olive brown	
410	GS		@409.77' bgs - no significant changes	Total Depth = 409.77' bgs (2/5/2018)
415				
420				
425				
430				

Reported By:

Print Name	Title	Signature	Date
C. BURNS	Geologist	[signature]	2/5/18

A-6006-993 (REV 0)

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699-38-64B (C9608)
Log Data Report

Borehole Information

Log Date	2018-02-08	Filename	C9608_HG-NM_2018-02-08	Site	200-UP-1

DTW[1] (ft)	DTW Date	DTW Source	Drill Date	Total Depth (ft)	Depth Datum
327.38	01/31/18	Gram NW	02/06/18	408.8	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Welded Steel	Air Rotary	2.3	16	15 1/4	3/8	-2.3	195
Welded Steel	Air Rotary	3.0	12 3/4	12	3/8	-3.0	409.77

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up and casing diameters. The maximum logging depth achieved was 408.01 ft. Zero reference is ground surface.

Logging Equipment Information

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

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

SGLS Log Run Information

Log Run	1	2 Repeat	7	8	9 Repeat
HEIS Number	1020156	1020157	1020158	1020159	1020160
Date	01/15/18	01/15/18	02/07/18	02/08/18	02/08/18
Logging Engineer	McClellan/Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	0.0	110.0	195.01	251.01	375.0
Finish Depth (ft)	194.01	130.01	250.0	408.01	400.02
Count Time (sec)	100	100	100	100	100
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA	NA

[1] depth to water inside casing
[2] Spectral Gamma Logging System
[3] Neutron Moisture Logging System

Log Run	1	2 Repeat	7	8	9 Repeat
Pre-Verification	C9608ALD2018 0115AV00CAB1	C9608ALD2018 0115AV00CAB1	C9608ALD2018 0207AV00CAB1	C9608ALD2018 0208BV00CAB1	C9608ALD2018 0208BV00CAB1
Start File	AD000000	BD011000	AD019501	BD025101	CD037500
Finish File	AD019401	BD013001	AD025000	BD040801	CD040002
Post-Verification	BV00CAA1	BV00CAA1	AV00CAA1	CV00CAA1	CV00CAA1
Depth Return Error (in.)	N/A	0.0	2.0 low	N/A	2.5 low
Comments	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made	No fine gain adjustments made

NMLS Log Run Information

Log Run	3	4 Repeat	5	6 Repeat	
HEIS Number	1020161	1020162	1020163	1020164	
Date	01/15/18	01/15/18	02/07/18	02/07/18	
Logging Engineer	Spatz/McClellan	Spatz	Spatz/McClellan	Spatz	
Start Depth (ft)	0.0	150.0	193.0	315.0	
Finish Depth (ft)	194.05	170.01	350.01	335.01	
Count Time (sec)	15	15	15	15	
Live/Real	R	R	R	R	
Shield (Y/N)	N	N	N	N	
MSA Interval (ft)	0.25	0.25	0.25	0.25	
Log Speed (ft/min)	NA	NA	NA	NA	
Pre-Verification	C9608AHD2018 0115AV00CAB1	C9608AHD2018 0115AV00CAB1	C9608AHD2018 0207AV00CAB1	C9608AHD2018 0207AV00CAB1	
Start File	AD000000	BD015000	AD019300	BD031500	
Finish File	AD019405	BD017001	AD035001	BD033501	
Post-Verification	BV00CAA1	BV00CAA1	BV00CAA1	BV00CAA1	
Depth Return Error (in.)	N/A	2.0 high	N/A	3.0 high	
Comments	None	None	None	None	

Logging Operation Notes

A centralizer was installed on the sondes during logging of the second casing string. During logging of the first casing string, the sonde was positioned near the casing wall and no centralizer was used.

Analysis Notes

Analyst	P.D. Henwood	Date	02/20/18
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

A casing correction for a 3/8-in. thick casing was applied to the log data.

A water correction was applied below 392.6 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in an EXCEL template identified as ALD20171019 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

An interpreted data set was created for this borehole. Depth overlaps from consecutive log runs or where two casings existed were removed from 193 and 194 ft and 249 and 250 ft. This results in a data set where only one data point is presented for each depth.

NMLS data are reported in counts per second. Static water level occurred at 327.38 ft. Moisture logging was terminated 20 ft below this level.

HGU[4] is an empirical unit of gamma activity proposed as a means to standardize gamma log response across multiple logging systems with different response characteristics. The HGU is defined in terms of measurements in the Hanford Borehole Calibration Facility, and the magnitude is selected such that 1 HGU is approximately equivalent to typical Hanford background activity, based on data from background samples as reported in *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE/RL-96-12).

Results and Interpretations

No manmade radionuclides were detected in this borehole.

Radon appears to be in the water inside the casing from approximately 393 ft to the bottom of the borehole as evidenced by the enhanced concentrations of naturally occurring U-238.

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.

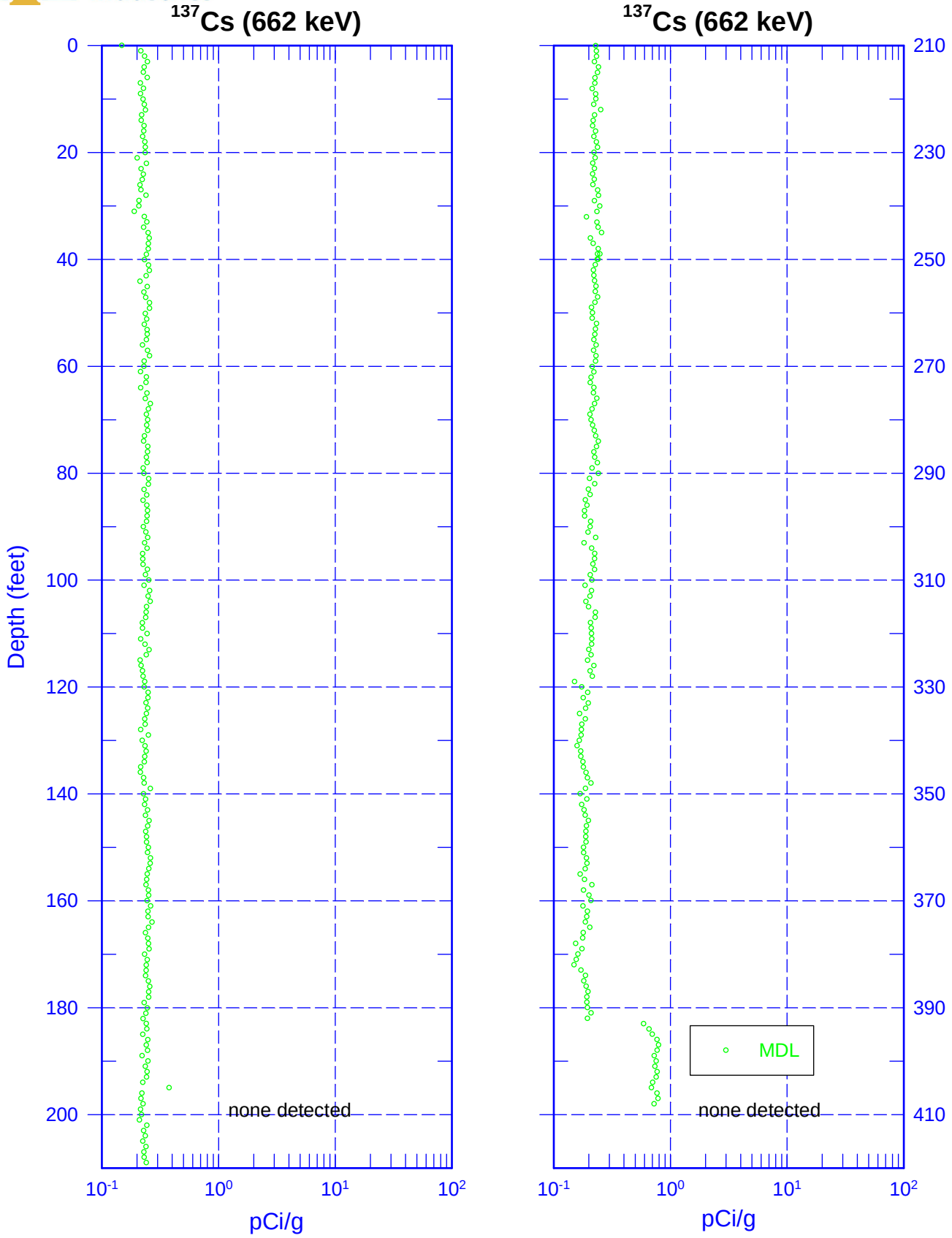
List of Log Plots

Depth Reference is ground surface.

Manmade Radionuclides (0-420 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (150-310 ft)
Natural Gamma Logs (300-460 ft)
Combination Plot (0-120 ft)
Combination Plot (110-230 ft)
Combination Plot (220-340 ft)
Combination Plot (330-450 ft)
Combination Plot (0-420 ft)
Total Gamma & Moisture (0-160 ft)
Total Gamma & Moisture (150-310 ft)
Total Gamma & Moisture (300-460 ft)
Total Gamma & Hanford Gamma Unit (0-420 ft)
Repeat Section of Natural Gamma Logs (110-130 ft)
Repeat Section of Natural Gamma Logs (375-400 ft)
Moisture Repeat Section (150-170 ft)
Moisture Repeat Section (315-335 ft)

[4] Hanford Gamma Unit

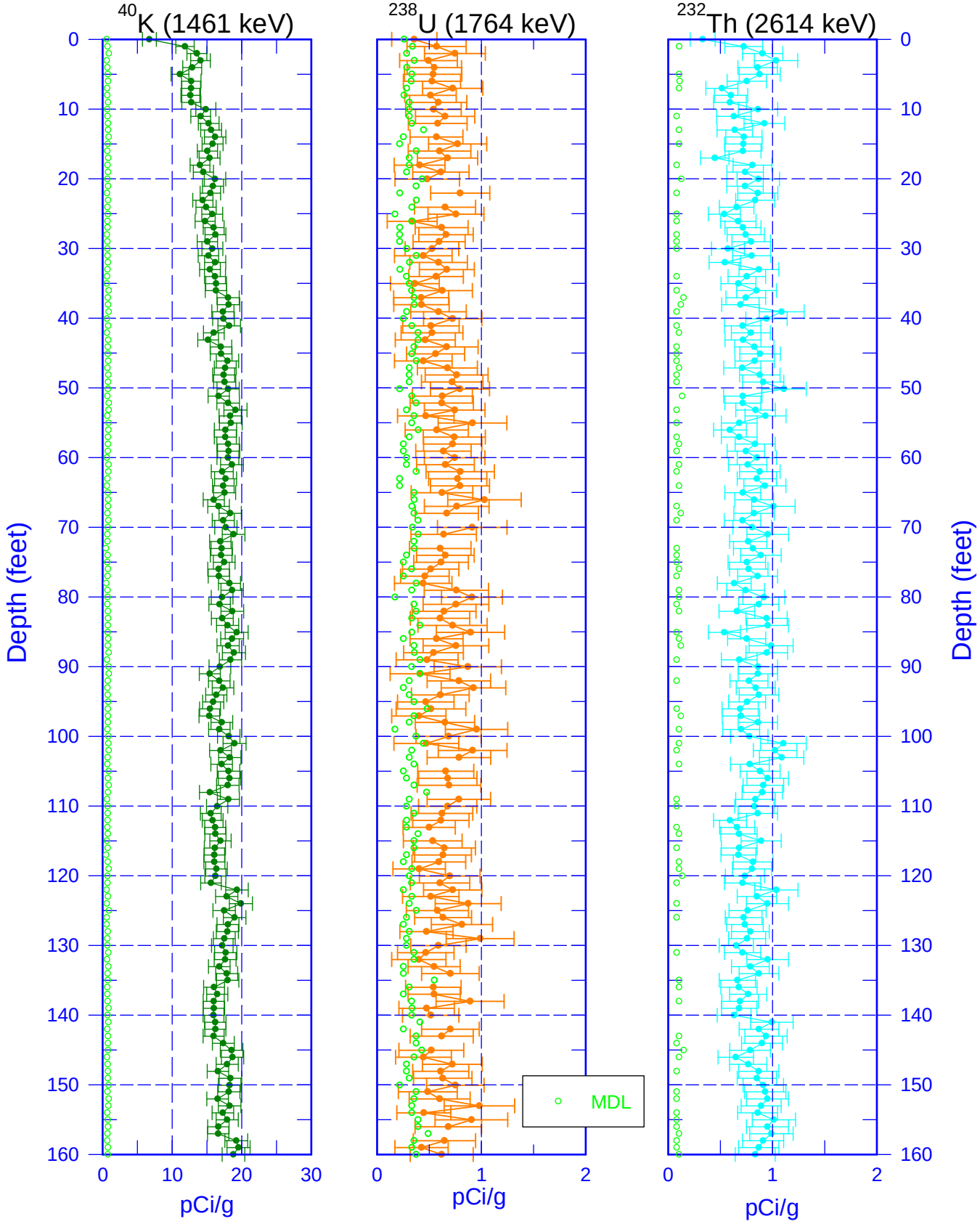
699-38-64B (C9608)
Manmade Radionuclides



Zero Reference - Ground Surface

Huntington Ingalls Industries

699-38-64B (C9608)
Natural Gamma Logs

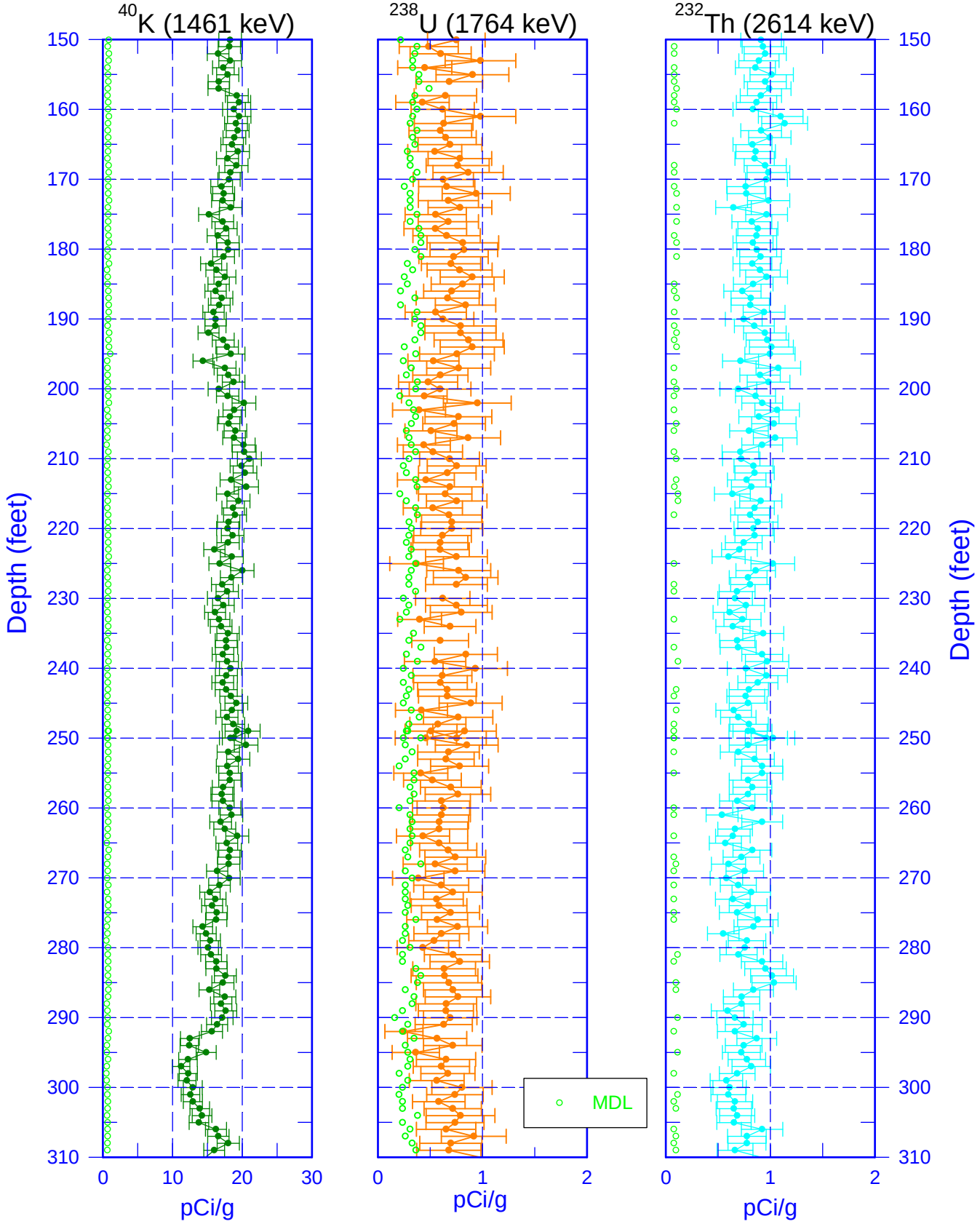


Zero Reference - Ground Surface

Huntington Ingalls Industries

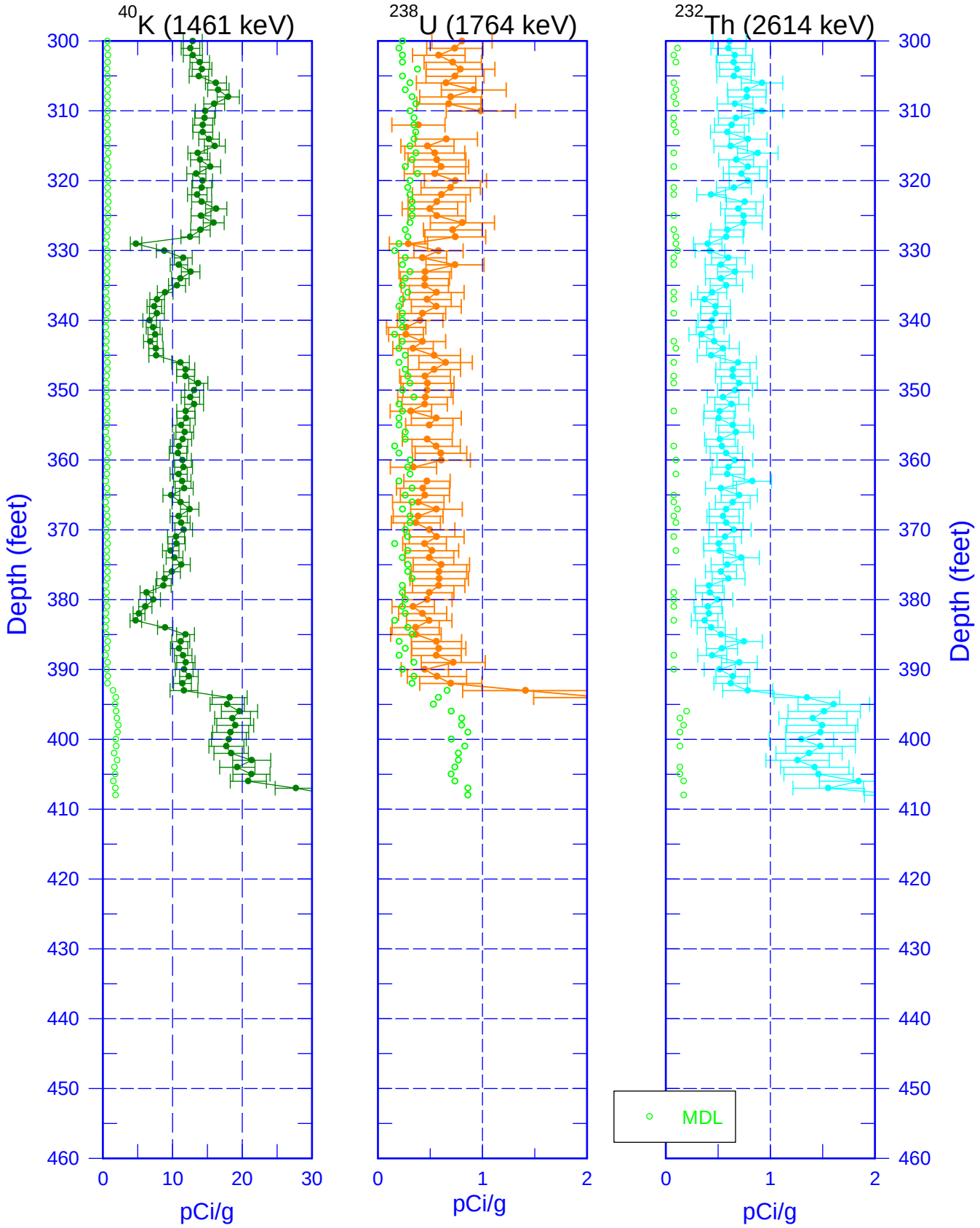
699-38-64B (C9608)

Natural Gamma Logs



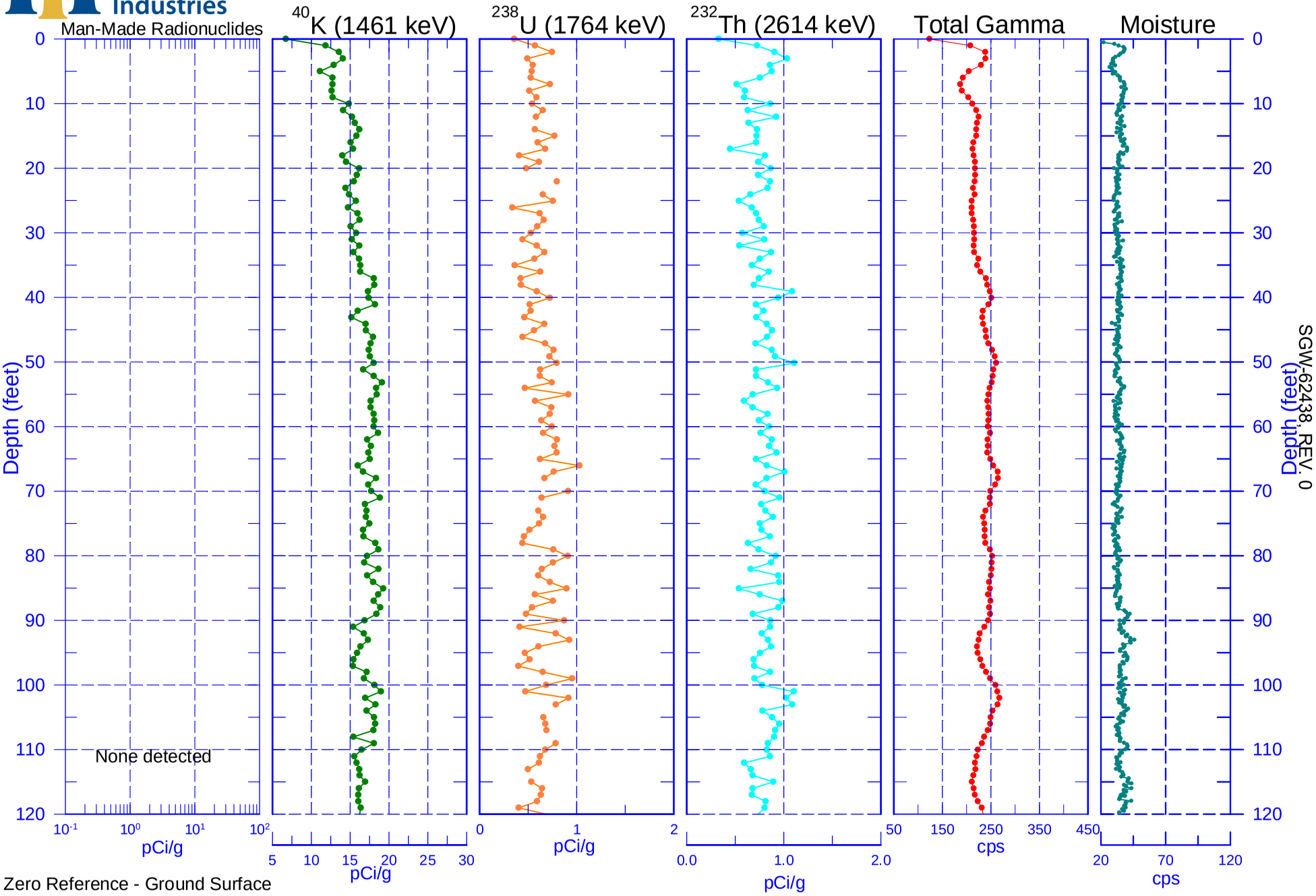
Zero Reference - Ground Surface

699-38-64B (C9608)
Natural Gamma Logs



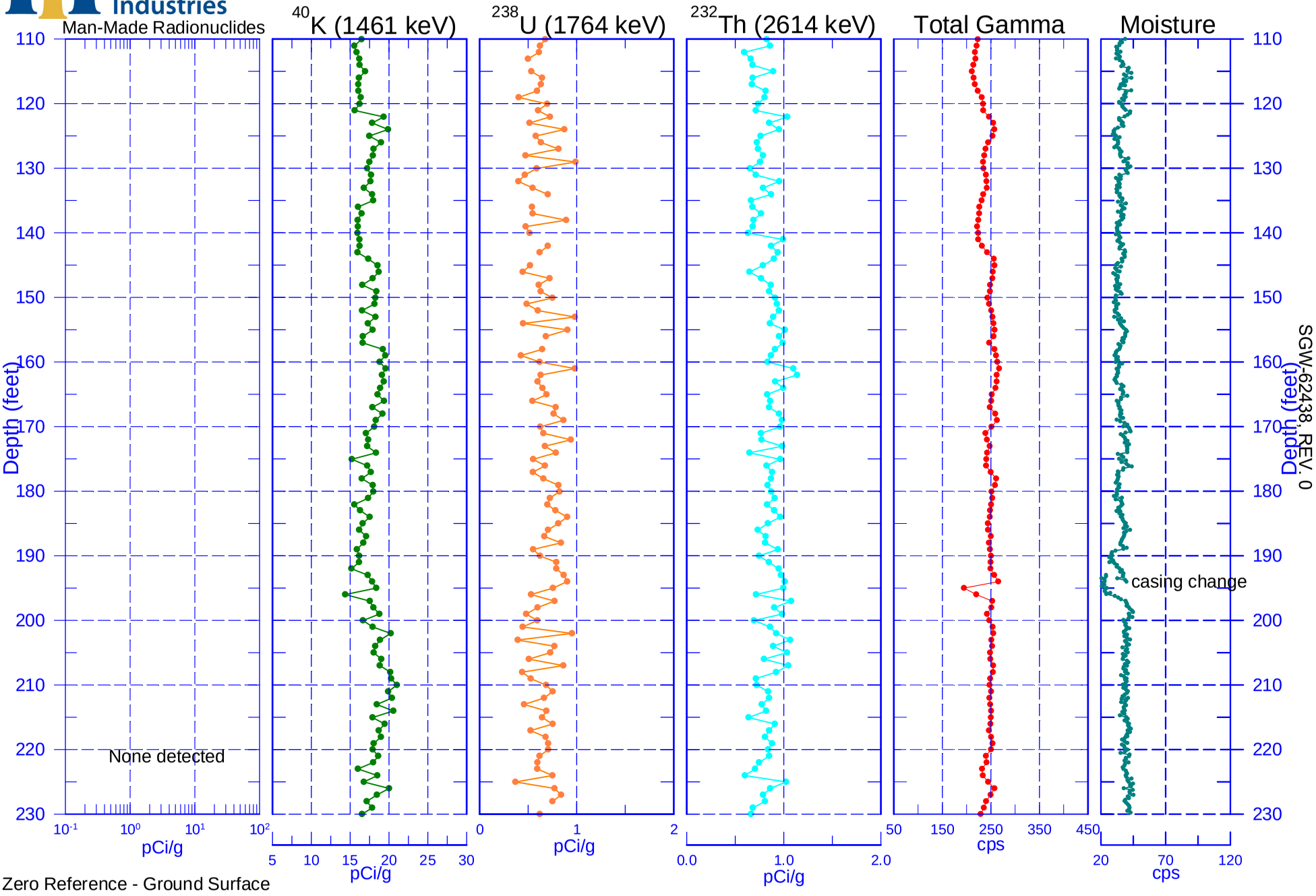
Zero Reference - Ground Surface

699-38-64B (C9608) Combination Plot



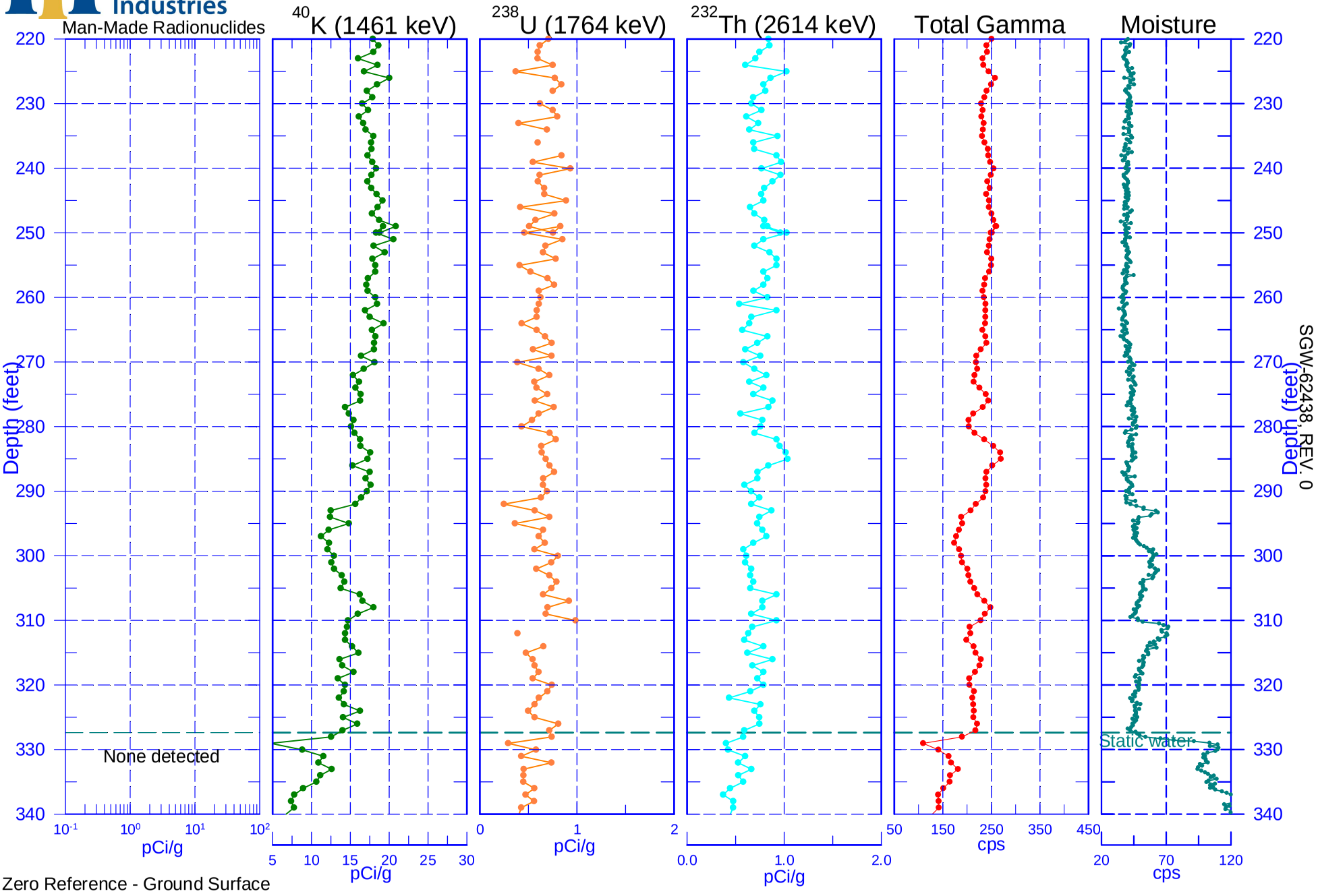
Zero Reference - Ground Surface

699-38-64B (C9608) Combination Plot



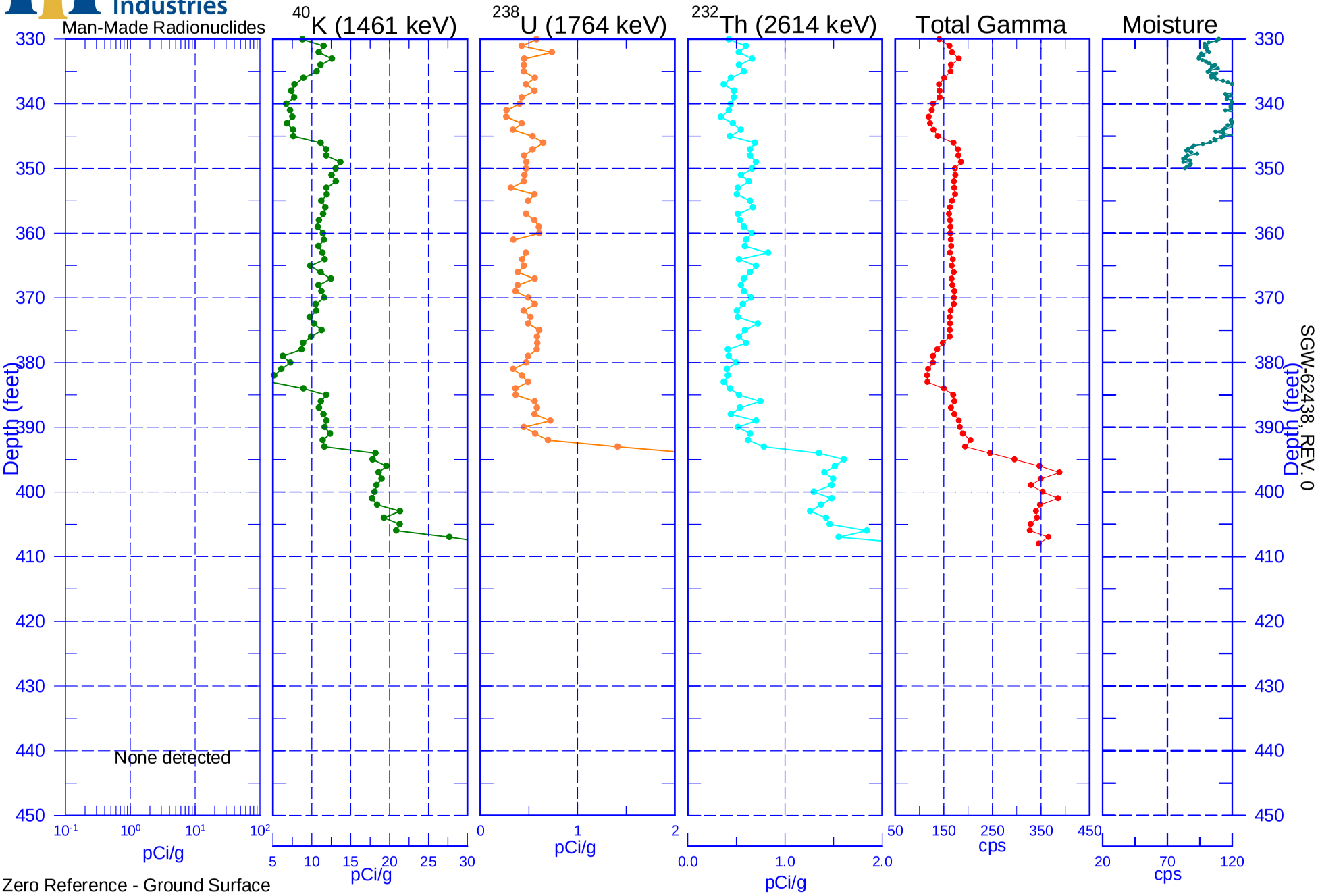
Zero Reference - Ground Surface

699-38-64B (C9608) Combination Plot

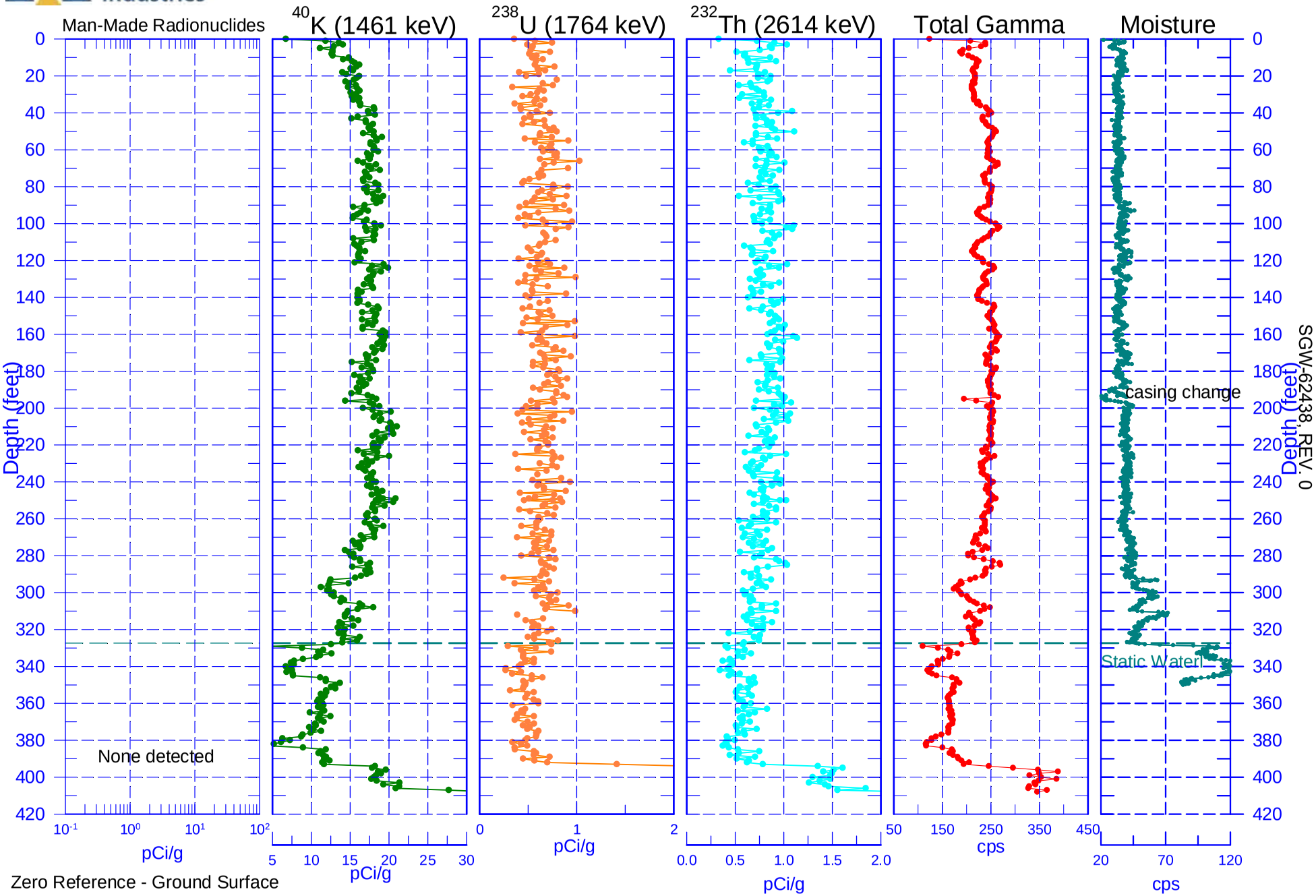


Zero Reference - Ground Surface

699-38-64B (C9608) Combination Plot

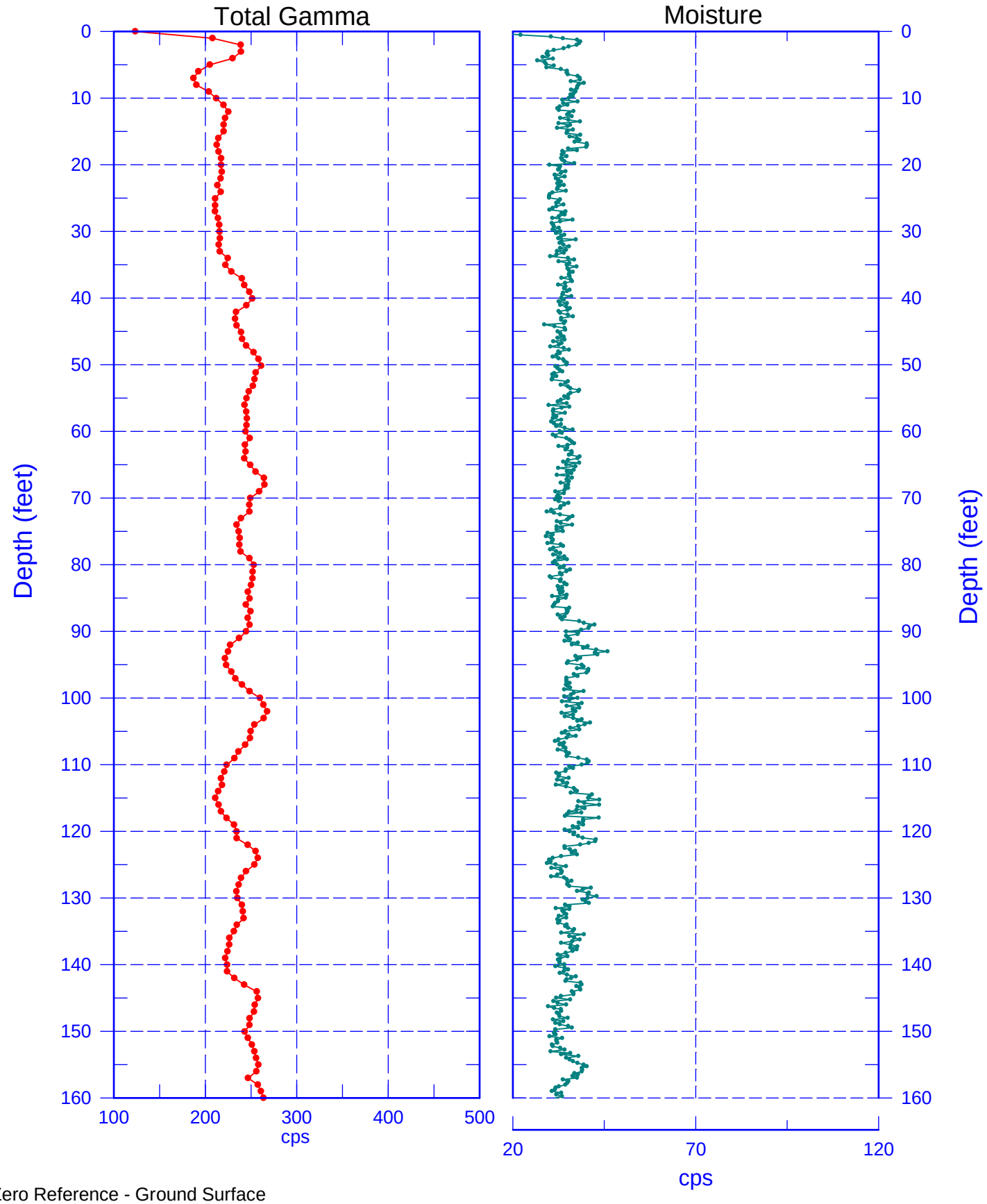


699-38-64B (C9608) Combination Plot



Huntington Ingalls Industries

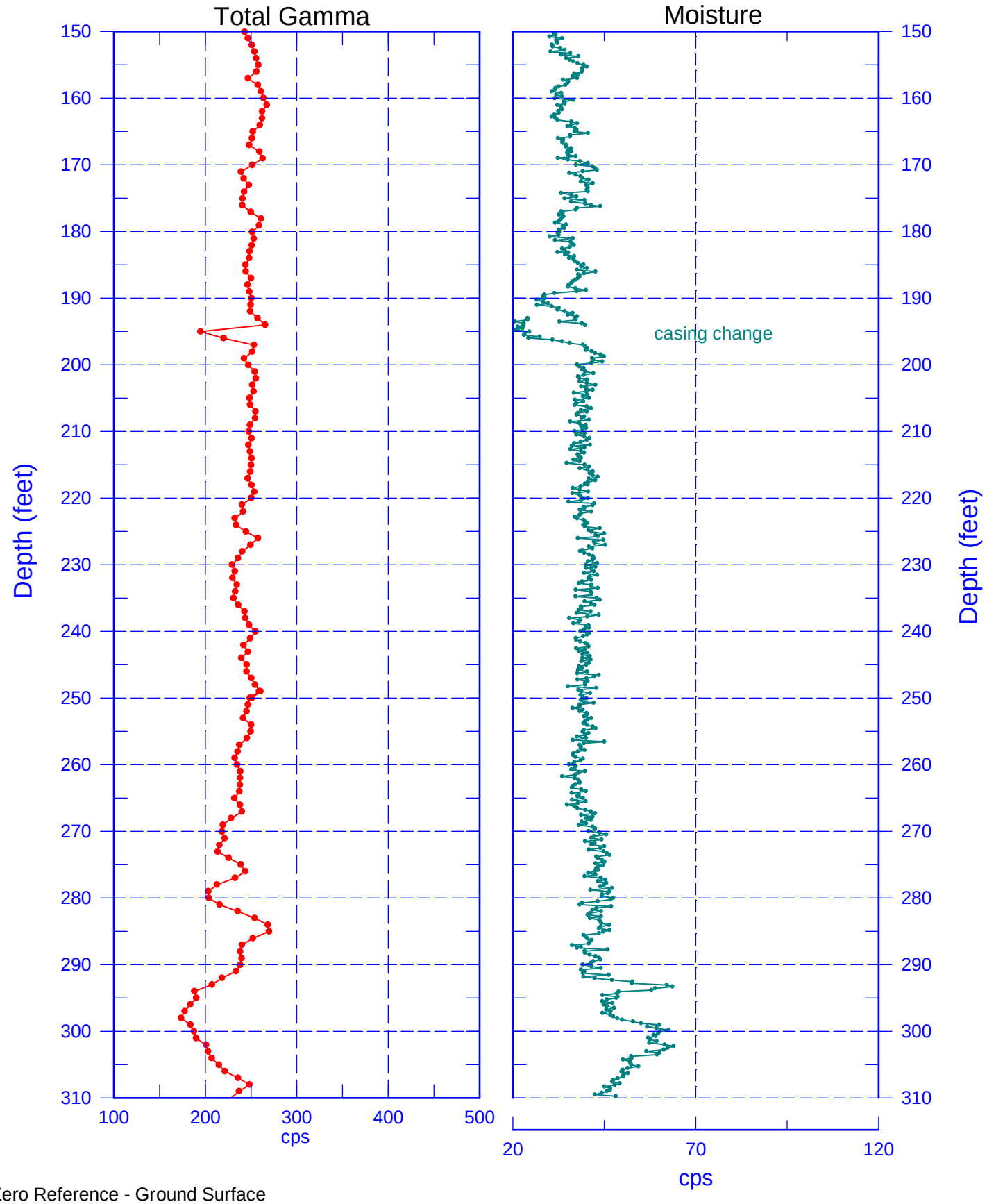
699-38-64B (C9608)
Total Gamma & Moisture



Zero Reference - Ground Surface

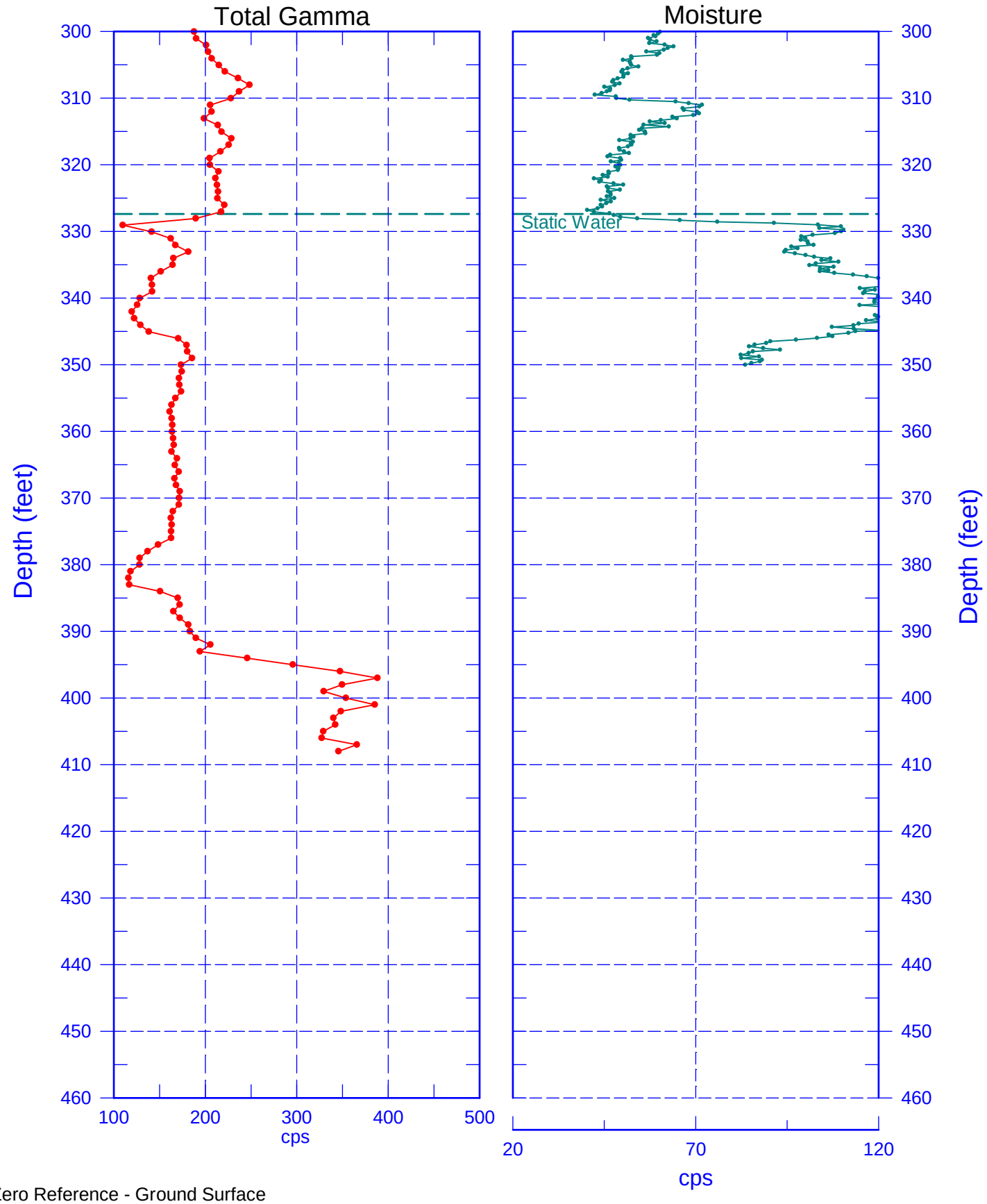
Huntington Ingalls Industries

699-38-64B (C9608)
Total Gamma & Moisture



Zero Reference - Ground Surface

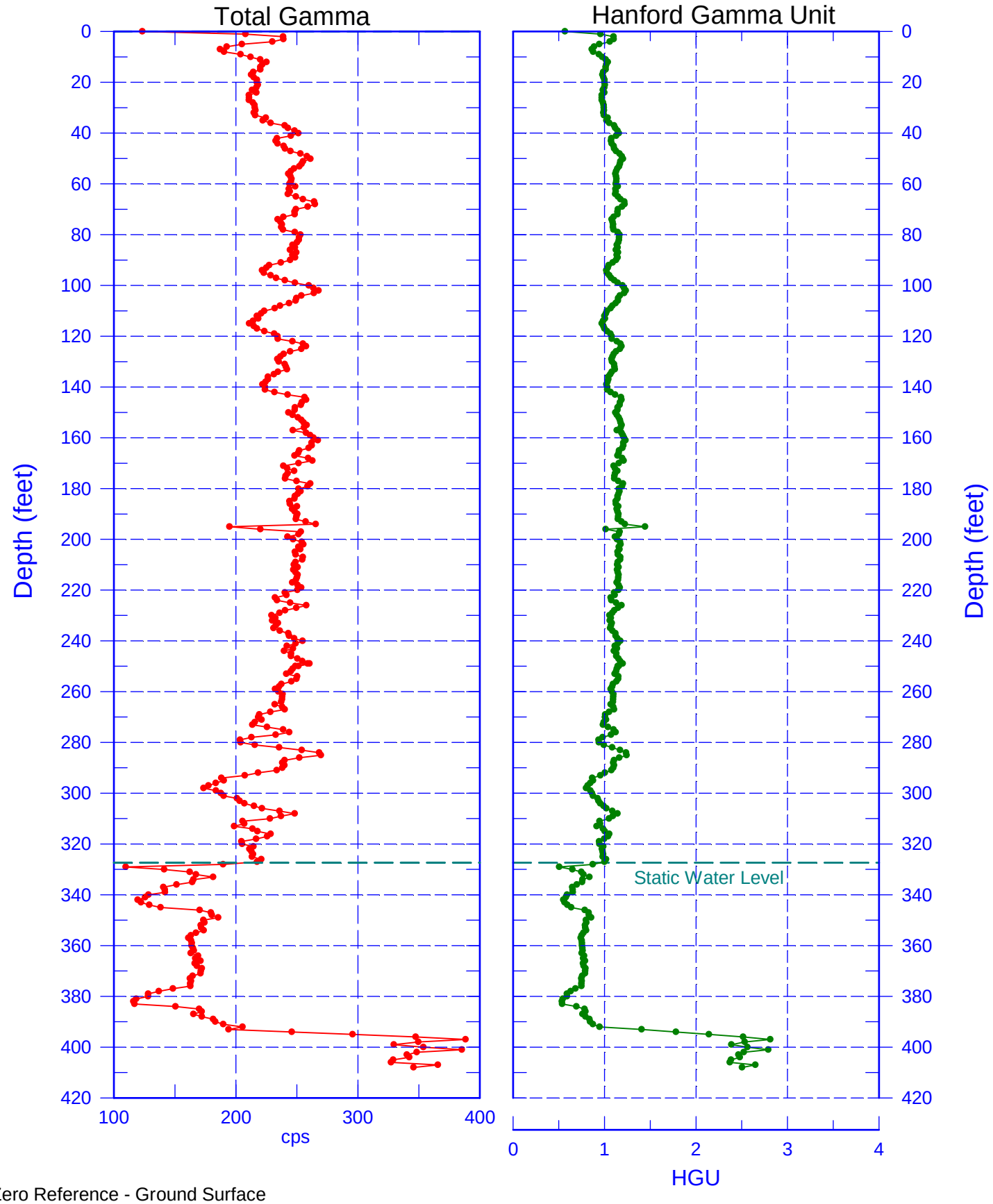
699-38-64B (C9608)
Total Gamma & Moisture



Zero Reference - Ground Surface

Huntington Ingalls Industries

699-38-64B (C9608)
Total Gamma & Hanford Gamma Unit

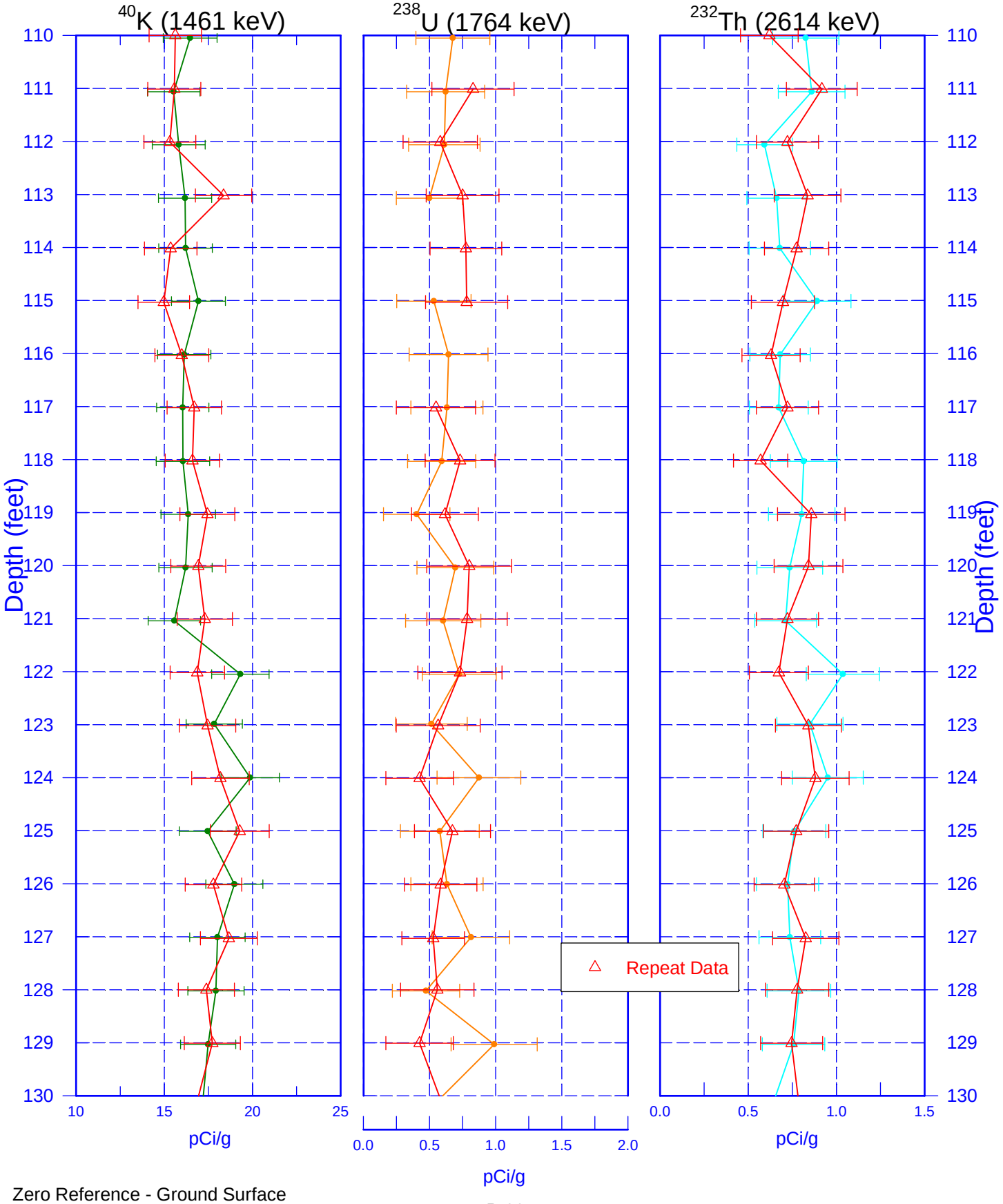


Zero Reference - Ground Surface

Huntington Ingalls Industries

699-38-64B (C9608)

Repeat Section of Natural Gamma Logs

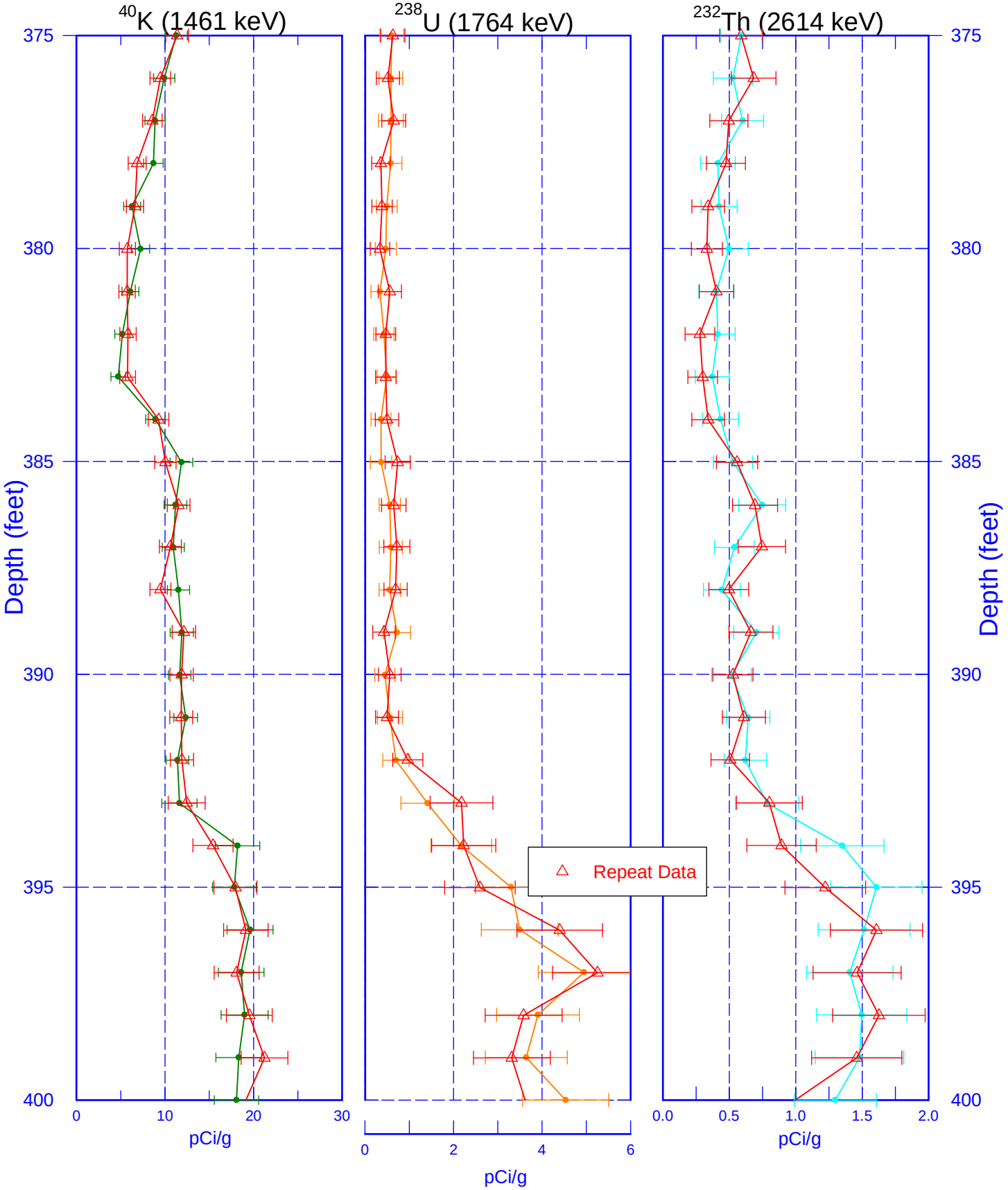


Zero Reference - Ground Surface

Huntington Ingalls Industries

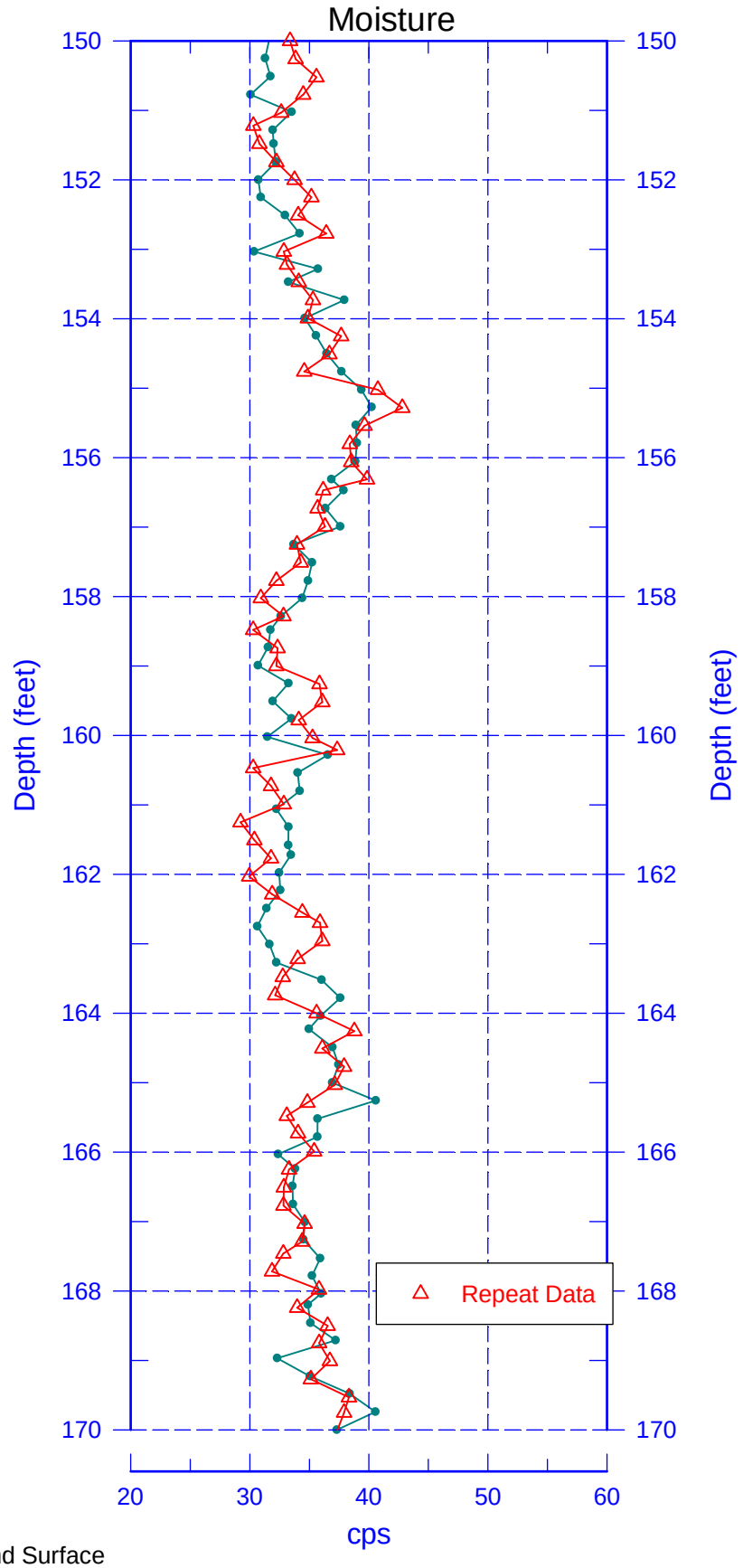
699-38-64B (C9608)

Repeat Section of Natural Gamma Logs



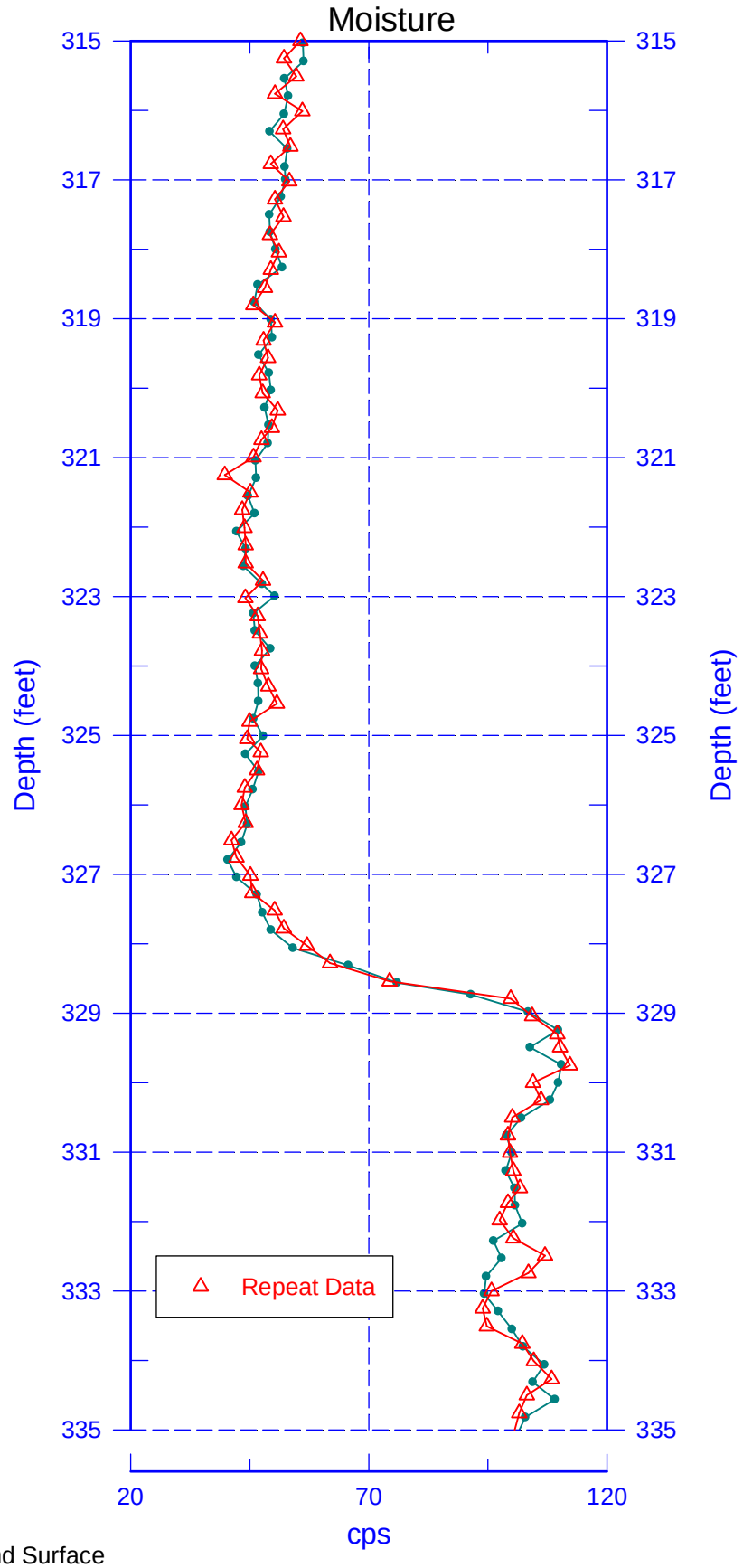
Zero Reference - Ground Surface

699-38-64B (C9608)
Moisture Repeat Section



Zero Reference - Ground Surface

699-38-64B (C9608)
Moisture Repeat Section



Zero Reference - Ground Surface

SURVEY DATA REPORT

Request No. 183-087

Project No.	Title	File No.
	UP-1 Well C9608 (699-38-64B) Final Survey	6AT12R26

Job. No.	Prepared By	Date	Reviewer
CACN: 304398-JPRC	N.P. Fastabend	5/24/18	CBM

DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Obtained final coordinates (C/L Casing) and elevations of UP-1 Well C9608 (699-38-64B) located southwest of the 200 Area Fire Station (609A Building).	Survey File	OR		
	L.D. Bultena	1		
	K.M. Whitley	1		
	J.L. Smoot	1		
	J.B. Geiger	1		
Horizontal Coordinate System: WCS83S/91 (Meters) Vertical Datum: NAVD88 (Meters)	B.J. Howard	1		
	A.J. Green	1		

SURVEY RESULTS AND COMMENTS

See Attached Well Survey Data Report Sheet

FOR OFFICE USE ONLY

OR Doc Type:	WMU Code(S):

A-6006-495 (REV 1)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 05/02/18	Requestor: Leonard D. Bultena (CHPRC)
Date of Survey: 05/24/18	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of UP-1 Well C9608 (699-38-64B) located southwest of the 200 Area Fire Station (609A Building).	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 600A

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
2W-147 (CHPRC) and 2W-148 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9608	699-38-64B	569900.22	135319.93		Center of Casing
				229.996	Top Outer Casing,N.Edge Stamped "X"
				229.778	Top Inner 8"SS Casing, N.Edge
				229.157	Brass Survey Marker

Notes:

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

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

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

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
5-24-18

A-6003-659 (REV 1)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9608	Well Name: 699-~~35~~ 38-64B	Date: 3/14/18
Location: ~20.5 mi NE of ERDF	JLH 5/14/18	

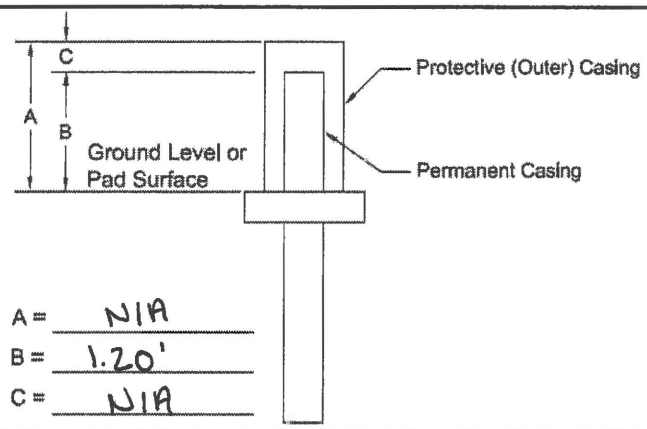
Reference Measuring Point *(unless otherwise noted)*: TOP OF OUTER CASING (TOC)

Has the well been surveyed? ◯ Yes ⊘ No

Does the well have a cement pad? ◯ Yes ⊘ No

Initial Conditions

	Start of Job	End of Job
STATIC WATER LEVEL:		
Date: 3/19/18	327.95' bgs	N/A*
Date: 3/20/18	327.88' bgs	N/A*
DEPTH TO BOTTOM:		
Date: 3/19/18	405.6' bgs	N/A
Date: 3/26/18	N/A	405.2' bgs



A = N/A
B = 1.20'
C = N/A

Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbitidy (NTU) Initial	Turbitidy (NTU) Final	Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
394.83	max: 1.96 avg: 1.16	390.83	overrange	~~4~~ 10.3 BT 3/20/18	0910 (3/19/18)	1538 (3/19/18)	max 110 avg. 65	56.11' (3/19/18)
394.83	2.34	390.83	53.3	4.77	0745 1005 ~~1005~~ BT 3/20/18	0757 1134	75	32.10 (3-21-18)
384.47	2.35	378.47	254	4.86	0728	0845	75	31.91 (3-22-18)

Total Pumped: 47,550 gal

Pump Model: GRUNDFOSX 3-Phase Franklin Electric Model 23606166020, 30 HP, 60 Hz

Troll Serial Number and Pressure Range (PSI and depth): In-Situ Inc. Level Troll 700 SIN 168724, Range: 21m/69ft/vented

Comments: Development during construction, no monument
Log file names: C9608_develop_pretest_~~3/19/18~~ BT 3/19/18 3-15-18 ← issue w/ control box, pump never on while collecting data
C9608_develop_interval#1_3-19-18 and C9608_develop_interval#2_3-20-18
~~C9608_develop_interval#2~~ BT 3/26/18
C9608_dev_interval#1b_3-28-18
C9608_dev-int-2

* e-tape was stuck down hole during development; water depths taken from rugged reader

Prepared By:

Brandon Thurman / Andrew Rawlerson — Print Name
Brandon Thurman / [signature] — Signature
3/28/18 — Date

Reviewed By:

Jennifer Hammons — Print Name
[signature] — Signature
5/14/2018 — Date

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6005-205 (REV 2)

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Photo Log

0-5 bgs

5-10 bgs

10-15 bgs

15-20 bgs

20-25 bgs

25-30 bgs

30-35 bgs

35-40 bgs

40-45 bgs

45-50 bgs

50-55 bgs

55-60 bgs

60-65 bgs

65-70 bgs

70-75 bgs

75-80 bgs

80-85 bgs

85-90 bgs

90-95 bgs

95-100 bgs

100-105 bgs

105-110 bgs

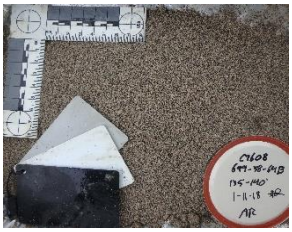
110-115 bgs

115-120 bgs

120-125 bgs

125-130 bgs

130-135 bgs


135-140 bgs

140-145 bgs

145-150 bgs

150-155 bgs

155-160 bgs

160-165 bgs

165-170 bgs

170-175 bgs

175-180 bgs

180-185 bgs

185-190 bgs

190-195 bgs

195-200 bgs

200-205 bgs

205-210 bgs

210-215 bgs

215-220 bgs

220-225 bgs

225-230 bgs

230-235 bgs

235-240 bgs

240-245 bgs

245-250 bgs

250-255 bgs

255-260 bgs

260-265 bgs

265-270 bgs

270-275 bgs

275-280 bgs

280-285 bgs

285-290 bgs

290-295 bgs

295-300 bgs

300-305 bgs

305-310 bgs

310-315 bgs

315-320 bgs

320-325 bgs

325-330 bgs

330-335 bgs

335-340 bgs

340-345 bgs

345-350 bgs

350-355 bgs

355-360 bgs

360-365 bgs

365-370 bgs

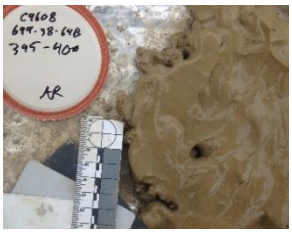
370-375 bgs

375-380 bgs

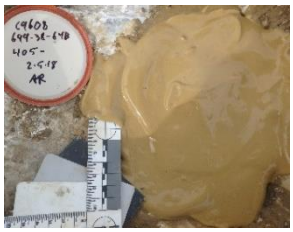
380-385 bgs

385-390 bgs

390-395 bgs


395-400 bgs

400-405 bgs



405-409.77 bgs (TD)

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