

Borehole Summary Report for the Installation of Wells 199-K-231 (C9919), 199-K-232 (C9920) and 199-K-234 (C9922) in the 100-KR-4 OU, FY2018

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

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

CH2MHILL
Plateau Remediation Company

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

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Date

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Terms

| | |
|---------|--------------------------------------------------------------------------------------|
| bgs | below ground surface |
| CERCLA | <i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i> |
| CHPRC | CH2M Hill Plateau Remediation Company |
| CrVI | hexavalent chromium |
| D.O. | dissolved oxygen |
| Ecology | Washington State Department of Ecology |
| ft | feet |
| gpm | gallons per minute |
| HCl | hydrochloric acid |
| HEIS | <i>Hanford Environmental Information System</i> |
| HII | Huntington Ingalls Industries |
| ID | identification |
| hp | horsepower |
| in. | inch |
| NMLS | Neutron Moisture Logging System |
| NTU | Nephelemetric Turbidity Units |
| OU | operable unit |
| RCT | radiological control technician |
| RUM | Ringold Formation member of Wooded Island – “upper mud” unit |
| Rwie | Ringold Formation member of Wooded Island – unit E |
| SGLS | Spectral Gamma Logging System |
| TD | total depth |
| WAC | Washington Administrative Code |

Metric Conversion Chart

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

1 Introduction

This report presents field-generated records and summarizes field activities performed during the installation of three dual-purpose groundwater wells in the 100-K Area of the Hanford Site. The objectives and requirements for these wells are defined in SGW-60843, FY2018 *Plume Containment and Remediation Utilization Plan*. In general, the three new wells will be used to update the conceptual site model and support definition/delineation of the hexavalent chromium (Cr[VI]) plume inland (and upgradient) of the 105KE Reactor area. The wells were installed as part of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)* interim remedial actions further described in EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington*. DOE/RL-2013-33, *Remedial Design/Remedial Action Work Plan for the 100-KR-4 Groundwater Operable Unit Interim Action* supports implementation of interim remedial actions, established in the interim action record of decision (EPA/ROD/R10-96/134) and EPA et al., 2009, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision Hanford Site Benton County, Washington*, within the 100-KR-4 Groundwater Operable Unit (OU). Field activities carried out during the installation of the three new wells included drilling, soil and groundwater sampling, well construction, and development.

The 100-K Area is located in the northwestern portion of the Hanford Site along the southern shoreline of the Columbia River and is approximately 27 miles north-northwest of Richland, Washington. The 100-K Area includes the 105KE and 105KW Reactor areas and adjacent portions of the 600 Area. Groundwater contamination at the 100-KR-4 OU originated from discharges of contaminated waste water and chemical solutions during the period of operation of the 105KE and 105KW plutonium production reactors. Groundwater contamination by Cr(VI), which is the basis for the current interim remedy, originated from planned discharges of chromium-treated cooling water, primarily to the ground at the 116-K-2 Trench and 116-K-1 Crib, and from planned and unplanned releases of concentrated sodium dichromate solution used to treat the reactor cooling water. Other groundwater co-contaminants of concern are strontium-90, carbon-14, nitrate, trichloroethene, and tritium (DOE/RL-2013-33).

The current interim remedy at 100-KR-4 OU consists of three pump and treat systems that capture contaminated groundwater, treat it to remove Cr(VI), and inject the treated water back into the aquifer. The interim remedy is currently capturing the Cr(VI) plume, however, additional activities can increase contaminant removal for aquifer restoration, refine the area conceptual site model, and optimize the effectiveness of pump and treat systems (SGW-60843)

Drilling and construction of the three new wells occurred from April 10, 2018, through September 7, 2018, and was performed by Carpenter Drilling LLC, under the direction of CH2M HILL Plateau Remediation Company (CHPRC). Freestone Environmental Services, Inc. provided well site geology and well construction documentation services. Technical Solutions, a division of Huntington Ingalls Industries (HII) provided geophysical logging services. Sediment and groundwater samples were collected by the CHPRC Soil and Groundwater Remediation Project.

1.1 Purpose and Scope

This document summarizes the observations and measurements made during the drilling and installation of three new wells in the 100-KR-4 OU. This summary report includes copies of the field notes and forms prepared during the drilling, sampling, construction, and development of the wells. Additional information provided in this report includes geologic observations, geophysical log data reports, results of

the well location and elevation civil survey, descriptions of the management and disposition of drilling-derived waste, and a summary of the well acceptance activity.

Technical requirements, applicable CHPRC procedures, and other supporting information were summarized in SGW-61655, *Description of Work for the Installation of Four 100-KR-4 Groundwater Operable Unit Monitoring Wells, FY2018*. Soil and groundwater samples were collected as described in DOE/RL-2013-36, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan*, and DOE/RL-2013-36-ADD5, *Addendum 5: Wells 199-K-231, 199-K-232, 199-K-233, and 199-K-234*.

Appendices A (C9919), B (C9920), and C (C9922), contain the Well Summary Sheet, borehole geologic log, drill cutting photographs, Well Development and Testing Data, Log Data Report, and Well Survey Data Report for each respective well.

All drilling data are reported in the original units recorded at the time of measurement. Table 1-1 lists the wells' identification number and name, and Figure 1-1 presents the well locations. The three new wells will hereafter be referred to in the text by the borehole identification number (e.g., C9919).

Table 1-1. Identification and Location Information for Three New Wells in the 100-KR-4 Operable Unit

| Borehole ID | Well Name | Ecology Tag ID | Northing ^a | Easting ^a | Elevation of Brass Survey Marker ^b | Field Activity Dates | |
|-------------|-----------|----------------|-----------------------|----------------------|-----------------------------------------------|----------------------|----------------------------------|
| | | | meters | | | Initiate Drilling | Conclude Field Work ^c |
| C9919 | 199-K-231 | BKG 095 | 146643.38 | 569511.98 | 146.66 | 4/11/2018 | 7/18/2018 |
| C9920 | 199-K-232 | BIF 379 | 147313.89 | 569245.51 | 127.08 | 4/11/2018 | 6/14/2018 |
| C9922 | 199-K-234 | BKG 096 | 146874.03 | 569005.78 | 136.81 | 5/15/2018 | 9/07/2018 |

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

b. Elevation values are based on *North American Vertical Datum of 1988 (NAVD88)* and are rounded to 0.01 meter.

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

Ecology = Washington State Department of Ecology

ID = identification

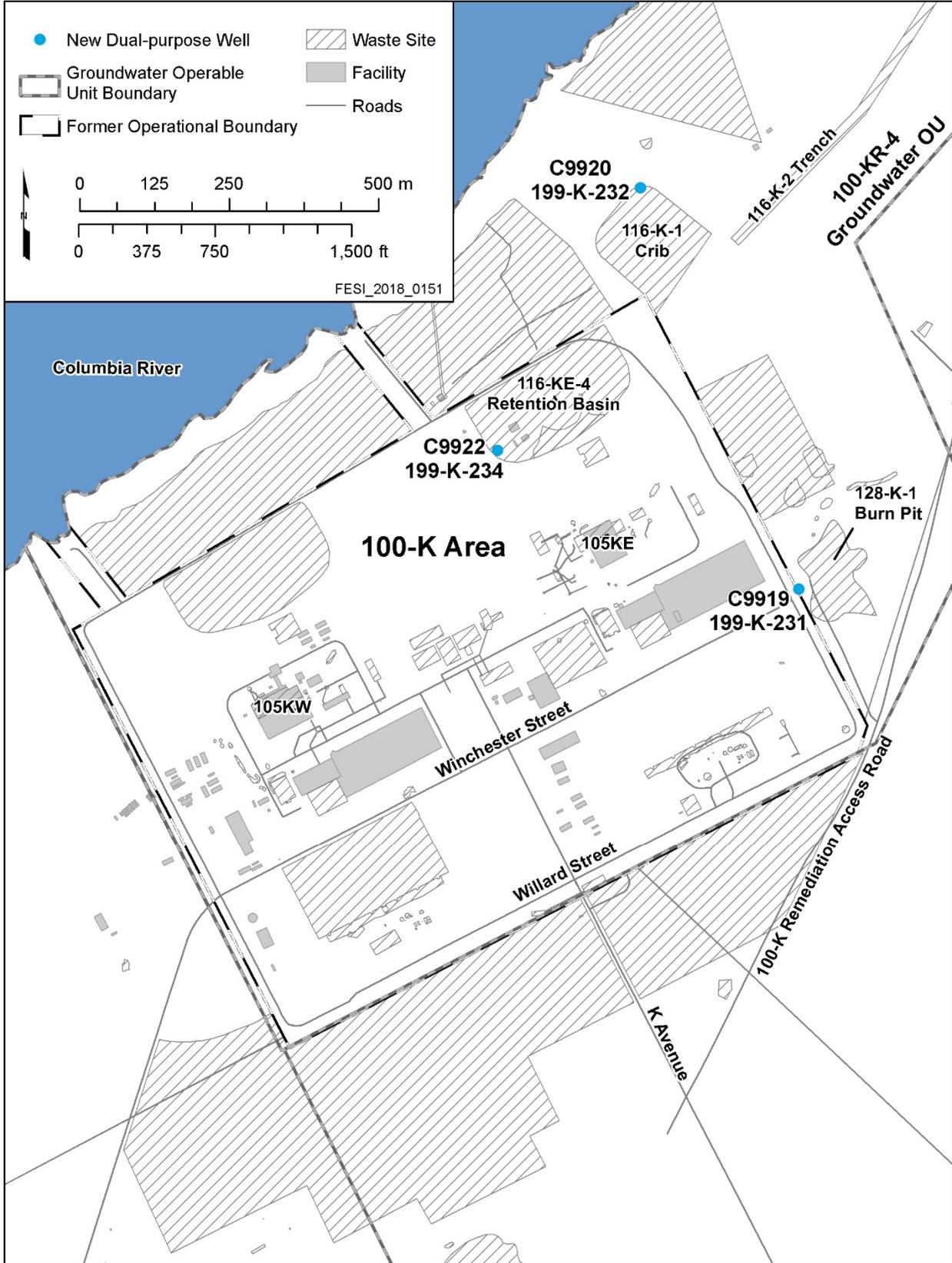


Figure 1-1. New Well Locations in the 100-KR-4 Operable Unit

2 Drilling, Sampling, and Well Construction Activities

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

2.1 General Information

The new wells were constructed in compliance with WAC 173-160, *Minimum Standards for Construction and Maintenance of Wells*. Well construction and development activities were recorded and borehole geology was logged in accordance with applicable procedures.

2.1.1 Drilling, Sampling and Borehole Logging

The boreholes were advanced to depths between 112.8 to 177.7 feet below ground surface (ft bgs), extending between 4.9 and 7.3 ft into the Ringold Formation member of Wooded Island – “upper mud” unit (RUM). Boreholes were drilled, constructed, and developed using a Bucyrus Erie Model 22-W Series Three Cable Tool drilling rig (Figure 2-1). Two strings of temporary threaded carbon steel casing with



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

outer-diameters of 14-in. and 10 3/4-in. were used to drill through potentially radioactively contaminated sediment and ensure the annulus had a “minimum of four inches greater in diameter than the nominal size of the permanent casing”, in accordance with the substantive standards of WAC 173-160.

Archive samples were collected from the drill cuttings at each borehole, at 5-ft intervals and at changes in lithology. Archive samples were not collected if the drill cuttings were interpreted as backfill or identified as contaminated based on field screening. Samples were placed in labeled one-pint glass jars and sequential chip tray compartments for archive storage. Scaled digital photographs of drill cuttings were taken during archive sample collection to accompany field descriptions. Borehole geologic logs and drill cutting photographs are presented in Appendices A through Appendix C.

Sediment samples were collected for sieve analysis throughout the saturated zone every 5 ft and subsequently composited over 20-ft intervals. A sieve analysis was performed on each composite sample for C9919, C9920, and C9922 which was used to determine the appropriate screen slot size for each completed well.

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

were collected from the drive barrel during drilling. Split spoon and grab sample depths with associated Hanford Environmental Information System (HEIS) numbers are included for each well in Section 2.2.

During drilling, depth-discrete groundwater samples were collected at the upper, mid to upper, and bottom of the unconfined aquifer using a temporary submersible pump. Groundwater samples were collected by CHPRC nuclear chemical operators after a minimum of one borehole volume had been purged and field parameters (temperature, pH, conductivity, dissolved oxygen, and oxidation-reduction potential) stabilized within 10 % of variance over three consecutive measurements. Final groundwater samples were also collected at the end of well development for laboratory analysis. All groundwater sample depths and associated HEIS numbers are included in Section 2.2.

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

2.1.2 Health and Safety Screening

A radiological control technician (RCT) performed radiological surveys of the drill cuttings, geologic samples, temporary drive casing, core barrel, and drillers' control station using standard field screening instruments. Continuous RCT coverage was required at boreholes C9920 and C9922. Borehole C9919 was surveyed every morning and afternoon. The RCT used standard field screening instruments to detect and measure alpha, beta, and gamma radiological contamination, if present. No measurements above background levels were reported during drilling activities.

Atmospheric monitoring was performed by an industrial hygiene technician using a hand-held multi-gas meter and a photoionization detector. Monitoring was performed at least twice daily of the drillers' breathing zone near the wellhead, any fresh drill cuttings, geologic samples, and any other areas of potential concern. No field measurements above background levels were reported during drilling activities.

2.1.3 Well Construction and Development

The three new wells were constructed using 6-in. nominal diameter, Schedule 10, 304/304L stainless steel casing, V-slot continuous wire wrap stainless steel screen and a sump with end cap. Centralizers were installed above and below the screen and at 40-ft intervals to ground surface. The primary filter pack consists of either 8-16, or 10-20 mesh Colorado Silica Sand extending from below the well sump to between 4.4 and 5.2 ft above the top of the screen. Following the placement of each 10-ft interval of filter pack within a saturated zone, the filter pack was surged using a dual surge block until measured settling met CHPRC well development specifications (e.g., less than 0.1 ft of settling in 15 minutes of surging). Annular seal materials include 3/8-in. bentonite pellets, medium granular bentonite crumbles or chips, and type I/II/V cement grout. Well-specific installation and construction depths are presented in Section 2.2 and in Table 2-1.

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

Well development was conducted at each well. Development was performed in four to five intervals using a 25-horsepower (hp) Grundfos submersible pump. Each interval was pumped until water was less than 5.0 nephelometric turbidity units (NTU) and additional water quality parameters (e.g., conductivity, pH, and temperature) stabilized. The water level was monitored using an In-Situ Inc., Level TROLL¹ 700 pressure transducer accompanied by a Rugged Reader². Final development data is summarized in Table 2-2.

2.2 Well-Specific Information

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

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

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

Table 2-1. Well Construction Information

| Borehole ID | Total Depth (ft bgs) | Permanent Casing and Screen | | | | | Annulus: Seal and Filter Pack | | | | Filter Pack Size (mesh) |
|-------------|----------------------|-----------------------------------|-------------------------|---------------------------|---------------------|----------------------------|----------------------------------|--------------------------------------|------------------------------------|--------------------------|-------------------------|
| | | Screen and Casing Diameter (inch) | Screen Slot Size (inch) | Blank Casing ^a | Screen ^a | Sump/ End Cap ^a | Cement Surface Seal ^b | Granular Bentonite Seal ^c | Pellet Bentonite Seal ^d | Filter Pack ^e | |
| | | | | | | | | | | | |
| C9919 | 177.7 | 6 | 0.050 | +2.10 – 77.92 | 77.92 – 172.58 | 172.58 – 177.55 | 0.0 – 11.0 | 11.0 – 70.0 | 70.0 – 73.0 | 73.0 – 177.7 | 8 – 16 |
| C9920 | 112.8 | 6 | 0.040 | +1.99 – 20.54 | 20.54 – 105.56 | 105.56 – 110.56 | 0.0 – 8.6 | 8.6 – 13.2 | 13.2 – 16.1 | 16.1 – 112.8 | 10 – 20 |
| C9922 | 139.9 | 6 | 0.050 | +2.01 – 43.40 | 43.40 – 133.44 | 133.44 – 138.39 | 0.0 – 10.2 | 10.2 – 32.0 | 32.0 – 38.2 | 38.2 – 139.9 | 8 – 16 |

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

b. Type I/II/V cement grout.

c. Medium bentonite chips.

d. Coated bentonite pellets (3/8-in.).

e. Premier Colorado Silica sand.

+ = above ground surface.

ft bgs = feet below ground surface.

ID = identification.

Table 2-2. Well Development Information

| Borehole ID | Static Water Level | | Intake Depth (ft bgs) | Duration (min) | Average Flow Rate (gpm) | Final Turbidity (NTU) | Maximum Drawdown (ft) | Total Gallons Pumped ^a | Specific Capacity (gpm/ft) |
|-------------|--------------------|-----------|-----------------------|----------------|-------------------------|-----------------------|-----------------------|-----------------------------------|----------------------------|
| | ft bgs / date | | | | | | | | |
| C9919 | 81.9 | 7/12/2018 | 165.7 | 58 | 200 | 2.31 | 22.2 | 9.0 | 9.0 |
| | 81.8 | 7/16/2018 | 145.7 | 22 | 125 | 1.49 | 11.0 | 2,750 | 11.4 |
| | | | 124.8 | 18 | 120 | 0.92 | 10.4 | 2,160 | 11.5 |
| | | | 103.9 | 16 | 120 | 1.05 | 10.8 | 1,920 | 11.2 |
| | | | 92.4 | 39 | 75 | 0.61 | 8.5 | 2,925 | 8.8 |
| C9920 | 22.0 | 6/14/2018 | 102.9 | 47 | 169 | 1.84 | 54.5 | 7,943 | 3.1 |
| | | | 82.9 | 20 | 100 | 1.83 | 12.7 | 2,000 | 7.9 |
| | | | 62.9 | 22 | 100 | 1.72 | 11.0 | 2,200 | 9.1 |
| | | | 42.9 | 35 | 100 | 0.72 | 11.5 | 3,500 | 8.7 |
| C9922 | 59.9 | 9/07/2018 | 125.9 | 33 | 230 | 5.36 | 17.9 | 7,590 | 12.8 |
| | | | | 23 | 180 | 1.12 | 13.9 | 4,140 | 12.9 |
| | | | 104.8 | 20 | 150 | 0.74 | 12.8 | 3,000 | 11.7 |
| | | | 83.7 | 21 | 140 | 1.43 | 9.3 | 2,940 | 15.1 |
| | | | 72.2 | 60 | 107 | 0.78 | 7.1 | 6,420 | 15.1 |

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

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

ft bgs = feet below ground surface.

gpm = gallons per minute.

Table 2-2. Well Development Information

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

ID = identification.

min = minutes

NTU = nephelometric turbidity unit.

2.2.1 Well 199-K-231 (C9919)

Borehole C9919 was drilled from ground surface to a TD of 177.7 ft bgs on April 11, 2018 through May 24, 2018. The borehole was drilled using 12-in. and 8 3/8-in. core barrel, and carbide button bit, with 14-in. threaded temporary casing to a depth of 31.6 ft bgs and 10 3/4-in. casing to a depth of 178.0 ft bgs. Approximately 32.8 gallons of water was added to the borehole during drilling operations.

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

Following placement of the 14-in. temporary casing, the borehole was logged by HII using SGLS and NMLS on April 18, 2018 from ground surface to 30.01 ft bgs and from ground surface to 31.26 ft bgs, respectively. Following placement of the 10 3/4-in. temporary casing, the borehole was logged by HII using SGLS and NMLS on May 24, 2018 from 29.0 to 177.01 ft bgs and from 30.0 to 93.52 ft bgs, respectively.

Well installation and construction took place from June 25, 2018 through July 18, 2018. Prior to well construction, a borehole straightness test was passed on June 25, 2018. The well was constructed as a 6-in. nominal diameter well with 80.02 ft of schedule 10 stainless steel casing, 94.66 ft of 50-slot (0.050-in.) screen, and a 4.97 ft sump with end cap. The well was placed at 177.55 ft bgs, extending 2.10 ft above ground surface. From TD to surface, the annulus was filled with a 104.7-ft interval of 8-16 mesh sand, 3.0-ft interval of 3/8-in. bentonite pellets, 59.0-ft interval of bentonite chips, and 11.0-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on July 18, 2018. See Table 2-1 and Appendix A for well construction details.

Well development occurred on July 12, 2018 through July 16, 2018 with a 25-hp Grundfos submersible pump. Well development information may be found in Table 2-2. Static water level was measured before well development at 81.9 ft bgs.

Table 2-3. C9919 Split Spoon Samples

| Date | Sample Depth (ft bgs) | Sample Method | Media | Recovery % | HEIS number |
|-----------|-----------------------|---------------|-------|------------|--------------------------------|
| 5/1/2018 | 83.9 – 85.8 | Split spoon | Soil | 97 | B3J618, B3J619 |
| 5/14/2018 | 124.9 – 125.8 | | | 50 | B3J620, B3J621, B3J622, B3J623 |
| 5/22/2018 | 164.5 – 166.9 | | | 100 | B3J624, B3J625 |

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-4. C9919 Groundwater Sample Collection Summary

| Date | Sample Depth (ft bgs) | Sample Method | Pump Rate (gpm) | Volume Purged (gallons) | Turbidity (NTU) | D.O. at Sample Collection (mg/L) | HEIS number |
|-----------|-----------------------|------------------|-----------------|-------------------------|-----------------|----------------------------------|----------------------------------------------------------------------------------------|
| 5/2/2018 | 91.1 | Submersible Pump | 10 | 930 | 31.1 | 8.52 | B3J630, B3J631, B3J632, B3J633, B3J634, B3J635, B3J636, B3J637, B3J638 |
| 5/15/2018 | 126.9 | | 0.8 | 308 | 97.3 | 7.11 | B3J640, B3J642, B3J643, B3J639, B3J641 |
| 5/22/2018 | 165.0 | | 3.0 | 364 | >1,000 | 6.13 | B3J645, B3J647, B3J648, B3J644, B3J646 |
| 7/16/2018 | 92.4 ^a | | 75 | 2,925 | 1.26 | 8.18 | B3J649, B3J650, B3J651, B3J652, B3J653, B3J654, B3J655, B3J656, B3J657, B3J661, B3J662 |

a. Sample collected during the last well development interval.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

2.2.2 Well 199-K-232 (C9920)

Borehole C9920 was drilled from ground surface to a TD of 112.8 ft bgs on April 11, 2018 through May 7, 2018. The borehole was drilled using 12-in. and 8 3/8-in. core barrel, and carbide button bit, with 14-in. threaded temporary casing to a depth of 31.5 ft bgs and 10 3/4-in. casing to a depth of 111.9 ft bgs. No water was added to the borehole during drilling operations.

Three split spoon soil samples and four soil grab samples were collected and are summarized in Table 2-5. Four groundwater samples were collected and are summarized in Table 2-6. The final groundwater sample was collected during well development.

Following placement of the 14-in. temporary casing, the borehole was logged by HII using SGLS and NMLS on April 17, 2018 from ground surface to 29.01 ft bgs and from ground surface to 26.51 ft bgs, respectively. Following placement of the 10 3/4-in. temporary casing, the borehole was logged by HII using SGLS. SGLS logging occurred on May 08, 2018, from 28.0 to a depth of 111.02 ft bgs.

Well installation and construction took place from May 10, 2018 through June 14, 2018. Prior to well construction, a borehole straightness was passed on May 10, 2018. The well was constructed as a 6-in. nominal diameter monitoring well with 22.53 ft of schedule 10 stainless steel casing, 85.02 ft of 40-slot (0.040-in.) screen, and a 5.00 ft sump with end cap. The well was placed at 110.56 ft bgs, extending 1.99 ft above ground surface. From TD to surface, the annulus was filled with a 96.7-ft interval of 10-20 mesh sand, 2.9-ft interval of 3/8-in. bentonite pellets, 4.6-ft interval of bentonite chips, and 8.6-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on June 14, 2018. See Table 2-1 and Appendix B for well construction details.

Well development occurred on June 14, 2018 with a 25-hp Grundfos submersible pump. Well development information may be found in Table 2-2. Static water level was measured before well development at 22.0 ft bgs.

Table 2-5. C9920 Soil Samples

| Date | Sample Depth (ft bgs) | Sample Method | Media | Recovery % | HEIS number |
|-----------|-----------------------|---------------|-------|------------|------------------------|
| 4/12/2018 | 12.9 | Grab | Soil | - | B3J690, B3J689, B3J688 |
| | 14.8 | | | - | B3J694, B3J693, B3J691 |
| 4/16/2018 | 20.6 | Grab | | - | B3J697, B3J696, B3J695 |
| | 24.8 | | | - | B3J6B0, B3J699, B3J698 |
| 4/17/2017 | 27.8 – 30.3 | Split spoon | | 75 | B3J6B3, B3J6B2, B3J6B1 |
| 4/25/2018 | 71.1 – 72.6 | | | 100 | B3J6B7, B3J6B8, B3J6B9 |
| 5/7/2018 | 107.0 – 109.5 | | | 100 | B3J6C3, B3J6C4, B3J6C5 |

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-6. C9920 Groundwater Sample Collection Summary

| Date | Sample Depth (ft bgs) | Sample Method | Pump Rate (gpm) | Volume Purged (gallons) | Turbidity (NTU) | D.O. at Sample Collection (mg/L) | HEIS number |
|-----------|-----------------------|------------------|-----------------|-------------------------|-----------------|----------------------------------|-----------------------------------------------------------------------------------------|
| 4/18/2018 | 31.5 | Submersible Pump | 4 | 304 | 39.2 | 8.15 | B3J658, B3J659, B3J660, B3J673, B3J674, B3J675 |
| 4/30/2018 | 68.5 | | 11 | 660 | 42.4 | 8.55 | B3J6F9, B3J6F8, B3J6F7, B3J6F6, B3J6F5, B3J6F4, B3J6H0, B3J6H1, B3J6H2, B3J6H3, B3J6H4, |
| 5/7/2018 | 106.0 | | 10 | 1,580 | 64.6 | 8.27 | B3J6J0, B3J6H5, B3J6H6, B3J6H7, B3J6H8, B3J6H9 |
| 6/14/2018 | 42.9 ^a | | 100 | 3,500 | 0.72 | 8.43 | B3J6K1, B3J6J9, B3J6K0, B3J6J1, B3J6J2, B3J6J3, B3J6J4, B3J6J5, B3J6J6, B3J6J7, B3J6J8 |

a. Sample collected during last well development interval.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

2.2.3 Well 199-K-234 (C9922)

Borehole C9922 was drilled from ground surface to a TD of 139.9 ft bgs on May 15, 2018 through June 13, 2018. The borehole was drilled using 12-in. and 8 3/8-in. core barrel, and carbide button bit, with 14-in. threaded temporary casing to a depth of 7.4 ft bgs. Due to concrete and rebar material encountered at 7.4 ft bgs, the 14-in. temporary casing was removed and drilling resumed with 10 3/4-in. temporary casing to a depth of 137.6 ft bgs, and an 8 3/8-in. core barrel to a TD of 139.9 ft bgs. No water was added to the borehole during drilling operations.

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

Following placement of the 10 3/4-in. temporary casing, the borehole was logged by HII using SGLS and NMLS. SGLS logging occurred on June 14, 2018, from ground surface to a depth of 61.0 ft bgs and on June 18, 2018, from 60.0 to 138.0 ft bgs. NMLS logging occurred on June 14, 2018, from ground surface to 53.0 ft bgs.

A borehole straightness test was successfully performed on July 23, 2018. Well construction took place from July 24, 2018 through August 29, 2018. The well was constructed as a 6-in. nominal diameter well with 45.41 ft of schedule 10 stainless steel casing, 90.04 ft of 50-slot (0.050-in.) screen, and a 4.95 ft sump with end cap. The well was placed at 138.39 ft bgs, extending 2.01 ft above ground surface. From TD to surface, the annulus was filled with a 101.7-ft interval of 8-16 mesh sand, 6.2-ft interval of 3/8-in. bentonite pellets, 21.8-ft interval of bentonite chips, and 10.2-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on August 29, 2018. See Table 2-1 and Appendix C for well construction details.

Well development occurred on September 7, 2018 with a 25-hp Grundfos submersible pump. Well development information may be found in Table 2-2. Static water level was measured before well development at 59.9 ft bgs.

Table 2-7. C9922 Split Spoon Samples

| Date | Sample Depth (ft bgs) | Sample Method | Media | Recovery % | HEIS number |
|-------------|------------------------------|----------------------|--------------|-------------------|----------------------------------------------------------------|
| 5/29/2018 | 53.7 – 56.2 | Split spoon | Soil | 100 | B3J750, B3J751, B3J752, B3J753 |
| 6/04/2018 | 93.9 – 95.0 | Split spoon | Soil | 50 | B3J754, B3J755, B3J756, B3J757, B3J759, B3J760, B3J761, B3J762 |
| 6/12/2018 | 130.9 – 133.4 | Split spoon | Soil | 100 | B3J764, B3J765, B3JF00, B3JF01 |

ft bgs = feet below ground surface.

HEIS = Hanford Environmental Information System.

Table 2-8. C9922 Groundwater Sample Collection Summary

| Date | Sample Depth (ft bgs) | Sample Method | Pump Rate (gpm) | Volume Purged (gallons) | Turbidity (NTU) | D.O. at Sample Collection (mg/L) | HEIS number |
|-----------|-----------------------|------------------|-----------------|-------------------------|-----------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------|
| 5/30/2018 | 57.0 | Submersible Pump | 2.5 | 203 | 16.9 | 10.02 | B3J768, B3J769, B3J770, B3J771, B3J772, B3J773, B3J774, B3J775 |
| 6/05/2018 | 93.9 | | 10 | 670 | >1,000 | 7.86 | B3J784, B3J785, B3J786, B3J787, B3J776, B3J777, B3J778, B3J779, B3J780, B3J781, B3J782, B3J783, B3JF25, B3JF24, B3JF26 |
| 6/12/2018 | 131.0 | | 10 | 950 | >1,000 | 7.94 | B3J788, B3J789, B3J790, B3J791, B3J792, B3J793, B3JF27, B3J7B7 |
| 9/07/2018 | 72.2 ^a | | 107 | 6,420 | 0.97 | 8.60 | B3J7B3, B3J7B4, B3J795, B3J796, B3J797, B3J798, B3J799, B3J7B0, B3J7B1, B3J7B2, B3J7B5 |

a. Sample collected during fifth well development interval.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

3 Geologic Observations

This section summarizes the general geology of the 100-KR-4 OU near the four new wells and presents the stratigraphy encountered during the drilling of each well.

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

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

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

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

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

Drilling continued from 4.9 to 7.3 ft into the RUM. The saturated thickness varied from 79.0 ft at C9922 to 86.3 ft at C9919 but can fluctuate significantly in response to stage changes in the Columbia River downstream of Priest Rapids Dam.

3.2 Borehole Geology

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

Stratigraphic unit contacts included in this document are based on field drill cuttings examination (e.g., lithology, texture, color, reaction to 10% dilute hydrochloric acid [HCl], etc.) and drilling observations (e.g., drill rate) in the field. As such, the unit contacts included herein should not be considered final. Final stratigraphic unit contact depths will be determined during data review and will incorporate the field observations, borehole geophysical logging information, and regional stratigraphic interpretations. The basis for the field stratigraphic unit contacts is included in the individual borehole summaries below.

3.2.1 Borehole Geology for Well 199-K-231 (C9919)

Stratigraphic units encountered during drilling of C9919 were the Hanford formation, Rwie, and RUM. Recovered sediments from C9919 are primarily sandy gravel and silty sandy gravel, with some gravel, gravelly sand, sand, and silt

The sediments encountered from ground surface to 5.0 ft bgs consist of reworked Hanford formation backfill. Sandy gravel is present from 5.0 to 36.6 ft bgs and 40.3 to 58.0 ft bgs with silty sandy gravel present from 36.6 to 40.3 ft bgs. Within the sandy gravel intervals, the gravel fraction varies from 50 to 75 % and is poorly sorted, round to subangular clasts ranging from small cobbles to coarse pebbles from 5.0 to 25.0 ft bgs and very poorly sorted cobbles to very fine pebbles from 25.0 to 58.0 ft bgs. Gravels within the sandy gravel consist of 85 to 90 % mafic minerals and the sand consist of 80 to 90% mafic grains. The sediments had a moderate to weak reaction to HCl from 5.0 to 15.0 ft bgs and are predominantly grayish brown (2.5Y 5/2) and dark gray (5Y 1/4) in color. The silty sand gravel present from 36.6 to 40.3 ft bgs and consists of 64% gravel, 25% sand, and 11% silt, with a weak reaction to HCl and medium plasticity silt/clay.

At 49.6 ft bgs, felsic content in the sandy gravel increases from 10 to 70% in the gravel fraction and from 15 to 80% in the sand fraction, with a color change from dark gray (2.5Y 4/4) to dark grayish brown (2.5Y 4/2), which may indicate the contact between the Hanford formation and Rwie. Sediments have small amounts of mica present and do not react to HCl. From 58.0 to 95.0 ft bgs, the retrieved sediments are silty sand gravel primarily grayish brown (2.5Y 5/2) composed of 50% gravel, 38% sand, and 12% silt. The gravel fraction is moderate to poorly sorted, primarily fine to medium pebbles. The gravel fraction is poorly sorted, rounded to subangular, primarily fine to medium pebbles with occasional small cobbles. The sand fraction is moderately sorted, fine to medium-grained. Hard tool drilling occurred from 65.0 to 79.0 ft bgs and occasional nodules of low-plasticity clay is present.

From 95.0 to 99.5 ft bgs, sediments consist of gravelly sand that is 15% gravel, 78% sand, and 7% silt. The gravel fraction is primarily made of moderately sorted, round to angular small cobbles, with some very coarse and coarse pebbles that are 65 % mafic in composition. The sand fraction is moderately sorted, primarily medium sand that is 45 % mafic in composition. Sediments are brownish gray (2.5Y 6/2) in color with no reaction to HCl.

From 99.5 to 115.8 ft bgs, sediments are sandy gravel composed of between 60 and 82 % gravel, 15 and 35 % sand, and 3 and 5 % silt. The gravel fraction is poorly sorted, round to angular small cobbles to fine pebbles (maximum clast size of 92 mm) that are 45 to 70% mafic. The sand fraction is moderately sorted, very coarse to medium sand that is 40 to 50% mafic.

A downward coarsening sequence from sand to gravel occurs from 115.8 to 150.0 ft bgs. From 115.8 to 119.4 ft bgs, sediments are 2% gravel, 90% sand, and 8% silt. The sand is moderately to well sorted medium sand, 60 % mafic in composition. From 119.4 to 150.0 ft bgs, sediments are sandy gravel composed of 35 to 70% gravel, 20 to 60% sand, and 2 to 5% silt. The gravel fraction is poorly sorted, primarily small cobbles to medium pebbles (maximum clast size of 120 mm) that are round to angular in shape and 50 to 65 % mafic in composition. The sand fraction is poorly to moderately sorted, coarse to fine sand that is 45 to 50 % mafic in composition. Sediments are grayish brown (2.5Y 5/2) in color with no reaction to HCl.

Gravel is present from 150.0 to 151.5 ft bgs, consisting of 20% small cobbles and 60% felsic clasts. Sandy gravel is present from 151.5 to 169.0 ft bgs and is compositionally equivalent to sandy gravel encountered from 119.4 to 150.0 ft bgs. From 169.0 to 172.8 ft bgs, sediments are gravel composed of

85% gravel, 14% sand, and 1% silt. The gravel is round and angular small cobbles to medium pebbles that are 80 % mafic. The sand fraction is well sorted medium sand that is 45% mafic.

A sharp contact between the Rwie and the RUM occurs at 172.8 ft bgs and continues to TD at 177.7 ft bgs. Sediments are 100% silt that is light olive brown (2.5Y 5/3) in color, dry, with high plasticity when water is added, friable when dry, very well consolidated with no reaction to HCl. At the time of drilling, the saturated thickness was approximately 86.3 ft bgs.

3.2.2 Borehole Geology for Well 199-K-232 (C9920)

The contact between the Hanford formation and the Rwie could not be inferred at this borehole but drilling terminated in the RUM. Recovered sediments from C9920 are primarily sandy gravel with short intervals of gravelly sand and sand before transitioning to sandy silt.

The sediments encountered from ground surface to 8 ft bgs consist of reworked Hanford formation backfill. From 8.0 to 105.5 ft bgs, sediments are sandy gravel with a gravelly sand interval from 38.0 to 43.0 ft bgs and two sand intervals from 62.5 to 64.0 ft bgs and 77.0 to 83.0 ft bgs. At 8.0 ft bgs, sediments are 50% gravel, 45% sand, and 5% silt. The gravel is poorly sorted, with the average size consisting of coarse pebbles and a maximum clast size of 200 mm. Within the gravel fraction, clasts are 75% mafic and very fine to coarse pebbles are angular to subangular and coarse to cobble-sized clasts are round to subround. Sand is moderately sorted and 70 % felsic, primarily very fine to fine sand, with 2 to 3 % of the sand consisting of mica. Sediments are slightly moist, with no reaction to HCl and are olive brown (2.5Y 4/3) in color. At 13.0 ft bgs, the mafic content within the gravel decreases from 75 to 25% and has some iron staining on larger clasts (very coarse pebbles to cobbles). The sand is moderately to well sorted, 100% very fine to fine sand with some fine material streaked with gray. Sediments are light yellowish brown (2.5Y 6/4) with some mica. From 27.5 to 35.0 ft bgs, gravel is rounded and felsic. At 35.0 ft bgs, mafic content increases from 25 to 60% in the gravel fraction and decreases from 75 to 50% in the sand fraction.

From 37.0 to 38.0 ft bgs, sediments transition from sandy gravel to gravelly sand. From 38.0 to 43.0 ft bgs, a short interval of gravelly sand occurs, composed of 25% gravel, 75% sand, with trace amounts of silt. The gravel fraction is moderately sorted and bimodal; 50 % of clasts are 60 to 100 mm and 20 % mafic, and 50% of clasts are 2 to 15 mm and 60 % mafic. Sand is well sorted fine to medium sand 15% mafic with trace amounts of mica. Sediments are pale olive in color and do not react to HCl.

Between 43.0 to 105.5 ft bgs, sandy gravel sediments are composed of between 70 and 75% gravel, 20 to 25% sand, and 0 and 10% silt. At 43 ft bgs, sediments are 70% gravel, 20% sand, and 10% silt. The gravel fraction is 90% mafic, composed of 50% cobbles (maximum clast-size of 220 mm), with many large, basalt rock fragments with fresh surfaces due to drilling method. The sand fraction is well sorted, with very fine to fine grains forming compacted, sand-silt layers around pebbles and cobbles, and medium to very coarse sand that is not compacted, light yellowish brown (2.5Y 6/3) in color. About 5 % of the sand is composed of mica. A 2-in. layer of brownish yellow (10YR 6/6) silt occurs within the sandy gravel. At 55.0 ft bgs, the gravel fraction is bimodal, with average size ranging from 2 to 8 mm and 60 to 120 mm. The sand is 50% coarse to very coarse sand, subangular, and light olive brown (2.5Y 5/4) when wet and dark olive brown (2.5Y 3/3) when dry. At 60.0 ft bgs, the gravel fraction is composed 70% of very fine to medium pebbles that are 20% mafic and 30% coarse to cobble-sized clasts that are 40% mafic. From 62.5 to 64.0 ft bgs, a sandy interval occurs, with hard contacts with compositionally identical sandy gravel on either side (mid-drive barrels). The sand is 100% of the recovered sediments with trace amounts of gravel. The sand is 80 % fine to medium sand that is moderately to well sorted and 45 % mafic. From 64.0 to 75.0 ft bgs, clumps of silt and clay with thin laminations of different colors and

sand intervals less than 0.5 ft thick intersperse the sandy gravel. No lithologic changes over this interval are sustained. At 76.0 ft bgs, the very fine to fine sand forms a slip around the gravel, as a clay-like substance that tightly packs. From 77.0 to 83.0 ft bgs, a sandy interval occurs, composed 100% of sand and trace amounts of gravel. The sand is 70 % fine to medium sand that is moderately to well sorted and 30 % mafic. From 83.0 to 105.5 ft bgs, recovered sediments are sandy gravel composed of 75% gravel, 20% sand, and 5% silt. The gravel fraction is poorly sorted (average size of 20 mm; maximum size of 90 mm), 80 % mafic, and round. The sand fraction is moderately sorted fine to very coarse sand and is 60 % mafic, subangular to subround. Sediments are olive brown (2.5Y 4/5) in color and do not react to HCl.

From 105.5 to 106.0 ft bgs, sediments transition from a sandy gravel to the silty sand of the RUM, corresponding with an increase in silt content from 5% to 30%. Sediments are light gray (10YR 7/1) with a strong reaction to HCl. From 106.0 to the TD of 112.8 ft bgs, sandy silt is composed of 20% sand and 80% silt. The sand is well sorted and 100 % very fine to fine sand. Sediments are moist, grayish brown (10YR 5/2) in color, with high plasticity and moderate reaction to HCl. At the time of drilling, the saturated thickness was approximately 79.2 ft.

3.2.3 Borehole Geology for Well 199-K-234 (C9922)

The contact between the Hanford formation and the Rwie could not be inferred at this borehole but drilling terminated in the RUM. Recovered sediments from C9922 are primarily sandy gravel.

The sediments from ground surface to 13.0 ft bgs consist of reworked Hanford formation backfill. Sandy gravel is present from 13.0 to 100 ft bgs. From 13.0 to 27.0 ft bgs, the sandy gravel consists of 45% gravel, 50% sand, and 5% silt and is very dark brown (10YR 2/2) in color with an occasional weak reaction to HCl. Color changes to light olive brown (2.5Y 5/3) at 15.0 ft bgs. The gravel fraction contains angular to round clasts between fine pebble and very coarse pebble in size. The sand fraction is moderately sorted, angular, 95% mafic decreasing to 25% at 15.0 ft, and varies between coarse and very coarse. At 27.0 ft, the average size of sand decreases to very fine and is 45% mafic. At 32.0 ft bgs, the sandy gravel consists of 60 to 75 % gravel, 20 to 30 % sand and up to 10 % silt. The gravel fraction contains clasts between very fine pebbles and large cobbles that are sub-angular to round. The sand grain size varies between very fine and fine. Mafic content in the sand varies from 45 to 55% and between 25 and 70% in the gravel fraction, independent of depth. A very strong reaction to HCl occurs at 42.0 ft bgs, transitioning to a weak reaction at 53.0 ft bgs.

A coarsening downward sequence occurs from 100.0 to 118.0 ft bgs with sediments transitioning from sand, to gravelly sand, to sandy gravel, and finally gravel. At 100.0 ft bgs, sediments are 95% sand with 5% gravel, olive brown (2.5Y 4/4) in color which coarsens to a poorly sorted, gravelly sand at 105.0 ft bgs. The gravelly sand interval from 105.0 to 110.0 ft bgs contains 15 % gravel and 85 % sand. The gravel fraction is 45% mafic and contains very fine to medium pebbles that are angular to sub-angular. The sand is 50% mafic and the grain size varies from very fine to coarse. Sediments from 110.0 to 115.0 ft bgs are sandy gravel, which grades into gravel at 115.0 ft bgs. The sandy gravel is 70% gravel, 30% sand, and trace silt with sand and gravel 45 to 50% mafic in composition. The sand fraction is poorly sorted, very fine to very coarse grained. Gravel is present from 115.0 to 118.0 ft bgs. The sediments are made up of 85% gravel, with fine to very coarse pebbles that are 25% mafic; 15% sand, medium to coarse grained, 50% felsic in composition; and trace silt and clay. Sediments are olive brown (2.5Y 4/4) in color and have a moderate reaction to HCl.

Sandy gravel is present from 118.0 to 127.0 ft bgs. Within the interval, the gravel fraction decreases with depth from 70 to 50%, and the sand content increases from 30 to 50%. The gravel fraction is poorly sorted and contains very fine to very coarse pebbles that are round. The average grain size of sand is very

fine to medium, and 50% mafic in composition. At 127.0 ft bgs, silty sandy gravel is encountered and extends to 133.0 ft bgs with a lens of gravelly sand from 132.0 to 133.0 ft bgs. The silty sand gravel contains 50% gravel, 35% sand, and 15% silt. The gravel fraction is poorly sorted and consists of, angular to round, very fine to fine pebbles that are 60% felsic. The sand fraction is 80% very fine grained, moderately to well sorted, and is 30% felsic. Sediments are light yellowish brown (2.5Y 6/4) in color and have localized reactions to HCl throughout. The gravelly sand encountered from 132.0 to 133.0 ft bgs contains 20 % gravel, 80 % sand and trace silt. The gravel is poorly sorted very fine to very coarse pebbles. The sand fraction is poorly sorted consisting of very fine to very coarse sand.

The RUM was encountered at 133.0 ft bgs and extends to the TD of 139.9 ft bgs. The RUM, composed of 100% silt, with trace gravel and sand, is light olive brown (2.5Y 5/4). The silt is highly plastic with no reaction to HCl. At the time of drilling, the saturated thickness was approximately 79.0 ft.

4 Waste Management

Waste generated during the activities described in this document were managed in accordance with DOE/RL-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Unit*, and was characterized to the extent necessary to meet the requirements of DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*, and DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*.

Waste generated throughout performance of this project include drill cuttings from both the vadose zone and groundwater saturated zone, and miscellaneous solid waste such as sampling equipment, plastic, paper, and personal protective equipment. All waste was managed as investigation-derived waste and surveyed by RCTs and industrial hygiene personnel prior to transfer and disposal at the Environmental Restoration Disposal Facility.

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

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

5 Civil Survey

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

6 Well Acceptance

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

Representatives from CHPRC and Carpenter Drilling LLC (drilling contractor) participated in the acceptance inspection for C9919 on July 25, 2018, C9920 on July 9, 2018, and C9922 on September 10, 2018. Final well acceptance is documented by completion of a checklist and signatures from representatives of the drilling contractor and CHPRC. A Quality Assurance Work Site Assessment for C9919, C9920 and C9922 was prepared on October 2, 2018, to document well acceptance.

7 References

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Appendix A

Well Documentation for C9919 (199-K-231)

Contents

| | |
|-----------------------------------------|------|
| Well Summary Sheet | A-1 |
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| Well Development and Testing Data | A-14 |
| Log Data Report | A-15 |
| Well Survey Data Report | A-30 |

WELL SUMMARY SHEET

| | | |
|-----------------------------------------|--------------------------------|------------------------|
| Well ID : C9919 | Well Name: 199-K-231 | Start Date: 4/10/2018 |
| Project: Three New Wells in 100-KR-4 OU | Location: 325 m East of 105-KE | Finish Date: 7/18/2018 |

| CONSTRUCTION DATA | | Depth in Feet | GEOLOGIC/HYDROLOGIC DATA | |
|-------------------------------------------------------------------------------------------------|---------|---------------|--------------------------|--------------------------------------|
| Description | Diagram | | Graphic Log | Lithologic Description (ft bgs) |
| Concrete Pad: 0.50 ft above ground surface (ags) | | 0 | | 0.0 - 5.0 Crushed Gravel Drill Pad |
| 6-in. Protective Casing: 3.00 ft ags - 2.00 ft below ground surface (bgs) | | 10 | | 5.0 - 36.6 Sandy Gravel (sG) |
| Type I/II Portland Cement Grout: 0.0 - 11.0 ft bgs | | 20 | | 36.6 - 40.3 Silty Sandy Gravel (msG) |
| 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.10 ft ags - 77.92 ft bgs | | 30 | | 40.3 - 58.0 Sandy Gravel (sG) |
| #8 Bentonite Crumbles: 11.0 - 70.0 ft bgs | | 40 | | 58.0 - 95.0 Silty Sandy Gravel (msG) |
| Stainless steel centralizer installed above and below screen and every 40 ft | | 50 | | |
| | | 60 | | |

| | | | | |
|--------------|----------------------------------------|----------------------------------|----------------------|-------------------------|
| Reported By: | Kim Schuyler <i>Print Name</i> | Geologist <i>Title</i> | <i>Signature</i> | 9/9/2018 <i>Date</i> |
| Reviewed By: | Jennifer Richardt <i>Print Name</i> | Well Coordinator <i>Title</i> | <i>Signature</i> | 9/12/18 <i>Date</i> |

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|---------------------|--------------|
| OR Doc Type: | WMU Code(s): |

WELL SUMMARY CONTINUATION SHEET

| Well ID: C9919 | | Well Name: 199-K-231 | | Project: Three New Wells in 100-KR-4 OU | |
|-------------------------------------------------------------------------------------------------------------------|---------|----------------------|--------------------------|----------------------------------------------|--|
| CONSTRUCTION DATA | | Depth in Feet | GEOLOGIC/HYDROLOGIC DATA | | |
| Description | Diagram | | Graphic Log | Lithologic Description (ft bgs) | |
| 3/8-in. Coated Bentonite Pellet Seal: 70.0 - 73.0 ft bgs | | 70 | | 58.0 - 95.0 Silty Sandy Gravel (msG) | |
| 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.10 ft ags - 77.92 ft bgs | | 80 | | Static Water Level: 81.81 ft bgs (7/16/2018) | |
| 8-16 mesh Filter Pack Sand: 73.0 - 177.7 ft bgs | | 90 | | 95.0 - 99.5 Gravelly Sand (gS) | |
| | | 100 | | 99.5 - 115.8 Sandy Gravel (sG) | |
| | | 110 | | 115.8 - 119.4 Sand (S) | |
| 6-in. I.D. Schedule 10, Type 304/304L, 50-slot (0.050 in.) Stainless Steel Screen: 77.92 - 172.58 ft bgs | | 120 | | 119.4 - 150.0 Sandy Gravel (sG) | |
| | | 130 | | | |
| | | 140 | | | |
| | | 150 | | 150.0 - 151.5 Gravel (G) | |
| | | 160 | | 151.5 - 169.0 Sandy Gravel (sG) | |

A-6006-997 (Rev. 2)

WELL SUMMARY CONTINUATION SHEET

| Well ID: C9919 | | Well Name: 199-K-231 | | Project: Three New Wells in 100-KR-4 OU | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------|--|
| CONSTRUCTION DATA | | Depth in Feet | GEOLOGIC/HYDROLOGIC DATA | | |
| Description | Diagram | | Graphic Log | Lithologic Description (ft bgs) | |
| 6-in. I.D. Schedule 10, Type 304/304L, 50-slot (0.050 in.) Stainless Steel Screen: 77.92 - 172.58 ft bgs 8-16 mesh Silica Filter Pack Sand: 73.0 - 177.7 ft bgs 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 172.58 - 177.55 ft bgs | | 170 180 190 200 210 220 230 240 250 260 | | 151.5 - 169.0 Sandy Gravel (sG) 169.0 - 172.8 Gravel (G) 172.8 - 177.7 Silt (M) Total Depth: 177.7 ft (5/24/2018) | |
| Straightness Test: Pass, 06/25/2018 Depths are in ft below ground surface. Borehole drilled with 14-in. O.D. casing from 0.0 - 31.6 ft bgs Borehole drilled with 10 3/4-in. O.D. casing from 0.0 - 178.0 ft bgs All temporary drill casing was removed from the ground. | | | | | |

A-6006-000 (Rev 0)

| BOREHOLE LOG | | | | Page <u>1</u> of <u>5</u> |
|--------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Well ID: <u>C9919</u> | | Well Name: <u>199-K-231</u> | | Date: <u>4-11-2018</u> |
| Project: <u>Install of 3 dual-purpose monitoring wells + 1 Optional, 100-KR-4 DU</u> | | | Location: <u>325m East of 105KE</u> | |
| | | | Reference Measure Point: <u>Ground Surface</u> | |
| Depth (ft) | Sample | Graphic Log | Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other | Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other |
| 0 | | | 0'-5': Gravel pad and reworked Hanford formation | Cable tool, drive barrel. 10 3/4" OD temporary casing. |
| 5 | G | | 5'-36.6': Sandy Gravel (SG) | @5': silty/clayey sedimentary clast |
| | G | | 5': 65% G, 30% S, 5% M; Gravel: 15% Cob, 55% Vcp, 15% Cpeh, 10% mpeb, 5% F-VFpeb, max = 65mm, avg = 45mm, poorly sorted | occasionally present; strong rxn w/HCl; mod rxn on gravel surfaces. |
| | G | | 10% FeI, 90% maf, round-sub ang.; Sand: 30% VF, 45% C, 15% M | |
| | G | | 10% F-VF, poorly sorted, 85% maf, 15% FeI, sub-round-sub ang. | @7': Contingency waste sample collected - silty sedimentary clasts |
| | G | | moist, 2.5V 3/4 Dark Olive Brown, mod rxn w/HCl. | |
| | G | | 10.2': 50% G, 45% S, 5% M; Gravel: 25% scob, 35% vepc, 20% cpeh, 10% mpeb, 10% peb, poorly sorted, avg = 35mm, max = 80mm, round-sub ang, 70% maf/10% FeI | 10' added 0.4gal H2O |
| | G | | Sand: 45% VF, 35% C, 15% M, 5% F, mod to poorly sorted, sub-round to sub ang. | |
| | G | | 85% maf/15% FeI, 2.5V 1/2 Grayish Brown, dry, nonplastic, weak rxn | |
| | G | | or some gravel surfaces. | |
| | G | | 15': 45% G, 30% S, 5% M; Gravel: 20% scob, 30% vepc, 15% cpeh, 15% mpeb, 7% Fpeb, 3% vepc, poorly sorted, max = 70mm, avg = 35mm, round to sub ang, 70% maf | |
| | G | 10% FeI, Sand: 85% C, 80% F, 5% VF, bimodal, sub-round-sub ang, 85% maf/15% FeI, 2.5V 1/2 Dark grayish brown, dry, nonplastic, no rxn | | |
| 20 | G | | 19.4': 75% G, 20% S, 5% M; Gravel: 15% scob, 25% vepc, 25% cpeh, 15% mpeb, 15% Fpeb, 5% VFpeb, poorly sorted, max = 90mm, avg = 45mm, round-sub ang, 90% maf/10% FeI; Sand: 85% C, 15% M, well sorted, sub-round-sub ang, 85% maf/15% FeI, 2.5V 1/2 Dark grayish brown, dry, nonplastic, no rxn. | @19.4': sparse mica |
| 25 | G | | 24.5': 75% G, 25% S; Gravel: 10% scob, 20% vepc, 20% cpeh, 25% mpeb, 15% Fpeb, 10% VFpeb, poorly sorted, max = 70mm, avg = 35mm, round-sub ang, 90% maf | @24.5': sparse mica |
| | G | | 10% FeI, 85% C, 15% M, well sorted, SR-SA, 80% maf/10% FeI, 2.5V 1/2 Dark grayish brown, dry, nonplastic, no rxn w/HCl | |
| 30 | G | | 29.5': 75% G, 25% S, 2% M; Gravel: 10% scob, 15% vepc, 25% cpeh, 25% mpeb, 15% Fpeb, 10% VFpeb, poorly sorted, max = 70mm, avg = 30mm, R-SA, 90% maf/10% FeI; Sand: 70% VF, 20% C, 7% F, 3% VF, bimodal, well sorted to mod sorted - SA-A, 85% maf | @29.5': occasional sedimentary clast; react weakly w/HCl; TD = 177.7 Hgts; BOC = 178.0 Hgts; DTW = 86.5 5/23/18 |
| | G | | 15% FeI, 5V 1/4 Dark gray, moist, nonplastic, no rxn w/HCl | |

Reported By: Paul Prevon Print Name Paul Prevon Geologist Title Paul Prevon Signature 4-11-18 Date

Reviewed By: Sarah Springer Print Name Sr. Geologist Title Sarah Springer Signature 08-14-18 Date

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| BOREHOLE LOG (Cont.) | | | Page 2 of 5 | |
|---------------------------------------|--------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Well ID: 09919 | | | Date: 5-24-18 | |
| Well Name: 197-K-231 | | Location: 325m East of 105KE | | |
| 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 | | 36.6' - 40.3' Silty Sandy Gravel (msG) @36.6': 6% G, 25% S, 11% M; Gravel: 35% Boulder, 10% Vepch, 10% Cpech, 25% mpech, 10% Fepch, 10% Vepch, bimodal, round-angular, 90% maf/10% Fel; Sand: 60% VC, 25% C, 10% F, 5% VE, med-sorted, sub-round to sub-ang, 25% maf/15% Fel, 2.5V 3/4 Very dark gray, moist, med. plasticity, weak rxn w/HCl. | |
| 40 | G | | 40.3' - 58.0' Sandy Gravel (SG) 40.3': 55% G, 36% S, 9% M; Gravel: 10% Scob, 20% Vepch, 20% Cpech, 30% Mpech, 10% Fepch, 10% Vepch, poorly sorted, round-subang., max = 67mm, 90% maf/10% Fel; Sand: 15% VC, max C, 10% M, 10% E, 5% VE, med-sorted, 85% maf/15% Fel, sub-round to sub-ang, moist, low plasticity, no rxn, 2.5V 1/2 dark gray. | |
| 45 | G | | 44.2': 59% G, 46% S, 7% M; Gravel: 5% Scob, 20% Vepch, 20% Cpech, 20% Mpech, 20% Fepch, 15% Vepch, poorly sorted, 90% maf/10% Fel; Sand: 70% VC, 20% C, 10% M, med-well sorted, sub-ang. to ang, 85% maf/15% Fel, 2.5V 1/2 dark gray, nonplastic, no rxn w/HCl. | |
| 50 | G | | 49.6': 50% G, 47% S, 3% M; Gravel: 10% Scob, 10% Vepch, 10% Cpech, 40% Mpech, 25% Fepch, 5% Vepch, poorly sorted, sub-round, max = 65mm, 80% maf/20% Fel; Sand: 70% VC, 25% M, 5% C, E, med-sorted, sub-ang, 20% maf/80% Fel, 2.5V 1/2 dark grayish brown, no rxn w/HCl, nonplastic. | |
| 55 | G | | 55': 50% G, 48% S, 2% M; Gravel: 5% Scob, 5% Cpech, 10% Vepch, 40% Mpech, 20% Cpech, 7% Fepch, 20% Vepch, poorly sorted, max = 170mm, avg = 40mm, sub-rounded, 20% maf/80% Fel; Sand: 85% VC, 5% C, 20% M, 5% E, med-sorted, sub-ang, 20% maf/80% Fel, 2.5V 3/4 Light olive brown, dry, nonplastic, no rxn w/HCl. | |
| 60 | G | | 58': 50% G, 38% S, 12% M; Gravel: 15% Scob, 20% Vepch, 20% Cpech, 15% Mpech, 15% Fepch, 15% Vepch, poorly sorted, max = 38mm, avg = 32mm, Round-SubAng, 60% maf/40% Fel; Sand: 20% VC, 20% C, 35% M, 15% E, poorly sorted, sub-round-subAng, 60% maf/40% Fel, 2.5V 3/4 light gray, dry, low plasticity, no rxn w/HCl. | |
| 65 | G | | 65': 65% G, 20% S, 15% M; Gravel: 60% Mpech, 25% Fepch, 15% Vepch, med-poorly sorted, max = 12mm, sub-rounded-angular, 40% maf/60% Fel; Sand: 5% VC, 20% C, 55% M, 10% S, 10% VE, Med-sorted, sub-rounded-subAngular, 15% maf/85% Fel, 2.5V 5/8 Grayish brown, dry, low plasticity, no rxn. | |
| 70 | G | | 70': 65% G, 20% S, 15% M; Gravel: 45% Mpech, 40% Fepch, 15% Vepch, Med-sorted, max = 12mm, sub-rounded-angular, 40% maf/60% Fel; Sand: 5% VC, 35% C, 40% M, 10% E, 10% VE, Med-sorted, sub-round-sub-ang, 15% maf/85% Fel, 2.5V 5/8 Grayish brown, dry, low plasticity, no rxn w/HCl. | |
| | | | | <p>@55': one large cobble (170mm) @55' added 0.75 gal H₂O @57' added 0.15 gal H₂O @58': Sparse micas @65': Hard tool sample; may not be representative. H₂O added Added 32 gal H₂O while hard tooling @70': Hard tool sample; may not be representative. H₂O added</p> <p>TD = 177.7 ft bgs BOL = 178.0 ft bgs</p> |
| Reported By: Paul Perou Print Name | | | Geologist Title | |
| | | | Signature Date: 5-24-18 | |

| BOREHOLE LOG (Cont.) | | | Page <u>3</u> of <u>5</u> | |
|-----------------------------------------------|--------------------------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Well ID: <u>C9919</u> | | Well Name: <u>199-K-231</u> | Date: <u>5.24.18</u> | |
| Location: <u>325m East of 105NE</u> | | | | |
| Depth (ft) | Sample | Graphic Log | Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other | Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other |
| 75 | G Hard Tool | | @75': 55% G, 30% S, 15% M; Gravel: 50% Med, 30% Fne, 20% Vnch, poorly-med. sorted, max = 1mm, subround to sub ang. 45% Mat/55% Fel; Sand: 5% Vn, 10% C, 40% Med, 30% F, 15% Vn, med. sorted, subround to sub ang, 15% Mat/85% Fel, 2.5V 3/4 Grayish Brown, dry, med. plasticity, no rxn w/ HCl. | @75': Hard tool sample; not represent. water added. |
| 80 | G | | @80.5': 65% G, 20% S, 15% M; Gravel: 15% Sub, 15% Vnch, 35% Cpeh, 20% Mpeh, 15% Fpeh, poorly sorted, max = 20mm, Fe/Mat/55% Fel; Sand: 25% Vn, 25% C, 15% Med, 10% F, 5% Vn, poorly sorted, sub-ang - ang., 60% Mat/40% Fel, 5V 1/2 gray, wet, med. plasticity, no rxn w/ HCl. | @80.5': sparse micas; sediment rehydrated by water added to hatchets on 4/30/2018 |
| 85 | G Zalblaus 97.1 recovery | | @85.3': 40% G, 45% S, 15% M; Gravel: 25% Sub, 25% Vnch, 25% Cpeh, 15% Mpeh, 10% Fpeh, poorly sorted, max = 20mm, round-ang., 60% Mat/40% Fel; Sand: 15% Vn, 60% C, 25% F, med. sorted, 50% Mat/50% Fel, 2.5V 1/2 Grayish Brown, wet, low plasticity, no rxn w/ HCl | @85.3': Abundant micas split spoon 83.9-85.8 Initial depth to water = 83.1' 5/11/18 |
| 90 | G W | | @90.5': 40% G, 20% S, 15% M; Gravel: 20% Sub, 25% Vnch, 25% Cpeh, 15% Mpeh, 10% Fpeh, 5% Vnch, poorly sorted, max = 100mm, round-ang., 60% Mat/40% Fel, 20% Vn, 35% C, 20% M, 5% F, med - poorly sorted, subround - sub ang., 25% Mat/75% Fel, 3.5V 1/2 light brownish gray, wet, med. plasticity, no rxn w/ HCl | @90.5': Abundant micas; some fines possibly washed from core barrel. 91.1' water sample depth DTW = 84.8' 5/7/18 |
| 95 | G | | @95.0': 15% G, 70% S, 15% M; Gravel: 10% Sub, 10% Vnch, 15% Cpeh, 5% Vnch, bimodal, max = 20mm, round to ang., 65% Mat/35% Fel; Sand: 5% Vn, 20% C, 20% M, 5% F, med. sorted, round-ang., 45% Mat/55% Fel, 2.5V 1/2 light brownish gray, wet, low plasticity, no rxn w/ HCl | @95': Abundant micas |
| 100 | G | | 99.5-105.B: Sandy Gravel (SG) @99.5': 60% G, 35% S, 5% M; Gravel: 50% Sub, 25% Vnch, 10% Cpeh, 5% Mpeh, 5% Fpeh, 5% Vnch, poorly-med. sorted, max = 30mm, round-ang., 65% Mat/35% Fel; Sand: 10% Vn, 30% C, 15% M, 5% F, poorly-med. sorted, round-ang., 50% Mat/50% Fel, 2.5V 1/2 light brownish gray, moist, low plasticity, no rxn w/ HCl. | @99.5': Abundant micas TD = 177.7 ft bgs Boc = 178.0 ft bgs |
| 105 | G | | @105': 75% G, 20% S, 5% M; Gravel: 30% Vnch, 20% Cpeh, 15% Mpeh, 25% Fpeh, 10% Vnch, poorly sorted, max = 60mm, round-ang., 70% Mat/30% Fel; Sand: 10% Vn, 10% C, 20% M, 10% F, med. sorted, sub-round-ang., 40% Mat/60% Fel, 2.5V 1/2 light brownish gray, nonplastic, wet, no rxn w/ HCl | @105': Micas |
| 110 | G Hard Tool | | @109.2': 82% G, 15% S, 3% M; Gravel: 20% Sub, 20% Vnch, 15% Cpeh, 10% Mpeh, 5% Fpeh, poorly sorted, max = 20mm, round-ang., 45% Mat/55% Fel; Sand: 25% Vn, 15% C, 15% M, 5% F, med. sorted, 50% Fel/50% Mat, 2.5V 1/2 Grayish brown, moist, no rxn w/ HCl | @109.2': sparse micas, sparse clay, occasional soft clasts @113' add ~25 lbs of bentonite chips to borehole |
| Reported By: <u>Paul Paveau</u> Print Name | | <u>Geologist</u> Title | <u>Paul Paveau</u> Signature | <u>5.24.18</u> Date |

| BOREHOLE LOG (Cont.) | | | Page 4 of 6 | |
|----------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Well ID: C 9919 | | | Date: 5-24-18 | |
| Well Name: 177-k-231 | | | Location: 325 m East of 105KE | |
| 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 hard too | | 115.8' - 119.4': Sand (S) | |
| | G | | @115.8': 2% G, 80% S, 8% M; Gravel: 100% Vep, well-sorted, Max = 4.5mm, sub-round to ang., 40% Mat/40% Fel; Sand: 10% VC, 5% E, 88% M, 3% F, med-well-sorted, 40% Mat/40% Fel, 5V 1/2 Dark gray, moist, no rxn w/ HCl | @115.8': Sparse micas, sand is compact |
| 120 | G | | 119.4' - 124.9': Sandy Gravel (SG) | |
| | G | | @119.4': 75% G, 20% S, 5% M; Gravel: 35% Lch, 20% Vcp, 35% Cp, 15% Mpb, 3% Ep, 2% Vep, poorly sorted, round-angular, Max = 120mm, 65% Mat/35% Fel; Sand: 10% VC, 50% C, 35% Med, 5% F, poorly sorted, round-sub-ang., 35% Mat/45% Fel, 5V 1/2 Olive gray wet, no rxn w/ HCl | @119.4': Abundant micas, occasional sedimentary clasts |
| 125 | GT 275 blow W 50% cel | | @124.9': 70% G, 25% S, 5% M; Gravel: 35% Vcp, 15% C, 30% Mpb, 10% Ep, 5% Vep, poor sorting; Sand: 15% VC, 35% C, 25% M, 15% F, poorly sorted, round-sub-ang., 45% Mat/55% Fel, 2.5V 1/2 Dark grayish brown, wet, no rxn | @124.9': Abundant micas Split screen: 124.9-125.8 (refusal) Water sample: 126.9' |
| 130 | G | | @129.8': 35% G, 60% S, 5% M; Gravel: 15% Sck, 20% Vcp, 35% Cp, 30% Ep, 10% Vep, bimodal; Sand-ang., 60% Mat/40% Fel; Sand: 5% VC, 20% C, 70% M, 5% F, med. sorted, sub-round-ang., 45% Mat/55% Fel, 2.5V 1/2 Grayish brown, moist, no rxn | @129.8': Abundant micas |
| 135 | G | | @135.5': 65% G, 30% S, 2% M; Gravel: 55% Vcp, 25% Cp, 10% Mpb, 7% Ep, 3% Vep, poor sorting; Sand-ang., 60% Mat/40% Fel; Sand: 5% VC, 20% C, 70% M, 5% F, med. sorted, 50% Mat/50% Fel, 2.5V 1/2 Grayish brown, moist, no rxn | @135.5': Abundant micas, occasional poorly indurated sed. clasts w/ no rxn to HCl |
| 140 | G | | @141.0': 65% G, 30% S, 2% M; Gravel: 15% Sck, 40% Vcp, 20% Cp, 15% Mpb, 7% Ep, 3% Vep, poorly sorted, round-ang., 50% Mat/50% Fel; Sand: 5% VC, 15% C, 70% M, 10% F, med. sorted, sub-round-ang., 50% Mat/50% Fel, 5V 1/2 Olive gray, moist, med. plasticity, no rxn w/ HCl | @141.0': Sparse micas |
| 145 | G | | @145.0': 65% G, 30% S, 2% M; Gravel: 25% Vcp, 40% Mpb, 25% Cp, 7% Ep, 3% Vep, poorly sorted, round-ang., 40% Mat/60% Fel; Sand: 25% VC, 30% M, 5% F, med. sorted, SA, 50% Mat/50% Fel, 2.5V 1/2 Grayish brown, wet, low plasticity, no rxn | @145.0': Sparse micas; sample may include heavy sand / not be representative |
| 150 | G | | 150 - 151.5': Gravel (G) | |
| | G | @150.0': 81% G, 19% S, 2% M; Gravel: 20% Sck, 25% Vcp, 30% Cp, 15% Mpb, 7% Ep, 3% Vep, poorly sorted, round-ang., 40% Mat/60% Fel; Sand: 10% VC, 20% C, 60% M, 10% F, poorly sorted, sub-ang., 65% Mat/35% Fel, 2.5V 1/2 dark grayish brown, low plasticity, no rxn | @150.0': Micas TD = 177.3 ft bgs Bot = 178.0 ft bgs | |

Reported By:
Paul Prevon
Print Name

geologist
Title

Paul Prevon
Signature

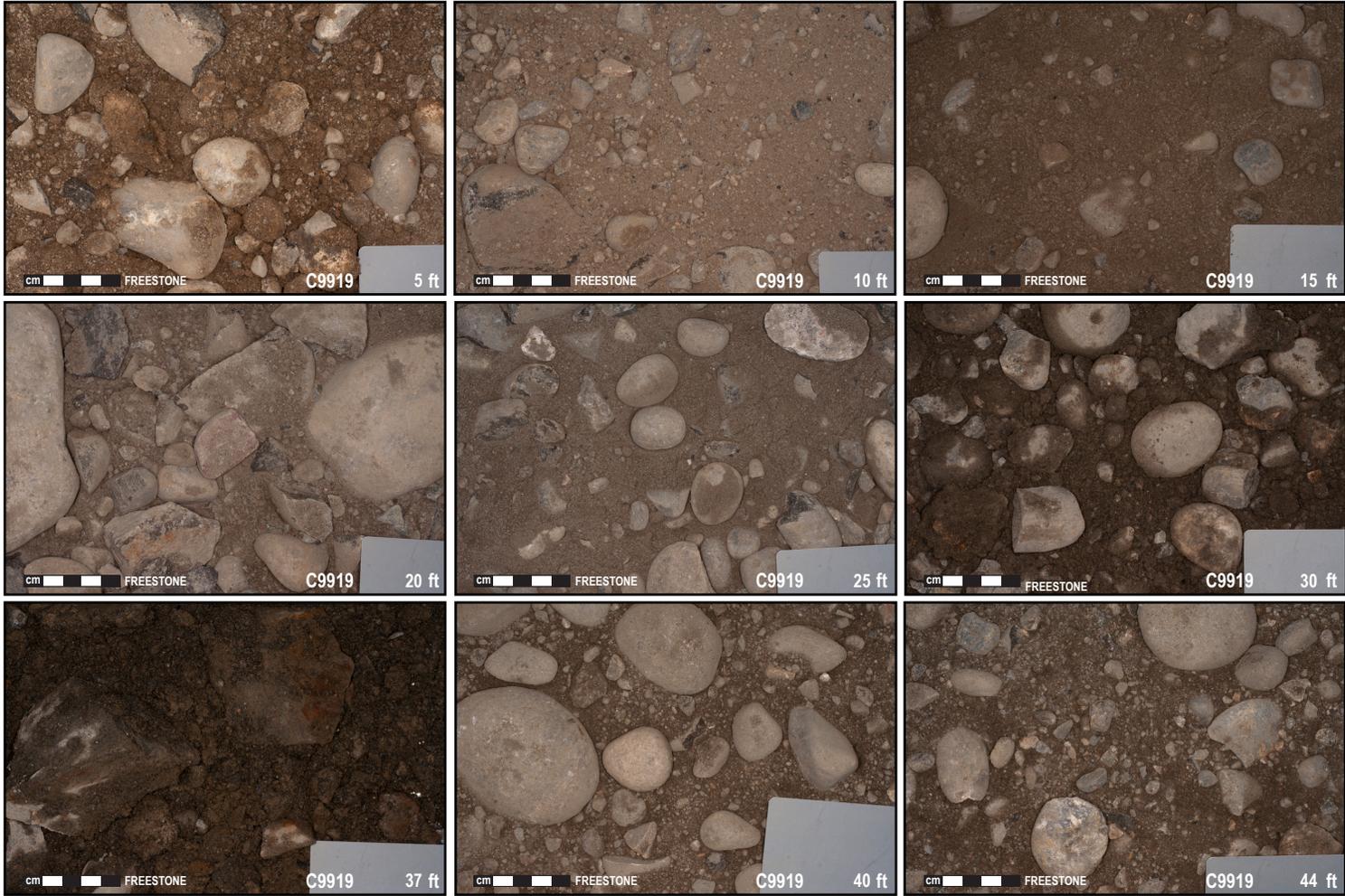
5-24-18
Date

| BOREHOLE LOG (Cont.) | | | | Page <u>5</u> of <u>5</u> |
|------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Well ID: C9919 | | Well Name: 199-A-231 | | Date: 5-24-18 |
| Location: 385M East of 105KE | | | | |
| 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 | | 151.5'-169.0': Sandy Gravel (SG) | |
| | | | @151.5': 30%G, 20%S, 2%F, 2%M; Gravel: 35%Gr, 15%Vc, 35%C, 10%M, 3%Sp, 2%Vp, poorly sorted, Max: 118mm, round-ang, 45%Mat/55%Fcl, 25%Vc, 4%C, 25%M, 2%E, 3%Vp, poorly sorted, SR-ang, 55%Mat/45%Fcl, 2.5V% Grayish brown, moist, low plasticity, no rxn | @151.5': Sparse micas; sampled from plug |
| 160 | G | | @155.0': 79%G, 20%S, 1%M; Gravel: 30%Gr, 20%Vc, 35%C, 12%M, 3%E, poorly sorted, Round-ang, 40%Mat/60%Fcl; Sand: 50%Vc, 38%C, 10%M, 2%E, med-poorly sorted, SR-ang, 50%Mat/50%Fcl, 2.5V% Grayish brown, wet, nonplastic, no rxn | @155.0': Abundant micas |
| 165 | W | | @160.0': 74%G, 25%S, 1%M; Gravel: 15%Gr, 25%Sp, 15%Mp, 5%Fp, poorly sorted, round-ang, 30%Mat/70%Fcl; Sand: 20%Vc, 55%C, 20%M, 3%E, poorly sorted, SR-ang, 50%Mat/50%Fcl, 2.5V% dark grayish brown, moist, no rxn | @160.0': Micas Split spoon: 164.5-166.9 |
| 165 | G | | @165.0': 68%G, 30%S, 2%M; Gravel: 20%Gr, 20%Vc, 20%Co, 35%Mp, 5%Sp, poorly sorted, round-ang, 30%Mat/70%Fcl; Sand: 6%Vc, 70%C, 15%M, 7%E, 3%Vp, med. clays sorted, round-sub-ang, 50%Mat/50%Fcl, 2.5V% dark grayish brown, wet, low plasticity, no rxn | @165.0': Mica, occasional Fe-rich clays Water Sample @ 166.0' |
| 170 | | 169'-172.8': Gravel (G) | | |
| | | @169.0': 85%G, 14%S, 1%M; 35%Gr, 35%Vc, 25%Co, 10%Mp, 3%Sp, 2%Vp, poorly sorted, 30%Mat/70%Fcl, round-ang; Sand: 5%Vc, 3%Co, 87%M, 3%E, 2%Vp, med-to well-sorted, 45%Mat/55%Fcl, 2.5V% grayish brown, moist, low plast, no rxn | @169.0': Fine micas | |
| 175 | G | 172.8'-177.7' (TD): Silt (M) | | |
| | | @172.8': 0%G, 0%S, 100%M, 2.5V% light olive brown, dry, high plasticity when wet, friable when dry, very well-consolidated, no rxn unless clay present | | |
| 180 | | | | TD=177.7 Ft bgs BDC=178.0 Ft bgs DTW=86.5 5/23/18 |
| 185 | | | | |
| 190 | | | | |

NOT Used
Tm 5/11/18

Reported By: Paul Peron Geologist Paul Peron 5-24-2018
 Print Name Title Signature Date

A-9

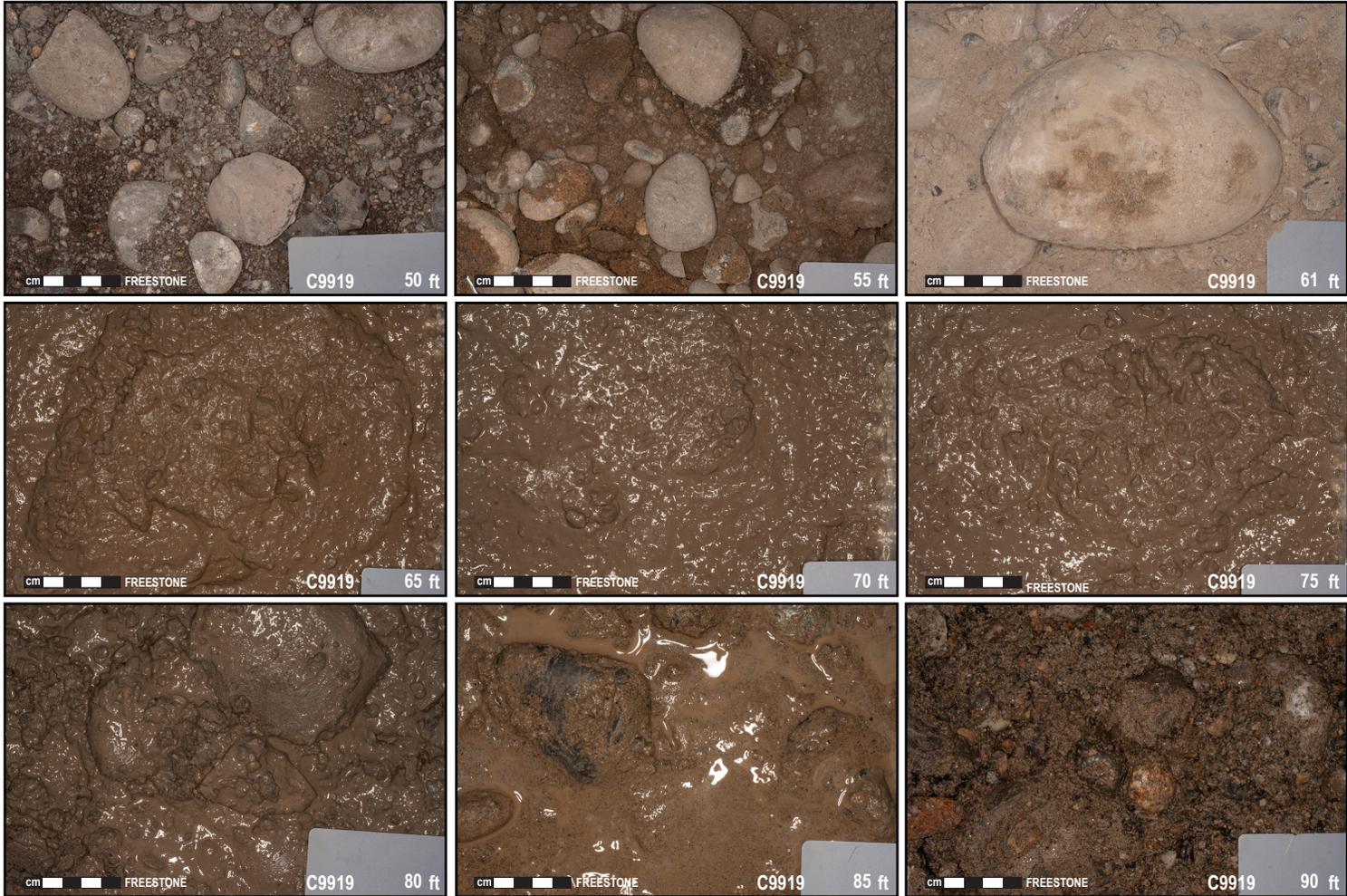


SGW-62712, REV. 0



Drill Cutting Photographs for C9919 (199-K-231)

A-10

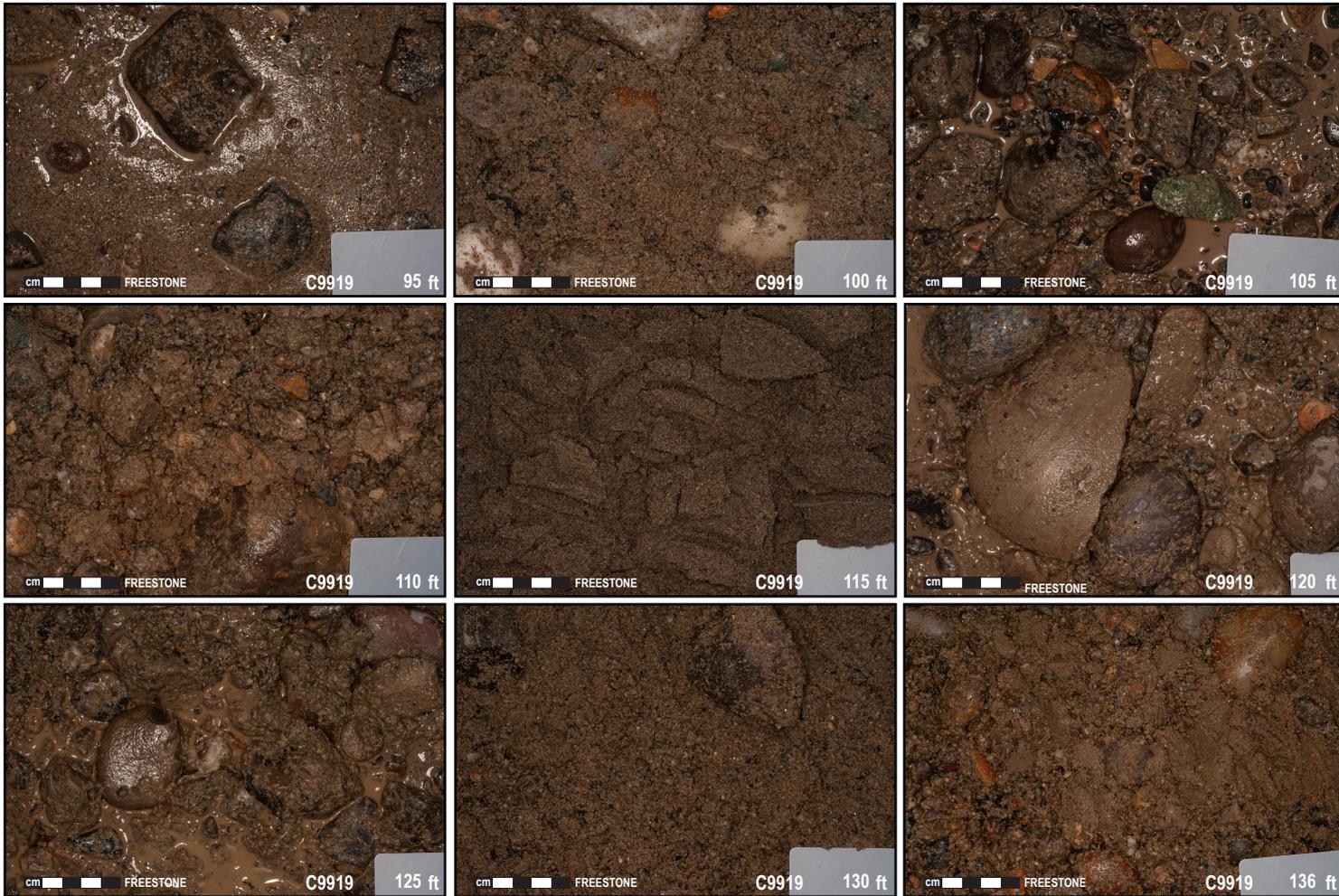


SGW-62712, REV. 0



Drill Cutting Photographs for C9919 (199-K-231)

A-11



SGW-62712, REV. 0



Drill Cutting Photographs for C9919 (199-K-231)

A-12



SGW-62712, REV. 0



Drill Cutting Photographs for C9919 (199-K-231)



| WELL DEVELOPMENT AND TESTING DATA | | | | | | | | | |
|--------------------------------------------------------------------------------------------|----------------------------|----------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------|-----------------|--------------------|-----------------------|------------|
| Well ID: C9919 | | | Well Name: 199-K-231 | | | Date: 7/12/2018 | | | |
| Location: 325 m East of 105-KE | | | | | | | | | |
| Reference Measuring Point (unless otherwise noted): TOP OF OUTER CASING (TOC) | | | | | | | | | |
| Has the well been surveyed? <input type="radio"/> Yes <input checked="" type="radio"/> No | | | | Does the well have a cement pad? <input type="radio"/> Yes <input checked="" type="radio"/> No | | | | | |
| Initial Conditions | | | <p style="margin-left: 20px;">A = 3.00 B = 2.10 C = 0.90</p> | | | | | | |
| | | Start of Job | | | | | | | End of Job |
| STATIC WATER LEVEL: | | | | | | | | | |
| Date: 7/12/18 | 81.9 | 81.8 | | | | | | | |
| Date: 7/16/18 | 81.8 | 81.8 | | | | | | | |
| DEPTH TO BOTTOM: | | | | | | | | | |
| Date: 7/12/18 | 175.6 | - | | | | | | | |
| Date: 7/16/18 | - | 177.5 | | | | | | | |
| Intake Depth (ft bgs) | Specific Capacity (gpm/ft) | Troll Depth (ft bwt) | Turbidity (NTU) | | Pump Start | Pump Stop | Pumping Rate (gpm) | Maximum Drawdown (ft) | |
| | | | Initial | Final | | | | | |
| 165.7 | 9.0 | 83.43 | 259 | 2.31 | - | 58 min* | 200 | 22.20 | |
| 145.7 | 11.4 | 62.30 | 28.4 | 1.49 | 0821 | 0843 | 125 | 10.99 | |
| 124.8 | 11.5 | 40.99 | 21.5 | 0.92 | 0855 | 0913 | 120 | 10.41 | |
| 103.9 | 11.2 | 19.75 | 3.02 | 1.05 | 0922 | 0938 | 120 | 10.75 | |
| 92.4 | 8.8 | 8.40 | 3.05 | 0.61 | 0959 | 1038 | 75 | 8.50 | |
| Total Pumped: 21,355 gallons | | | | | | | | | |
| Pump Model: Grundfos 25 hp | | | | | | | | | |
| Troll Serial Number and Pressure Range (PSI and depth): 553248 70 m / 231 ft | | | | | | | | | |
| Comments: *To accommodate purge truck capacity, pump was on/off 1312-1345 and 1427-1452 | | | | | | | | | |
| Prepared By: | | | | | | | | | |
| Kim Schuyler | | | | | | 9/10/2018 | | | |
| Print Name | | Signature | | | | Date | | | |
| Reviewed By: | | | | | | | | | |
| Jennifer Richardt | | | | | | 9/12/18 | | | |
| Print Name | | Signature | | | | Date | | | |
| For Office Use Only | | | | | | | | | |
| OR Doc Type: | | | WMU Code(s): | | | | | | |



199-K-231 (C9919) Log Data Report

Borehole Information

| | | | | | | |
|-----------------------|------------|----------|------------------------|------------|------------------|----------------|
| Log Date | 2018-05-24 | Filename | C9919_HG-NM_2018-05-24 | | Site | 100-KR-4 |
| DTW ¹ (ft) | | DTW Date | DTW Source | Drill Date | Total Depth (ft) | Depth Datum |
| 93.7 | | 05/24/18 | SN3 | 05/24/18 | 177.7 | Ground Surface |

Casing Information

| Casing Type | Drill Type | Stickup (ft) | Diameter (in.) | | Thickness (in.) | Top (ft) | Bottom (ft) |
|----------------|------------|--------------|----------------|--------|-----------------|----------|-------------|
| | | | Outer | Inside | | | |
| Threaded Steel | Cable Tool | 0 | 14 1/8 | 12 1/2 | 13/16 | 0 | 31.6 |
| Threaded Steel | Cable Tool | 2.0 | 10 7/8 | 9 1/2 | 11/16 | -2.0 | 178.0 |

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 177 ft. Zero reference is ground surface.

Logging Equipment Information

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

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

| | | | |
|----------------------------|---------------------|-------------------|-------------------------------------|
| Logging System | Gamma 1HD | Type | He-3 (CPN 503DR) NMLS |
| Effective Calibration Date | 10/16/2017 | Serial No. | H310700353 |
| 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 Repeat | |
|-------------|---------|----------|---------|----------|--|
| HEIS Number | 1020190 | 1020191 | 1020192 | 1020193 | |

¹ depth to water inside casing

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Technical Solutions

| Log Run | 1 | 2 Repeat | 5 | 6 Repeat | |
|--------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--|
| Date | 04/18/18 | 04/18/18 | 05/24/18 | 05/24/18 | |
| Logging Engineer | Spatz/McClellan | Spatz/McClellan | Spatz/McClellan | Spatz | |
| Start Depth (ft) | 0.0 | 25.0 | 29.0 | 160.0 | |
| Finish Depth (ft) | 30.0 | 30.01 | 177.01 | 175.0 | |
| Count Time (sec) | 100 | 100 | 100 | 100 | |
| Live/Real | R | R | R | R | |
| Shield (Y/N) | N | N | N | N | |
| MSA Interval (ft) | 1.0 | 1.0 | 1.0 | 1.0 | |
| Log Speed (ft/min) | NA | NA | NA | NA | |
| Pre-Verification | C9919FTB20180 418AV00CAB1 | C9919FTB20180 418AV00CAB1 | C9919ALD2018 0524AV00CAB1 | C9919ALD2018 0524AV00CAB1 | |
| Start File | AD000000 | BD002500 | AD002900 | BD016000 | |
| Finish File | AD003000 | BD003001 | BD017701 | BD017500 | |
| Post-Verification | C9919FTB20180 418BV00CAA1 | C9919FTB20180 418BV00CAA1 | C9919ALD2018 0524BV00CAA1 | C9919ALD2018 0524BV00CAA1 | |
| Depth Return Error (in.) | N/A | 0.5 high | N/A | 0 | |
| Comments | No fine gain adjustments made | No fine gain adjustments made | No fine gain adjustments made | No fine gain adjustments made | |

NMLS Log Run Information

| Log Run | 3 | 4 Repeat | 7 | 8 Repeat | |
|--------------------------|------------------------------|------------------------------|------------------------------|------------------------------|--|
| HEIS Number | 1020194 | 1020195 | 1020196 | 1020197 | |
| Date | 04/18/18 | 04/18/18 | 05/24/18 | 05/24/18 | |
| Logging Engineer | Spatz/McClellan | Spatz/McClellan | Felt | Felt | |
| Start Depth (ft) | 0.0 | 26.0 | 30.0 | 87.0 | |
| Finish Depth (ft) | 31.26 | 31.01 | 93.52 | 93.52 | |
| 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 | C9919FPB20180 418AV00CAB1 | C9919FPB20180 418AV00CAB1 | C9919AHD2018 0524AV00CAB1 | C9919AHD2018 0524AV00CAB1 | |
| Start File | AD000000 | BD002600 | AD003000 | BD008700 | |
| Finish File | AD003126 | BD003101 | AD009352 | BD009352 | |
| Post-Verification | C9919FPB20180 418BV00CAA1 | C9919FPB20180 418BV00CAA1 | C9919FPB20180 524BV00CAA1 | C9919FPB20180 524BV00CAA1 | |
| Depth Return Error (in.) | N/A | 0.5 high | N/A | 0 | |
| Comments | None | None | None | None | |

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Logging Operation Notes

A centralizer was not installed on the sondes for the first casing to 29 ft. A centralizer was installed on each sonde for the second casing.

Analysis Notes

| | | | |
|---------------------|------------------------------------------------------|-------------|----------|
| Analyst | P.D. Henwood | Date | 06/13/18 |
| Reference(s) | SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0 | | |

A casing correction for a 13/16-in. thick casing was applied to the SGLS log data for the first casing and a correction for 11/16-in. thick casing for the second casing.

NMLS data are reported in counts per second for the entire length of the borehole. An attempt was made to convert the NMLS data to vol% moisture, but the calculated moisture values appeared anomalously high, which is suspected to be the result of uncertainty in the measurement of the casing diameter and wall thickness. Because of the uncertainty in the measurements of the drill casing dimensions, the data are not converted to vol% moisture.

A water correction was applied below 93.7 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in EXCEL templates identified as 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 were removed from 29 and 30 ft. This results in a data set where only one data point is presented for each depth.

HGU² 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

Cs-137 was detected at ground surface at a concentration of 0.6 pCi/g. The KUT plots suggest the bottom 2 ft of the borehole may be impacted by mud inside the casing causing concentrations to be overestimated.

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

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

List of Log Plots

Depth Reference is ground surface.

Manmade Radionuclides (0-200 ft)
 Natural Gamma Logs (0-160 ft)
 Natural Gamma Logs (150-310 ft)
 Combination Plot (0-120 ft)
 Combination Plot (110-230 ft)
 Combination Plot (0-200 ft)

² Hanford Gamma Unit

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Total Gamma & Moisture (0-160 ft)
Total Gamma & Hanford Gamma Unit (0-200 ft)
Repeat Section of Natural Gamma Logs (25-30 ft)
Repeat Section of Natural Gamma Logs (160-175 ft)
Moisture Repeat Section (87-94 ft)

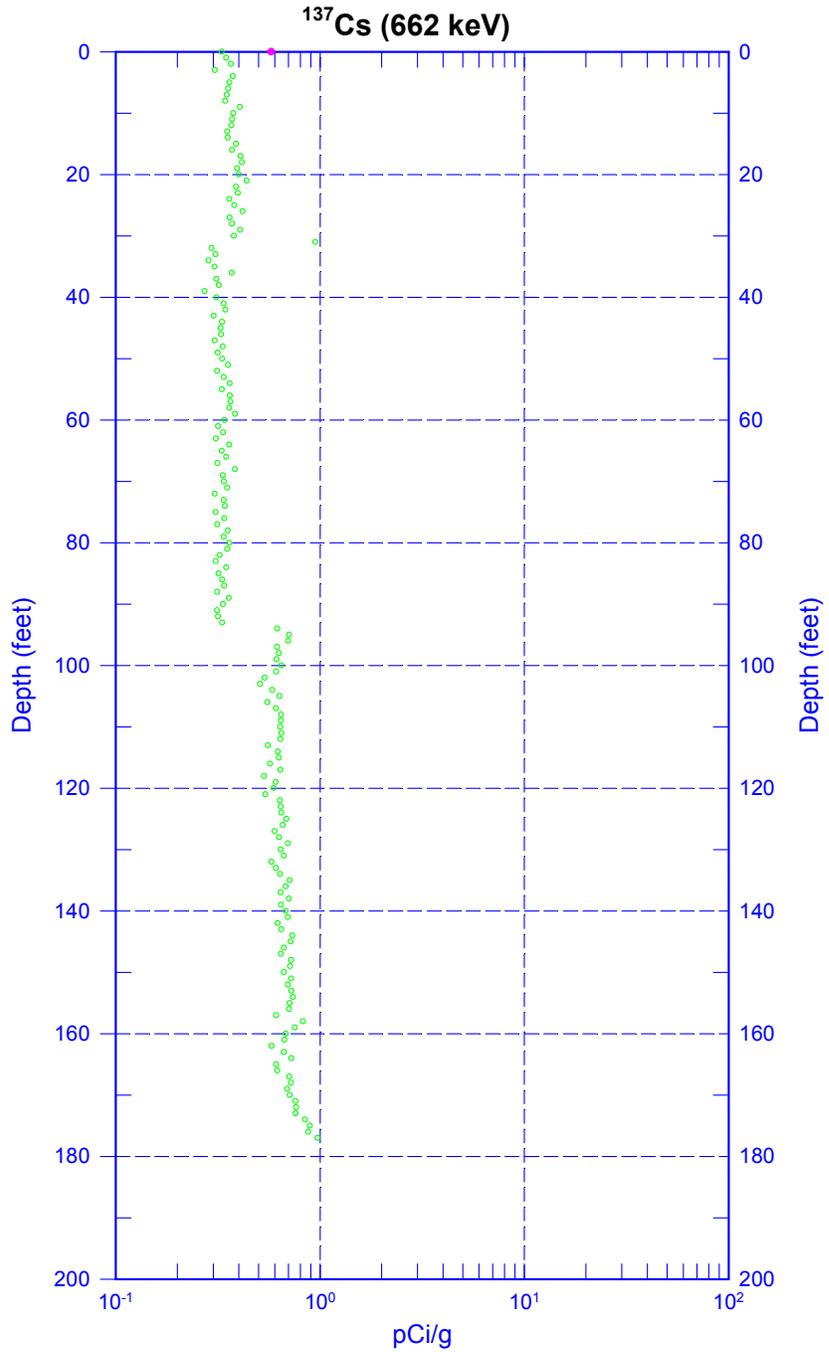
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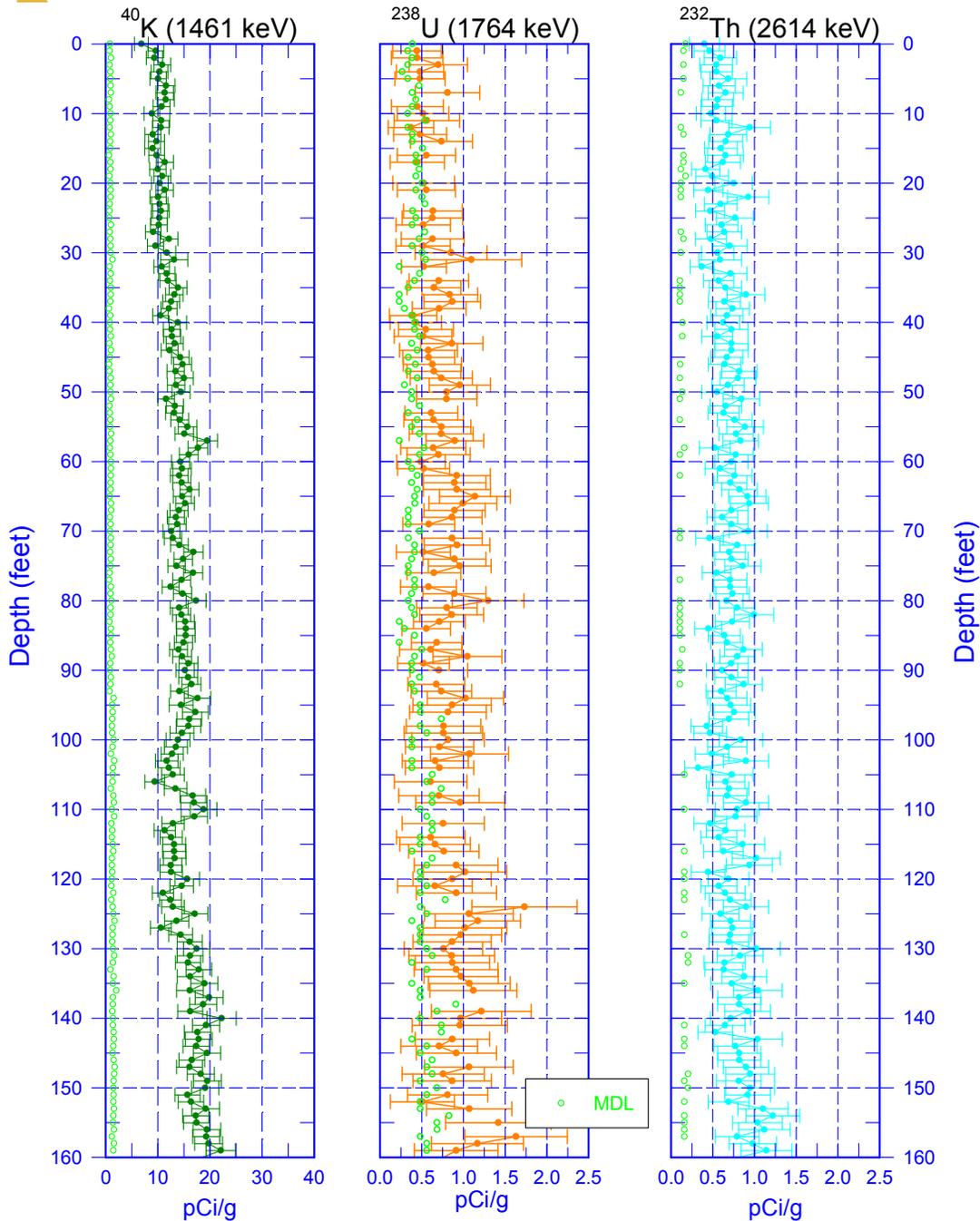
199-K-231 (C9919) Manmade Radionuclides



Zero Reference - Ground Surface



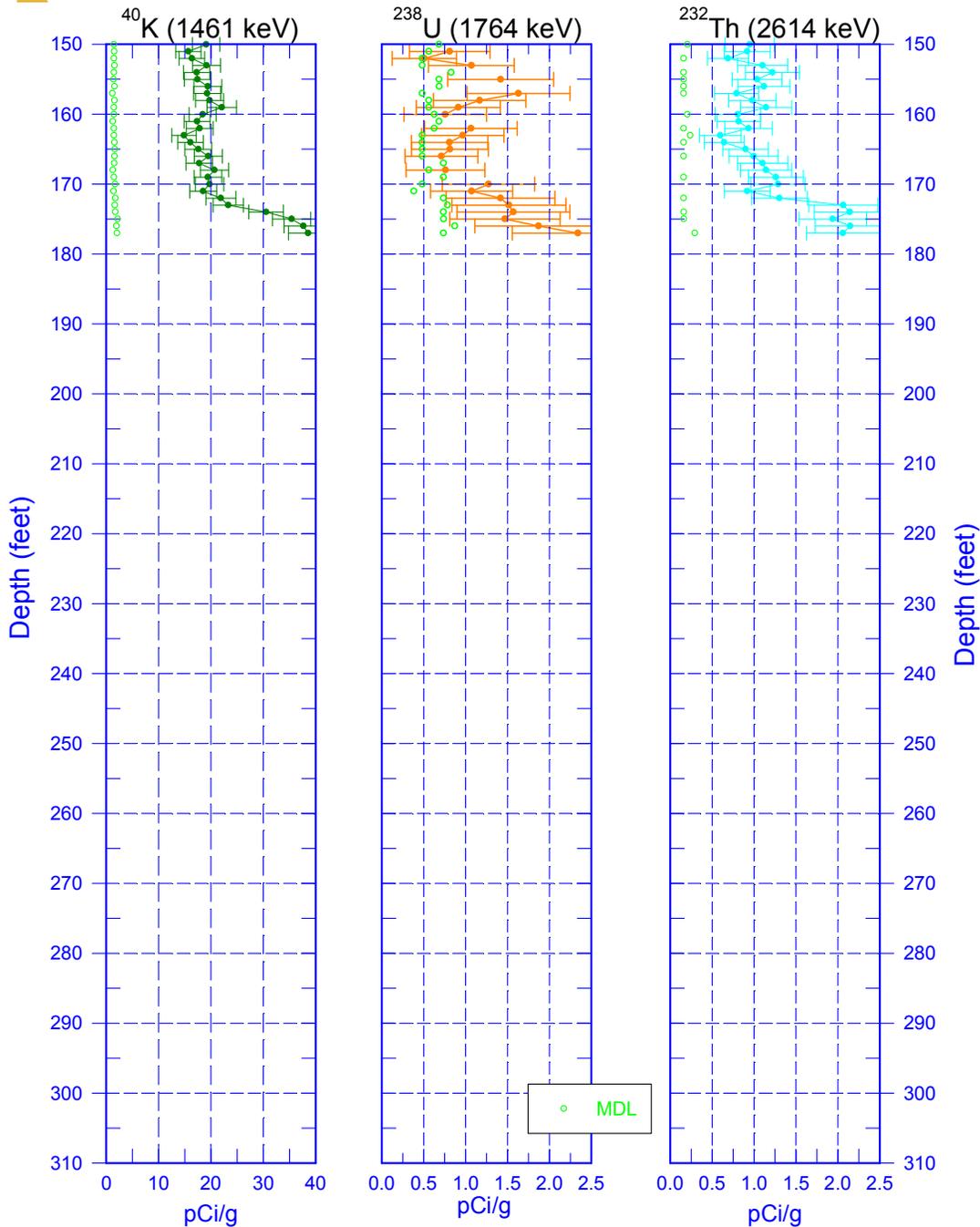
199-K-231 (C9919) Natural Gamma Logs



Zero Reference - Ground Surface



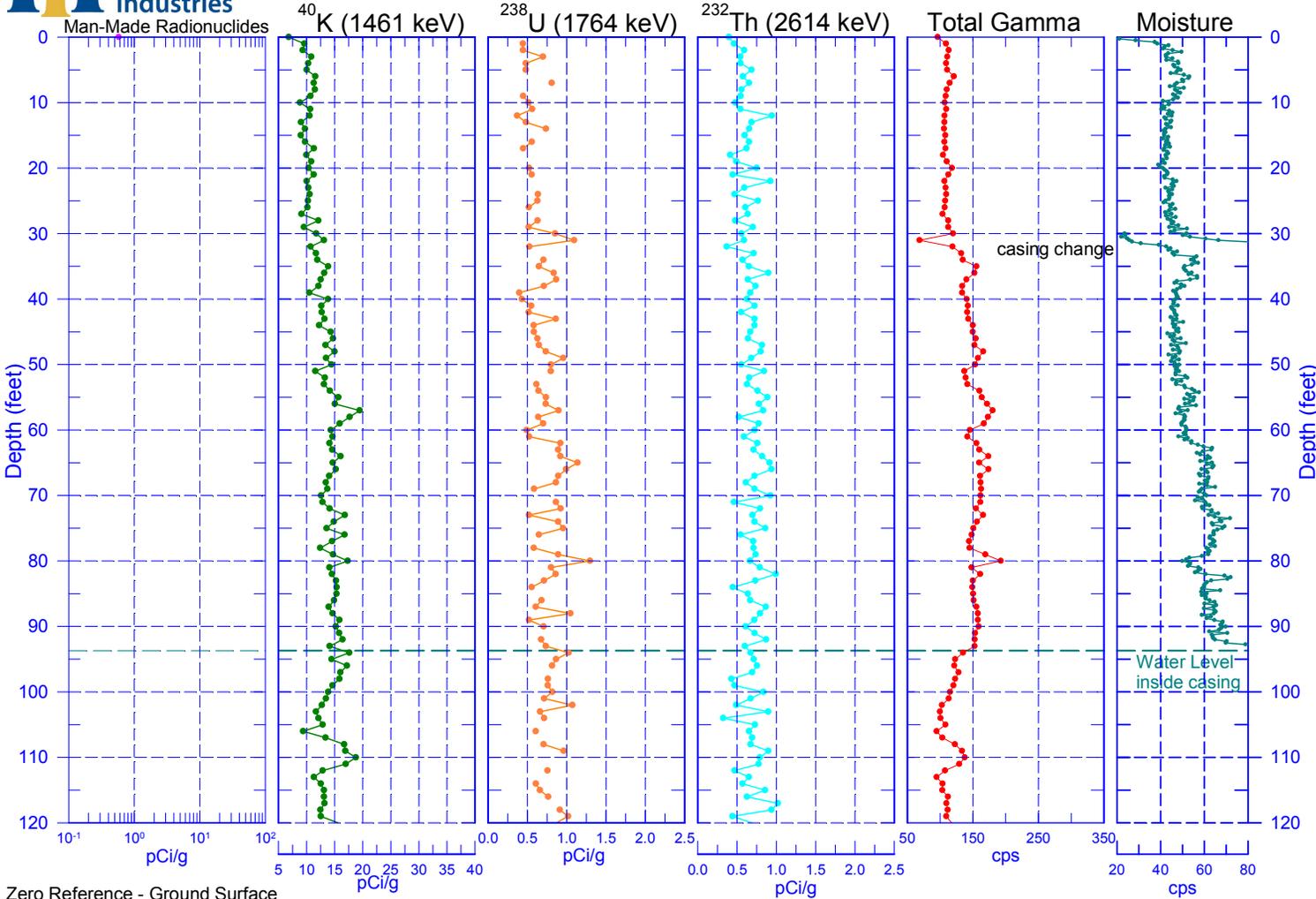
199-K-231 (C9919) Natural Gamma Logs



Zero Reference - Ground Surface



199-K-231 (C9919) Combination Plot

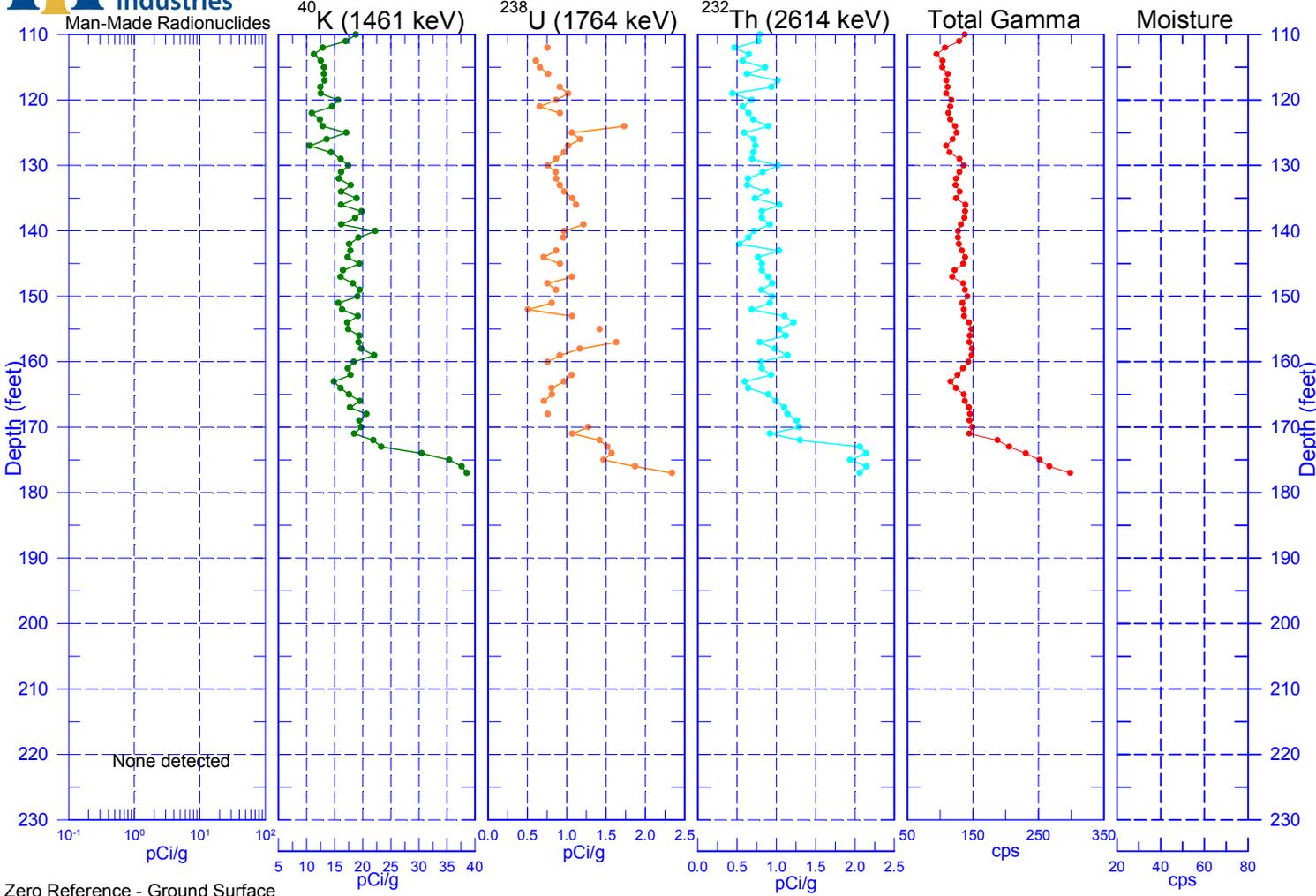


A-22

SGW-62712, REV. 0



199-K-231 (C9919) Combination Plot

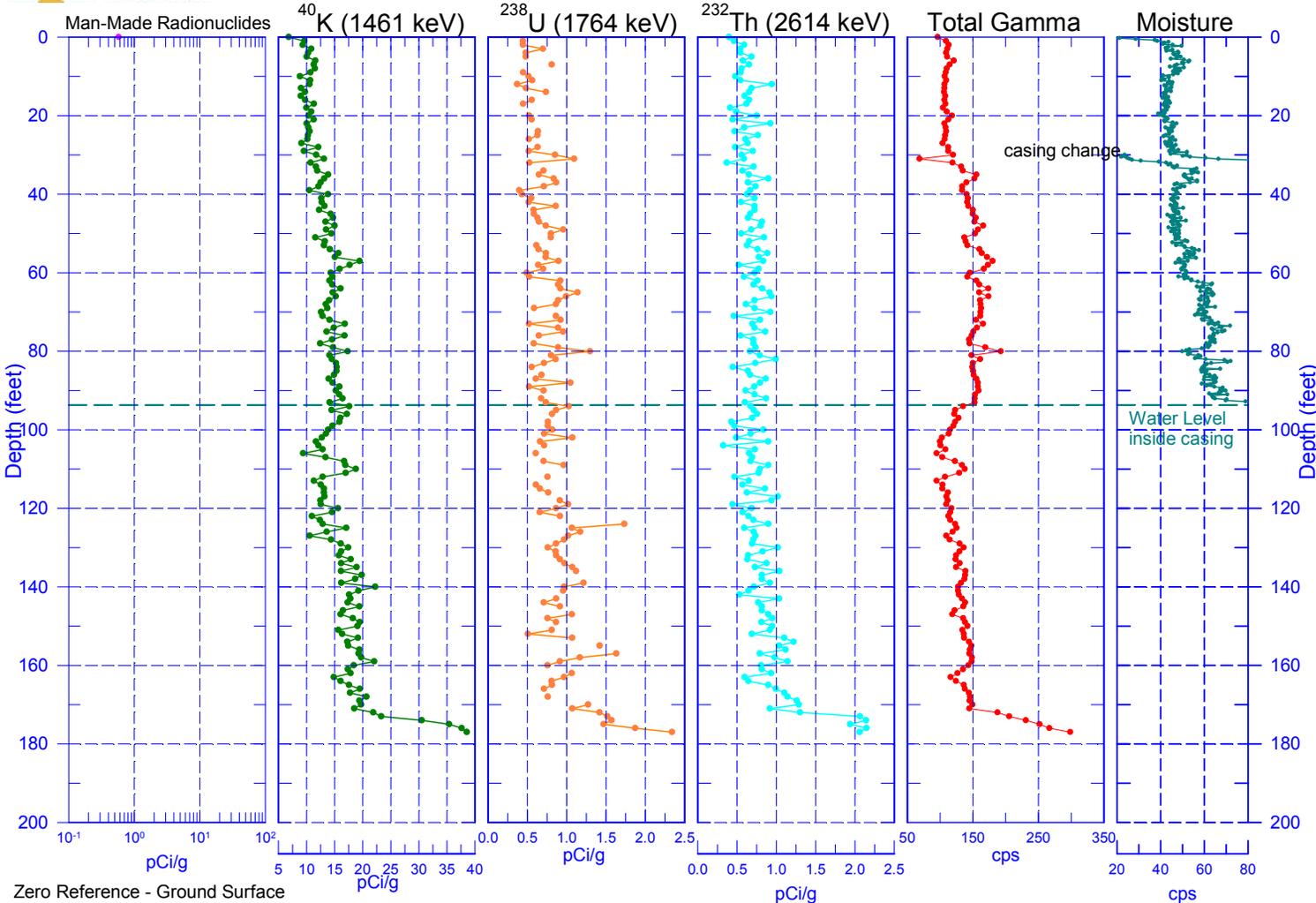


A-23

SGW-62712, REV. 0



199-K-231 (C9919) Combination Plot

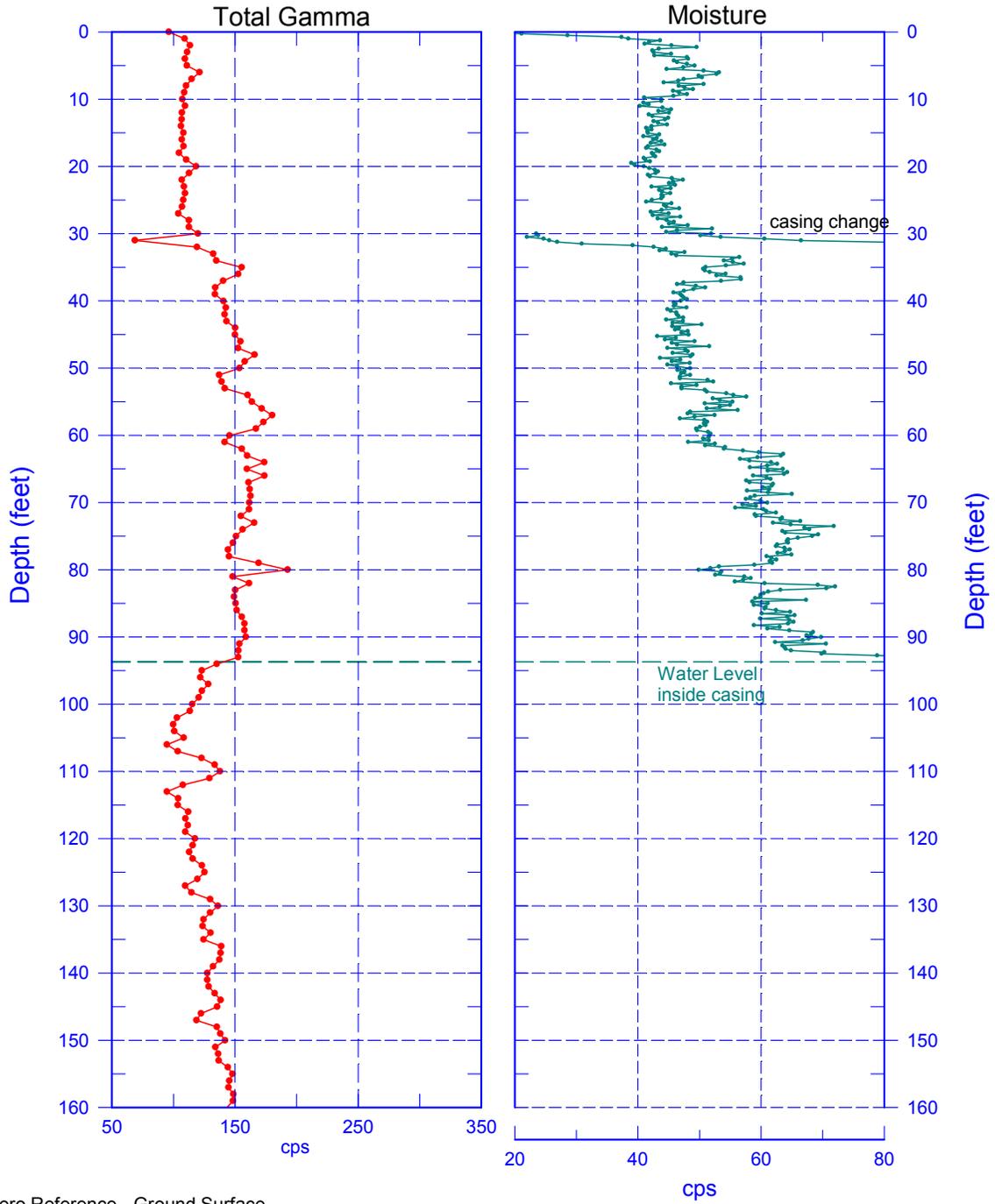


A-24

SGW-62712, REV. 0



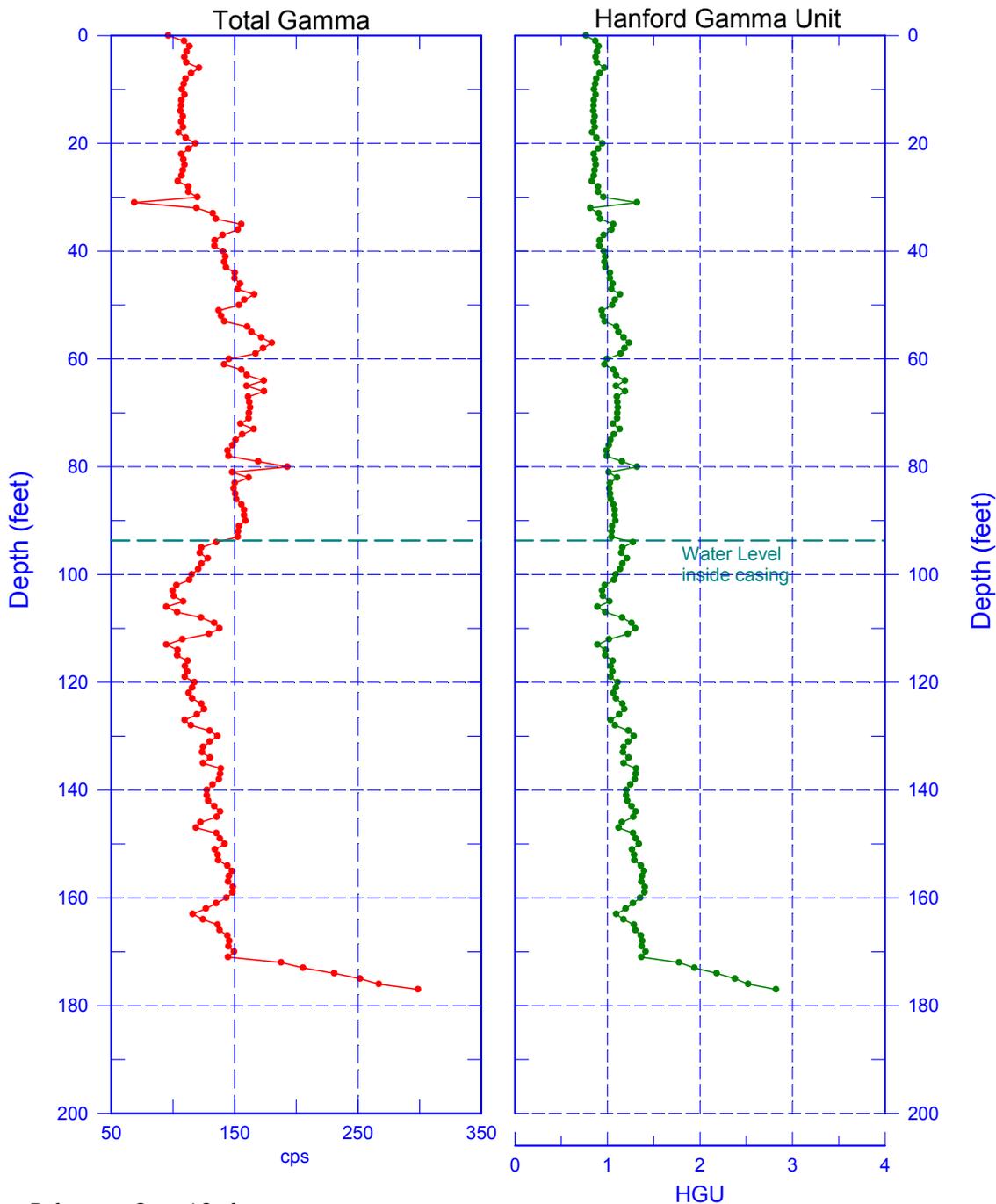
199-K-231 (C9919) Total Gamma & Moisture



Zero Reference - Ground Surface



199-K-231 (C9919) Total Gamma & Hanford Gamma Unit

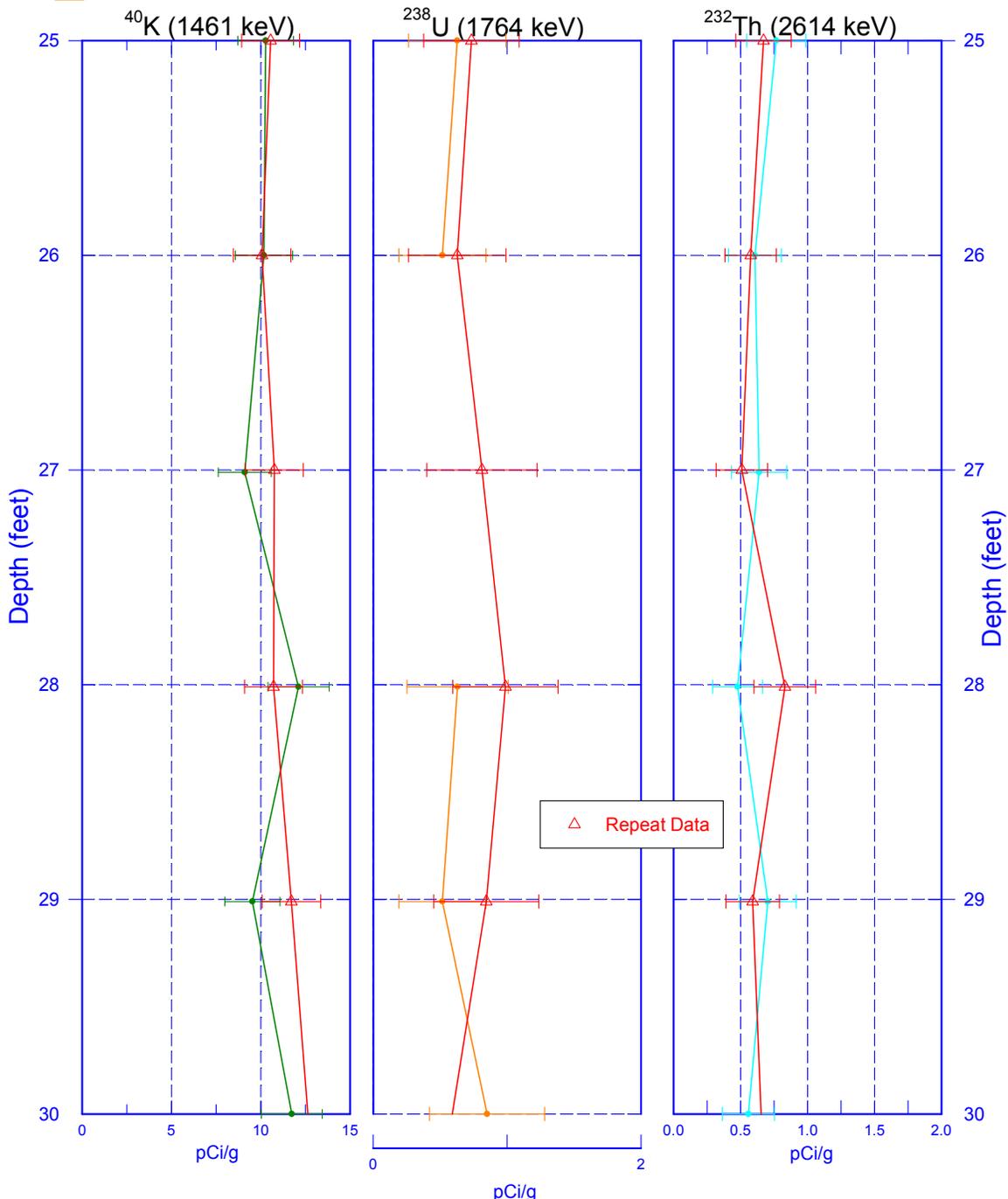


Zero Reference - Ground Surface



199-K-231 (C9919)

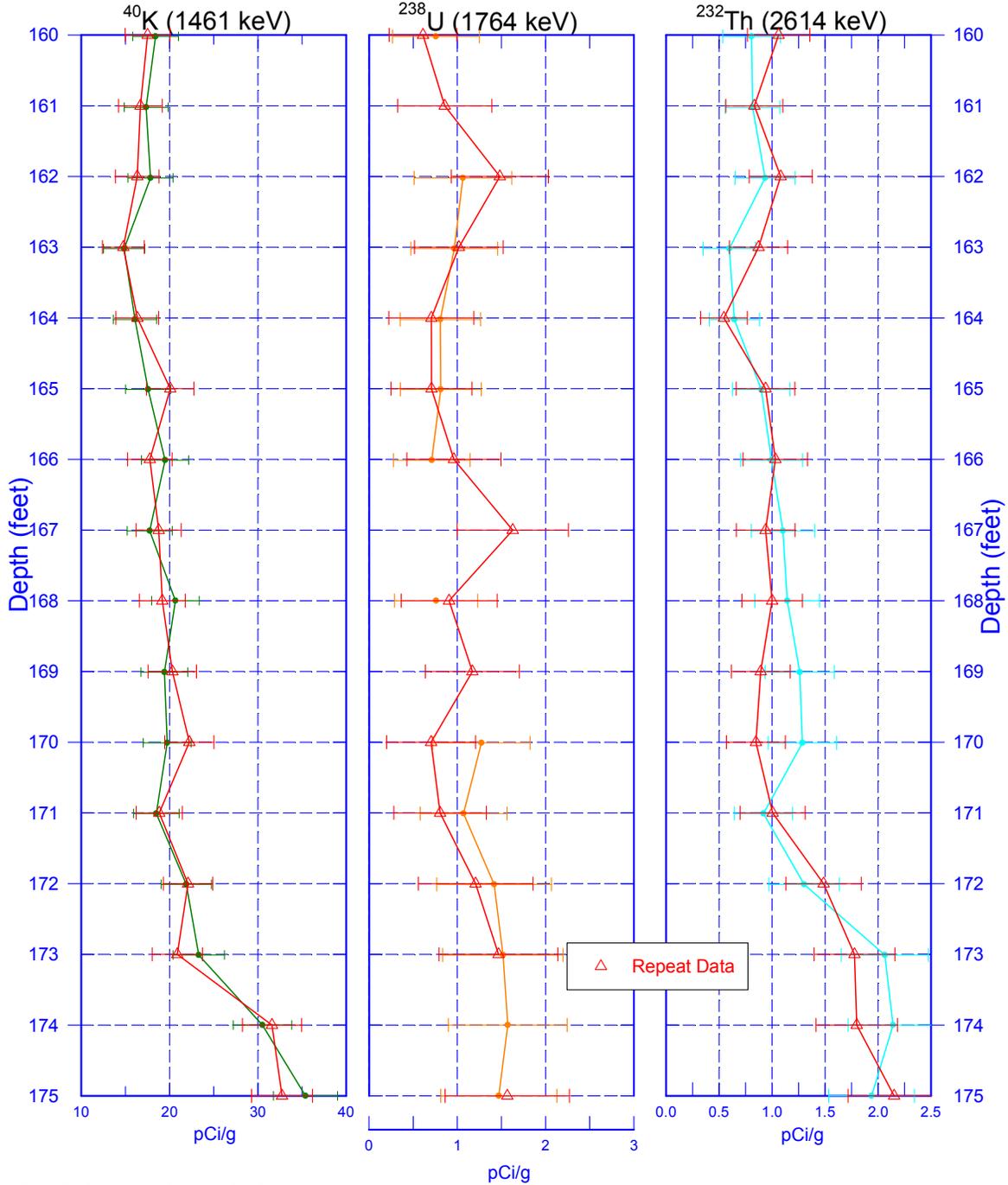
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



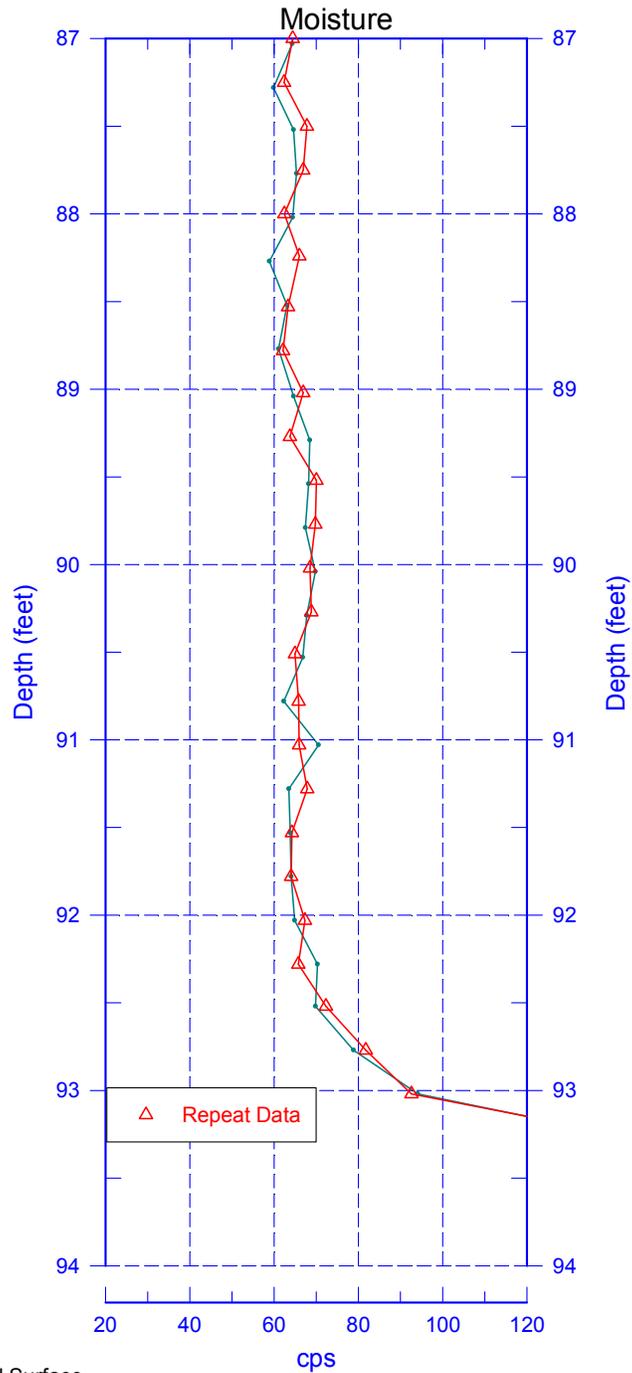
199-K-231 (C9919) Repeat Section of Natural Gamma Logs

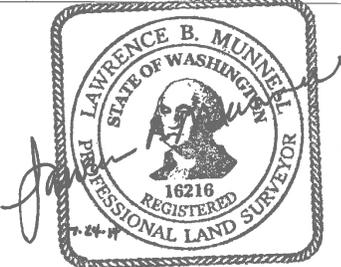


Zero Reference - Ground Surface



199-K-231 (C9919) Moisture Repeat Section



| WELL SURVEY DATA REPORT | | | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|-----------------------------------------------------------|-----------|--------------------------------------------------------------------------------------|
| Project: | | | Prepared By: Neil P. Fastabend | | |
| | | | Company: CHPRC | | |
| Date Requested: 07/10/18 | | | Requestor: James D. Mehrer (CHPRC) | | |
| Date of Survey: 07/24/18 | | | Surveyor / Company: Lawrence B. Munnell (CHPRC) | | |
| Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9919 (199-K-231) located on east side of 100K Area. | | | Horizontal Datum: NAD83 (91) | | |
| | | | Vertical Datum: NAVD88 | | |
| | | | Units: Meters | | |
| | | | Hanford Area Designation: 100K | | |
| Coordinate System: Washington State Plane Coordinates (South Zone) | | | | | |
| Horizontal Control Monuments: Washington State Reference Network | | | | | |
| Vertical Control Monuments: 100K-1 (CHPRC) and M49 (COE) . | | | | | |
| Well ID | Well Name | Easting | Northing | Elevation | |
| C9919 | 199-K-231 | 569511.98 | 146643.38 | | Center of Casing |
| | | | | 147.473 | Top Outer Casing, N. Edge Stamped "X" |
| | | | | 147.172 | Top Inner 6"SS Casing, N. Edge |
| | | | | 146.659 | Brass Survey Marker |
| | | | | | |
| | | | | | |
| | | | | | |
| Notes: | | | | | |
| Brass Survey Marker elevation was taken on top domed brass cap in concrete. | | | | | |
| Equipment Used: Trimble R8 RTK GPS Trimble DiNi 12 Level | | | | | |
| Surveyor Statement: | | | | | |
| I, Lawrence B. Munnell, a Professional Land Surveyor registered in the State of Washington (Registration No. 16216), hereby certify this report is based on a field survey performed by me, or under my direct supervision. | | | | |  |

Appendix B

Well Documentation for C9920 (199-K-232)

Contents

| | |
|-----------------------------------------|------|
| Well Summary Sheet | B-1 |
| Borehole Log | B-3 |
| Drill Cutting Photographs | B-6 |
| Well Development and Testing Data | B-9 |
| Log Data Report | B-10 |
| Well Survey Data Report | B-21 |

| WELL SUMMARY SHEET | | | Page 1 of 2 | | | | | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------|------------------------------|----------------------------------|
| Well ID : C9920 | | Well Name: 199-K-232 | | Start Date: 4/11/2018 | | | | |
| Project: Three New Wells in 100-KR-4 OU | | Location: 1,000 ft South of Columbia River | | Finish Date: 6/14/2018 | | | | |
| CONSTRUCTION DATA | | Depth in Feet | GEOLOGIC/HYDROLOGIC DATA | | | | | |
| Description | Diagram | | Graphic Log | Lithologic Description (ft bgs) | | | | |
| Concrete Pad: 0.50 ft above ground surface (ags) 6-in. Protective Casing: 3.00 ft ags - 2.00 ft below ground surface (bgs) Type I/II Portland Cement Grout: 0.0 - 8.6 ft bgs 8-20 Bentonite Crumbles: 8.6 - 13.2 ft bgs 3/8-in. Coated Bentonite Pellet Seal: 13.2 - 16.1 ft bgs 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.99 ft ags - 20.54 ft bgs 6-in. I.D. Schedule 10, Type 304/304L, 40-slot (0.040 in.) Stainless Steel Screen: 20.54 - 105.56 ft bgs 10-20 mesh Filter Pack Sand: 16.1 - 112.8 ft bgs Stainless steel centralizer installed above and below screen and every 40 ft | | 0 10 20 30 40 50 60 | | 0.0 - 8.0 Crushed Gravel Drill Pad 8.0 - 38.0 Sandy Gravel (sG) Static Water Level: 27.2 ft bgs (5/7/2018) 38.0 - 43.0 Gravelly Sand (gS) 43.0 - 62.5 Sandy Gravel (sG) 62.5 - 64.0 Sand (S) 64.0 - 77.0 Sandy Gravel (sG) | | | | |
| Reported By: <table style="width:100%; border: none;"> <tr> <td style="width: 30%; text-align: center;"> <u>Kim Schuyler</u> <small>Print Name</small> </td> <td style="width: 20%; text-align: center;"> Geologist <small>Title</small> </td> <td style="width: 30%; text-align: center;"> <small>Signature</small> </td> <td style="width: 20%; text-align: center;"> 9/10/2018 <small>Date</small> </td> </tr> </table> | | | | | <u>Kim Schuyler</u> <small>Print Name</small> | Geologist <small>Title</small> | <small>Signature</small> | 9/10/2018 <small>Date</small> |
| <u>Kim Schuyler</u> <small>Print Name</small> | Geologist <small>Title</small> | <small>Signature</small> | 9/10/2018 <small>Date</small> | | | | | |
| Reviewed By: <table style="width:100%; border: none;"> <tr> <td style="width: 30%; text-align: center;"> <u>Jennifer Richard</u> <small>Print Name</small> </td> <td style="width: 20%; text-align: center;"> Well Coordinator <small>Title</small> </td> <td style="width: 30%; text-align: center;"> <small>Signature</small> </td> <td style="width: 20%; text-align: center;"> 9/12/18 <small>Date</small> </td> </tr> </table> | | | | | <u>Jennifer Richard</u> <small>Print Name</small> | Well Coordinator <small>Title</small> | <small>Signature</small> | 9/12/18 <small>Date</small> |
| <u>Jennifer Richard</u> <small>Print Name</small> | Well Coordinator <small>Title</small> | <small>Signature</small> | 9/12/18 <small>Date</small> | | | | | |
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| OR Doc Type: | | WMU Code(s): | | | | | | |

| WELL SUMMARY CONTINUATION SHEET | | Page 2 of 2 | | |
|----------------------------------------------------------------------------------------------------------|----------------------|-----------------------------------------|----------------------------------|--------------------------------|
| Well ID : C9920 | Well Name: 199-K-232 | Project: Three New Wells in 100-KR-4 OU | | |
| CONSTRUCTION DATA | | GEOLOGIC/HYDROLOGIC DATA | | |
| Description | Diagram | Depth in Feet | Lithologic Description (ft bgs) | |
| 6-in. I.D. Schedule 10, Type 304/304L, 40-slot (0.040 in.) Stainless Steel Screen: 20.54 - 105.56 ft bgs | | 70 | 64.0 - 77.0 Sandy Gravel (sG) | |
| | | | | |
| | | | 80 | 77.0 - 83.0 Sand (S) |
| | | | | |
| | | | | 83.0 - 105.5 Sandy Gravel (sG) |
| | | | | |
| 10-20 mesh Filter Pack Sand: 16.1 - 112.8 ft bgs | | | 90 | |
| | | | | |
| | | | 100 | |
| | | | | |
| 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 105.56 - 110.56 ft bgs | | 110 | 105.5 - 112.8 Sandy Silt (sM) | |
| | | | | |
| | | | Total Depth: 112.8 ft (5/7/2018) | |
| | | 120 | | |
| | | | | |
| | | 130 | | |
| | | | | |
| | | 140 | | |
| | | | | |
| | | 150 | | |
| | | | | |
| | | 160 | | |
| | | | | |

Straightness Test: Pass, 5/10/2018

Depths are in ft below ground surface.
 Borehole drilled with 14-in. O.D. casing from 0.0 - 31.5 ft bgs
 Borehole drilled with 10 3/4-in. O.D. casing from 0.0 - 111.9 ft bgs
 All temporary drill casing was removed from the ground.

| BOREHOLE LOG | | | Page <u>1</u> of <u>3</u> | |
|------------------------------------------------|--------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Well ID: <u>C9920</u> | | Well Name: <u>199-K-232</u> | | |
| Project: <u>Three new wells in 100-KR-4 OU</u> | | Location: <u>1,000' S of NW Columbia River</u> | | |
| | | Reference Measure Point: <u>Ground Surface</u> | | |
| Depth (ft) | Sample | Graphic Log | Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other | |
| | | | Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other | |
| 0 | | | 0-8 ft bgs: Backfill from Hanford formation. Sandy gravel (SG), A subtle transition occurs over 6-8' bgs. | |
| 5 | GB | | 8-38 ft bgs: Sandy gravel (SG), 50% gravel, 45% sand, 5% silt. The gravel is poorly sorted, avg size = 40-50mm max = 70mm. Small gravel (very fine pebbles [vfp]) to coarse pebbles [cp] are angular to subangular. cp are round to subround, 25% felsic, 75% mafic. Sand is moderately sorted, 70% very fine to fine sand (vfs-fs), 30% ms, trace coarse to very coarse sand (cs-vcs). 2-5% composed of mica. Sand is 70% felsic. Seds are slightly moist with no rxn to HCl. Olive brown in color (2.5y 4/5). Sediments are more compact upon removal than backfill. w/trace mica. | |
| 10 | GB | | @ 13 ft: Felsic content from 25% to 70%. Gravel is mostly round-subround, sand is 100% very fine-fine sand (vfs-fs) and moderately well sorted, 70% felsic, some fine material, to cobbles (fs and silt) are streaked w/gray. Seds are light yellowish brown (2.5y 4/5). Seds have high tension. (mica present in fines) | |
| 15 | GB | | @ 15 ft: Seds are very dry. | |
| 20 | GB | | @ 20 ft: Gravel to 40%, Sand = 60%, Tr silt. Gravel clast size decreases to vfp-cp, avg (5-20mm), Max = 45mm. Sand is poorly sorted and slightly moist, 4-5% of sand silt mica. | |
| 25 | GB | | @ 27 ft bgs: Seds from drive barrel are composed of 55% gravel, 45% sand, Tr silt, poorly sorted gravel, max = 100mm, larger pebbles are more felsic. Seds are 2.5y 4/2 (dark grayish brown). | |
| 30 | WS | | @ 27.5' bgs: 70% gravel, 25% sand, 5% silt. Gravel is poorly sorted, 75% vfp-mp are felsic, 10% cp-small cobbles are felsic and composed of river rock, very felsic overall, 2.5y 4/5 (light olive brown). Occ. cobbles, mafic content in gravel ↑ to 60% (vfp-mp) | |
| | | | @ 35': mafic content in sand ↑ to 50%. 2.5y 5/2 (grayish-brown) in color | |
| | | | | 14" OD starter casing from 10' depth (0411 F118) |
| | | | | Water @ 27.85' (4/11/18), static @ 26.8' bgs (4/18/18) |
| | | | | *SS = split spoon 27.8-30.3' |
| | | | *WS = water sample @ 31.45' bgs, 14" OD | |
| | | | occasional cobbles make drilling slow. | |
| | | | * NCO's scheduled grab samples for chemical analysis @ 10, 15, 20, 25' bgs. | |
| | | | @ 8' bgs: contact with native Hanford formation. | |
| | | | gravel has iron-staining on vcp | |

Reported By: Kat Robertson Geologist [Signature] 04/16/18

Reviewed By: Sarah Springer Sr. Geologist [Signature] 08-14-18

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| BOREHOLE LOG (Cont.) | | | Page 2 of 5 | |
|----------------------|--------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| | | | Date: | |
| Well ID: C9920 | | Well Name: 199-K-232 | Location: 1,000 ft S of the Columbia River | |
| 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 | GB | | 8-38' bgs: sandy gravel (SG) | Cable tool Drill rig 1 1/2" OD Starter casing 10 5/4" temp casing |
| | GB | | @ 37' bgs: transitions from SG to gravelly sand | |
| 40 | GB | | 38-43' bgs: gravelly sand (GS) 25% gravel, 75% sand, Tr silt. Gravel is moderately sorted and bimodal, ~50% 2-15mm, ~50% 60-100mm, w/ occasional cobbles and coarse pebbles. Gravel is 40% felsic in very fine pebbles (VFP) to fine pebbles (FP), and 10% felsic (20% mafic) in medium pebbles (mp) to cobbles. Sand is 100% fs (fine sand) to medium sand (ms) w/ occasional coarse and very coarse sand. The sand is well sorted, 85% felsic, w/ Tr mica. Sods are slightly moist, 2y 1/3, pale olive, in color. | |
| 45 | GB | | 43-62.5' bgs: 62.5' bgs sandy gravel (SG). 70% gravel, 20% sand, 10% silt. Gravel is 50% cobbles (max=720mm), many rock fragments, so could be larger. Most rock fragments are pure basalt (in BS-90% very coarse pebbles to cobbles). Sand is 100% VFS, 20% FS, 20% MS-VCS, well sorted (VFS-FS forms compacted sand-silt layer around pebbles and cobbles, MS-VCS is not compacted), about 5% of the VFS-MS is mica. Silt is around cobbles/pebbles, with a layer ~2" thick of 10µ, 1/6 brownish yellow silt (w/ VFS). Sand is 70% felsic and 2.5y 1/3 light yellowish brown. | |
| 50 | GB | | @ 44' bgs: 70% VFP-PP, 30% MP-CP, occ. sand. Avg size = 20mm, and is moderately sorted, while other gravel is poorly sorted, gravel is 20% felsic. Sand is poorly sorted, less 20% felsic, moist, 2.5y 1/3 light olive brown. | |
| 55 | GB | | @ 55' bgs: gravel is bimodal, avg 2-8mm and 60-120mm, max=130mm, 20mm pebbles are moderately sorted, and 60-120mm are poorly sorted. Sand is 50% CS-VCS, subangular, 2.5y 1/3 light olive brown, when dug 2.5y 3/3 (dark olive brown) in color. → mg-sublany | |
| 60 | GB | | @ 60' bgs: gravel is 60% FP-mp, 10% PP (mp is 80% felsic), 20% CP-VCP, 10% cobbles (cp + fs 60% felsic ground-silt round) sand is 80% fs-ms, moderately well sorted. | |
| 65 | GB | | 62.5-64' bgs: Sand (S), hard contacts on either side, changed mid drive barrel. Sand is same as at 60', gravel is Tr, but all VFP-PP. Only change is sand 100% Tr gravel. | 68-69' (1hr take) Water Sample @ 71.8' bgs (1/20/18) |
| 70 | WS | | 64-77' bgs: sandy gravel (SG), compositionally and texturally identical to SG before sand layer. From 64-75' bgs, clumps of silt and clay, thin laminations of different colors, and sand intervals less than 6" thick appear. No lithologic changes are sustained. | 1 hr pick up 3/6 ppm VOCs (1/2/25/18) @ borehole @ 72.8' sand pump |

Reported By:

Kat Robertson

Print Name

Geologist

Title

[Handwritten Signature]

Signature

05/02/18

Date

| BOREHOLE LOG (Cont.) | | | Page <u>3</u> of <u>3</u> |
|----------------------------------------------|--------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Well ID: <u>C9920</u> | | Well Name: <u>199-K-232</u> | Date: <u>05/09/18</u> |
| Location: <u>1000 Ft S of Columbia River</u> | | | |
| Depth (ft) | Sample | Graphic Log | Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other |
| | | | Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other |
| 75 | GB | | (69-77 ft bgs (cont) Sandy Gravel (SG) @ 75 ft bgs: 75% gravel, 25% sand, Tr silt. Gravel is 70% very fine pebble to medium pebble (avg=2), 30% coarse pebble to cobble, avg size = 2-3 mm, max = 7.5 mm, moderately sorted, 50% felsic, sand is poorly sorted, 65% felsic, moist, 2.54 4/5 (olive brown). |
| | GB | | @ 76 ft bgs: vfs-fs (very fine to fine sand) forms gravel, as a clay-like substance that tightly packs. |
| 80 | GB | | 77-83 ft bgs: sand (S), Tr Gravel, 10% sand, 10% silt. Sand is 70% FS to MS (fine to medium sand), mod to well sorted, 70% felsic, moist, 2.54 1/3 (olive brown). |
| 85 | GB | | 83-105.5 ft bgs: Sandy Gravel (SG), 75% gravel, 20% sand, 5% silt. Gravel is poorly sorted, avg 20mm, max = 90mm, 80% mafic, round, sand is moderately sorted, avg size = FS-VCS and is 40% felsic, 60% mafic, subang-subround, sediments are wet, with no rxn. to HCl, colored olive brown (2.54 4/5). |
| 90 | GB | | @ 88 ft bgs: sand to 70% felsic and is well sorted medium sand (MS), Tr mica. |
| 95 | GB | | @ 93 ft bgs: gravel clast size ↑ avg size = 20mm, max 40mm. sed. color is brown (10YR 4/5). |
| | GB | | @ 103 ft bgs: gravel is poorly sorted, avg = 15mm, max = 120mm, felsic ↑ size, subround. Sand is moderately sorted, vfs-vcs (avg = FS-MS), color is 2.5Y 5/2, grayish brown, sand felsic content ↑ 80%. |
| 100 | GB | | silty sand (MS), Tr Gravel, 30% sand, |
| 105 | GB | | @ 105.5 ft bgs: 30% silt. strong rxn to HCl. 10YR 7/1, (light gray) contact, likely a Paleosol. |
| | GB | | 105.5-110 ft bgs transition to mud, sandy silt (SM) 0% gravel, 70% sand, 80% silt. Sand is well sorted, 100% vfs-fs, sediments are moist, react moderately to HCl and is grayish brown in color (10YR 5/2). |
| 110 | GB | | sediment (silt) is plastic and can be molded in to thread. |
| | GB | | TD @ 112.8 ft bgs casing @ 111.8 ft bgs DTN @ 25.1 ft bgs (5107118) starter casing (14" OD) @ 31.45 ft bgs |

Reported By:

Kat Robertson

Print Name

Geologist

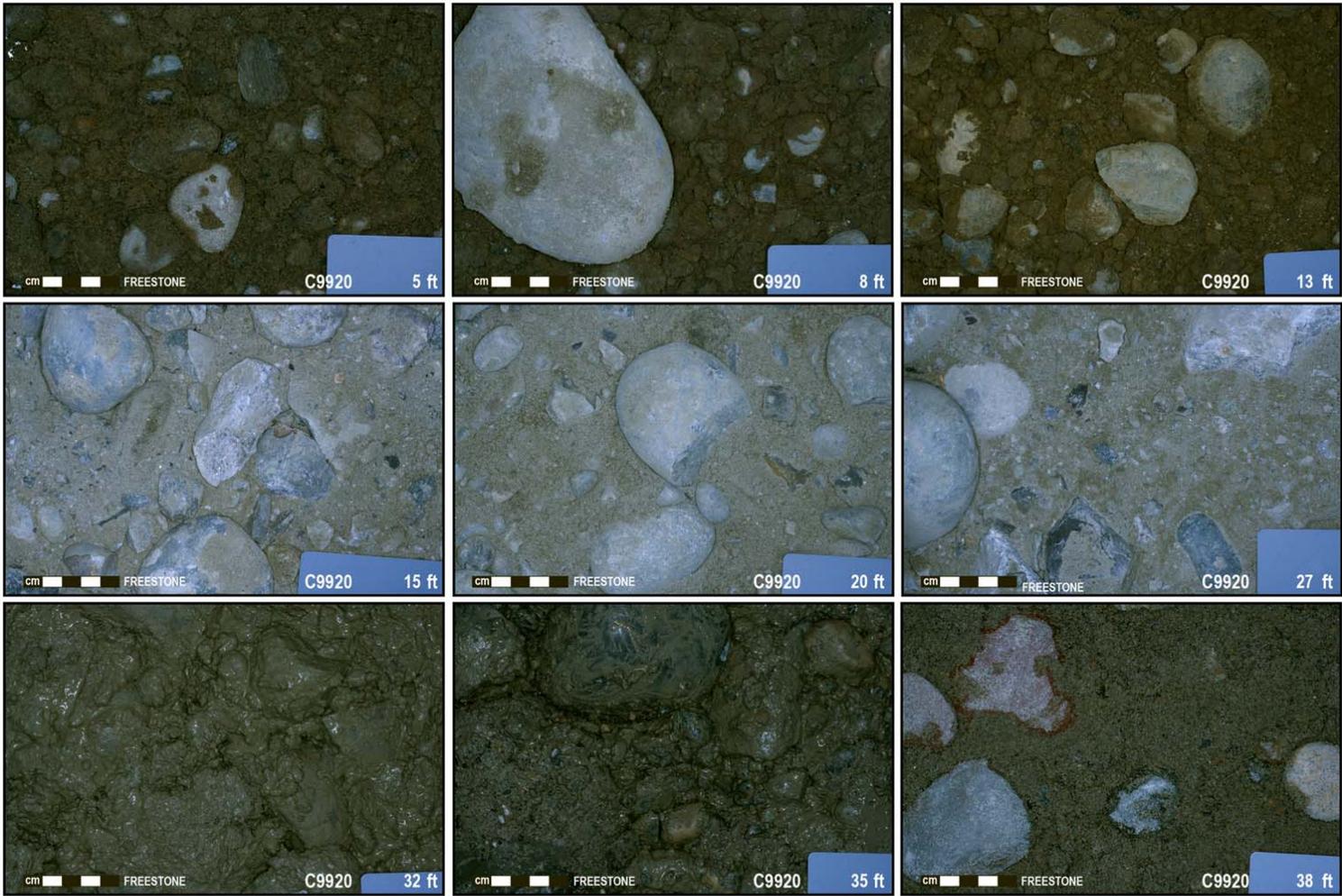
Title

[Handwritten Signature] 05/09/18

Signature

Date

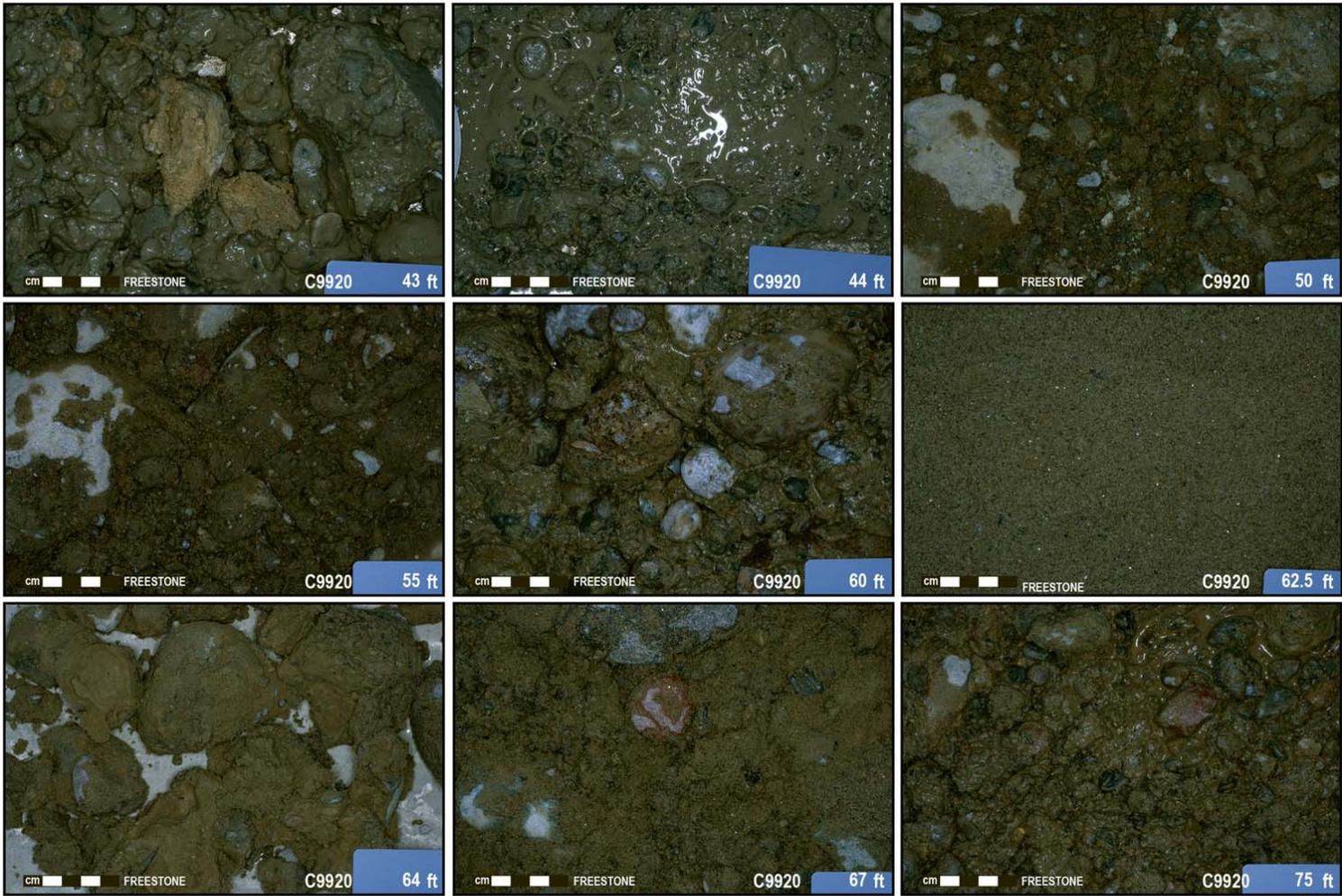
B-6



Drill Cutting Photographs for C9920 (199-K-232)

SGW-62712, REV. 0

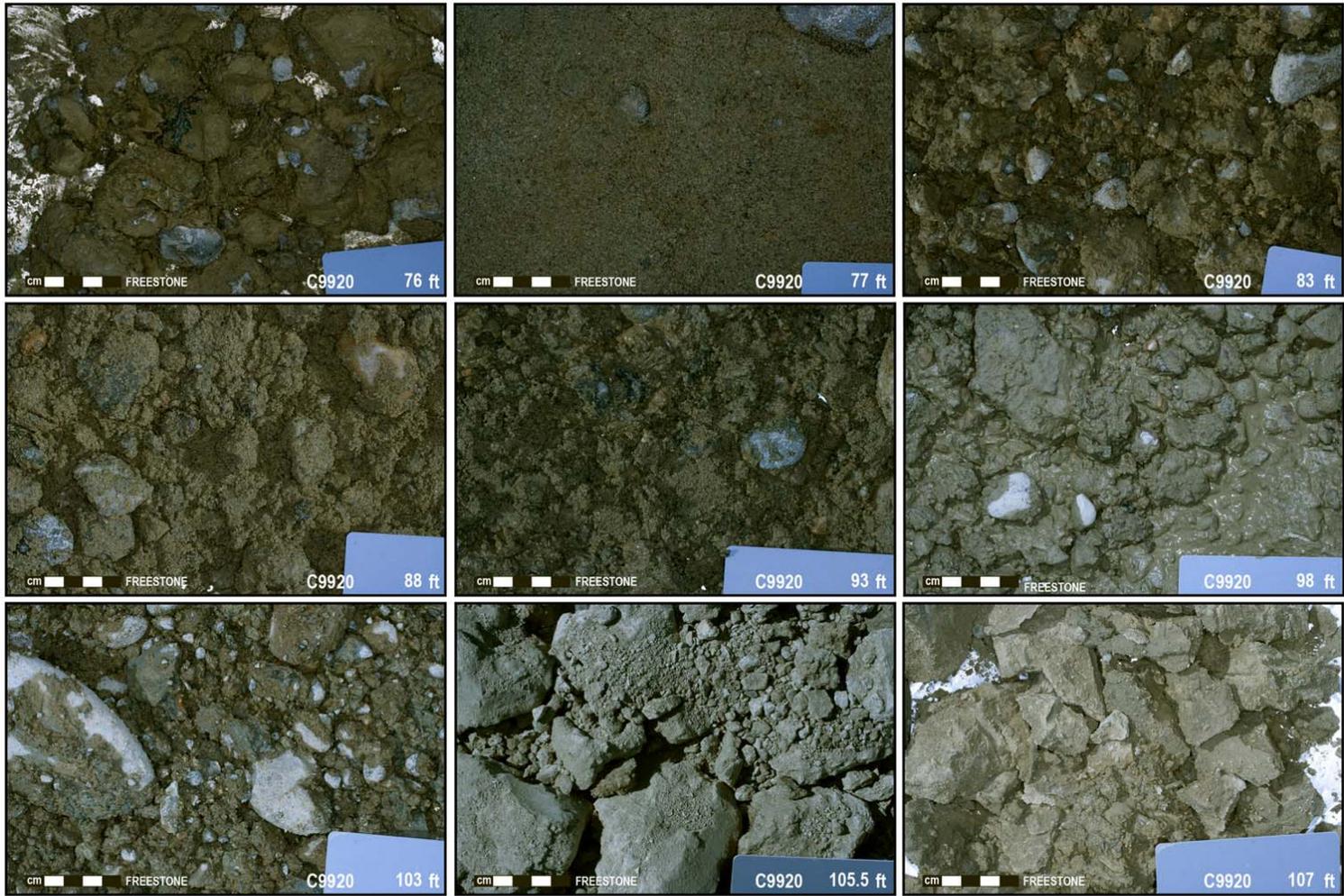
B-7



Drill Cutting Photographs for C9920 (199-K-232)

SGW-62712, REV. 0

B-8



Drill Cutting Photographs for C9920 (199-K-232)

SGW-62712, REV. 0

| WELL DEVELOPMENT AND TESTING DATA | | | | | | | | | | |
|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------|----------------------|----------------------|------------|------------------------------------------------------------------------------------------------|-----------|--------------------|-----------------------|--|--|
| Well ID: C9920 | | | Well Name: 199-K-232 | | | | Date: 6/14/2018 | | | |
| Location: 1,000 ft South of Columbia River | | | | | | | | | | |
| Reference Measuring Point (unless otherwise noted): TOP OF OUTER CASING (TOC) \pm bgs | | | | | | | | | | |
| Has the well been surveyed? <input type="radio"/> Yes <input checked="" type="radio"/> No | | | | | Does the well have a cement pad? <input type="radio"/> Yes <input checked="" type="radio"/> No | | | | | |
| Initial Conditions | | | | | <p style="margin-left: 20px;">A = 3.00 B = 1.99 C = 1.01</p> | | | | | |
| | | Start of Job | | End of Job | | | | | | |
| STATIC WATER LEVEL: | | | | | | | | | | |
| Date: 6/12/18 | | 22.2 | | - | | | | | | |
| Date: 6/14/18 | | 22.0 | | 21.9 | | | | | | |
| DEPTH TO BOTTOM: | | | | | | | | | | |
| Date: 6/12/18 | | 110.1 | | - | | | | | | |
| Date: 6/14/18 | | - | | 110.1 | | | | | | |
| Intake Depth (ft bgs) | Specific Capacity (gpm/ft) | Troll Depth (ft bwt) | Turbidity (NTU) | | Pump Start | Pump Stop | Pumping Rate (gpm) | Maximum Drawdown (ft) | | |
| | | | Initial | Final | | | | | | |
| 102.9 | 3.1 | 78.21 | 73.3 | 1.84 | - | 47 min* | 169 | 54.5 | | |
| 82.9 | 7.9 | 57.27 | 77.8 | 1.83 | 0954 | 1014 | 100 | 12.7 | | |
| 62.9 | 9.1 | 36.19 | 34.7 | 1.72 | 1027 | 1049 | 100 | 11.0 | | |
| 42.9 | 8.7 | 15.04 | 10.7 | 0.72 | 1102 | 1137 | 100 | 11.5 | | |
| Total Pumped: 15,600 gallons | | | | | | | | | | |
| Pump Model: Grundfos 25 hp | | | | | | | | | | |
| Troll Serial Number and Pressure Range (PSI and depth): 553248 70 m / 231 ft | | | | | | | | | | |
| Comments: *Cumulative pump time Well development was attempted on 6/12/2018 and 6/14/2018, pump was unable to stress aquifer. | | | | | | | | | | |
| Prepared By: | | | | | | | | | | |
| Kim Schuyler | | | | | | | 9/10/2018 | | | |
| Print Name | | | Signature | | | | Date | | | |
| Reviewed By: | | | | | | | | | | |
| Jennifer Richardt | | | | | | | 9/12/18 | | | |
| Print Name | | | Signature | | | | Date | | | |
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6/14/18

199-K-232 (C9920) Log Data Report

Borehole Information

| | | | | | |
|-----------------------------|------------|-------------------|------------------------|-------------------------|--------------------|
| Log Date | 2018-05-08 | Filename | C9920_HG-NM_2018-05-08 | Site | 100-KR-4 |
| DTW¹ (ft) | | DTW Date | | Drill Date | |
| 27.35 | | 05/08/18 | SN3 | 05/07/18 | |
| | | DTW Source | | Total Depth (ft) | |
| | | | | 112.8 | Depth Datum |
| | | | | | Ground Surface |

Casing Information

| Casing Type | Drill Type | Stickup (ft) | Diameter (in.) | | Thickness (in.) | Top (ft) | Bottom (ft) |
|----------------|------------|--------------|----------------|--------|-----------------|----------|-------------|
| | | | Outer | Inside | | | |
| Threaded Steel | Cable Tool | 1.1 | 14 1/8 | 12 1/2 | 13/16 | -1.1 | 31.45 |
| Threaded Steel | Cable Tool | 2.25 | 10 7/8 | 9 1/2 | 11/16 | -2.25 | 111.86 |

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 111 ft. Zero reference is ground surface.

Logging Equipment Information

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

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

SGLS Log Run Information

| Log Run | 1 | 2 Repeat | 5 | 6 Repeat | |
|-------------------|-----------------|-----------------|-----------------|-----------------|--|
| HEIS Number | 1020184 | 1020185 | 1020186 | 1020187 | |
| Date | 04/17/18 | 04/17/18 | 05/08/18 | 05/08/18 | |
| Logging Engineer | Spatz/McClellan | Spatz/McClellan | Spatz/McClellan | Spatz/McClellan | |
| Start Depth (ft) | 0.0 | 24.0 | 28.0 | 98.0 | |
| Finish Depth (ft) | 29.01 | 29.01 | 111.02 | 107.01 | |

¹ depth to water inside casing



| Log Run | 1 | 2 Repeat | 5 | 6 Repeat | |
|--------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--|
| Count Time (sec) | 100 | 100 | 100 | 100 | |
| Live/Real | R | R | R | R | |
| Shield (Y/N) | N | N | N | N | |
| MSA Interval (ft) | 1.0 | 1.0 | 1.0 | 1.0 | |
| Log Speed (ft/min) | NA | NA | NA | NA | |
| Pre-Verification | C9920FTB20180 417AV00CAB1 | C9920FTB20180 417AV00CAB1 | C9920ALD2018 0508AV00CAB1 | C9920ALD2018 0508AV00CAB1 | |
| Start File | AD000000 | BD002400 | AD002800 | BD009800 | |
| Finish File | AD002901 | BD002901 | AD011102 | BD010701 | |
| Post-Verification | C9920FTB20180 417BV00CAA1 | C9920FTB20180 417BV00CAA1 | C9920ALD2018 0508BV00CAA1 | C9920ALD2018 0508BV00CAA1 | |
| Depth Return Error (in.) | N/A | 0.5 high | N/A | 1.0 low | |
| Comments | No fine gain adjustments made | No fine gain adjustments made | No fine gain adjustments made | No fine gain adjustments made | |

NMLS Log Run Information

| Log Run | 3 | 4 Repeat | | |
|--------------------------|------------------------------|------------------------------|--|--|
| HEIS Number | 1020188 | 1020189 | | |
| Date | 04/17/18 | 04/17/18 | | |
| Logging Engineer | Spatz/McClellan | Spatz/McClellan | | |
| Start Depth (ft) | 0.0 | 21.0 | | |
| Finish Depth (ft) | 26.51 | 26.02 | | |
| Count Time (sec) | 15 | 15 | | |
| Live/Real | R | R | | |
| Shield (Y/N) | N | N | | |
| MSA Interval (ft) | 0.25 | 0.25 | | |
| Log Speed (ft/min) | NA | NA | | |
| Pre-Verification | C9920FPB20180 417AV00CAB1 | C9920FPB20180 417AV00CAB1 | | |
| Start File | AD000000 | BD002100 | | |
| Finish File | AD002651 | BD002602 | | |
| Post-Verification | C9920FPB20180 417BV00CAA1 | C9920FPB20180 417BV00CAA1 | | |
| Depth Return Error (in.) | N/A | 0 | | |
| Comments | None | None | | |

Logging Operation Notes

A centralizer was not installed on the sondes for the first casing to 29 ft. A centralizer was installed for the second casing on the SGLS sonde.

Analysis Notes

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

Prepared by Technical Solutions

A DIVISION OF HUNTINGTON INGALLS INDUSTRIES

A casing correction for a 13/16-in. thick casing was applied to the SGLS log data for the first casing and a correction for 11/16-in. thick casing for the second casing.

A water correction was applied below 27.35 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in EXCEL templates identified as 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 were removed from 28 and 29 ft. This results in a data set where only one data point is presented for each depth.

Neutron moisture data are reported in counts per second as there is no calibration available to convert to volumetric moisture for a 14 1/8-in. OD casing.

HGU² 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

Cs-137 was detected at ground surface at a concentration of 1.4 pCi/g. The KUT plots suggest the bottom 3 ft of the borehole may be impacted by mud inside the casing causing concentrations to be overestimated.

The neutron moisture log primarily responds to moisture present in the surrounding formation. In general, an increase in count rate reflects an increase in moisture content. Moisture content may increase in sediments of relatively high silt or clay content.

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

List of Log Plots

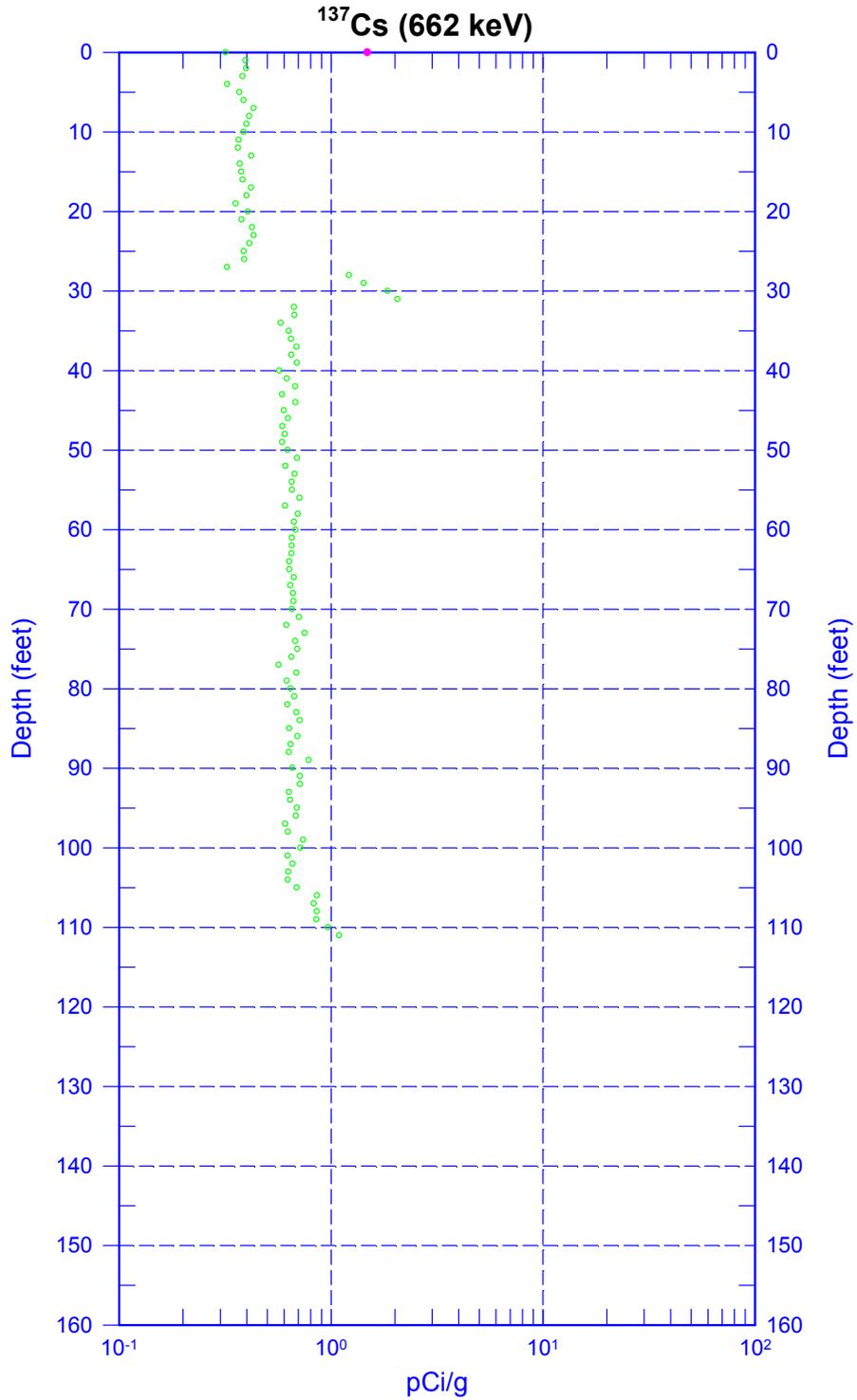
Depth Reference is ground surface.

Manmade Radionuclides (0-160 ft)
 Natural Gamma Logs (0-160 ft)
 Combination Plot (0-120 ft)
 Total Gamma & Moisture (0-160 ft)
 Total Gamma & Hanford Gamma Unit (0-160 ft)
 Repeat Section of Natural Gamma Logs (24-29 ft)
 Repeat Section of Natural Gamma Logs (98-107 ft)
 Moisture Repeat Section (21-26 ft)

² Hanford Gamma Unit



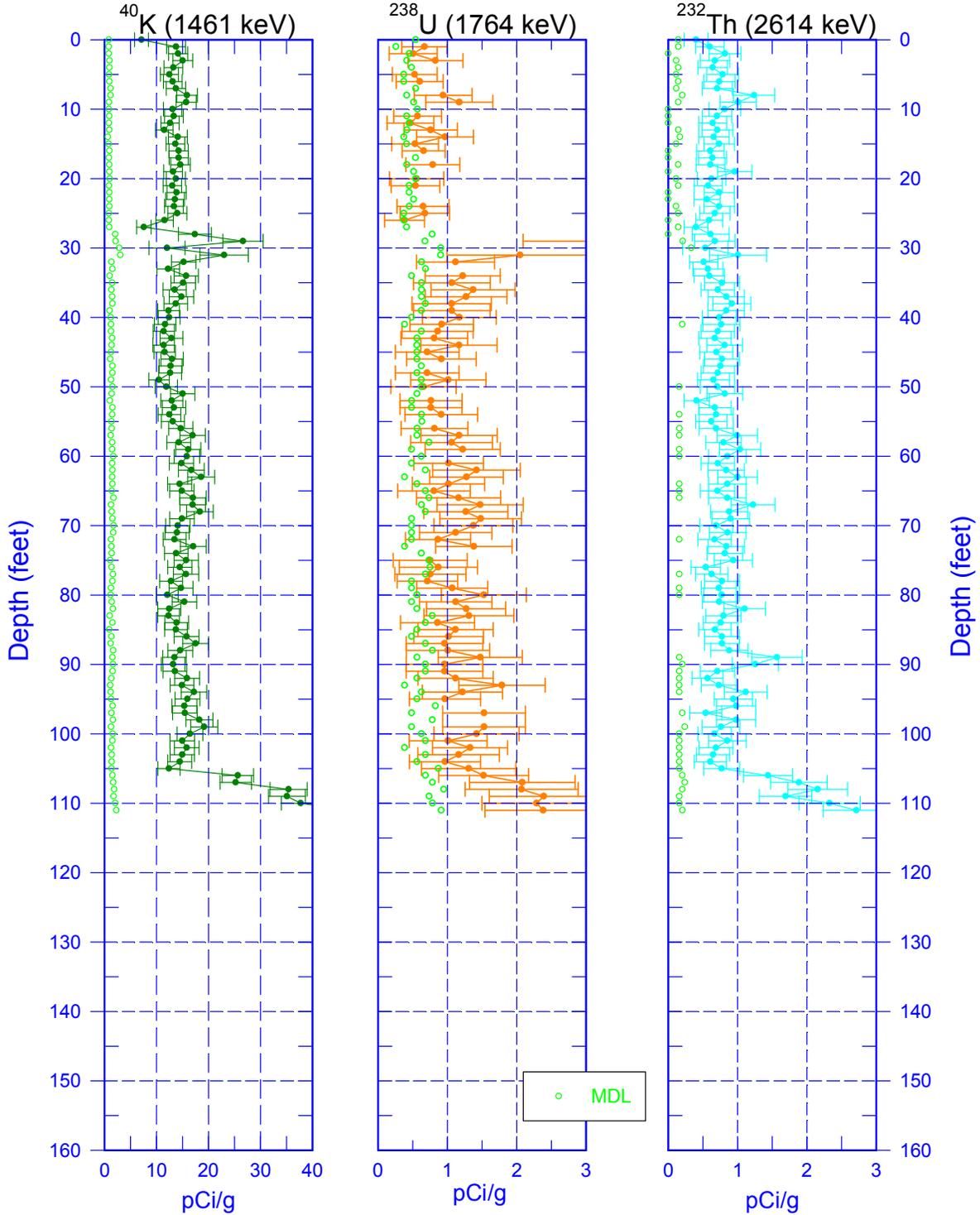
199-K-232 (C9920) Manmade Radionuclides



Zero Reference - Ground Surface



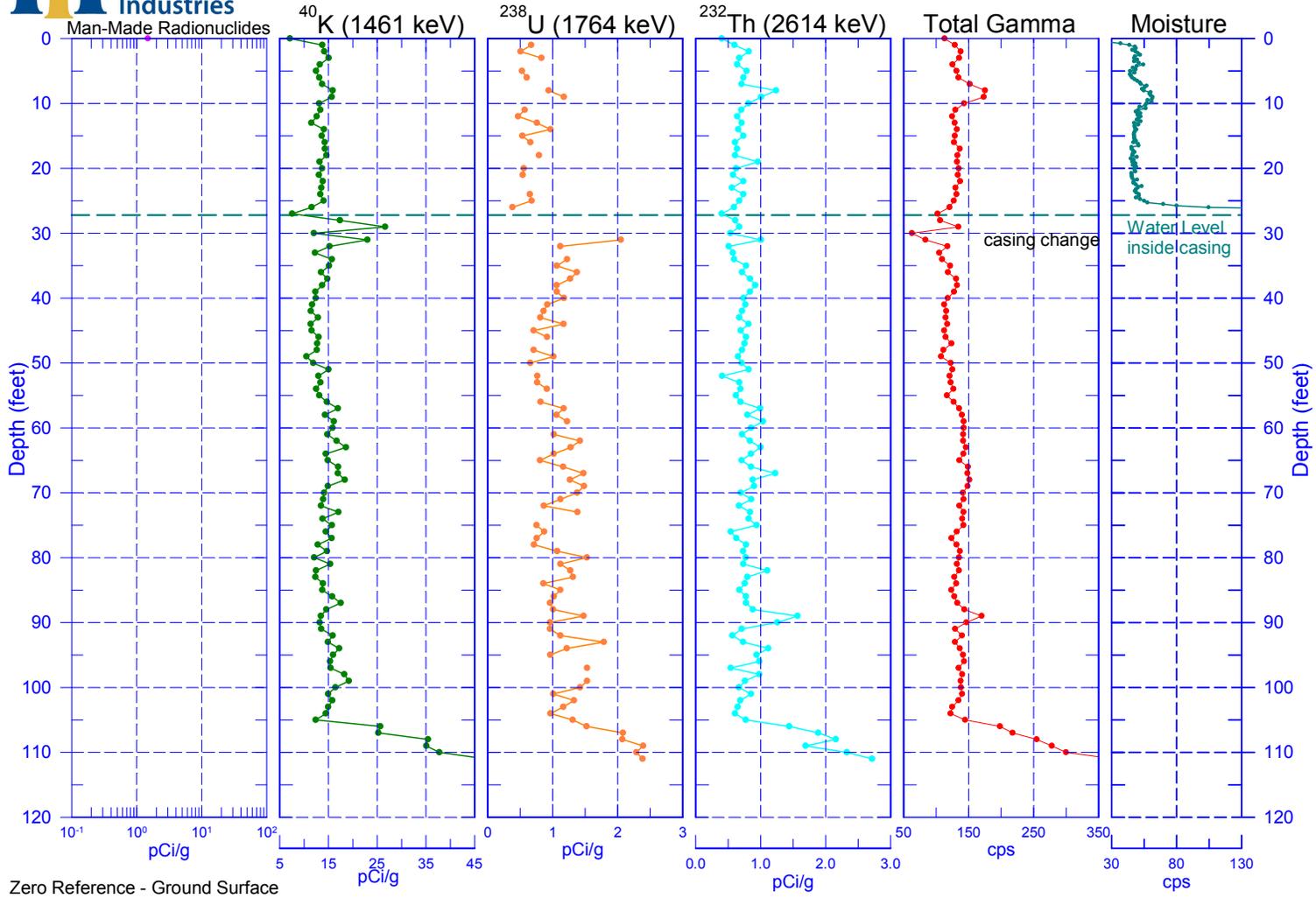
199-K-232 (C9920) Natural Gamma Logs



Zero Reference - Ground Surface



199-K-232 (C9920) Combination Plot

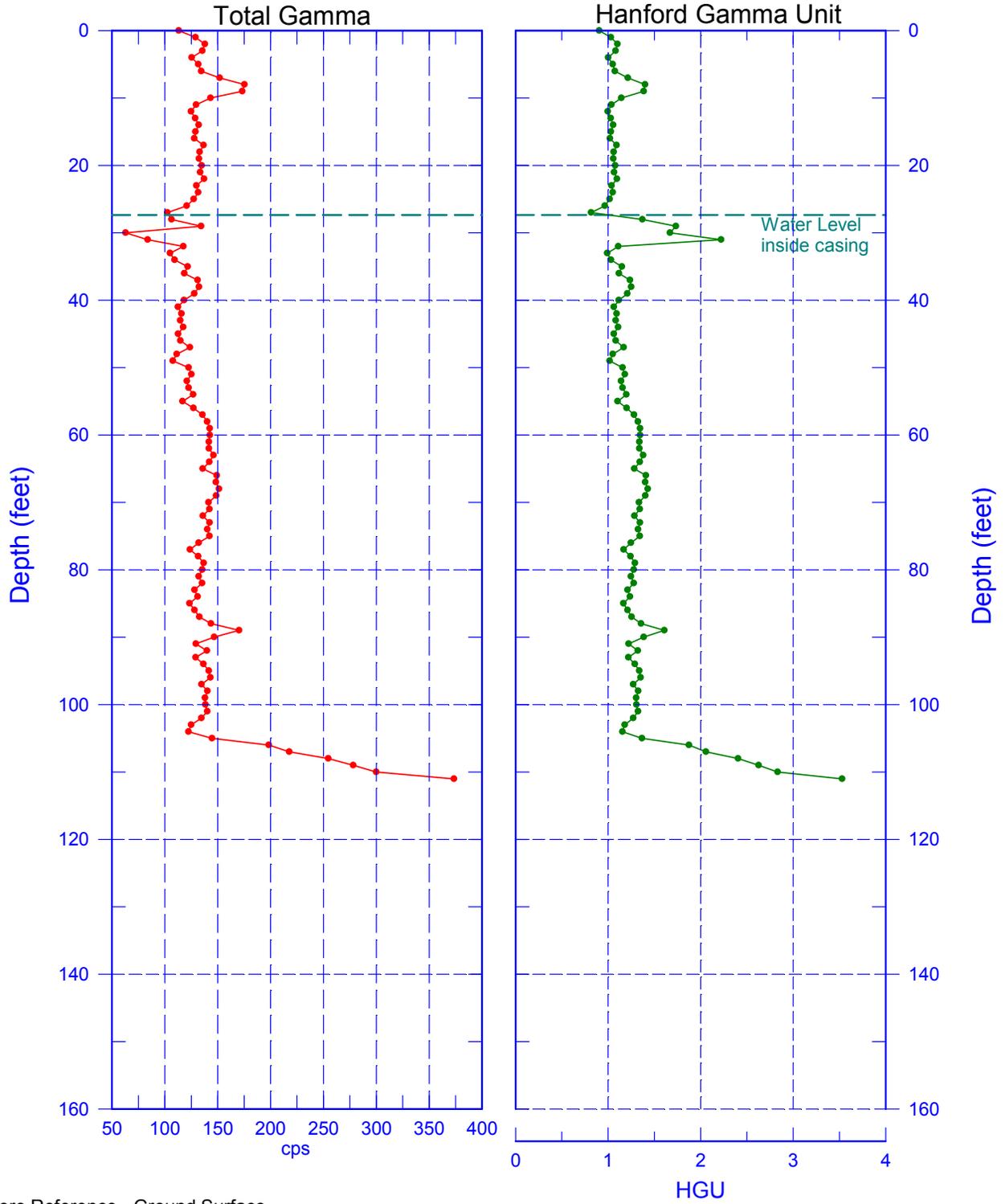


B-15

SGW-62712, REV. 0



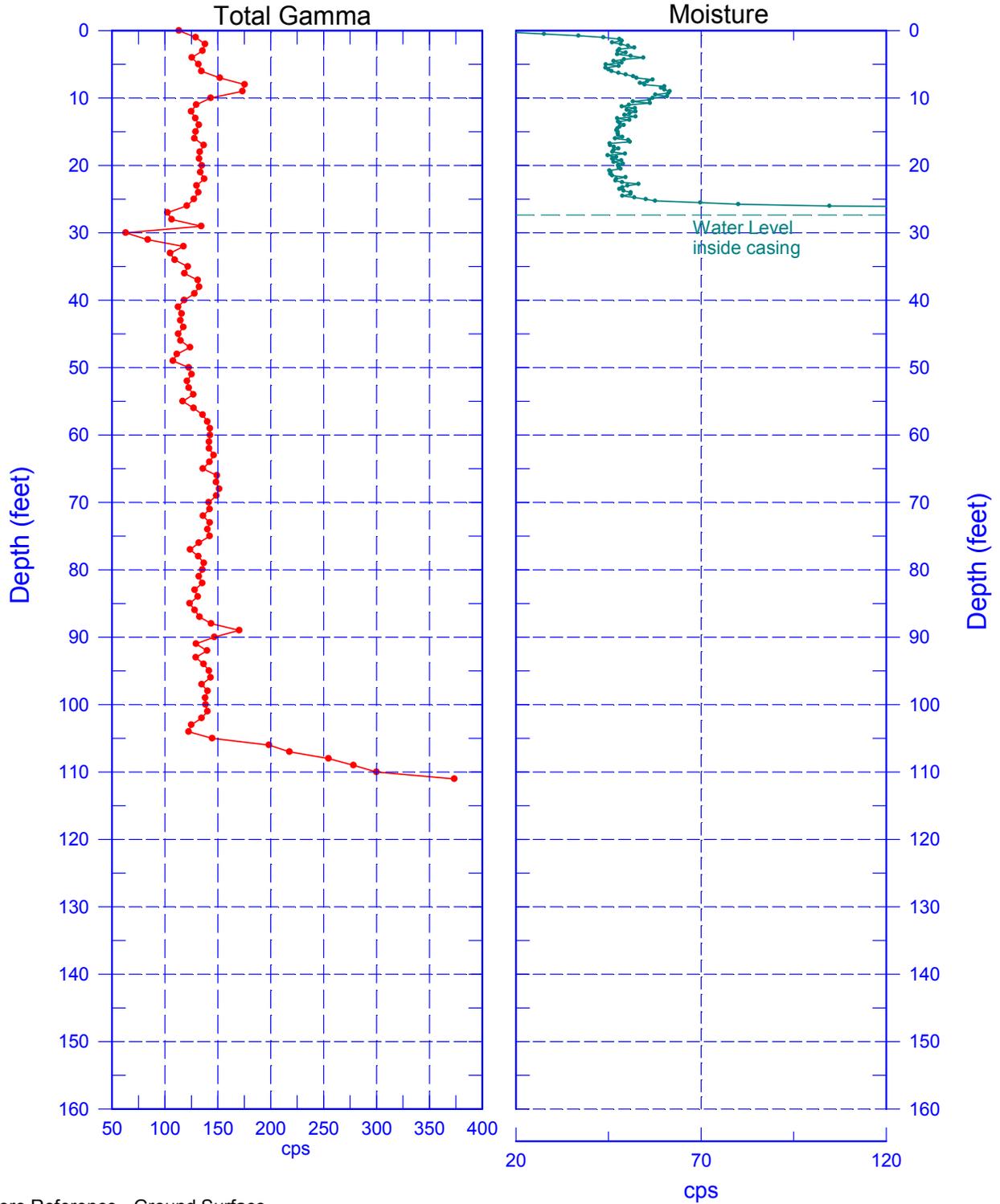
199-K-232 (C9920) Total Gamma & Hanford Gamma Unit



Zero Reference - Ground Surface



199-K-232 (C9920) Total Gamma & Moisture

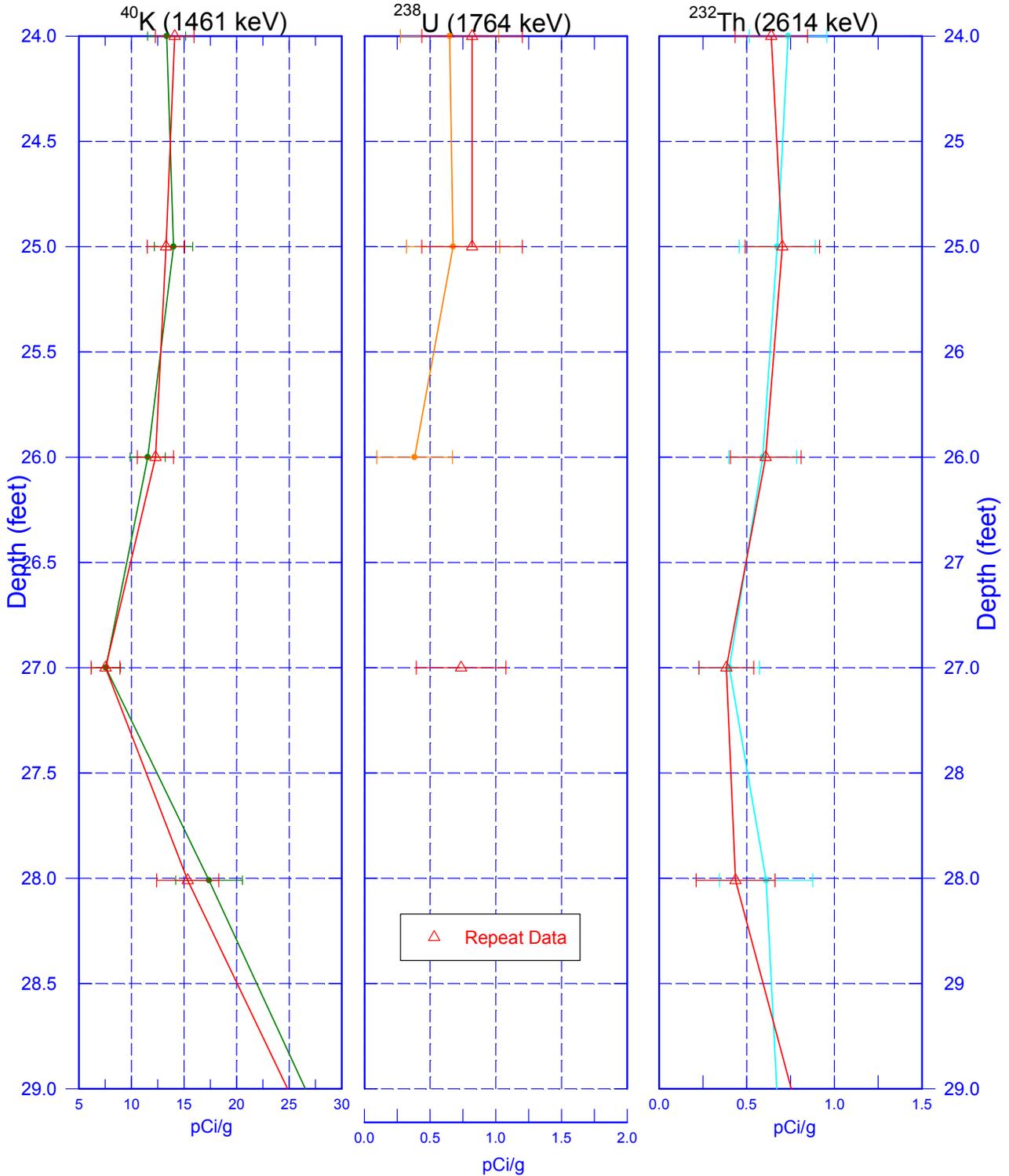


Zero Reference - Ground Surface



199-K-232 (C9920)

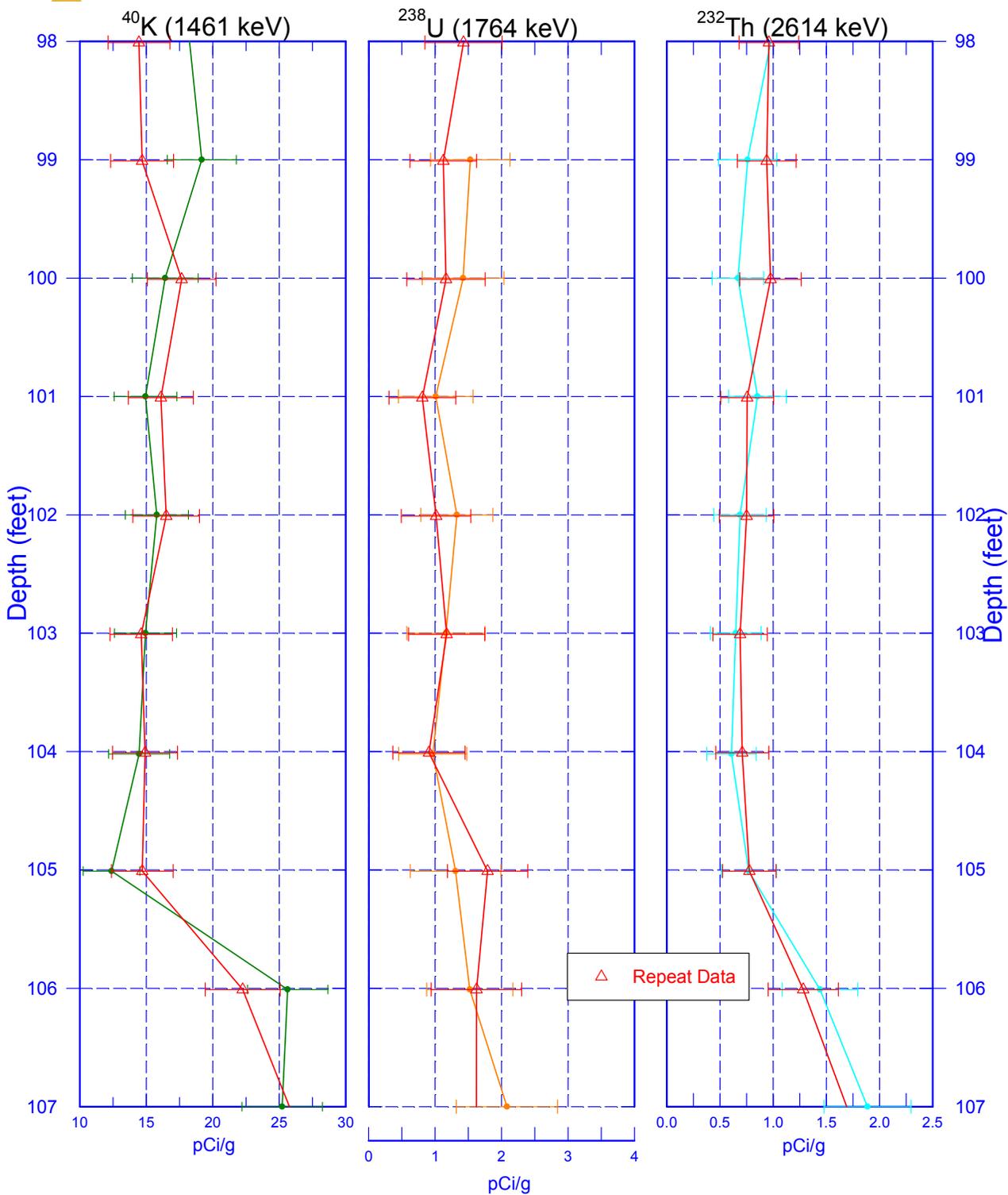
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



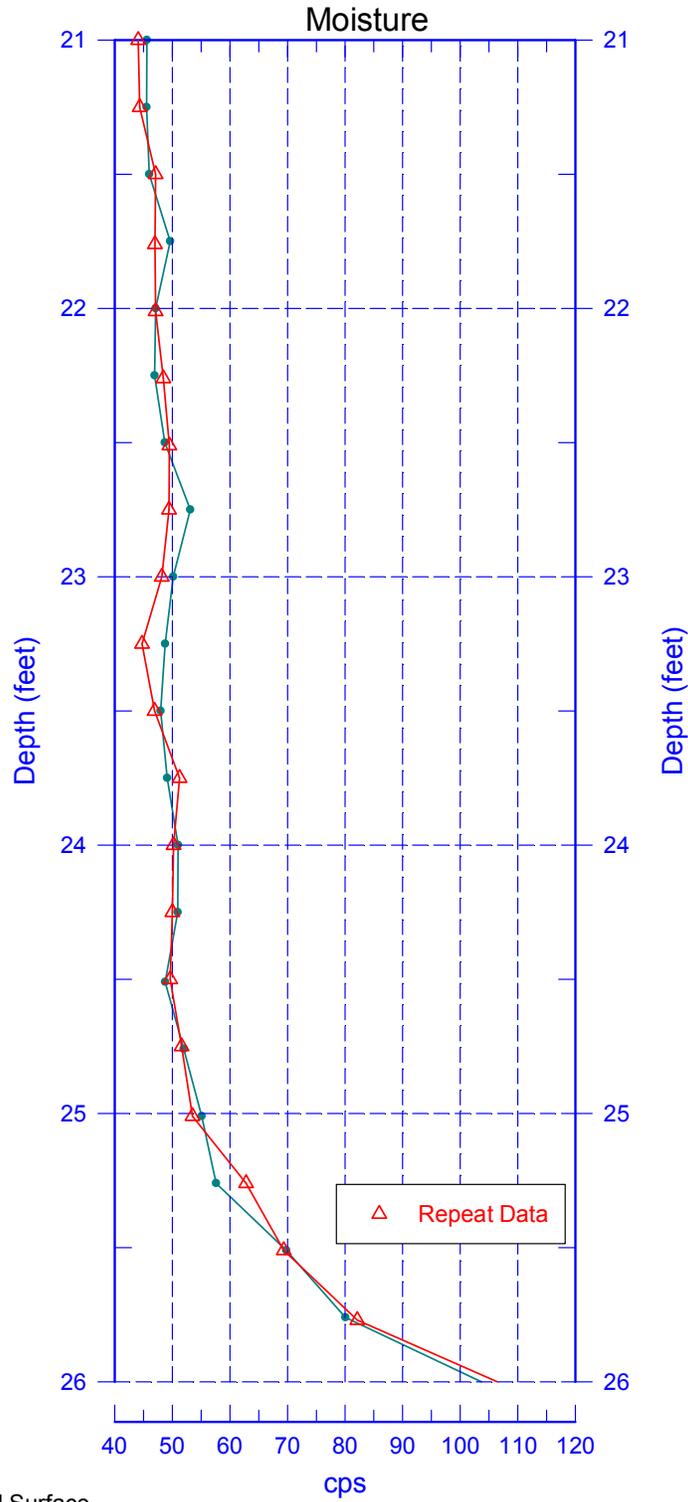
199-K-232 (C9920) Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



199-K-232 (C9920) Moisture Repeat Section



WELL SURVEY DATA REPORT

| | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| Project: | Prepared By: Neil P. Fastabend |
| | Company: CHPRC |
| Date Requested: 07/10/18 | Requestor: James D. Mehrer (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 KR-4 Well C9920 (199-K-232) located northeast of 100K Area. | Horizontal Datum: NAD83 (91) |
| | Vertical Datum: NAVD88 |
| | Units: Meters |
| | Hanford Area Designation: 100K |
| Coordinate System: Washington State Plane Coordinates (South Zone) | |
| Horizontal Control Monuments: Washington State Reference Network | |
| Vertical Control Monuments: T324 (COE) and FLINE (COE) | |

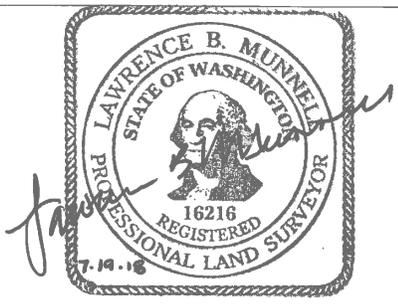
| Well ID | Well Name | Easting | Northing | Elevation | |
|---------|-----------|-----------|-----------|-----------|---------------------------------------|
| C9920 | 199-K-232 | 569245.51 | 147313.89 | | Center of Casing |
| | | | | 127.837 | Top Outer Casing, N. Edge Stamped "X" |
| | | | | 127.533 | Top Inner 6"SS Casing, N. Edge |
| | | | | 127.084 | Brass Survey Marker |
| | | | | | |
| | | | | | |
| | | | | | |

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

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

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



Appendix C

Well Documentation for C9922 (199-K-234)

Contents

| | |
|-----------------------------------------|------|
| Well Summary Sheet | C-1 |
| Borehole Log | C-3 |
| Drill Cutting Photographs | C-7 |
| Well Development and Testing Data | C-10 |
| Log Data Report | C-11 |
| Well Survey Data Report | C-23 |

WELL SUMMARY SHEET

Well ID : C9922 Well Name: 199-K-234 Start Date: 5/14/2018

Project: Three New Wells in 100-KR-4 OU Location: 200 ft Northwest of Bldg. 105-KE Finish Date: 9/7/2018

| CONSTRUCTION DATA | | Depth in Feet | GEOLOGIC/HYDROLOGIC DATA | |
|----------------------------------------------------------------------------------------------------------|---------|---------------|--------------------------|---------------------------------------------|
| Description | Diagram | | Graphic Log | Lithologic Description (ft bgs) |
| Concrete Pad: 0.50 ft above ground surface (ags) | | 0 | | 0.0 - 13.0 Crushed Gravel Drill Pad |
| 6-in. Protective Casing: 3.00 ft ags - 2.00 ft below ground surface (bgs) | | | | 13.0 - 100.0 Sandy Gravel (sG) |
| Type I/II Portland Cement Grout: 0.0 - 10.2 ft bgs | | 10 | | |
| 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.01 ft ags - 43.40 ft bgs | | 20 | | |
| #8 Bentonite Crumbles: 10.2 - 32.0 ft bgs | | 30 | | |
| 3/8-in. Coated Bentonite Pellet Seal: 32.0 - 38.2 ft bgs | | 40 | | |
| Stainless steel centralizer installed above and below screen and every 40 ft | | | | |
| 8-16 mesh Filter Pack Sand: 38.2- 139.9 ft bgs | | 50 | | |
| 6-in. I.D. Schedule 10, Type 304/304L, 50-slot (0.050 in.) Stainless Steel Screen: 43.40 - 133.44 ft bgs | | 60 | | |
| | | | | Static Water Level: 54.4 ft bgs (6/12/2018) |

Reported By: Kim Schuyler Geologist *Kim Schuyler* 9/9/2018
 Print Name Title Signature Date

Reviewed By: Jennifer Richardt Well Coordinator *J. Richardt* 9/17/18
 Print Name Title Signature Date

For Office Use Only

OR Doc Type: WMU Code(s):

WELL SUMMARY CONTINUATION SHEET

Well ID: C9922 Well Name: 199-K-234 Project: Three New Wells in 100-KR-4 OU

| CONSTRUCTION DATA | | Depth in Feet | GEOLOGIC/HYDROLOGIC DATA | | |
|-------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|---------------------------------|--|
| Description | Diagram | | Graphic Log | Lithologic Description (ft bgs) | |
| 8-16 mesh Filter Pack Sand: 38.2- 139.9 ft bgs | | 70 | | 13.0 - 100.0 Sandy Gravel (sG) | |
| | | 80 | | | |
| | | 90 | | | |
| | | 100 | | 100.0 - 105.0 Sand (S) | |
| | | 105.0 - 110.0 Gravelly Sand (gS) | | | |
| | | 110 | | 110.0 - 115.0 Sandy Gravel (sG) | |
| | | 115.0 - 118.0 Gravel (G) | | | |
| | | 118.0 - 127.0 Sandy Gravel (sG) | | | |
| | | 127.0 - 133.0 Silty Sandy Gravel (msG) | | | |
| | | 133.0 - 139.9 Silt (M) | | | |
| 6-in. I.D. Schedule 10, Type 304/304L, 50-slot (0.050 in.) Stainless Steel Screen: 43.40 - 133.44 ft bgs | | 140 | Total Depth: 139.9 ft (6/13/2018) | | |
| | | 150 | | | |
| | | 160 | | | |
| | | 6-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 133.44 - 138.39 ft bgs | | | |
| | | Straightness Test: Pass, 7/23/2018 | | | |
| | | Depths are in ft below ground surface. Borehole drilled with 14-in. O.D. casing from 0.0 - 7.4 ft bgs Borehole drilled with 10 3/4-in. O.D. casing from 0.0 - 137.6 ft bgs All temporary drill casing was removed from the ground. | | | |

| BOREHOLE LOG | | | | Page 1 of 4 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Well ID: CA922 | | Well Name: 199-K-234 | | Date: 05/15/18 |
| Project: | | Location: 700 Ft NW of 105-EE | | Reference Measure Point: 105-EE Grand 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 | | | 0-13': Backfill from Hanford formation | 14" OD casing (starter) 0-7.40 ft logs (backfilled on 05/16/18) Drill rig = cable tool 10 1/4" inch temp. casing. |
| 5 | | | | |
| 10 | | | @ 12' logs: sediment transitions from backfill to native formation, changing from dry, dusty sediment, to moist sediment w/ higher mafic content. | |
| 15 | G |  | 13-100' logs: sandy gravel (SG), 45% gravel, 50% sand, 5% silt. Gravel is moderately sorted and bimodal (avg size 5-10mm; 10-35mm), 70% very fine to fine pebbles, 90% mafic, gravel <mp is angular, else round. Sand is 80% coarse to very coarse sand, mostly basalt and well-sorted, 95% mafic, and angular. Sediment is moist and only dusty, clumps of sand (1/2 mm) react with HCl, color is 10 yr 2/2 (very dark brown) initially, but dries quick to 2.5 yr 9/1 (dark gray). | |
| 20 | G | | @ 15': gravel = 65% gravel, 30% sand, 5% silt. Biotite and muscovite present; sands poorly sorted. Sediments are either (compact) feldspar, large (4mm max) biotite, muscovite w/ gravel (1/3 of sand fraction) or loose, mixed with gravel. max gravel = 100mm, salt pepper sand. no (m) HCl. color = 2.5 yr 5/3 (light olive brown) | |
| 25 | G | | @ 15-21' logs, felsic content ↑ (gravel from 25-60% felsic; sand 40-75% felsic). gravel is poorly sorted, mdr rxn to HCl. (very fine sand) (fine sand) | |
| 30 | G | | @ 27': sand is well sorted, 80% VFS, 20% FS, w/ 5-10% sand is mica. gravel is 45% felsic, sand is 65% felsic. sps are barely moist, some rocks are lightly coated in dust that reacts to HCl. | |
| Reported By: <u>Kat Robertson</u> geologist 87 <u>[Signature]</u> 05/15/18 Print Name Title Signature Date | | | | |
| Reviewed By: <u>Sarah Springer</u> Sr. geologist <u>[Signature]</u> 08-14-18 Print Name Title Signature Date | | | | |
| For Office Use Only | | | | |
| OR Doc Type: | | WMU Code(s): | | |

| BOREHOLE LOG (Cont.) | | | Page <u>2</u> of <u>4</u> | |
|--------------------------------------|--------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Well ID: <u>C9972</u> | | Well Name: <u>19A-K-23A</u> | Date: <u>05/21/18</u> | |
| Location: <u>200 FT NW of 105-KE</u> | | | | |
| Depth (ft) | Sample | Graphic Log | Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other | Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other |
| 35 | | | 13-100 ft bags: Sandy Gravel (SG) | |
| | G | | @ 32 ft: 70% gravel, 30% sand, Tr silt. gravel is poorly sorted (max=50mm), 50% felsic, angular-round. Sand is poorly sorted, 45% felsic subangular. sediment is very dry, with no rxn HCl. | |
| 40 | G | | @ 37 ft: max gravel is 100mm (broken with fresh surfaces, so many karas), 75% felsic. Sand is well sorted, 90% very fine to fine sand. | |
| | G | | @ 42 ft: gravel is 60% ^{gravel} , 30% sand, 10% silt. coarse pebbles, gravel is angular-subangular, otherwise, subround to round. ^{gravel} within sand fraction, there are white clumps that react very strongly to HCl. other sed have mild rxn HCl. | |
| 45 | G | | @ 53 ft: gravel is moderate to poorly sorted, avg 220mm, max of 100mm, gravel < 30mm is 75% mafic, larger than 30mm is ~35% mafic. HCl reacts strongly when sed dry. color = 2.5y 4/2 (dark grayish brown). | * over the weekend (5/22/18 - 5/29/18) went from dry to wet with no additional drilling. Water level @ 52.9' (05/29/18) * 55 = split spoon |
| 50 | G | | | |
| 55 | G | | 75% gravel, 20% sand, 5% silt. | |
| | G | | @ 58 ft: gravel is moderately sorted and bimodal (70% very fine to fine pebbles, 20% coarse pebbles), 30% felsic. sand is poorly sorted, 10% felsic. sed are wet, 2.5y 4/3 (olive brown), HCl rxn when dry same. | |
| 60 | G | | @ 63 ft: gravel is poorly sorted (max=90mm), 55% felsic. sand is well sorted, 90% very fine sand, 55% felsic, rxn w/ HCl. | |
| 65 | G | | | |
| 70 | G | | | |

Reported By: Kat Robertson Geologist [Signature] 05/30/18
 Print Name Title Signature Date

| BOREHOLE LOG (Cont.) | | | Page <u>3</u> of <u>4</u> | | |
|-----------------------------------------|--------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Well ID: <u>C9922</u> | | Well Name: <u>199R-23A</u> | Date: <u>05/30/18</u> | | |
| Location: <u>200 Ft W of bldg 105KE</u> | | | | | |
| Depth (ft) | Sample | Graphic Log | Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other | Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other | |
| 75 | | | 13-100 ft bgs: Sandy gravel (SG). | | |
| 75-80 | GB | | <p>@ 78': 75% gravel, 20% sand, 5% silt, 10% gravel is very fine to medium pebbles. Gravel is moderately sorted, 55% felsic, angular to subangular. Sand is well sorted, 100% very fine to fine sand, 50% felsic. Seds are wet, react w/ HCl, (2.5y 1/4) olive brown in color.</p> | | |
| 80-85 | GB | | | | |
| 85-90 | GB | | | | |
| 90-95 | GB | | | | |
| 95-100 | GB | | | @ 93': gravel is poorly sorted (max = 65 mm). | |
| 100-105 | GB* | | | 100-118 ft bgs: coarsening downward sequence. | @ 98' bgs, hearing formation, so no gravel obtained. |
| 105-110 | GB | | | <p>① 105-108 ft bgs: Sand (S). 5% gravel, 95% sand 0% silt. max gravel size = 10 mm. Sand is 90% medium sand, very well sorted, 75% felsic. Seds are wet, no rxn to HCl, 2.5y 1/4 (olive brown).</p> <p>② 105-110 ft bgs: Gravelly sand (GS) - 15% gravel, 85% sand, tr silt. gravel is poorly sorted, very fine to medium pebbles, 55% felsic, angular to subangular. Sand is poorly sorted, 50% felsic, wet, no rxn to HCl, 2.5y 1/4 (olive brown).</p> <p>@ 108 ft transition to SG begins.</p> | <p>↳ 108 ft bgs, depth recovery leads to alternating sand pump and drive barrel.</p> |
| 110-115 | GB | | | <p>③ 110-115 ft bgs: sandy gravel (SG). 70% gravel, 30% sand, tr silt. Gravel is poorly sorted (max = 60 mm), 75% felsic, angular or round. Sand is poorly sorted, 50% felsic, wet, some rxn HCl, 2.5y 1/4 (olive brown).</p> | |

Reported By: Kat Robertson Geologist [Signature] 05/30/18
 Print Name Title Signature Date

| BOREHOLE LOG (Cont.) | | | Page <u>A</u> of <u>4</u> | |
|-----------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Well ID: <u>C9922</u> | | | Date: <u>05/06/18</u> | |
| Well Name: <u>199-K-284</u> | | Location: <u>200 ft NW of 105 KE</u> | | |
| Depth (ft) | Sample | Graphic Log | Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other | Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other |
| 115 | GB | | 110-118 ft bags: coarsening downward sequence. | |
| | | | ① 110-105 ft: sand (s) | |
| | | | ② 105-110 ft: gravelly sand (gs) | |
| | | | ③ 110-115 ft: sandy gravel (sg) | |
| | | | ④ 115-118 ft: gravel. 85% gravel, 15% sand, tr silt | |
| 120 | GB | | gravel is poorly sorted (max=60mm). A distinct change to river rocks occur (colorful, smooth, many are flat and oval; veinmg), 75% felsic, small (very fine to fine) pebbles are angular; otherwise, round. Sand is poorly sorted (50% med/medium sand) to coarse sand, 50% felsic. Sands are wet, react w/ HCl. | @118 ft: sample may not be representative. Had to be collected from sand pump due to difficult recovery. |
| | | | 2.5u 1/4 (olive brown). | @118 ft, drive barrel was used. |
| | | | ① 118-127 ft bags | |
| | | | 118 ft bags: Sandy gravel (sg). | |
| | | | @ 118 ft: sg. 70% gravel, 30% sand, tr silt. | |
| | | gravel is poorly sorted (max=50mm), 75% felsic, angular to sub angular (<medium pebbles), subround to round (>mp). Sand is moderately sorted, 100% fs, 20% very fine and medium sand, 50% felsic, wet, no rxn HCl. | TD @ 139.9 ft bags, DSC = 137.64 ft bags | |
| | | @ 122 ft: gravel & 50% sand & 50% silt | | |
| | | sand is well-moderately sorted, 80% fine to medium sand, rxn w/ HCl. | | |
| | | @ 127 ft: | | |
| | | 127-133 ft bags: silty sandy gravel (msg). | | |
| | | @ 127 ft: msg. 50% gravel, 35% sand, 15% silt. | | |
| | | gravel is poorly sorted (max=7.5mm), 60% felsic, angular to round. Sand is 80% very fine sand, 20% fs (fine sand) to medium sand, mod-well sorted, 30% felsic. Seeds are wet, but highly compacted w/ localized pins to HCl through out drive barrel. Color is varied, some 2.5u 9/2 (greenish brown), 2.5u 1/2 (grayish brown), 2.5u 3/2 (darker), 2.5u 4/4 (light yellowish brown). silt pinns thru sand. | white run clumps | |
| | | @ 132 ft: gravelly sand (gs). 20% gravel, 80% sand, tr silt | @ 132, sample left over from NCS, may not be representative | |
| | | gravel is poorly sorted (max=20mm). sand is poorly sorted. | * throughout borehole grab samples, mica has been present. | |
| | | 133-139.9 ft bags (TD): silt (m). tr gravel and sand, 100% silt. Silt is plast+ and malleable, no rxn to HCl, moist, with some less plastic clay layers. | | |
| | | 2.5u 5/4 (light olive brown). | | |

Reported By:

Kat Robertson

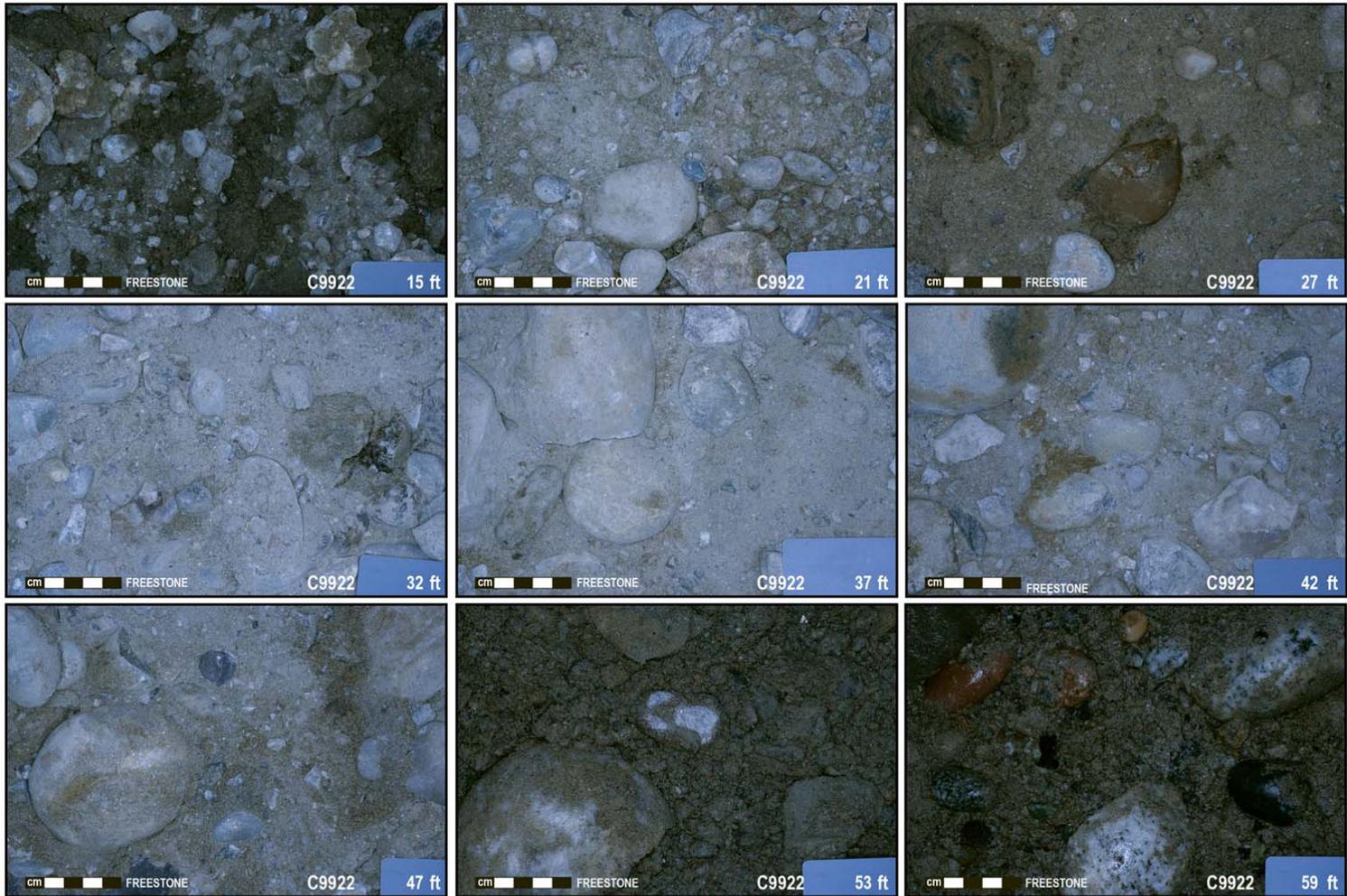
Geologist

Print Name

Title

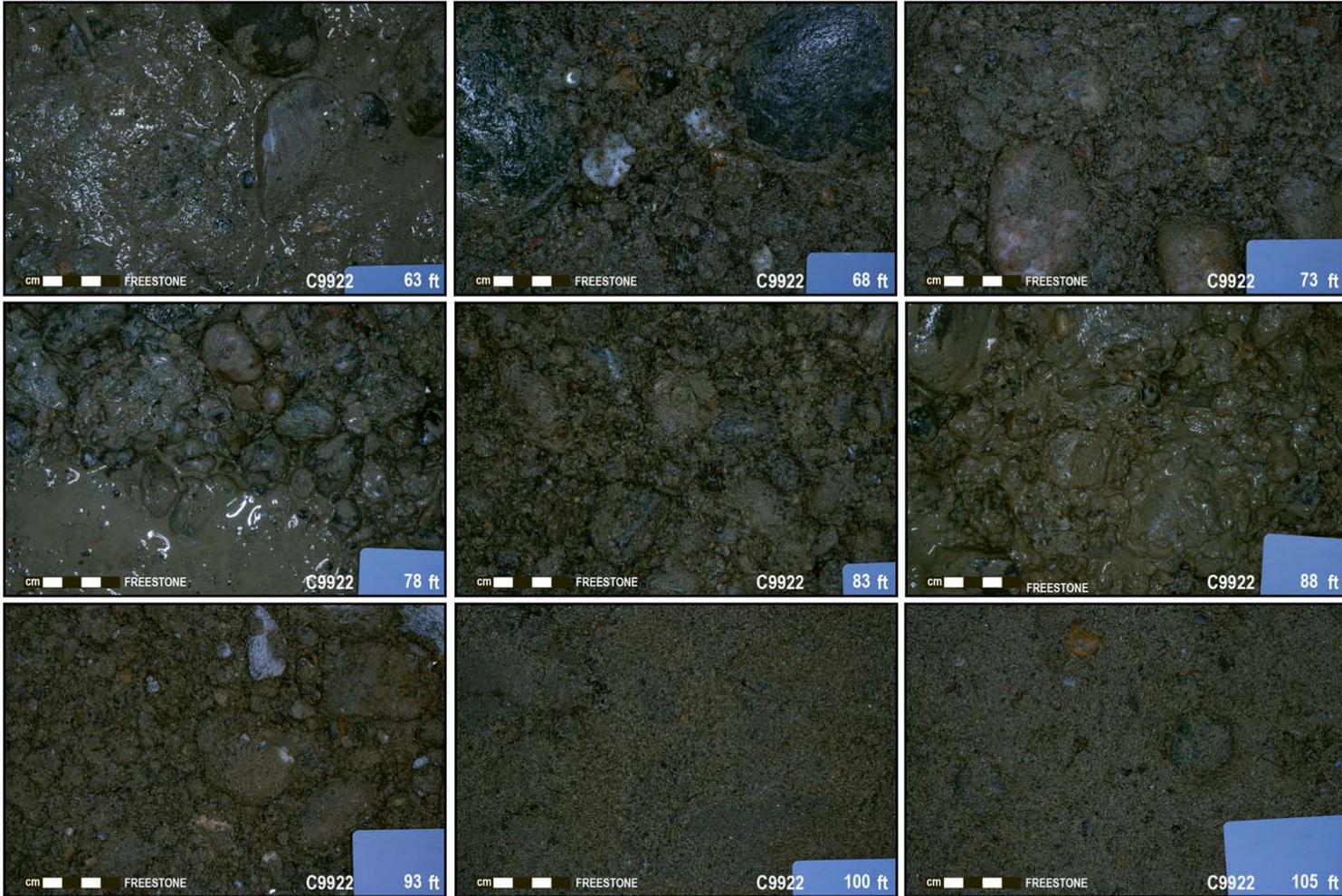
Signature

Date



Drill Cutting Photographs for C9922 (199-K-234)

C-8

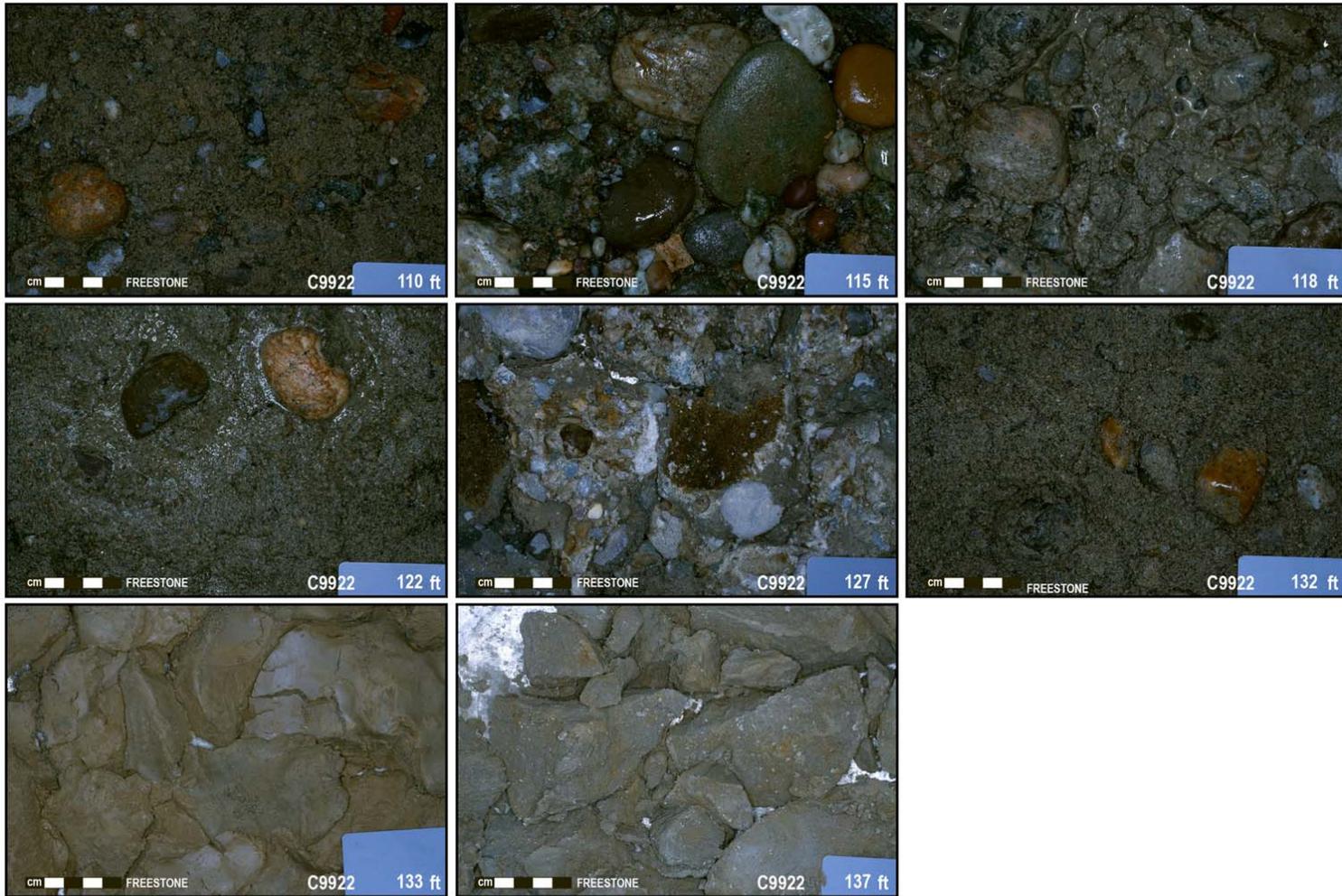


SGW-62712, REV. 0



Drill Cutting Photographs for C9922 (199-K-234)

C-9



SGW-62712, REV. 0



Drill Cutting Photographs for C9922 (199-K-234)

| WELL DEVELOPMENT AND TESTING DATA | | | | | | | | |
|-------------------------------------------------------------------------------------------|----------------------------|----------------------|----------------------|------------------------------------------------------------------------------------------------|------------|----------------|--------------------|-----------------------|
| Well ID: C9922 | | | Well Name: 199-K-234 | | | Date: 9/7/2018 | | |
| Location: 200 ft Northwest of Building 105-KE | | | | | | | | |
| Reference Measuring Point (unless otherwise noted): TOP OF OUTER CASING (TOC) | | | | | | | | |
| Has the well been surveyed? <input type="radio"/> Yes <input checked="" type="radio"/> No | | | | Does the well have a cement pad? <input checked="" type="radio"/> Yes <input type="radio"/> No | | | | |
| Initial Conditions | | | | <p style="margin-left: 20px;">A = <u>2.41</u> B = <u>1.01</u> C = <u>1.40</u></p> | | | | |
| | | Start of Job | End of Job | | | | | |
| STATIC WATER LEVEL: | | | | | | | | |
| Date: <u>9-7-18</u> | 59.92 'bgs | 60.39 'bgs | | | | | | |
| Date: | | | | | | | | |
| DEPTH TO BOTTOM: | | | | | | | | |
| Date: <u>9-7-18</u> | 138.8 'bgs | 141.5 'bgs | | | | | | |
| Date: .. | | | | | | | | |
| Intake Depth (ft bgs) | Specific Capacity (gpm/ft) | Troll Depth (ft bwt) | Turbidity (NTU) | | Pump Start | Pump Stop | Pumping Rate (gpm) | Maximum Drawdown (ft) |
| | | | Initial | Final | | | | |
| 125.9 | 12.8 | 109.1 | 34.5 | 5.36 | 0750 | 0823 | 230 | 17.9 |
| 125.9 | 12.9 | 109.1 | 5.80 | 1.12 | 0916 | 0939 | 180 | 13.9 |
| 104.8 | 11.7 | 77.20 | 6.62 | 0.74 | 1003 | 1023 | 150 | 12.8 |
| 83.7 | 15.1 | 77.20 | 11.7 | 1.43 | 1108 | 11.29 | 140 | 9.3 |
| 72.2 | 15.1 | 67.20 | 1.84 | 0.78 | 1158 | 1258 | 107 | 7.1 |
| Total Pumped: 24,090 gallons | | | | | | | | |
| Pump Model: Grundfos 25 hp | | | | | | | | |
| Troll Serial Number and Pressure Range (PSI and depth): 403065 70 m / 231 ft | | | | | | | | |
| Comments: | | | | | | | | |
| Prepared By: | | | | | | | | |
| Kim Schuyler | | | | | | 9/11/2018 | | |
| Print Name | | | Signature | | | Date | | |
| Reviewed By: | | | | | | | | |
| Jennifer Richard | | | | | | 9/17/18 | | |
| Print Name | | | Signature | | | Date | | |
| For Office Use Only | | | | | | | | |
| OR Doc Type: | | | | WMU Code(s): | | | | |



Technical Solutions

199-K-234 (C9922) Log Data Report

Borehole Information

| | | | | | | |
|-----------------------|------------|----------|------------------------|------------|------------------|----------------|
| Log Date | 2018-06-18 | Filename | C9919_HG-NM_2018-06-18 | | Site | 100-KR-4 |
| DTW ¹ (ft) | | DTW Date | DTW Source | Drill Date | Total Depth (ft) | Depth Datum |
| 53.36 | | 06/14/18 | SN3 | 06/13/18 | 139.9 | Ground Surface |

Casing Information

| Casing Type | Drill Type | Stickup (ft) | Diameter (in.) | | Thickness (in.) | Top (ft) | Bottom (ft) |
|----------------|------------|--------------|----------------|--------|-----------------|----------|-------------|
| | | | Outer | Inside | | | |
| Threaded Steel | Cable Tool | 4.0 | 10 3/4 | 9 1/2 | 5/8 | -4.0 | 137.64 |

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 138 ft. Zero reference is ground surface.

Logging Equipment Information

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

| | | | |
|----------------------------|---------------------|-------------------|-------------------------------------|
| Logging System | Gamma 1HD | Type | He-3 (CPN 503DR) NMLS |
| Effective Calibration Date | 10/16/2017 | Serial No. | H310700353 |
| Calibration Reference | HGLP-CC-161, Rev. 0 | Logging Procedure | SGRP-PRO-OP-53024, Rev. 0, Change 2 |

SGLS Log Run Information

| Log Run | 3 | 4 | 5 Repeat | | |
|--------------------|------------------------------|------------------------------|------------------------------|--|--|
| HEIS Number | 1020208 | 1020209 | 1020210 | | |
| Date | 06/14/18 | 06/18/18 | 06/18/18 | | |
| Logging Engineer | Felt/Meisner | Spatz/McClellan | Spatz/McClellan | | |
| Start Depth (ft) | 0.0 | 60.01 | 123.0 | | |
| Finish Depth (ft) | 61.02 | 138.01 | 137.01 | | |
| Count Time (sec) | 100 | 100 | 100 | | |
| Live/Real | R | R | R | | |
| Shield (Y/N) | N | N | N | | |
| MSA Interval (ft) | 1.0 | 1.0 | 1.0 | | |
| Log Speed (ft/min) | NA | NA | NA | | |
| Pre-Verification | C9922ALD2018 0614AV00CAB1 | C9922ALD2018 0618BV00CAB1 | C9922ALD2018 0618BV00CAB1 | | |

¹ depth to water inside casing

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| Log Run | 3 | 4 | 5 Repeat | | |
|--------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--|--|
| Start File | AD000000 | BD006001 | CD012300 | | |
| Finish File | AD006102 | BD013801 | CD013701 | | |
| Post-Verification | C9922ALD2018 0614AV00CAA1 | C9922ALD2018 0618CV00CAA1 | C9922ALD2018 0618CV00CAA1 | | |
| Depth Return Error (in.) | 1.0 high | N/A | 0.5 low | | |
| Comments | No fine gain adjustments made | No fine gain adjustments made | No fine gain adjustments made | | |

NMLS Log Run Information

| Log Run | 1 | 2 Repeat | | |
|--------------------------|------------------------------|------------------------------|--|--|
| HEIS Number | 1020211 | 1020212 | | |
| Date | 06/14/18 | 06/14/18 | | |
| Logging Engineer | Felt/Meisner | Felt/Meisner | | |
| Start Depth (ft) | 0.0 | 43.0 | | |
| Finish Depth (ft) | 53.03 | 49.0 | | |
| Count Time (sec) | 15 | 15 | | |
| Live/Real | R | R | | |
| Shield (Y/N) | N | N | | |
| MSA Interval (ft) | 0.25 | 0.25 | | |
| Log Speed (ft/min) | NA | NA | | |
| Pre-Verification | C9922AHD2018 0614AV00CAB1 | C9922AHD2018 0614AV00CAB1 | | |
| Start File | AD000000 | BD004300 | | |
| Finish File | AD005303 | BD004900 | | |
| Post-Verification | C9922AHD2018 0614GV00CAA1 | C9922AHD2018 0614GV00CAA1 | | |
| Depth Return Error (in.) | N/A | 0.25 high | | |
| Comments | None | None | | |

Logging Operation Notes

A centralizer was installed on the sondes.

Analysis Notes

| | | | |
|---------------------|------------------------------------------------------|-------------|----------|
| Analyst | P.D. Henwood | Date | 06/27/18 |
| Reference(s) | SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0 | | |

A casing correction for a 5/8-in. thick casing was applied to the SGLS log data.

Casing diameter and thickness corrections for 10 3/4-in. OD casing and 5/8-in. thick casing were applied to the NMLS data to convert to volume percent moisture. An initial count rate correction for a sediment composition of a 50-50% ratio of basalt fragments to quartzofeldspathic sand (HGLP-OTH-028, in progress) was also applied.

A water correction was applied to SGLS data below 53.36 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

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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 were removed from 60 and 61 ft. This results in a data set where only one data point is presented for each depth.

HGU² 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. The KUT plots suggest the bottom 2 ft of the borehole may be impacted by mud inside the casing causing concentrations to be overestimated.

The neutron moisture log primarily responds to moisture present in the surrounding formation. In general, an increase in count rate reflects an increase in moisture content. Moisture content may increase in sediments of relatively high silt or clay content.

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

List of Log Plots

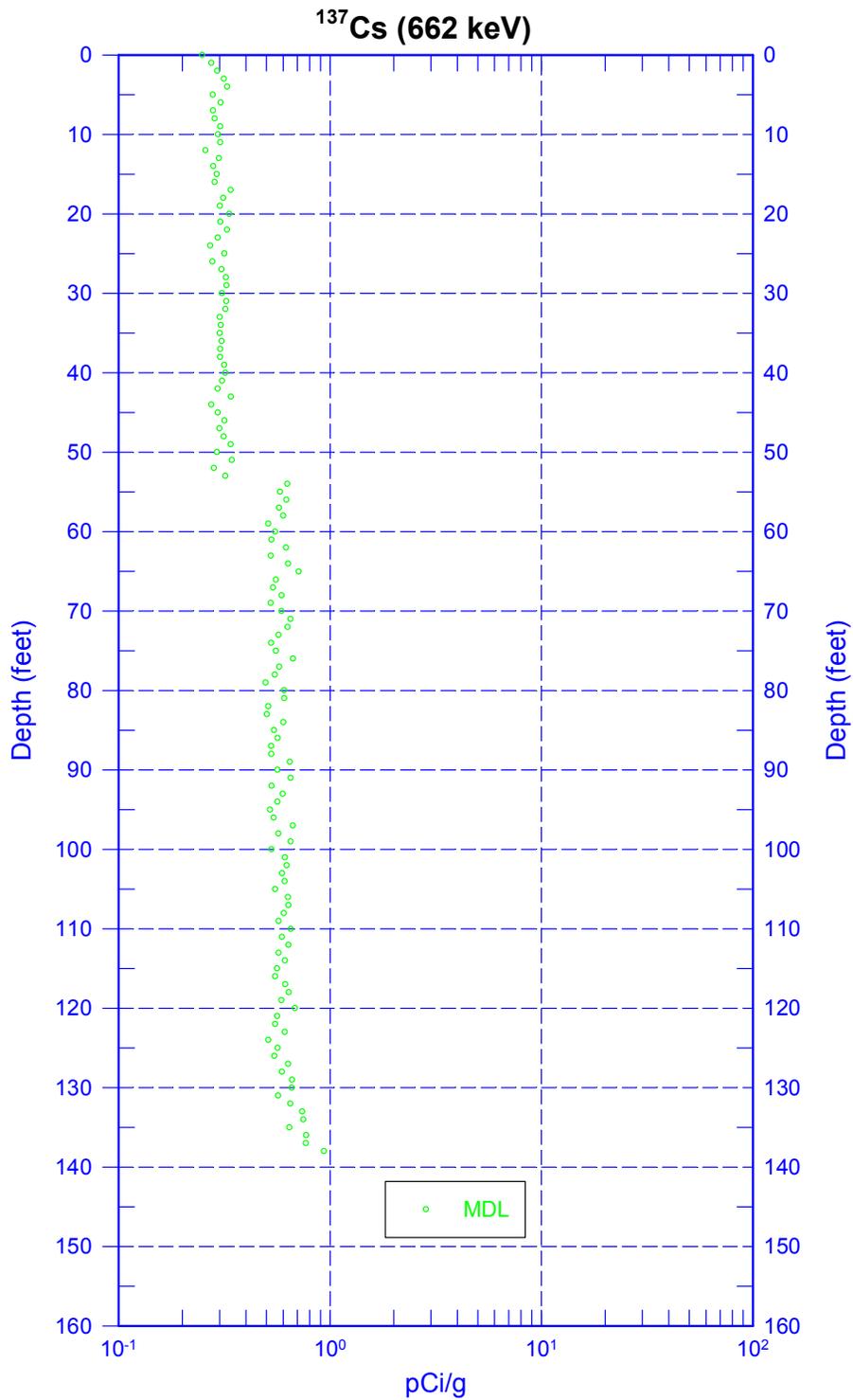
Depth Reference is ground surface.

- Manmade Radionuclides (0-160 ft)
- Natural Gamma Logs (0-160 ft)
- Combination Plot (0-120 ft)
- Combination Plot (110-230 ft)
- Combination Plot (0-150 ft)
- Total Gamma & Moisture (0-160 ft)
- Total Gamma & Hanford Gamma Unit (0-160 ft)
- Repeat Section of Natural Gamma Logs (123-138 ft)
- Moisture Repeat Section (43-49 ft)

² Hanford Gamma Unit



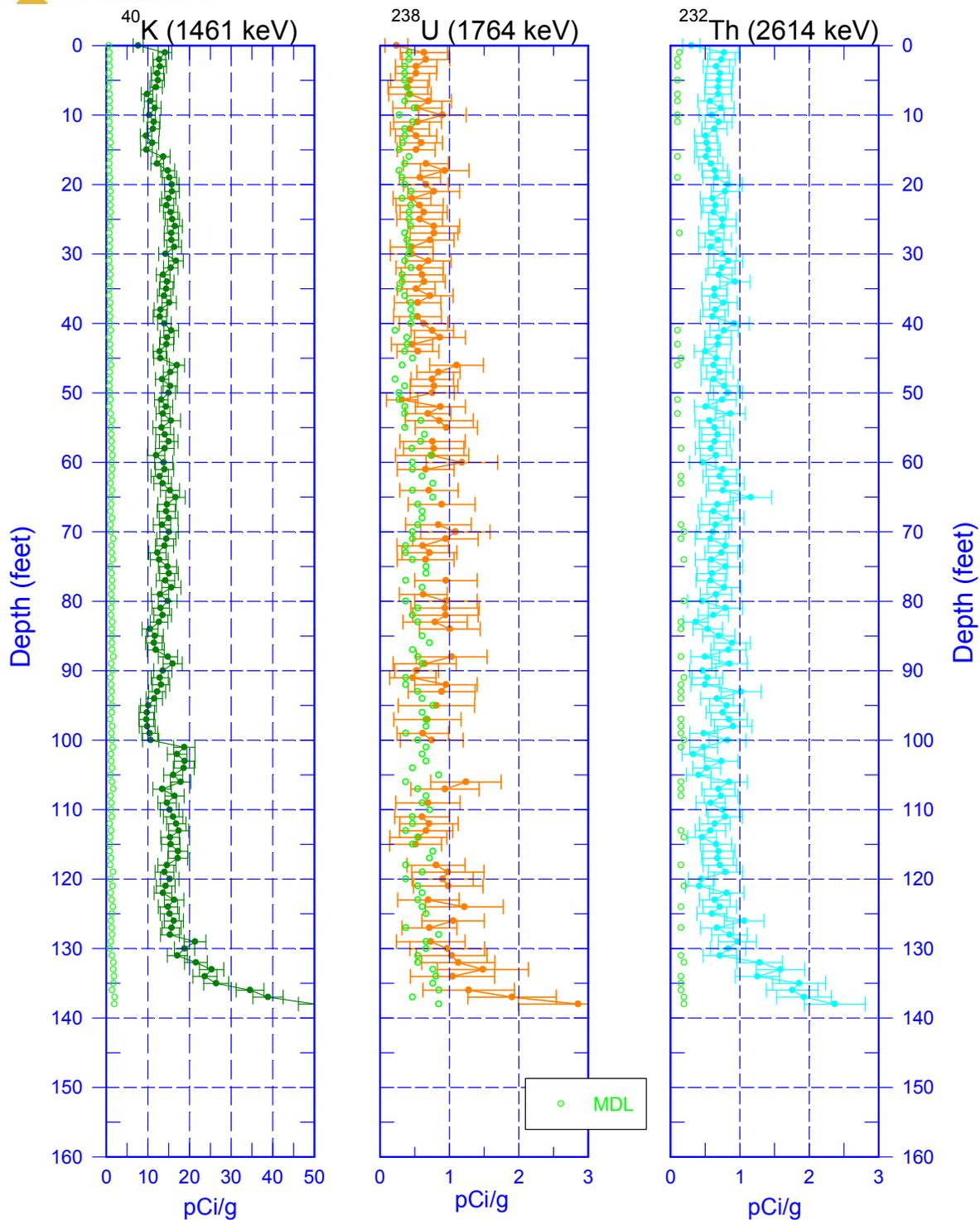
199-K-234 (C9922) Manmade Radionuclides



Zero Reference - Ground Surface



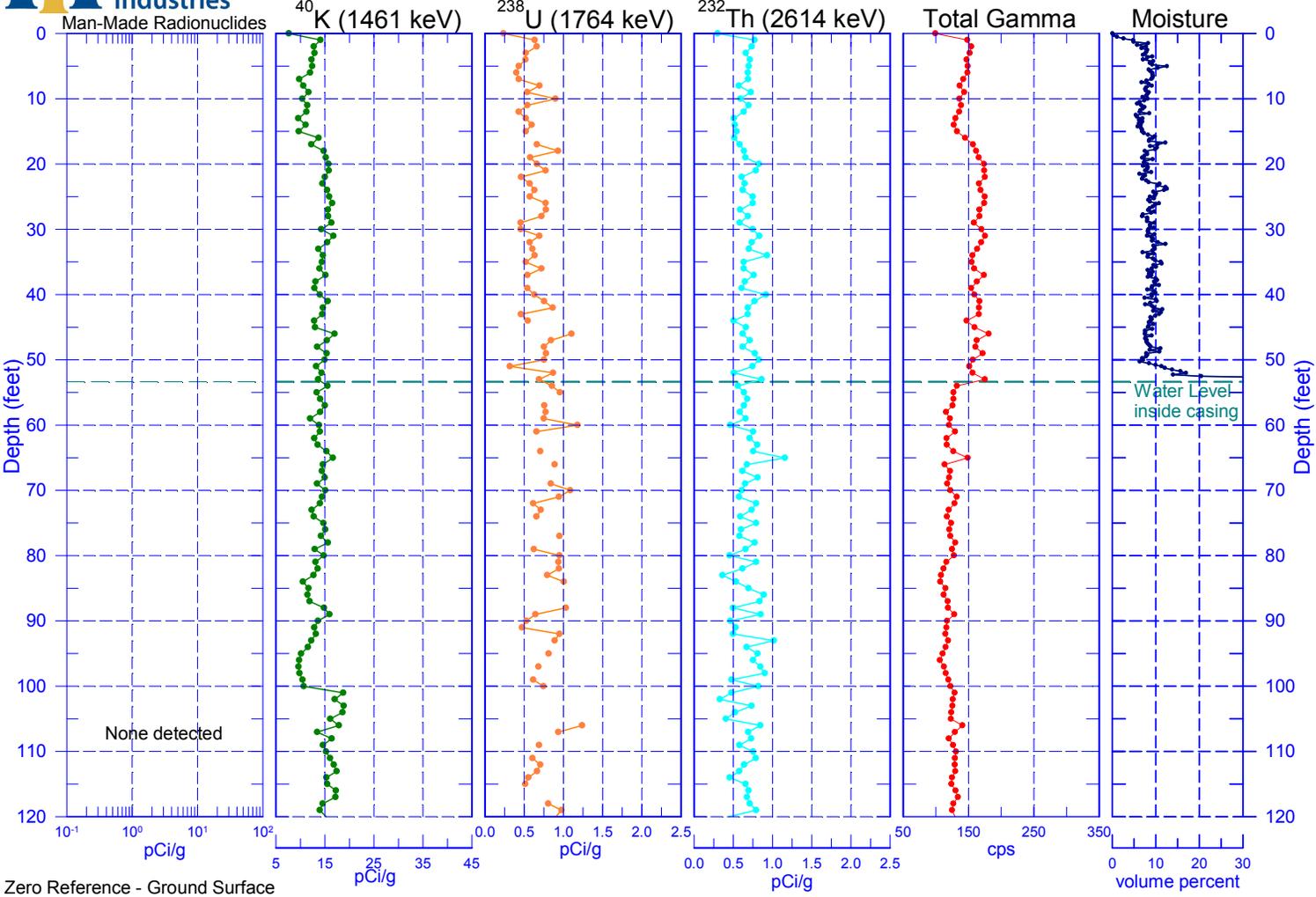
199-K-234 (C9922) Natural Gamma Logs



Zero Reference - Ground Surface



199-K-234 (C9922) Combination Plot

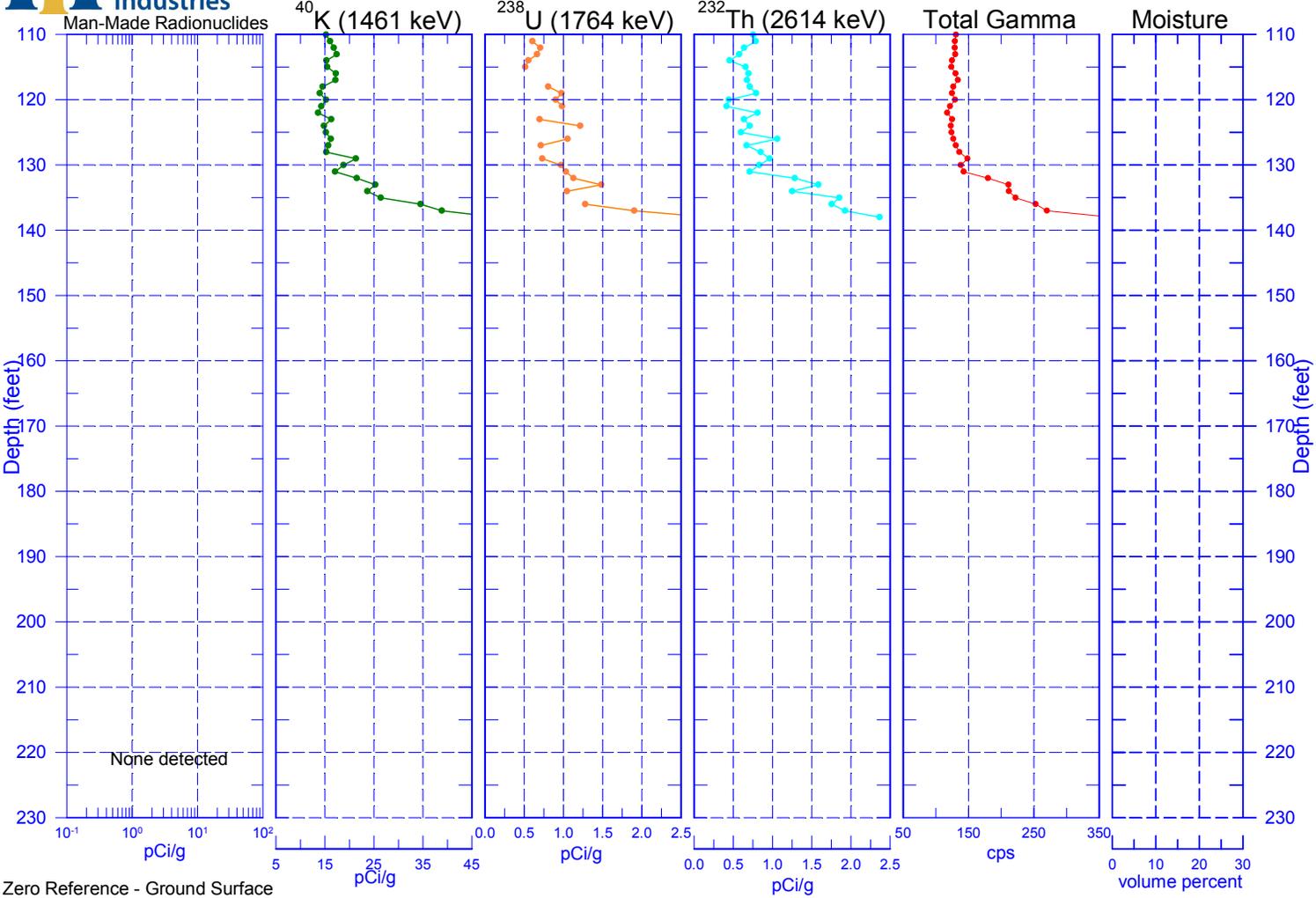


C-16

SGW-62712, REV. 0



199-K-234 (C9922) Combination Plot

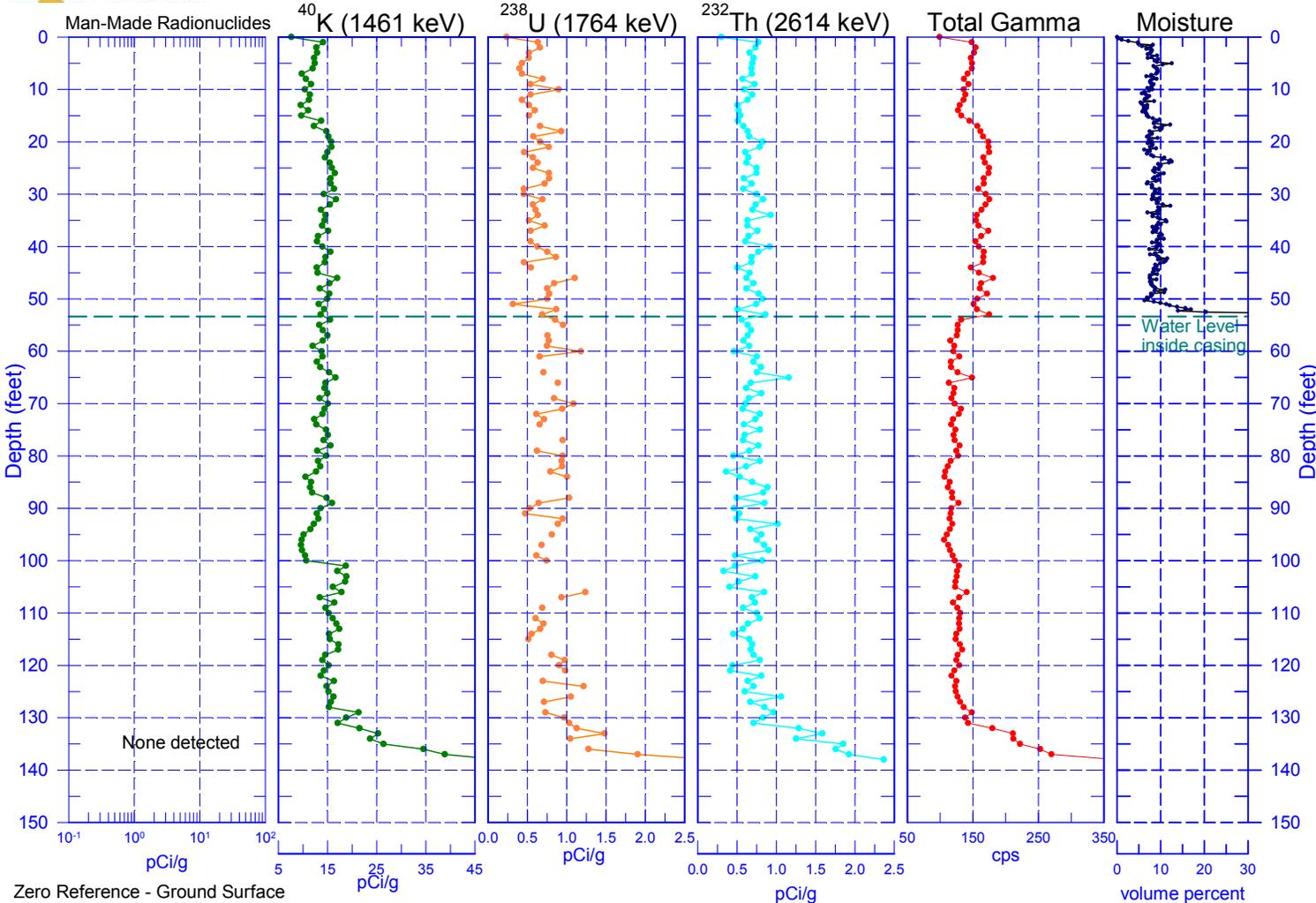


C-17

SGW-62712, REV. 0



199-K-234 (C9922) Combination Plot

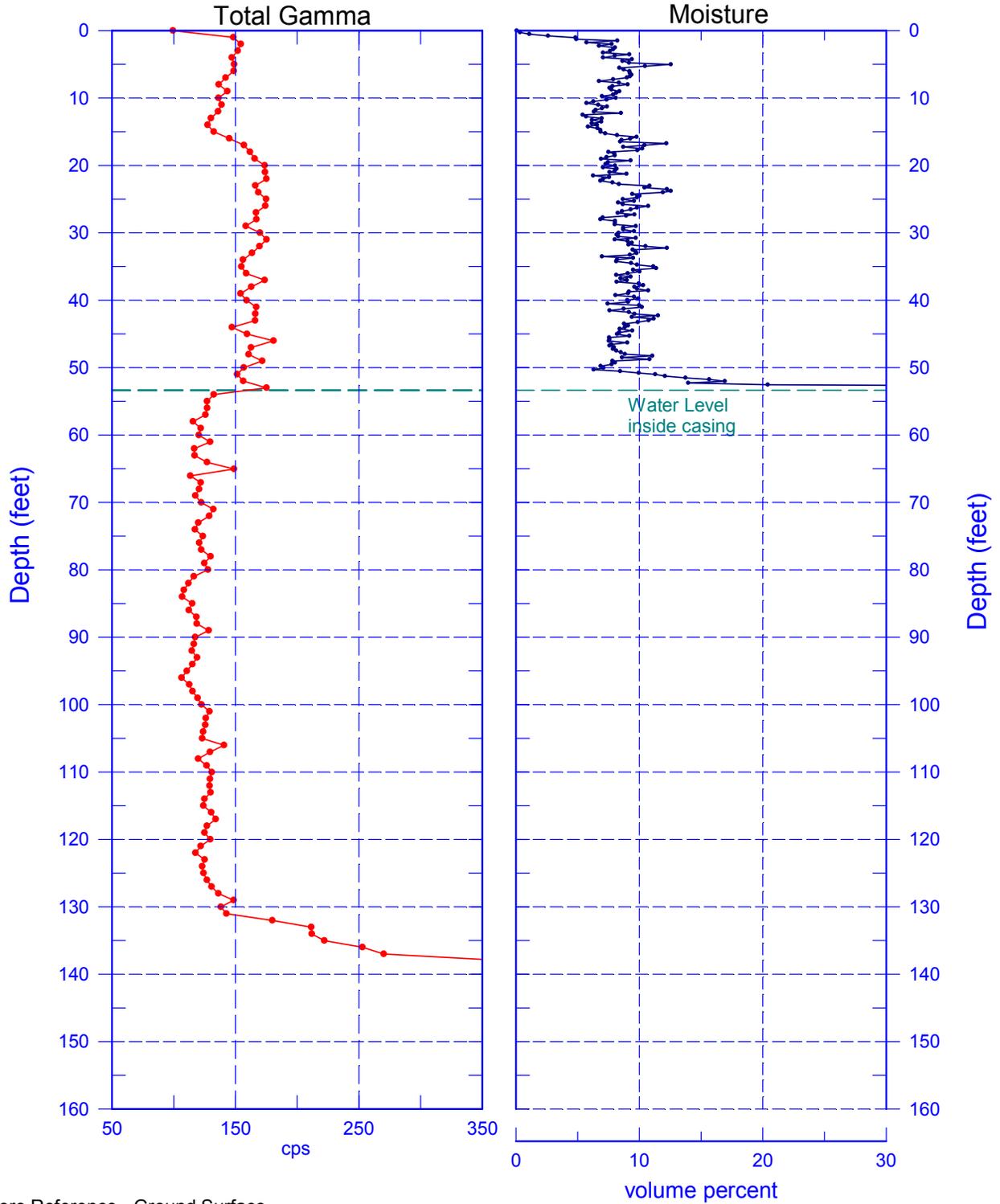


C-18

SGW-62712, REV. 0



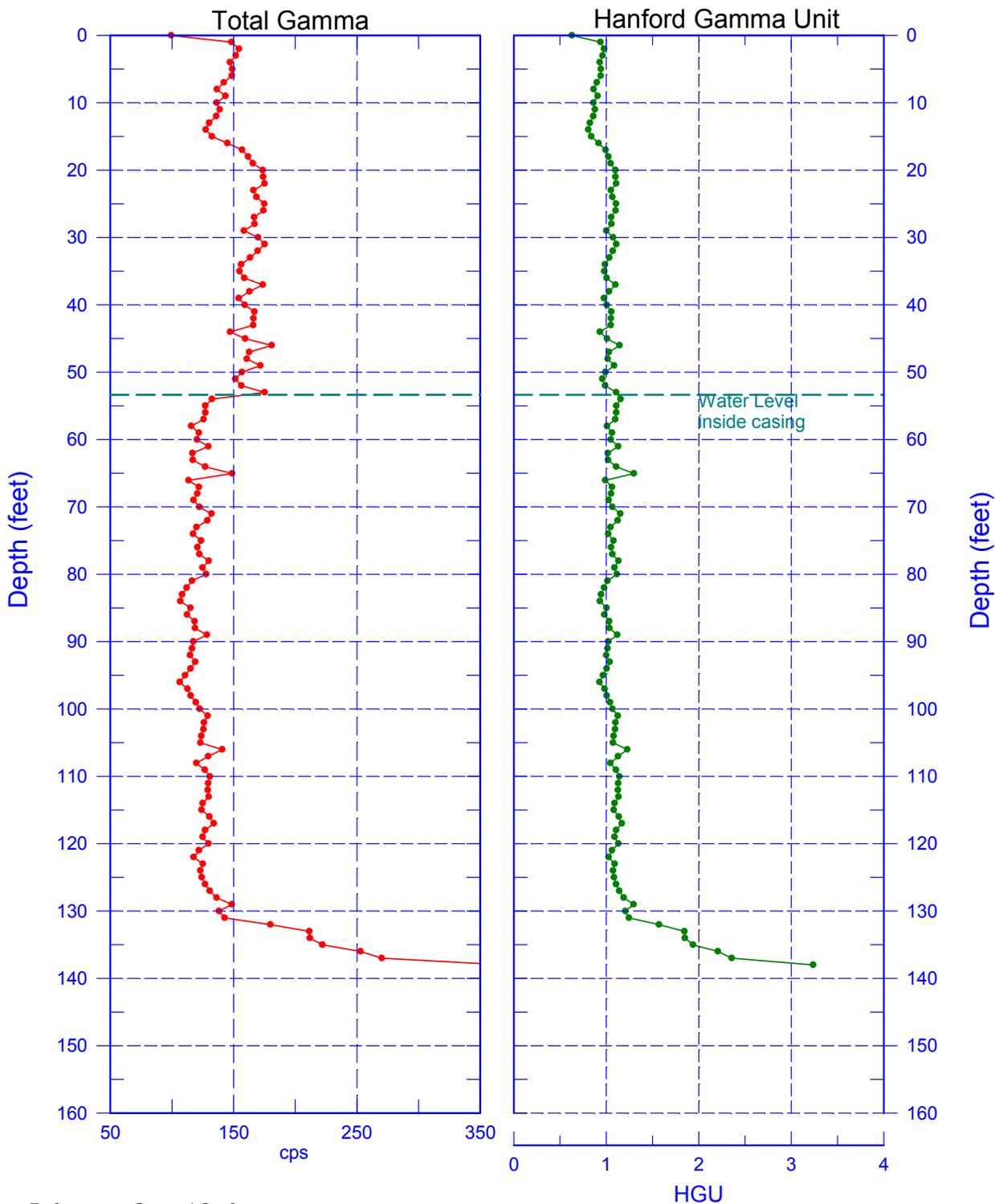
199-K-234 (C9922) Total Gamma & Moisture



Zero Reference - Ground Surface



199-K-234 (C9922) Total Gamma & Hanford Gamma Unit

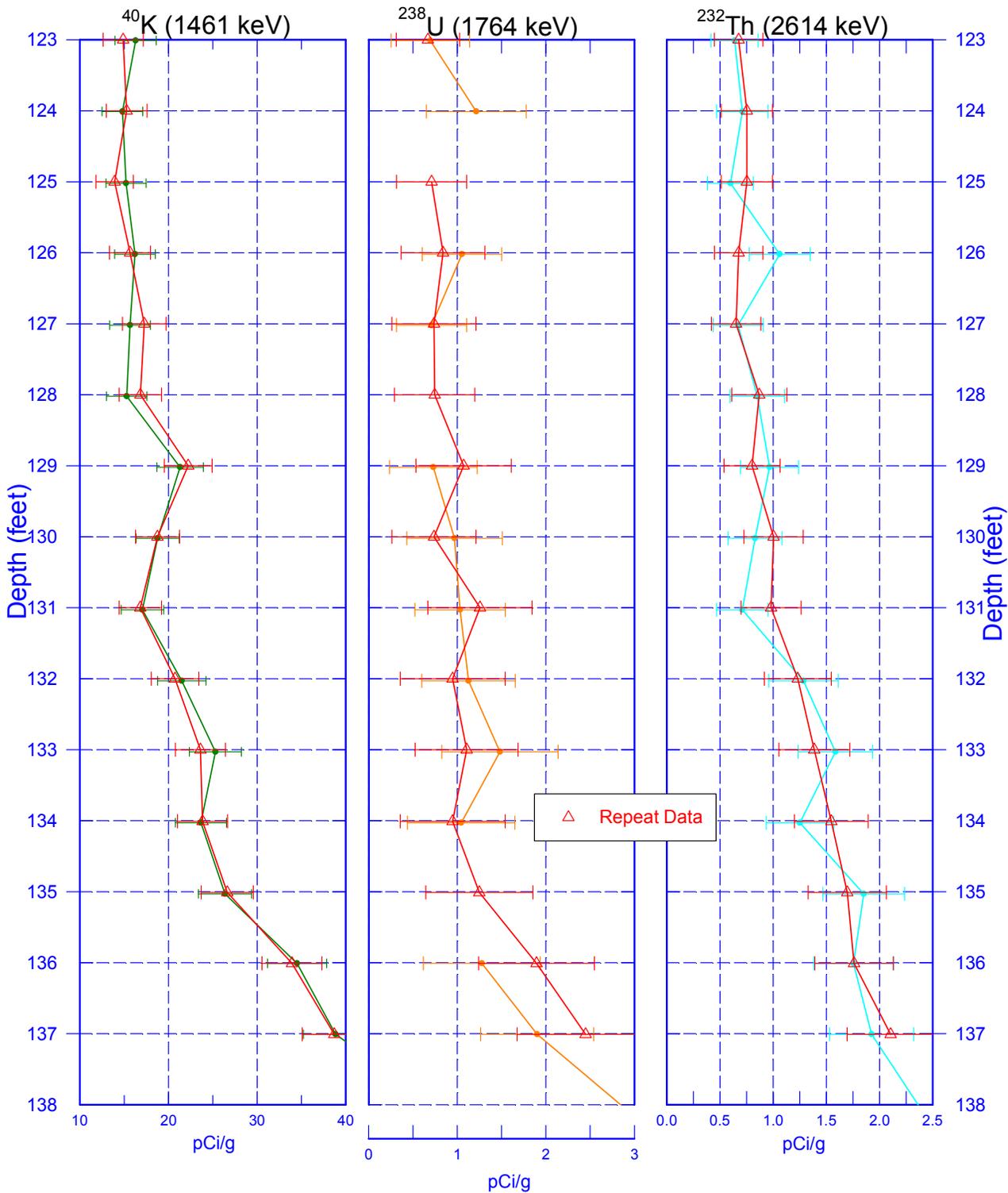


Zero Reference - Ground Surface



199-K-234 (C9922)

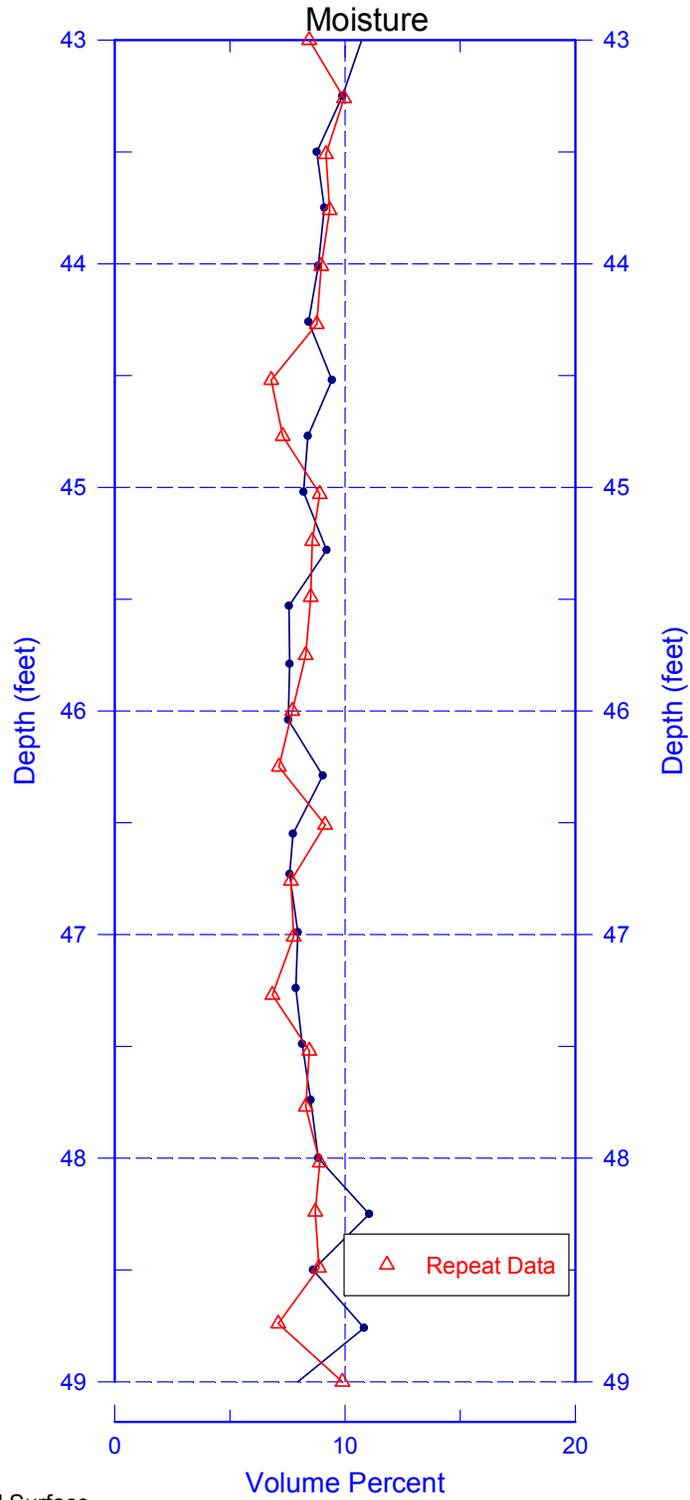
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

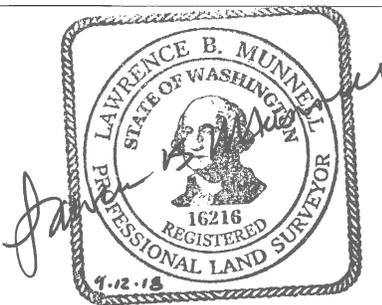


199-K-234 (C9922) Moisture Repeat Section



Zero Reference - Ground Surface

WELL SURVEY DATA REPORT

| Project: | | Prepared By: Neil P. Fastabend | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------------------------------------|-----------|-----------|--------------------------------------------------------------------------------------|
| | | Company: CHPRC | | | |
| Date Requested: 09/06/18 | | Requestor: James D. Mehrer (CHPRC) | | | |
| Date of Survey: 09/12/18 | | Surveyor / Company: Lawrence B. Munnell (CHPRC) | | | |
| Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9922 (199-K-234) located northwest of 105KE Reactor Building in 100K Area. | | Horizontal Datum: NAD83 (91) | | | |
| | | Vertical Datum: NAVD88 | | | |
| | | Units: Meters | | | |
| | | Hanford Area Designation: 100K | | | |
| Coordinate System: Washington State Plane Coordinates (South Zone) | | | | | |
| Horizontal Control Monuments: Washington State Reference Network | | | | | |
| Vertical Control Monuments: M49 (COE) and 100K-8 (CHPRC) | | | | | |
| Well ID | Well Name | Easting | Northing | Elevation | |
| C9922 | 199-K-234 | 569005.78 | 146874.03 | | Center of Casing |
| | | | | 137.558 | Top Outer Casing, N. Edge Stamped "X" |
| | | | | 137.273 | Top Inner 6"SS Casing, N. Edge |
| | | | | 136.812 | 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. | | | | |  |