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Revision 0

Borehole Summary Report for the Installation of Three Remedial Action Pump-and-Treat Wells for the 200-ZP-1 Operable Unit, FY 2009

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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Release Approval 3/3/2011 Date

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Contents

1 Introduction 5

1.1 Purpose and Scope *5*

1.2 Background *6*

1.3 Summary of Drilling and Sampling Activities *8*

2 Technical Data 11

2.1 Well 299-W15-225 (C7017) *11*
2.1.1 Drilling 11
2.1.2 Sampling 12
2.1.3 Geophysical Logging 17
2.1.4 Well Construction 17
2.1.5 Well Development/Aquifer Testing 19

2.2 Well 299-W14-20 (C7018) *22*
2.2.1 Drilling 22
2.2.2 Sampling 23
2.2.3 Environmental Monitoring 27
2.2.4 Geophysical Logging 28
2.2.5 Well Construction 28
2.2.6 Well Development/Aquifer Testing 31

2.3 Well 299-W14-73 (C7021) *33*
2.3.1 Drilling 33
2.3.2 Sampling 33
2.3.3 Environmental Monitoring 38
2.3.4 Geophysical Logging 38
2.3.5 Well Construction 39
2.3.6 Well Development/Aquifer Testing 41

3 Waste Management 43

3.1 Vadose Zone Derived Drill Cuttings *43*
3.1.1 Well 299-W15-225 (C7017) 43
3.1.2 Well 299-W14-20 (C7018) 43
3.1.3 Well 299-W14-73 (C7021) 44

3.2 Saturated Zone Derived Drill Cuttings *44*

3.3 Purgewater and Aquifer Water *44*

3.4 Miscellaneous Solid Waste *45*

4 Well Acceptance 46

5 Civil Survey 47

6 Geology 49

6.1 Structural Geology *49*

6.2 Borehole Geology/Hydrogeology *50*

6.2.1 WELL 299-W15-225 (C7017) 50
6.2.2 Well 299-W14-20 (C7018) 53
6.2.3 Well 299-W14-73 (C7021) 56

7 References 61

Appendix A A-1

Appendix B B-1

Appendix C C-1

Appendix D D-1

Figures

Figure 1-1. Locations of Project Wells within the 200 West Area 7
Figure 1-2. Generalized Well Design for 200-ZP-1 OU Remedial Action Wells 10
Figure 2-1. Summary of Borehole Stratigraphy, Total Gamma Response and Well Construction: Well 299-W15-225 (C7017). 21
Figure 2-2. Summary of Borehole Stratigraphy, Total Gamma Response and Well ConstructionWell 299-W14-20 (C7018). 32
Figure 2-3. Summary of Borehole Stratigraphy, Total Gamma Response and Well .Construction: Well 299-W14-73 (C7021) 42

Tables

Table 2-1. Well 299-W15-225 (C7017) Sample Summary 12
Table 2-2. Well 299-W15-225 (C7017) Tank Farm RCRA Compliance Sample Summary 15
Table 2-3. Well 299-W5-255 (C7017) Construction Summary 18
Table 2-4. Well 299-W14-20 (C7018) Sample Summary 23
Table 2-5. Well 299-W15-225 (C7017) Tank Farm RCRA Compliance Sample Summary 26
Table 2-6. Well 299-W14-20 (C7018): Tritium Samples by Depth 27
Table 2-7. Well 299-W4-20 (C7018) Construction Summary 30
Table 2-1. Well 299-W15-225 (C7017) Sample Summary 34
Table 2-9. Well 299-W15-225 (C7017) Tank Farm RCRA Compliance Sample Summary 37
Table 2-10. Well 299-W14-73 (C7021) Construction Summary 40
Table 5-1. Preliminary Civil Survey Data Summary 47

Terms

222-S	222-S Building Laboratory, Hanford, Washington.
Ags	above ground surface
bgs	below ground surface
bwt	below water table
CERCLA	*Comprehensive Environmental Response, Compensation Liability Act*, 1980
CHPRC	CH2M Hill Plateau Remediation Company
CS	Carbon Steel
Css	Colorado Silica Sand
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy, Richland Operations Office
dpm	disintegrations per minute
DQO	Data Quality Objective
Ecology	Washington State Department of Ecology
EBF	Electromagnetic Borehole Flow meter
EBRLNE	Eberline Analytical Corporation, Richmond, California
EPA	Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESL	Environmental Soil Laboratory (Pacific Northwest National Laboratory), Richland, Washington
ft	feet
fm	formation (informal)
Fm	Formation (formal)
FY	fiscal year
gpm	gallons per minute
HCl	hydrochloric Acid
HEIS	Hanford Environmental Information System
hp	horse power
ID	inner diameter
IDW	investigation derived waste
ID#	(borehole) identification number
in	inch
m	meter (meters)
MSW	Miscellaneous Solid Waste
NA-I	Sodium Iodide
NTU	Nephelometric Turbidity Units
OD	outer diameter
OU	Operable Unit
PAM	Portable Alpha Meter
PFP	Plutonium Finishing Plant
RCRA	Resource Conservation and Recovery Act, 1976
RL	U.S. Department of Energy, Richland Operations Office
SAP	Sampling Analysis Plan
SGLS	Spectral Gamma Logging System

TD	Total Depth
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
WAC	Washington Administrative Code
WIDS	Waste Information Data System
WMA	Waste Management Area
WSCF	Waste Sampling and Characterization Facility, Hanford, Washington

1 Introduction

This report presents field-generated records and chronicles activities carried out in the installation of three Phase 1 remedial action pump-and-treat wells for the 200-ZP-1 groundwater Operable Unit (OU) located in the 200 West Area in the west-central part of the Hanford Site. Work performed on wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021) throughout fiscal year (FY) 2009 is summarized herein.

Pursuant to *Comprehensive Environmental Response, Compensation Liability Act of 1980* (CERCLA) corrective measures, standards and timelines, the new wells have been installed as part of a preferred cleanup alternative set forth in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington*, (EPA et al. 2008). The record of decision calls for a pump-and-treat system as a preferred cleanup alternative for the 200-ZP-1 OU. The pump-and-treat system with associated extraction and injection wells will serve to fulfill the record of decision remedial objectives to:

1. extract and treat groundwater in which to reduce contaminant levels
2. monitor attenuation of contaminants
3. to provide-flow-path control to prevent the spread of contaminants.

1.1 Purpose and Scope

The purpose of this document is to compile and archive records based on observations and measurements associated with the installation of wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021). This document chronicles the following:

- Documentation of drilling activities
- Sample collection activities
- Well construction activities
- And well development activities

Additional information presented in this document includes:

- Environmental Monitoring
- Management of Drilling-Derived-Waste
- Geophysical logging results
- Civil survey results
- Well Acceptance criteria and findings
- And subsurface geologic descriptions

All data in this document are reported in English standard units in which they were recorded in the field.

1.2 Background

In response to the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA/ROD/R-10-95/114), an interim pump-and-treat system was brought on line in 1995 to remove carbon tetrachloride, and trace amounts of chloroform and trichloroethylene from the groundwater of the 200-ZP-1 OU.

According to DOE/RL-2008-25, *Treatability Test to Remove Technetium-99 from the 200-ZP-1 Groundwater Unit, Hanford* Site (DOE/RL-2008-25, 2008), in 2005 it was discovered that groundwater concentrations of technetium-99 within the influence of the pump-and-treat system began to rise. This was attributed to the presence of technietium-99 in wells connected to the interim pump-and-treat system of which the system was not designed to extract (DOE/RL 2008-25).

In fiscal year 2007 an ion-exchange-treatability test using Purolite resin was brought on line to test Purolite resin ion exchange as a potential remedial remedy to remove technetium-99 and other contaminants from the groundwater within the 200-ZP-1 OU (DOE/RL 2008-25). New wells drilled under the scope of this document will be attached to a new and larger pump-and-treat system that utilizes Purolite resin to more efficiently clean technetium-99 and other contaminants from the groundwater.

Location of wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021) are presented in Figure 1-1 below. Well survey data are presented in the Civil Survey section of this report as well as in Appendix G. Geologic and construction documentation for all three wells is presented in Appendices A through D at the end of this document.

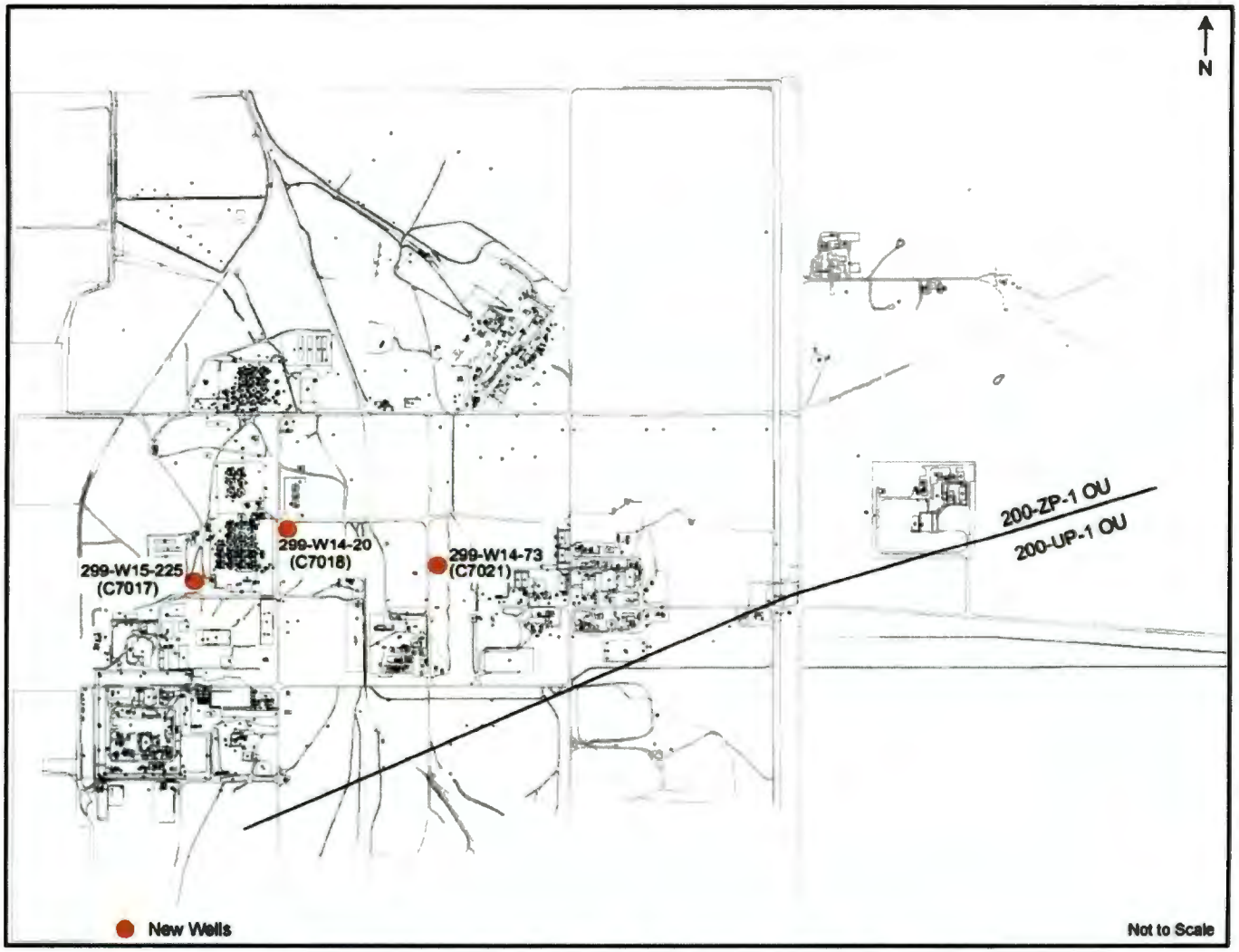

Figure 1-1. Locations of Project Wells within the 200 West Area.

1.3 Summary of Drilling and Sampling Activities

This section presents a summary of activities carried out in the installation of wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021) between January, 2008 and October, 2009. Information common to all three project wells is covered herein and will not be reiterated in-detail hereafter. Illustrations summarizing encountered borehole lithology, lithologic geophysical response and well design are provided at the end of each well summary section.

The three wells were drilled in the north central portion of the 200-West are in the vicinity of TY-TX tank farm east of the Plutonium finishing plant and west of the water treatment plant. Wells were to be drilled to bedrock or 10 feet below the first major confining layer encountered. A confining layer was encountered during the drilling of Wells C7017 and C7018 and these boreholes were terminated roughly 10 feet below the confining layer. A confining layer was not encountered at Well C7021 and this borehole was drilled to within 10 feet of bedrock.

During drilling numerous samples were collected and analyzed for archive, chemical, and sieve analysis purposes. Samples were collected and recorded in compliance with the *Sampling and Analysis Plan* [SAP] *for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit,* (DOE/RL 2008-57).

Samples for archive purposes were collected by a geologist at five foot intervals and at significant changes in lithology throughout each borehole.

Sieve samples for sediment size distribution were collected to determine well screen slot sizes and proper filter pack mesh sizes. Sieve samples were collected throughout the saturated zone of each borehole at varying intervals dependent upon the type of drilling method used (see technical data section for further details). All sieve samples were combined into 20-foot intervals in labeled clean plastic bags and sieved using a wet wash method and separated using screen sizes; 2-inch, 1.5-inch, .038-inch, #4 mesh, #10 mesh, #40 mesh, #60 mesh, #100 mesh, #200 mesh.

- Soil samples for chemical analysis were collected at 20-foot intervals throughout the saturated zone of each borehole.
- Water samples for chemical analysis were also collected at 20- foot intervals throughout the saturated zone of each borehole.

For analytical quality control purposes for each well, liquid trip blank samples (accompanying all water samples), equipment rinsate samples, replicate samples, and split samples were acquired for laboratory analysis. A liquid trip blank is a vial of deionized water brought to the sample site with a sample set. The trip blank is used as a baseline to preclude sample contaminants not originating from the sample source (e.g. vehicle exhaust). A trip blank sample accompanied each water sample collected from each borehole. Equipment rinsate blanks serve the same purpose as the trip blank but are used to test for contaminants originating from sampling equipment. A single equipment rinsate sample was collected at borehole C7017 from the wash of a split-spoon sampler. Equipment rinsate samples were not collected from boreholes C7018 or C7021 since split spoons were not used at these boreholes. A replicate sample is a liquid and or a soil sample

collected in tandem with an original sample from the same source. Both samples are processed at the same laboratory to check the precision of the laboratory analysis. A water and soil replicate sample was collected from each borehole. A split sample is a liquid or soil sample that is also collected in tandem with an original sample from the same source. Each sample from a split sample set is sent to separate laboratories to check the accuracy of a laboratories sample analysis. A water split sample was collected with each water sample from each borehole.

The three new wells are located in close proximity to Waste Management Area (WMA) TX/TY. Additional soil samples were collected from each well to fulfill sampling requirements for *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action compliance for tank farm-vadose zone characterization. These samples were collected from 95 to 230 ft bgs at five foot intervals through fine grained sediments that exist within the vadose zone of each well."

Environmental monitoring including radiological monitoring and air quality monitoring was provided at variable frequencies during the installation and testing of all three wells. Frequency of radiological monitoring varied for each well site based on preliminary risk assessments for each location. Radiological surveys were performed using Geiger-Mueller gamma radiation detectors, SPA-3[1] beta/gamma radiation meters with Sodium Iodide probes (generally referred to by the probe name NA-I) and Hanford Portable Alpha Meters (PAM)s. Items surveyed at drilling sites typically included the following:

- workers personal protective equipment (gloves, shoes, coveralls ect.)
- the ground around the borehole and waste containers
- equipment and tools used during daily activities
- casing and any equipment that came into contact with the ground and/or groundwater (pump equipment, sample equipment, drilling equipment ect.)

Industrial hygiene monitoring was provided twice daily throughout all activities performed at all there well sites. Radiological survey reports and industrial hygiene reports were not available when this borehole summary was written.

Geophysical logging using a spectral gamma logging system (SGLS) was conducted on each borehole when boreholes were downsized and when the boreholes were drilled to their total depths.

Well construction common to all three wells includes 8-inch stainless steel casing, screens, and sumps. Well screens are of variable lengths and have variable slot sizes throughout each well. Screen specifications are called out in the well construction sections for individual wells. All well heads have a 4 ft by 4 ft by 6 inch well pad reinforced with steel mesh and have four protective posts with one removable post for maintenance purposes. All well heads also have a 10-inch stainless steel protective casing with lockable cap and bolted access plate for electrical grounding. Figure 1-2 illustrates design features common to all three wells.

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[1] SPA-3 is a trademark of Thermo Electron Corporation, Waltham, Massachusetts

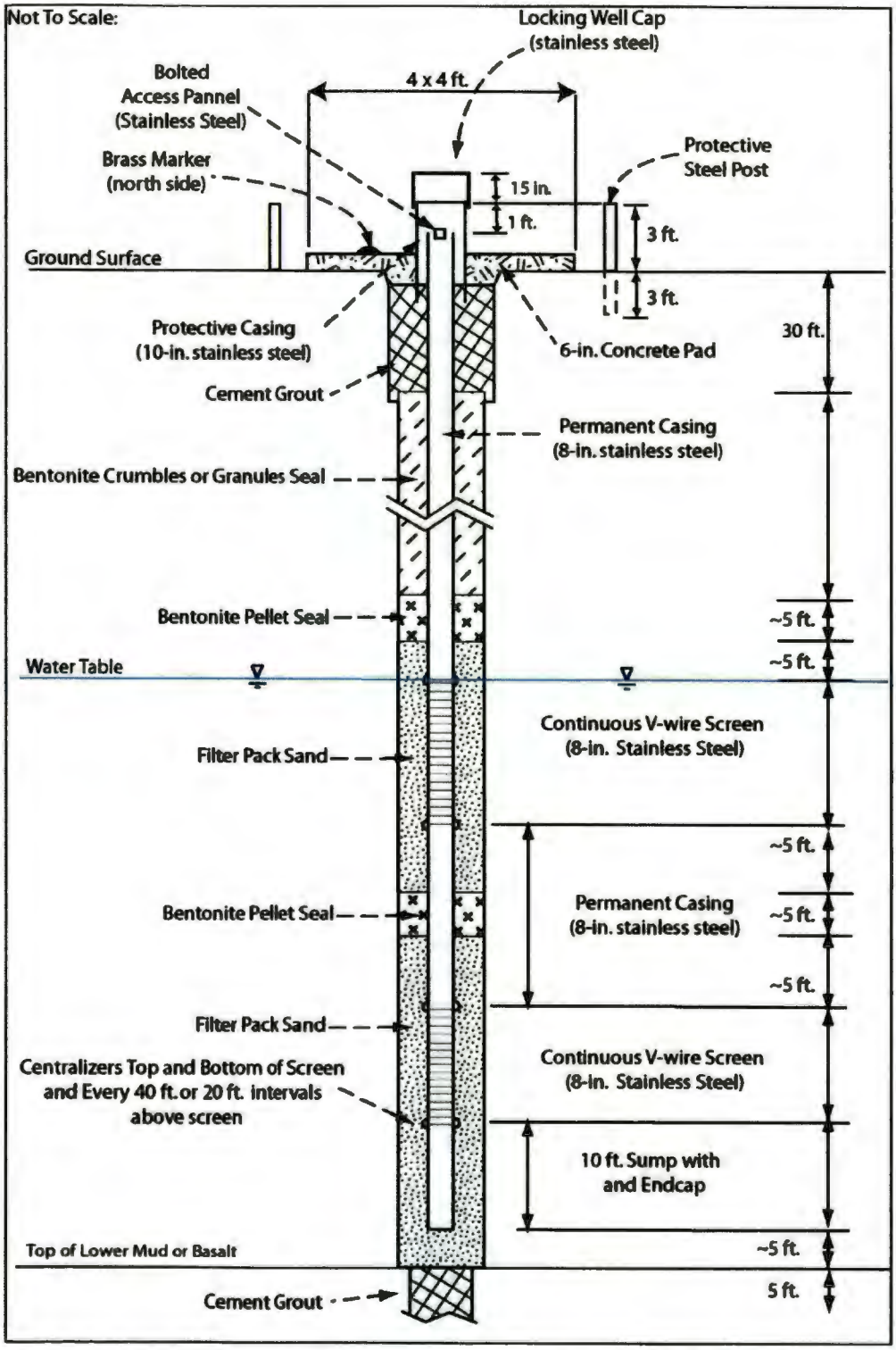

Figure 1-2. Generalized Well Design for 200-ZP-1 OU Remedial Action Wells.

2 Technical Data

This section presents information recorded in legal field records chronicling activities performed during the installation of wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021). This section includes technical information associated with the drilling, sampling, construction, and development/testing for each well. Well summary diagrams, well construction summary reports, borehole logs, and Geophysical log data reports are included in Appendices A through D.

2.1 Well 299-W15-225 (C7017)

Well 299-W15-225 (C7017) is located within the 200 West Area, 60 feet South West of TX Tank Farm and North of the Plutonium Finishing Plant (PFP). The well was installed and developed between January 30, 2009 and July 16, 2009.

2.1.1 Drilling

Drilling of this well took place from January 30, 2009 to May 8, 2009 and extended to a total depth (TD) of 461 ft bgs. All drilling was performed in compliance with WAC 173-160 "Minimum Standards for Construction and Maintenance of Wells." Throughout drilling, the borehole and temporary casing strings were downsized four times[2]. The following casing sizes were used during drilling operations:

- 16-inch outer diameter (OD), 15 1/2-inch inner diameter (ID) welded, carbon steel casing with a 16-inch OD, 14 1/4-inch ID shoe (referred to as 16-inch welded casing)
- 12 3/4-inch OD, 12-inch ID, welded, carbon steel casing with a 13 3/8-inch OD, 12-inch ID drive shoe (referred to as 12-inch welded casing)
- 11 3/4-inch OD, 10 3/4-inch ID, threaded, carbon steel casing with a 12-inch OD, 10 3/4-inch ID drive shoe (referred to as 11 3/4-inch casing)
- 8 1/2-inch OD, 7 1/2-inch ID, threaded, carbon steel casing with a flush cut piece of casing as the drive shoe (referred to herein as 8-inch casing)
- 5 5/8-inch OD, 5-inch ID, threaded carbon steel casing with a flush cut piece of casing used as the drive shoe (referred to herein as 5-inch casing)

Starting January 30, 2009, the borehole and 16-inch welded casing was advanced using an air rotary rig with a down-hole hammer bit from ground surface to 20 ft bgs. On February 2, 2009 the 16-inch casing was extracted from the borehole due to a collapsed shoe. Following this, the borehole and new 16-inch casing was advanced from 20 to 218 ft bgs using the above mentioned air rotary drill rig with down hole hammer and tri-cone bits. On February 23, 2009, prior to downsizing casing, a straightness test was performed and the borehole was logged using a spectral gamma logging system (SGLS). Starting February 27, 2009 the borehole and 12-inch welded casing was advanced using a cable tool rig with a drive barrel bit from 218 to 274 ft bgs where the drive shoe cracked and collapsed. On April 14, 2009 the 12-inch welded casing and shoe were completely removed. Starting April 21, 2009 the borehole and 11 3/4-inch threaded

[2] The 12-inch welded casing was replaced by the 11-3/4-inch threaded casing during drilling operations.

casing was installed and advanced using the original air rotary rig with tri-cone and down-hole hammer bits from 218 to 410 ft bgs where upon a major confining layer (known as the Ringold Lower Mud unit [RLM]) was encountered. Subsequently the 11 3/4-inch threaded casing was driven five feet into the RLM to 415 ft bgs and bentonite was added to the borehole to seal the casing off from the above aquifer. On April 30, 2009, before downsizing casing, a straightness test and geophysical logging using SGLS was performed from 215 to 410 ft bgs. Starting May 1, 2009 8-in. threaded casing was advanced into the RLM from 415 to 446 ft bgs using the above mentioned air rotary rig and bits. The borehole was advanced beyond the 8-in. casing (open hole) past the RLM lower contact at 458 ft bgs and into underlying gravels to a TD depth of 462 ft bgs. On May 6, 2009 a straightness test was performed throughout the 8-inch casing and thereafter 5-inch casing was installed to 461 ft bgs to prevent the borehole from collapsing. On May 7, 2009 geophysical logging using SGLS was performed from 446 to 461 ft bgs. On May 8, 2009, after the necessary sampling from below the RLM was performed, the 5-in. casing was removed. On May 11, 2009 geophysical logging using SGLS was performed from 410 to 446 ft bgs.

2.1.2 Sampling

Soil and water samples were collected for chemical constituent analysis and quality control purposes

2.1.2.1 Sampling for Laboratory Analysis

Samples were collected using split spoon sampling coring bits, drive barrel bits (a non-splitting coring bit) as well as using hand held jars to collect samples from the drill rig tailings exhaust. Pertaining to the tables below; sample depths expressed in interval notation designate the interval of which a coring bit was driven for sample collection. Sample depths provided in finite notation designate the depth of the bit when a grab sample was collected from the tailings exhaust of an air rotary rig. The below samples were collected and recorded in compliance with this project SAP (DOE/RL 2008-57). Table 2-1 summarizes details associated with individual sampling depths.

Table 2-1. Well 299-W15-225 (C7017) Sample Summary

Collection Depth	Collection Date	Sample Type	Collection Method	HEIS # and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
219.0	3/2/2009	Soil	Grab	----	B1YD08	----	----
218.7-221.2	3/2/2009	Soil	Split Spoon	B1YCV9 B1YCW0 B1YCW1 B1YCW2	----	B1YCW0	----
218.7-221.2	3/2/2009	Equipment Blank	From Split Spoon	B1YD89	----	B1YD89	----
218.7-221.2	3/2/2009	Trip Blank	----	B1YD92	----	----	----
229.0	3/3/2009	Soil	Grab	----	B1YD09	----	----

Table 2-1. Well 299-W15-225 (C7017) Sample Summary

Collection Depth	Collection Date	Sample Type	Collection Method	HEIS # and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
228.7-231.2	3/3/2009	Soil	Split Spoon	B1YCW3 B1YCW4 B1YCW5 B1YCW6	----	B1YCW4	----
228.7-231.2	3/3/2009	Trip Blank	----	B1YD93	----	----	----
247.5-248.5	3/4/2009	Soil	Grab	----	B1YD74	----	----
244.5-248.4	3/9/2009	Water	Pump	B1YCW7 B1YCW8 B1YCW9 B1YCX0	----	B1YCW8	----
244.5-248.4	3/9/2009	Trip Blank	----	B1YD94	----	----	----
272.5-273.0	3/26/2009	Soil	Grab	----	B1YD75	----	----
271.0-273.0	3/27/2009	Water	Pump	B1YCX3 B1YCX4 B1YCX5 B1YCX6	----	B1YCX4	----
271.0-273.0	3/27/2009	Water Replicate	Pump	B1YCY0 B1YCY1 B1YCY2	----	B1YCY0	----
271.0-273.0	3/27/2009	Trip Blank	----	B1YD95	----	----	----
295.0	4/21/2009	Soil	Grab	----	B1YD76	----	----
295.0	4/21/2009	Soil Replicate	Grab	----	B1YD88	----	----
295.0-296.0	4/21/2009	Water	Pump	B1YCY3 B1YCY4 B1YCY5 B1YCY6	----	B1YCY4	----
295.0-296.0	4/21/2009	Trip Blank	----	B1YD96	----	----	----
314.5	4/22/2009	Soil	Grab	----	B1YD77	----	----
315.0-316.0	4/22/2009	Water	Pump	B1YD20 B1YD21 B1YD22 B1YD23	----	B1YD21	----
315.0-316.0	4/22/2009	Trip Blank	----	B1YD97	----	----	----
335.0	4/22/2009	Soil	Grab	----	B1YD78	----	----
335.0-336.0	4/23/2009	Water	Pump	B1YD24 B1YD25 B1YD26 B1YD27	----	B1YD25	----
335.0-336.0	4/23/2009	Trip Blank	----	B1YD98	----	----	----
355.0	4/24/2009	Soil	Grab	----	B1YD79	----	----

Table 2-1. Well 299-W15-225 (C7017) Sample Summary

Collection Depth	Collection Date	Sample Type	Collection Method	HEIS # and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
355.0-356.0	4/24/2009	Water	Pump	B1YD28 B1YD29 B1YD30 B1YD31	----	B1YD29	----
355.0-356.0	4/24/2009	Trip Blank	----	B1YD99	----	----	----
375.5	4/27/2009	Soil	Grab	----	B1YD80	----	----
375.0-376.0	4/27/2009	Water	Pump	B1YD32 B1YD33 B1YD34 B1YD35	----	B1YD33	----
375.0-376.0	4/27/2009	Trip Blank	----	B1YDB0	----	----	----
395.0	4/28/2009	Soil	Grab	----	B1YD81	----	----
395.0-396.0	4/28/2009	Water	Pump	B1YD36 B1YD37 B1YD38 B1YD39	----	B1YD37	----
395.0-396.0	4/28/2009	Trip Blank	----	B1YDB1	----	----	----
414.0	4/29/2009	Soil	Grab	----	B1YD82	----	----
414-415	4/29/2009	Water	Pump	B1YD40 B1YD41 B1YD42 B1YD43	----	B1YD41	----
414-415	4/29/2009	Trip Blank	----	B1YDB2	----	----	----
462.0	5/5/2009	Soil	Grab	----	B1YD83	----	----
461.0-465.0	5/8/2009	Water	Pump	B1YD44 B1YD45 B1YD46 B1YD47	----	B1YD45	----
461.0-465.0	5/8/2009	Trip Blank	----	B1YDB3	----	----	----

Notes:

222-S = 222-S Building Laboratory, Hanford, Washington.
EBRLNE = Eberline Analytical Corporation, Richmond, California.
ESL = Environmental Soil Laboratory (Pacific Northwest National Laboratory), Richland, Washington.
HEIS # = Hanford Environmental Information System (Sample Number).
WSCF = Waste Sampling and Characterization Facility, Hanford, Washington.

2.1.2.2 Additional Sampling for Tank Farm RCRA Corrective Action Compliance

Vadose-zone-soil samples were collected from this borehole by the request of the Tank Farm Contractor to supplement vadose zone characterization pursuant of tank farm corrective actions.

Soil samples were collected from a fine grained interval in the vadose zone from 95 to 230 ft bgs at five foot intervals. Sample details are listed in Table 2-2 below.

Table 2-2. Well 299-W15-225 (C7017) Tank Farm RCRA Compliance Sample Summary

Collection Depth	Collection Date	Sample Type	Collection Method	HEIS # and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
95.0	2/9/2009	Soil	Grab	—	B1YD07	—	B1YCY9
100.0	2/9/2009	Soil	Grab	—	—	—	B1YD00
105.0	2/10/2009	Soil	Grab	—	—	—	B1YD01
103-105.5	2/10/2009	Soil	Split Spoon	B1YCV5 B1YCV6 B1YCV7 B1YCV8	—	B1YCV6	—
103-105.5	2/10/2009	Trip Blank	—	B1YD91	—	—	—
110.0	2/10/2009	Soil	Grab	—	—	—	B1YD02
115.0	2/10/2009	Soil	Grab	—	—	—	B1YD03
120.0	2/10/2009	Soil	Grab	—	—	—	B1YD04
125.0	2/10/2009	Soil	Grab	—	—	—	B1YD05
130.0	2/10/2009	Soil	Grab	—	—	—	B1YD06

Notes:

222-S = 222-S Building Laboratory, Hanford, Washington.

EBRLNE = Eberline Analytical Corporation, Richmond, California.

ESL = Environmental Soil Laboratory (Pacific Northwest National Laboratory), Richland, Washington.

HEIS # = Hanford Environmental Information System (Sample Number).

WSCF = Waste Sampling and Characterization Facility, Hanford, Washington.

2.1.2.3 Sampling for Sieve Analysis

Samples for sieve analysis were collected in a manner consistent with the SAP (DOE/RL 2008-57). Sieve samples were collected throughout the saturated zone of the borehole. They were collected at varying intervals controlled by the type of drilling method used. Sieve samples collected from rotary rig cuttings were collected at 5-foot intervals from the cuttings exhaust and or tailings hopper and composited into 20-foot intervals in labeled, clear plastic bags. Sieve samples collected from cable tool drilling were collected in 10-foot intervals using a hollow core barrel bit to capture sediments that were representative of in-situ sediments. These samples were also composited into 20-foot intervals in labeled, clear plastic bags.

2.1.2.4 Sampling for Geologic Archiving

Samples for archiving were collected in a manner consistent with the SAP (DOE/RL 2008-57). Archive samples were collected in pint-glass jars from drill tailings and core samplers at 5-foot intervals throughout the depth of the borehole.

2.1.2.5 Environmental Monitoring

Radiological Monitoring was provided on a full time basis during drilling activities that took place throughout the first 50 ft of the borehole.

2.1.2.6 Radiological Monitoring

Radiological monitoring was provided on a morning and afternoon basis throughout vadose zone drilling activities and was provided on an intermittent (relatively constant) basis during drilling that took place below the water table. Radiological monitoring was also provided on a full time basis during casing extraction during well construction.

No radiological contamination was encountered during drilling. However, radiological contamination was encountered during well development and construction activities at this site. On August 28, 2009 and August 31, 2009 the Radiological Technician reported encountering fixed and removable beta-emitting contamination on the 12-in. casing that was back pulled from below the water table. Highest readings encountered were 42,000 disintegrations per minute per 100 centimeters squared. The contamination was affixed to the casing and was removable only by physical abrasion. The likely suspect radionuclide matching the above criteria was Technitium-99 (Tc-99) based on the contamination's affinity to affix to carbon steel, its specific beta emission, and its known existence as a suspect radionuclide in the groundwater within the 200-ZP-1 OU. The contaminated casing was wrapped, labeled and stationed in the on-site waste containment area in a manner consistent with the "*Waste Management Plan for the Expedited Response Action for 200 West Area Carbon Tetrachloride Plume and the 200-ZP-1 and 200-PW-1 Operable Units*" (DOE/RL-2000-40).

On September 8, 2009 radiological contamination was also encountered during the removal of the development pump after the final well development had taken place. Upon removal of the pump and 4-inch drop pipe it was discovered that contamination had affixed to the sections of carbon steel drop pipe that had been placed in the ground water and left there for four days. The pipe was wrapped and stored in a temporary radiological materials area. The final disposition of these materials is not know at this time.

2.1.2.7 Industrial Hygiene (Air Quality) Monitoring

Air quality monitoring for organic vapors was provided on a morning and afternoon basis by an industrial hygienist. The industrial hygienist measured air quality above the borehole opening, above the drill cuttings (when present) and within the general breathing space around the work area. The Industrial hygienist reported all sustainable readings to be below the detectable limits of the organic vapor meter used to measure air quality.

2.1.3 Geophysical Logging

Geophysical logging was performed over four intervals throughout this borehole using a Spectral Gamma Logging System (SGLS). Since logging was performed through casing strings of variable diameters and thicknesses, the technician adjusted the data to account for the variations.

On February 2, 2009 the borehole was logged through the 16-in. casing from ground surface to 215 ft bgs. On April 30, 2009 the borehole was logged through the 12-in. threaded casing from 215 ft to 410 ft bgs. On May 7, 2009 the borehole was logged through the 5-in. threaded casing from 446 to 461 ft bgs (TD) after skipping an interval of 8-in. On May 15, 2009 after the 5-inch liner had been removed, the borehole was logged from 446 to 461 ft bgs through the 8-in. casing.

2.1.4 Well Construction

Well construction took place between May 12, 2009 and June 12, 2009. This well was constructed in compliance with WAC 173-160 for constructing resource protection wells to include compliance with WAC 173-160-450 standards for sealing wells. This well was constructed using 8 5/8-in. OD and 8-in ID, schedule-10 type 316 stainless steel casing, sump and continuous wrap v-wire screen. The well has stainless steel welded-tab centralizers positioned every 40 ft throughout its length. The screen is comprised of two sections of varying mesh size separated by a 10-ft section of solid casing. The upper screen mesh size is .040 slot and the lower mesh size is .055 slot. Additionally, this well contains a corrugated crimped splice between 361.5 and 366.5 ft bgs that repaired a broken weld at the base of the upper screen.

The materials used for borehole decommissioning below the well, annular filter pack and annular seals vary according to depth and use. The borehole is decommissioned through the lower aquifer from TD to the base of the RLM using 8-12 mesh Colorado Silica Sand (Css). The RLM (a major confining layer) is sealed using type I, II Portland Cement with between 3% and no more than 5% bentonite to prevent shrinkage. The borehole within the aquifer below the sump and above the RUM is decommissioned using 8-12 mesh Css. The lower filter sand pack is of 8-16 mesh Css and the upper filter sand pack is of 10-20 mesh Css. The annular seal above the filter pack is of #8 mesh bentonite crumbles. The cement surface seal, placed 33 ft thick, is comprised of type I, II Portland Cement with between 3 percent and, no more than, 5 percent bentonite. See Table 2-3 below for a summary of depths of construction materials.

The well head consist of a 4 ft by 4 ft by 6 in. thick, steel mesh reinforced concrete pad with a 10-inch diameter stainless steel proactive well casing encapsulating the 8 5/8-inch well casing. The protective casing extends three feet above ground surface and one foot above the top of the well and has a lockable cap and a removable access panel on the north side for access to an electrical grounding lug. The well head and pad are also protected by four, three-foot-tall, three-inch diameter protective posts located within on foot of each corner of the well pad. A protective post on the north side of the well is removable for access for maintenance. A brass survey marker bearing the well name, unique well number, and date of completion was installed in the concrete pad on the north side of the well.

Table 2-3. Well 299-W5-255 (C7017) Construction Summary

Total Depth (ft bgs)	Static Water Level (ft bgs)	Permanent Stainless Steel 8-Inch Diameter Screen and Casing						Annular Materials			
		Upper Screen Interval (ft bgs) [Slot Size (in)]	Screen Blank (ft bgs)	Lower Screen Interval (ft bgs) [Slot Size (in)]	Sump (ft bgs)	Top of Casing (ft ags)	Top of Guard Casing (ft ags)	Upper Sand Pack (ft bgs) [mesh]	Lower Sand Pack (ft bgs) [mesh]	Bentonite Seals {upper} [lower] (ft bgs)	Cement Seals {upper} [lower] (ft bgs)
465	228.5	246-265 [.040]	265-275 361.5-366.5	275-405 [.055]	405-415	1.1	2.1	225.1-265.9 [10/20]	265.9-415 [8/16] 415 -418 [8/12]	{33-225.1} [456.5-458]	{0-33} [418-456.5]

Notes:

ID = identification
In = inch
ft ags = above ground surface
ft bgs = below ground surface
N/A = Not applicable

2.1.5 Well Development/Aquifer Testing

Because well C7017 was the first of a series of wells built to optimize well screen transmisivity, extensive development and aquifer testing was performed on this well. Well development and testing at this site included:

1. sand pack surging
2. primary well development (to meet Washington State Ecology [Ecology] standards)
3. two graduated-step pump tests
4. a high-flow-rate aquifer stress test
5. raw-hiding and air lifting; and
6. 72 hour continuous-pump aquifer stress test

Additional aquifer testing performed on this well included electromagnetic borehole flow meter (EBF)[3] testing and pneumatic slug testing.

The primary phase of well development began with surging of the filter sand pack. Surging took place during the installation of the sand pack at 10-foot intervals throughout the length of the well screens. A duel brush surge block was repetitively stroked across an interval of screen to settle the sand pack within 0.10-ft over a 15 minute period. Much of the time, the sand pack would settle feet at a time and sand would have to be added repetitiously in order to maintain no open hole around the screen.

Development for Ecology requirements was the first development performed after the well had been built. This development was carried out on June 11, 2009 and June 12, 2009 by placing a 20-horse power submersible pump at no less than 40-ft intervals throughout the screens and pumping the aquifer at an average of 112 gallons per minute (gpm) until the water turbidity dropped below 5 Nephelometric Turbidity Units (NTU) and pH, conductivity, dissolved oxygen and temperature stabilized.

On June 17, 2009 a graduated-step pump test was performed. This test consists of pumping the well at periodically increased flow rates. The test was carried out using a 20-horse power (hp) submersible pump attached to variable frequency control panel (to control motor speed as opposed to controlling pressure). The intake was set at 393.5 ft bgs, 11.5 ft from the base of the lower screen. The pump was run at constant rates of 30, 60, 90, and 120 gpm for 15 minute intervals.

From June 19, 2009 to June 24, 2009 air lift development took place. Air lifting is a process which forces compressed air down the well through the center of two pipes and up the annulus of the two pipes. The bottom 10 ft of the outer pipe has perforations of which water is drawn through. The air moving up the annulus of the two pipes draws water through the perforations and forces water and sediments to the surface. The air lifting was carried out by moving the perforated pipe up and down at 20 ft intervals throughout the length of the well screens.

On June 26, 2009 raw hide development took place. Raw hide development consists of pumping the well at a high rate and periodically killing the pump (check valve removed) to allow the water in the pump drop pipe to back flush the well and screen. Raw hiding was carried out using

[3]An electromagnetic borehole flow meter is an instrument that measures vertical flow within a well.

a 50 hp pump with 4-inch diameter drop pipe to pump the well at 300 gpm and periodically shutting the pump off to backwash the well and screen. Raw hiding was performed at 20 ft intervals throughout the length of the screens.

On June 28, 2009 a second graduated-step pump test was performed. This test was carried out using the same 20-hp pump as used above and setting the pump intake at 388 ft bgs, 18 ft above the bottom of the lower screen. The pump was run at constant rates of 30, 60, 90, 120, and 150 gpm for two hour intervals.

From June 29, 2009 to July 2, 2009 a constant flow rate test was performed. This test was carried out using the same 20-hp pump as used above with the intake set at the same depth from the 28th (388 ft bgs, 18 ft above the bottom of the lower screen) and pumping the well continuously for 72 hours at 156 gpm. After the pump was turned off a seven-day aquifer recovery test was performed from July 2, 2009 to July 9, 2009. The well was not disturbed during this time.

From July 10, 2009 to July 13, 2009 an EBF test was performed. This test was carried out beginning with the placement of an inflated packer and EBF probe at the base of the well screen and measuring static conditions for baseline measurements. Baseline measurements continued at five foot intervals throughout the length of the screens. After baseline measurement had been established a 2 hp pump, EBF probe and inflated packer were again positioned at the base of the screened interval and the pumped at 10 gpm to acquire EBF measurements. The test continued at 5-ft intervals throughout the length of the screened interval of the well.

From July 14, 2009 to July 16, 2009 a series of pneumatic slug tests were performed. Slug tests were carried out by placing an inflated packer at depth and measuring water pressure variations as a shot of air of known volume is injected into the water above the packer. Subsequent slug tests were performed at 5-foot intervals throughout the length of the screens. This concluded the testing for the new high yield style wells. Development and testing on the remainder of wells built to this standard was limited to Ecology required development. Figure 2-1 Summarizes details of the Borehole Stratigraphy, Total Gamma Response, and Well Construction Well 299-W15-225 (C7017)

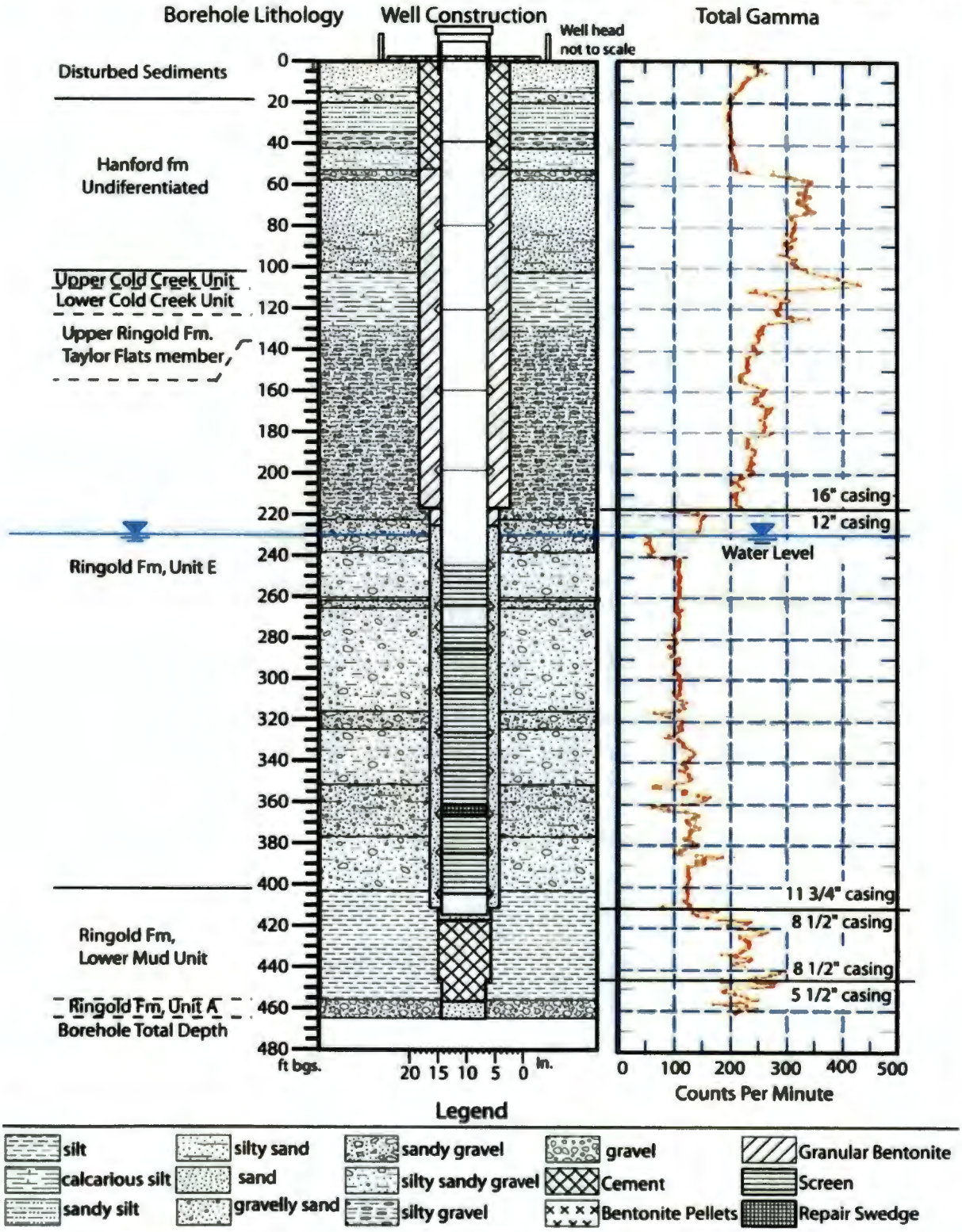

Figure 2-1. Summary of Borehole Stratigraphy, Total Gamma Response and Well Construction: Well 299-W15-225 (C7017).

2.2 Well 299-W14-20 (C7018)

Well 299-W14-20 (C7018) is located within the South-West 1/4 of North-East 1/4 section, of Section 1, Township 12 North, Range 25 West. Relative to nearby facilities and structures, the well is located within the 200 West Area, 60 feet East of TX Tank Farm. Well C7018 was installed and developed between January 30, 2009 and September 8, 2009.

2.2.1 Drilling

Drilling of borehole C7018 took place between January 30, 2009 and July 28, 2009 and extended to a total depth (TD) of 439 ft bgs. All drilling was performed in compliance with WAC 173-160 "Minimum Standards for Construction and Maintenance of Wells." Throughout drilling, the borehole and temporary casing strings were downsized three times[4]. The following casing sizes were used during drilling operations:

- 16-inch OD, 15 1/2-inch ID, welded, carbon steel casing with a flush cut piece of casing for a drive shoe[5] (referred to below as 16-in. casing without shoe).
- 16-inch OD, 15 1/2-inch ID welded, carbon steel casing with a 16-inch OD, 14 1/4-inch ID drive shoe (referred to as 16-inch welded casing);
- 11 3/4-inch OD, 10 3/4-inch ID, threaded, carbon steel casing with a 12-inch OD, 10 3/4-inch ID drive shoe (referred to as 11 3/4-in. threaded casing);
- 10 3/4-inch OD, 9 5/8-inch ID, threaded, carbon steel casing with flush cut piece of casing for a drive shoe (referred to as 10-inch casing)[6].
- 8 1/2-inch OD, 7 1/2-inch ID, threaded, carbon steel casing with a flush cut piece of casing as the drive shoe (referred to herein as 8-inch casing).

Drilling commenced on January 30, 2009 using a cable tool rig with drive barrel bits advancing the borehole and 16-in welded casing (without shoe) to 20 ft bgs by February 3, 2009. On February 5, 2009 the 16-in. casing (without shoe) was removed to install a tempered metal shoe. The 16-in. casing (with shoe) was driven to 23 ft bgs on February 6, 2009. Beginning March 24, 2009 the borehole and 16-in. casing was advanced using an air rotary rig with a down-hole hammer bit from 23 to 219 ft bgs. On April 6, 2009 a straightness test and geophysical scan using SGLS was performed prior to installing 10-in. casing. Starting April 9, 2009 a cable tool rig with drive barrel bits was used to advance the borehole and 10-in. casing from 219 to 249 ft where a slug test was performed on April 15, 2009 (21 ft below the water table). On April 17, 2009 the 10-in. casing was removed to permit multiple downsizing later. Beginning June 10, 2009, the borehole and 11 3/4-in. casing was advanced using the above mentioned cable tool rig with drive barrel bits from 249 to 270 ft bgs. From June 22, 2009 to July 7, 2009 the

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[4] The 10-inch and first string of 12-inch welded casings were pulled and replaced. These events do not constitute a casing and borehole size reduction, therefore regulations concerning borehole downsizing do not apply.

[5] This string of welded casing was removed to have a tempered steel drive shoe welded to its base.

[6] This string of welded 10-in. casing was removed and replaced by the 11

borehole and 11 3/4-in. casing was advanced using hard tool bits from 270 to 400 ft where the RLM was encountered. Following this the 11 3/4-in. casing was driven to 409 ft bgs sealing it into the confining layer and the borehole was advanced, uncased, to 436 ft bgs. On July 23, 2009 a straightness test and geophysical scan using SGLS was performed throughout the 11 3/4-in. casing. On July 24, 2009 drilling using hard tool bits continued from to 436 ft where gravels underlying the RLM were encountered. On July 27, 2009 8-in. casing was installed and sealed using bentonite. On July 28, 2009 the borehole and 8-in. casing was advanced using hard tool bits from 436 to TD at 439 ft bgs. Subsequently the 8-in. casing was tested for straightness and scanned using geophysical SGLS from 409 to 439 ft bgs.

2.2.2 Sampling

2.2.2.1 Sampling for Laboratory Analysis

Soil and water samples were collected for chemical constituent analysis and quality control purposes. Pertaining to the tables below; sample depths expressed in interval notation designate the interval of which a coring bit was driven for sample collection. Sample depths provided in finite notation designate the depth of the bit when a grab sample was collected from the tailings exhaust of an air rotary rig. The below samples were collected and recorded in compliance with this project SAP (DOE/RL 2008-57). Table 2-4 summarizes details associated with individual sampling depths.

Table 2-4. Well 299-W14-20 (C7018) Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF[1]	ESL	EBRLNE	222-S
217.7-219.7	4/6/2009	Soil	Split Spoon	B1YD12 B1YD15 B1YD18 B1YMN0	—	B1YD15	—
217.7-219.8	4/6/2009	Soil	Grab	—	B1YM91	—	—
217.7-219.9	4/6/2009	Trip Blank	—	B1YM74	—	—	—
227.7-228.9	4/10/2009	SOIL	Split Spoon	B1YD13 B1YD16 B1YD19 B1YMN1	—	B1YD16	—
228.5	4/10/2009	Soil	Grab	—	B1YM92	—	—
228.5	4/10/2009	Trip Blank	—	B1YM75	—	—	—
249.0-251.1	4/15/2009	Soil	Grab	—	B1YM93	—	—
249.0-251.0	4/16/2009	Water	Pump	B1YMD9 B1YMH4 B1YMJ9	—	B1YMD9	—
249.0-251.0	4/16/2009	Trip Blank	—	B1YM76	—	—	—
267.7-269.0	6/18/2009	Soil	Grab	—	B1YM94	—	—

Table 2-4. Well 299-W14-20 (C7018) Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
267.0-269.0	6/19/2009	Water	Pump	B1YH71 B1YMF0 B1YMH5 B1YMK0	—	B1YMF0	—
267.0-269.0	6/19/2009	Water Replicate	Pump	B1YMF1 B1YMH6 B1YMK1	—	B1YMF1	—
267.0-269.0	6/19/2009	Trip Blank	—	B1YM77	—	—	—
287.5-290.0	6/23/2009	Soil	Grab	—	B1YM95	—	—
287.5-290.0	6/23/2009	Soil Replicate	Grab	—	B1YM96	—	—
286.0-290.0	6/24/2009	Water	Pump	B1YMF2 B1YMH7 B1YMK2	—	B1YMF2	—
286.0-290.0	6/24/2009	Trip Blank	—	B1YM78	—	—	—
308.0-310.0	6/26/2009	Soil	Grab	—	B1YM97	—	—
306.0-310.0	6/29/2009	Water	Pump	B1YH73 B1YMF3 B1YMH8 B1YMK3	—	B1YMF3	—
306.0-310.0	6/29/2009	Trip Blank	—	B1YM79	—	—	—
328.0-330.0	7/6/2009	Soil	Grab	—	B1YM98	—	—
327.0-330.0	7/6/2009	Water	Pump	B1YMF4 B1YMH9 B1YMK4	—	B1YMF4	—
327.0-330.0	7/6/2009	Trip Blank	—	B1YM80	—	—	—
350.0-352.5	7/8/2009	Soil	Grab	—	B1YM99	—	—
347.0-350.0	7/9/2009	Water	Pump	B1YH75 B1YMF5 B1YMJ0 B1YMK5	—	B1YMF5	—
347.0-350.0	7/9/2009	Trip Blank	—	B1YM81	—	—	—
369-370	7/10/2009	Soil	Grab	—	B1YMB0	—	—
366-371	7/13/2009	Water	Pump	B1YMF6 B1YMJ1 B1YMK6	—	B1YMF6	—

Table 2-4. Well 299-W14-20 (C7018) Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
366-371	7/13/2009	Trip Blank	—	B1YM82	—	—	—
390.1-392.5	7/17/2009	Soil	Grab	—	B1YMB1	—	—
286.7-392.5	7/17/2009	Water	Pump	B1YH77 B1YMF7 B1YMJ2 B1YMK7	—	B1YMF7	—
390.1-392.5	7/17/2009	Trip Blank	—	B1YM83	—	—	—
408-410.5	7/21/2009	Soil	Grab	—	B1YMB2	—	—
398.5-410.0	7/21/2009	Water	Pump	B1YMF8 B1YMJ3 B1YMK8	—	B1YMF8	—
398.5-410.0	7/21/2009	Trip Blank	—	B1YM84	—	—	—
missing record	~(7/24/09)	Soil	Grab	—	B1YMB3	—	—
439.1-440.0	7/28/2009	Water	Pump	B1YH79 B1YMF9 B1YMJ4 B1YMK9	—	B1YMF9	—
438.0-440.0	7/28/2009	Trip Blank	—	B1YM85	—	—	—
438.0-440.0	7/28/2009	Soil	Grab	—	B1YMB4	—	—

Notes:

222-S = 222-S Building Laboratory, Hanford, Washington.

EBRLNE = Eberline Analytical Corporation, Richmond, California.

ESL = Environmental Soil Laboratory (Pacific Northwest National Laboratory), Richland, Washington.

HEIS # = Hanford Environmental Information System (Sample Number).

WSCF = Waste Sampling and Characterization Facility, Hanford, Washington.

2.2.2.2 *Additional Sampling for Tank Farm RCRA Corrective Action Compliance*

Vadose-zone-soil samples were collected from this borehole by the request of the Tank Farm Contractor to supplement vadose zone characterization pursuant of tank farm corrective actions. Soil samples were collected from a fine grained interval in the vadose zone from 95 to 230 ft bgs at five foot intervals. Sample details are listed in Table 2-5 below.

Table 2-5. Well 299-W15-225 (C7017) Tank Farm RCRA Compliance Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
90.0-92.5	3/26/2009	Soil	Split Spoon	B1YD11 B1YD14 B1YD17 B1YMM9	—	B1YD14	—
90.0-92.5	3/26/2009	Trip Blank	—	B1YM72	—	B1YM72	—
95.0	3/26/2009	Soil	Grab	—	B1YM90	—	B1YMB9
95.0	3/26/2009	Trip Blank	—	B1YM73	—	—	—
100.0	3/26/2009	SOIL	GRAB	—	—	—	B1YMC0
105.0	3/26/2009	SOIL	GRAB	—	—	—	B1YMC1
110.0	3/26/2009	SOIL	GRAB	—	—	—	B1YMC2
115.0	3/27/2009	SOIL	GRAB	—	—	—	B1YMC3
120.0	3/27/2009	SOIL	GRAB	—	—	—	B1YMC4
125.0	3/27/2009	SOIL	GRAB	—	—	—	B1YMC5
130.0	3/27/2009	SOIL	GRAB	—	—	—	B1YMC6

Notes:

222-S = 222-S Building Laboratory, Hanford, Washington.
EBRLNE = Eberline Analytical Corporation, Richmond, California.
ESL = Environmental Soil Laboratory (Pacific Northwest National Laboratory), Richland, Washington.
HEIS # = Hanford Environmental Information System (Sample Number).
WSCF = Waste Sampling and Characterization Facility, Hanford, Washington.

2.2.2.3 *Sampling for Sieve Analysis*

Samples for sieve analysis were collected in a manner consistent with the SAP (DOE/RL 2008-57). Sieve samples were collected throughout the saturated zone of the borehole. They were collected at varying intervals controlled by the type of drilling method used. Sieve samples collected from rotary rig cuttings were collected at 5-foot intervals from the cuttings exhaust and or tailings hopper and composited into 20-foot intervals in labeled, clear plastic bags. Sieve samples collected from cable tool drilling were collected in 10-foot intervals using a hollow core barrel bit to capture sediments that were representative of in-situe sediments. These samples were also composited into 20-foot intervals in labeled, clear plastic bags.

2.2.2.4 *Sampling for Geologic Archiving*

Samples for archiving were collected in a manner consistent with the SAP (DOE/RL 2008-57). Archive samples were collected in pint-glass jars from drill tailings and core samplers at 5-foot intervals throughout the depth of the borehole.

2.2.3 Environmental Monitoring

Monitoring was provided on a full time basis during drilling activities that took place throughout the first 50 ft of the borehole.

2.2.3.1 Radiological Monitoring

Radiological monitoring was provided on a morning and afternoon basis throughout vadose zone drilling activities and was provided on an intermittent (relatively constant) basis during drilling that took place below the water table. Radiological monitoring was also provided on a full time basis during casing extraction during well construction. Fixed and removable beta/gamma radiological contamination was detected on pieces of carbon steel drop pipe and a stainless steel pump that was used for well development. These articles were wrapped in plastic and placed in a radiological materials area on site. Additional beta/gamma radiological contamination was detected on sections of carbon steel temporary casing that had been driven below ground water. The final dispositions of these materials have yet to be determined at the time of this writing.

Since adjacent wells to Well C7018 have known Tritium (H-3) contamination, additional radiological monitoring for tritium was carried out throughout the saturated zone of Well C7018. Tritium smear samples were collected from drilling and sampling tools used throughout the zone of saturation. Table 2-6 below summarizes radiological activity of tritium in disintegrations per minute (dpm) by depth. Objects sampled were lowered through the water table to the total depth of the borehole. Sample depths reflect the objects lowest achieved depth.

Table 2-6. Well 299-W14-20 (C7018): Tritium Samples by Depth

Date	Survey #	Depth	dpm
6/26/2009	09-1264	305	0.00
6/29/2009	09-1286	320	9.22
6/30/2009	09-1290	320	2.75
7/1/2009	09-1310	322	59.85
7/2/2009	09-1308	322	0.00
7/6/2009	09-1313	330	67.68
7/7/2009	09-1324	340	29.85
7/8/2009	09-1334	351	17.51
7/9/2009	09-1347	340	52.90
7/13/2009	09-1362	340	14.53
7/16/2009	09-1402	390	NA
7/17/2009	09-1406	393	NA
7/20/2009	09-1417	412	NA
7/21/2009	09-1434	412	23.33
7/22/2009	09-1435	415	23.36
7/24/2009	09-1462	425	0.00

Table 2-6. Well 299-W14-20 (C7018): Tritium Samples by Depth

Date	Survey #	Depth	dpm
7/28/2009	09-1481	438	0.00
7/31/2009	09-1513	440	0.00

Notes:

dam = disintegrations per minute

NA = Not applicable. Indicating the absence of sample collection.

2.2.3.2 *Industrial Hygiene (Air Quality) Monitoring*

Air quality monitoring for organic vapors was provided on a morning and afternoon basis by an industrial hygienist. The industrial hygienist measured air quality above the borehole opening, above the drill cuttings (when present) and within the general breathing space around the work area. The Industrial hygienist reported all sustainable readings to be below the detectable limits of the organic vapor meter used to measure air quality.

2.2.4 Geophysical Logging

Geophysical logging was performed over three intervals throughout this borehole. Geophysical logging systems performed throughout the borehole included; Spectral Gamma Logging System (SGLS). Since logging was performed through casing strings of variable diameters and thicknesses, the technician adjusted the data to account for the changes in casing.

On April 6, 2009 and April 7, 2009 the borehole was logged through the 16-in. casing from ground surface to 219 ft bgs. On July 22, 2009 and July 23, 2009 the borehole was logged through the 11-3/4-in. casing from 218 to 410 ft bgs. On July 29, 2009 the borehole was logged through the 8-in. casing from 409 to 435 ft bgs.

2.2.5 Well Construction

Construction of Well C7018 took place between July 31, 2009 and September 8, 2009. This well was constructed in compliance with WAC 173-160 for constructing resource protection wells to include compliance with WAC 173-160-450 standards for sealing wells. This well was constructed using 8 5/8-in. OD and 8-in ID, schedule-10 type 316 stainless steel casing, sump and continuous wrap v-wire screen. The well has stainless steel welded-tab centralizers positioned every 40 ft throughout its length. The screen is comprised of two sections of varying mesh size separated by a 20-ft section of solid casing. The upper screen mesh size is .050 slot and the lower mesh size is .040 slot. The sump on this well is only five ft long in contrast to the project general design which calls for a 10 ft long sump.

The materials used for borehole decommissioning below the well, annular filter pack and annular seals also vary according to depth and use. The borehole is decommissioned through the lower aquifer from TD to the base of the RUM using 10-20 mesh Colorado Silica Sand (Css). The RUM (a major confining layer) is sealed using type I, II Portland Cement with between 3 percent and, no more than, 5 percent bentonite to prevent shrinkage. The lower filter sand pack is of 10-20 mesh Css and the upper filter sand pack is of 8/16 mesh Css. The annular seal between the two screens is of 3/8-in. coated bentonite pellets. The annular seal above the filter pack is of

#8 mesh bentonite crumbles. The cement surface seal, placed 30 ft thick, is comprised of type I, II Portland Cement with between 3 percent and, no more than, 5 percent bentonite. See Table 2-7 below for a summary of depths of construction materials.

The well head consist of a 4 ft by 4 ft by 6 in. thick, steel mesh reinforced concrete pad with a 10-inch diameter stainless steel proactive well casing encapsulating the 8 5/8-inch well casing. The protective casing extends three feet above ground surface and one foot above the top of the well and has a lockable cap and a removable access panel on the north side for access to an electrical grounding lug. The well head and pad are also protected by four, three-foot-tall, three-inch diameter protective posts located within on foot of each corner of the well pad. A protective post on the north side of the well is removable for access for maintenance. A brass survey marker bearing the well name, unique well number, and date of completion was installed in the concrete pad on the north side of the well.

Table 2-7. Well 299-W4-20 (C7018) Construction Summary

		Permanent Stainless Steel 8-Inch Diameter Screen and Casing						Annular Materials			
Total Depth Drilled (ft bgs)	Static Water Level (ft bgs)	Upper Screen Interval (ft bgs) [Slot Size (in)]	Screen Blank (ft bgs)	Lower Screen Interval (ft bgs) [Slot Size (in)]	Sump (ft bgs)	Top of Casing (ft ags)	Top of Guard Casing (ft ags)	Upper Sand Pack (ft bgs) [mesh]	Lower Sand Pack (ft bgs) [mesh]	Bentonite Seals {upper} [lower] (ft bgs)	Cement Seals {upper} [lower] (ft bgs)
439	228.75	244.8-374.8 [.050]	374.8-394.8	394.8-404.8 [.040]	404.8-409.8	2.1	2.1	220.3 -378 [8/16]	380 -409 [10/20] 429-439 [10/20]	{30 -220.3} [378 - 380] [426.5-429]	{0-30} [411-426.5]

Notes:

ID = identification
in = inch
ft ags = above ground surface
ft bgs = below ground surface
N/A = Not applicable

2.2.6 Well Development/Aquifer Testing

Development of this well consisted of sand pack surging and standard well development. Sand pack surging took place over no greater than 10 foot intervals throughout screened intervals. Final well development consisted solely of pumping the aquifer over intervals no greater than 15 feet. Each pumped interval was considered fully developed when the water chemistry had stabilized within 10 percent of three consecutive readings and the turbidity had dropped to or below 5 NTU. Figure 2-2. Summarizes the details of the Borehole Stratigraphy, Total Gamma Response, and Well Construction: Well 299-W14-20 (C7018).

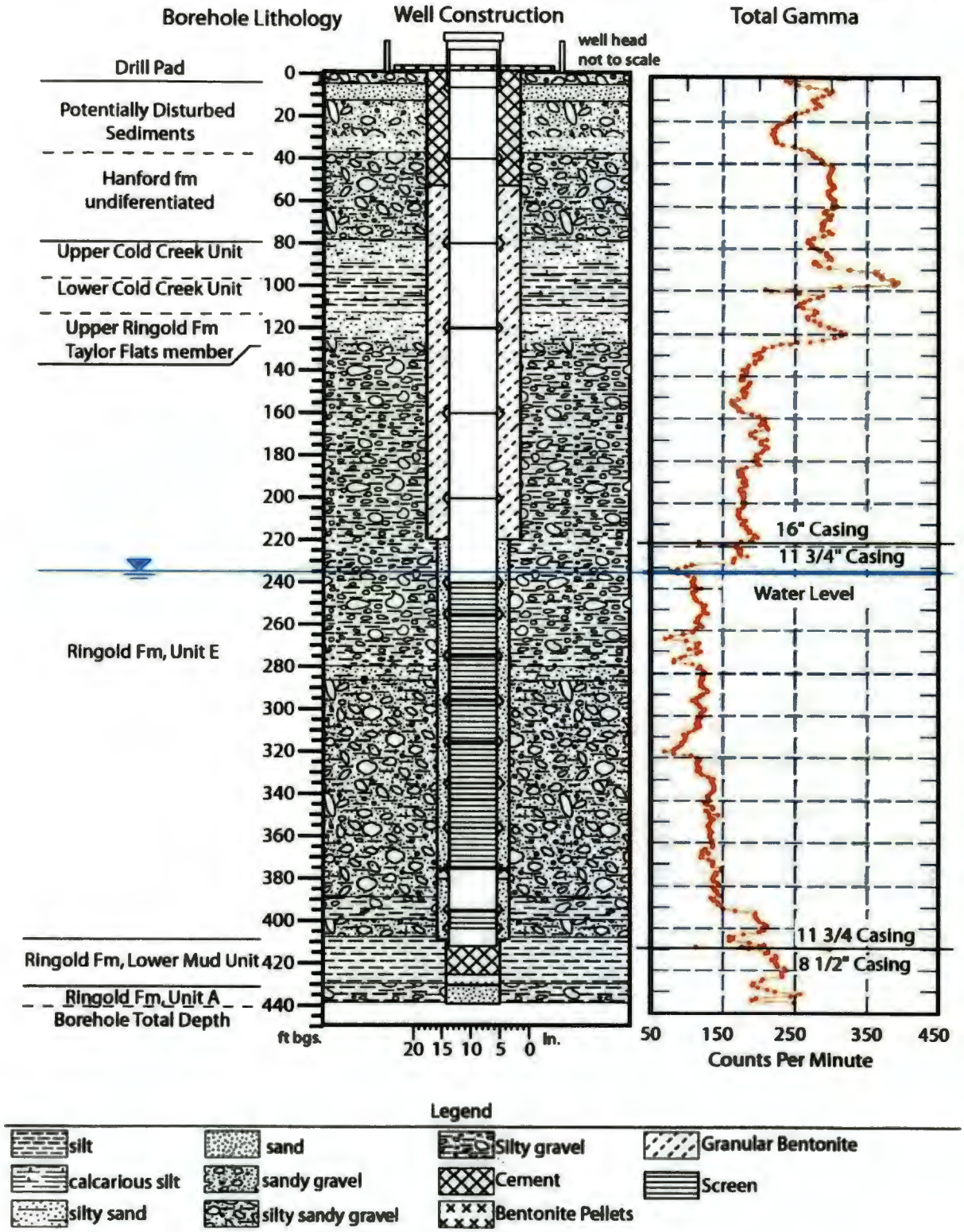

Figure 2-2. Summary of Borehole Stratigraphy, Total Gamma Response and Well Construction: Well 299-W14-20 (C7018).

2.3 Well 299-W14-73 (C7021)

Well 299-W14-73 (C7021) is located within the North-East 1/4 of the South-East 1/4 section, of Section 1, Township 12 North, Range 25 West. Relative to nearby facilities and structures, the well is located in 200 West Area, approximately 60 yards North East of the Water Treatment Plant. The installation and development of well C7021 took place between February 10, 2009 and July 21, 2009.

2.3.1 Drilling

Drilling of borehole C7021 took place between February 10, 2009 and June 5, 2009 and extended to a total depth (TD) of 507 ft bgs. All drilling was performed in compliance with WAC 173-160 "Minimum Standards for Construction and Maintenance of Wells." Throughout drilling, the borehole and temporary casing strings were downsized twice. The following casing sizes were used during drilling operations:

- 16-inch outer diameter (OD), 15 1/2-inch inner diameter (ID) welded, carbon steel casing with a 16-inch OD, 14 1/4-inch ID drive shoe (referred to as 16-inch welded casing);
- 11 3/4-inch OD, 10 3/4-inch ID, threaded, carbon steel casing with a 12 3/8-inch OD, 10 3/4-inch ID drive shoe (referred to as 11 3/4-inch casing);

Beginning February 10, 2009 a cable tool rig with a drive barrel bit advanced the borehole and 16-in. casing from ground surface to 22 ft bgs. On February 27th, 2009 an air rotary rig with a down-hole hammer bit advanced the borehole and 16-inch casing from 22 to 169 ft bgs where the drive shoe was torn off and drilled to the side of the borehole. On February 17, 2009 a straightness test and geophysical survey using SGLS was performed prior to downs sizing the casing. Following geophysical logging, the borehole and 11 3/4-in. casing was advanced from 169 to 235.7 ft bgs. Beginning March 23, 2009 a cable tool rig using a drive barrel bit continued to advance the borehole and 11 3/4-in. casing from 235.7 to 275 ft bgs. From 275 ft bgs the borehole and was advanced using a cable tool rig using hard tool bits to TD at 507.5 ft bgs. However, the 11 3/4-in. casing was only advanced to 485.5 ft bgs where it became lodged into the formation. On June 5, 2009 CHPRC project leads ordered to terminate the borehole before reaching bedrock. The borehole was advanced to TD at 507 ft on May 29, 2009 without encountering bedrock.

2.3.2 Sampling

Soil and water samples were collected for chemical constituent analysis and quality control purposes.

2.3.2.1 Sampling for Laboratory Analysis

Pertaining to the tables below; sample depths expressed in interval notation designate the interval of which a coring bit was driven for sample collection. Sample depths provided in finite notation designate the depth of the bit when a grab sample was collected from the tailings exhaust of an air rotary rig. The below samples were collected and recorded in compliance with this project SAP (DOE/RL 2008-57). Table 2-8 illustrates details associated with individual sampling depths.

Table 2-8. Well 299-W15-225 (C7017) Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
95.0	3/3/2009	Soil	Grab	—	B1YND4	—	B1YNH0
100.0	3/3/2009	Soil	Grab	—	—	—	B1YNH1
105.0	3/4/2009	Soil	Grab	—	—	—	B1YNH2
110.0	3/4/2009	Soil	Grab	—	—	—	B1YNH3
115.0	3/4/2009	Soil	Grab	—	—	—	B1YNH4
120.0	3/4/2009	Soil	Grab	—	—	—	B1YNH5
121.5-123.5	3/4/2009	Soil	Split Spoon	B1YNH9 B1YNJ2 B1YNJ5 B1YNJ8	—	B1YNJ2	—
121.5-123.5	3/4/2009	Trip Blank	—	B1YNB9	—	—	—
125.0	3/5/2009	Soil	Grab	—	—	—	B1YNH6
130.0	3/5/2009	Soil	Grab	—	—	—	B1YNH7
251.0-253.5	3/27/2009	Soil	Grab	—	B1YND7	—	—
251.0-253.5	3/27/2009	Soil	Split Spoon	B1YNJ0 B1YNJ3 B1YNJ6 B1YNJ9	—	B1YNJ3	—
251.0-253.5	3/27/2009	Trip Blank	—	B1YNC0	—	—	—
267.0-269.5	4/1/2009	Soil	Split Spoon	B1YNJ1 B1YNJ4 B1YNJ7 B1YNK0	—	B1YNJ4	—
267.0-269.5	4/1/2009	Trip Blank	—	B1YNC1	—	—	—
269.5-270.0	4/1/2009	Soil	Grab	—	B1YND5	—	—
291.0-294.0	4/3/2009	Soil	Grab	—	B1YND6	—	—
282.5-292.5	4/7/2009	Water	Pump	B1YNK4 B1YNN1 B1YNN2	—	B1YNK4	—
282.5-292.5	4/7/2009	Trip Blank	—	B1YNC2	—	—	—
311.5-313.5	4/9/2009	Soil	Grab	—	B1YND8	—	—
310.2-313.5	4/10/2009	Water	Pump	B1YNK6 B1YNN3 B1YNN4 B1YNN5	—	B1YNK6	—

Table 2-8. Well 299-W15-225 (C7017) Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
310.2-313.5	4/10/2009	Water Replicate	Pump	B1YNK8 B1YNN6 B1YNN7	—	B1YNK8	—
310.2-313.5	4/10/2009	Trip Blank	—	B1YNC3	—	—	—
311.5-313.5	4/13/2009	Soil	Grab	—	B1YND9	—	—
311.5-313.5	4/13/2009	Soil replicate	Grab	—	B1YNF0	—	—
330.0-332.5	4/15/2009	Water	Pump	B1YNL0 B1YNN8 B1YNN9	—	B1YNL0	—
330.0-332.5	4/15/2009	Soil	Grab	—	B1YNV5	—	—
330.0-332.5	4/15/2009	Trip Blank	—	B1YNC4	—	—	—
351.1-353.1	4/20/2009	Soil	Grab	—	B1YNF1	—	—
350.5-351.1	4/20/2009	Water	Pump	B1YNL2 B1YNP0 B1YNP1 B1YNP2	—	B1YNL2	—
350.5-351.1	4/20/2009	Trip Blank	—	B1YNC5	—	—	—
370.8-372.8	4/22/2009	Soil	Grab	—	B1YNF2	—	—
364.0-371	4/22/2009	Water	Pump	B1YNL4 B1YNP3 B1YNP4	—	B1YNL4	—
364.0-371	4/22/2009	Trip Blank	—	B1YNC6	—	—	—
391.0-392.0	4/27/2009	Soil	Grab	—	B1YNF3	—	—
391.0-392.0	4/27/2009	Water	Pump	B1YNL6 B1YNP5 B1YNP6 B1YNP7	—	B1YNL6	—
391.0-392.0	4/27/2009	Trip Blank	—	B1YNC7	—	—	—
407.2-409.2	4/29/2009	Soil	Grab	—	B1YNF4	—	—
404.0-410.0	4/29/2009	Water	Pump	B1YNL8 B1YNP8 B1YNP9	—	B1YNL8	—
404.0-410.0	4/29/2009	Trip Blank	—	B1YNC8	—	—	—
432.0-434.0	5/1/2009	Soil	Grab	—	B1YNF5	—	—

Table 2-8. Well 299-W15-225 (C7017) Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
424.0-434.0	5/4/2009	Water	Pump	B1YNM0 B1YNR0 B1YNR1 B1YNR2	---	B1YNM0	---
424.0-434.0	5/4/2009	Trip Blank	---	B1YNC9	---	---	---
450.5-452.5	5/6/2009	Soil	Grab	---	B1YNF6	---	---
444.0-452.0	5/8/2009	Water	Pump	B1YNM2 B1YNR3 B1YNR4	---	B1YNM2	---
444.0-452.0	5/8/2009	Trip Blank	---	B1YND0	---	---	---
471.0-473.5	5/15/2009	Soil	---	---	B1YNF7	---	---
467.0-470.0	5/15/2009	Water	Pump	B1YNM4 B1YNR5 B1YNR6 B1YNR7	---	B1YNM4	---
467.0-470.0	5/15/2009	Trip Blank	---	B1YND1	---	---	---
492.0-494.0	5/26/2009	Soil	Grab	---	B1YNF8	---	---
485.02-492.0	5/27/2009	Water	Pump	B1YNM6 B1YNR8 B1YNR9	---	B1YNM6	---
485.02-492.0	5/27/2009	Trip Blank	---	B1YND2	---	---	---

Notes:

222-S = 222-S Building Laboratory, Hanford, Washington.
EBRLNE = Eberline Analytical Corporation, Richmond, California.
ESL = Environmental Soil Laboratory (Pacific Northwest National Laboratory), Richland, Washington.
FIELD = Samples
HEIS # = Hanford Environmental Information System (Sample Number).
WSCF = Waste Sampling and Characterization Facility, Hanford, Washington.

2.3.2.2 Additional Sampling for Tank Farm RCRA Corrective Action Compliance

Vadose-zone-soil samples were collected from this borehole by the request of the Tank Farm Contractor to supplement vadose zone characterization pursuant of tank farm corrective actions. Soil samples were collected from a fine grained interval in the vadose zone from 95 to 230 ft bgs at five foot intervals. Sample details are listed in Table 2-9 below.

Table 2-9. Well 299-W15-225 (C7017) Tank Farm RCRA Compliance Sample Summary

Sample Depth	Collection Date	Sample Type	Collection Method	HEIS# and Laboratory Identifier			
				WSCF	ESL	EBRLNE	222-S
95.0	3/3/2009	Soil	Grab	—	B1YND4	—	B1YNH0
100.0	3/3/2009	Soil	Grab	—	—	—	B1YNH1
105.0	3/4/2009	Soil	Grab	—	—	—	B1YNH2
110.0	3/4/2009	Soil	Grab	—	—	—	B1YNH3
115.0	3/4/2009	Soil	Grab	—	—	—	B1YNH4
120.0	3/4/2009	Soil	Grab	—	—	—	B1YNH5
121.5-123.5	3/4/2009	Soil	Split Spoon	B1YNH9 B1YNJ2 B1YNJ5 B1YNJ8	—	B1YNJ2	—
121.5-123.5	3/4/2009	Trip Blank	—	B1YNB9	—	—	—
125.0	3/5/2009	Soil	Grab	—	—	—	B1YNH6
130.0	3/5/2009	Soil	Grab	—	—	—	B1YNH7

Notes:

222-S = 222-S Building Laboratory, Hanford, Washington.
EBRLNE = Eberline Analytical Corporation, Richmond, California.
ESL = Environmental Soil Laboratory (Pacific Northwest National Laboratory), Richland, Washington.
FIELD = Samples
HEIS # = Hanford Environmental Information System (Sample Number).
WSCF = Waste Sampling and Characterization Facility, Hanford, Washington.

2.3.2.3 *Sampling for Sieve Analysis*

Samples for sieve analysis were collected in a manner consistent with the SAP (DOE/RL 2008-57). Sieve samples were collected throughout the saturated zone of the borehole. They were collected at varying intervals controlled by the type of drilling method used. Sieve samples collected from rotary rig cuttings were collected at 5-foot intervals from the cuttings exhaust and or tailings hopper and composited into 20-foot intervals in labeled, clear plastic bags. Sieve samples collected from cable tool drilling were collected in 10-foot intervals using a hollow core barrel bit to capture sediments that were representative of in-situ sediments. These samples were also composited into 20-foot intervals in labeled, clear plastic bags.

2.3.2.4 *Sampling for Geologic Archiving*

Samples for archiving were collected in a manner consistent with the SAP (DOE/RL 2008-57). Archive samples were collected in pint-glass jars from drill tailings and core samplers at 5-foot intervals throughout the depth of the borehole.

2.3.2.5 *Sampling for Sieve Analysis*

Samples for sieve analysis were collected in a manner consistent with the SAP (DOE/RL 2008-57). Sieve samples were collected throughout the saturated zone of the borehole. They were collected at varying intervals controlled by the type of drilling method used. Sieve samples collected from rotary rig cuttings were collected at 5-foot intervals from the cuttings exhaust and or tailings hopper and composited into 20-foot intervals in labeled, clear plastic bags. Sieve samples collected from cable tool drilling were collected in 10-foot intervals using a hollow core barrel bit to capture sediments that were representative of in-situ sediments. These samples were also composited into 20-foot intervals in labeled, clear plastic bags.

2.3.2.6 *Sampling for Geologic Archiving*

Samples for archiving were collected in a manner consistent with the SAP (DOE/RL 2008-57). Archive samples were collected in pint-glass jars from drill tailings and core samplers at 5-foot intervals throughout the depth of the borehole.

2.3.3 Environmental Monitoring

2.3.3.1 *Radiological Monitoring*

Radiological Monitoring was not required on a full time basis during drilling activities that took place throughout the first 50 ft of the borehole. Radiological monitoring was provided however on a morning and afternoon basis throughout vadose zone drilling activities and was also provided on an intermittent (relatively constant) basis during drilling that took place below the water table. Radiological monitoring was also provided on a full time basis during casing extraction during well construction. No radiological contamination was encountered during activities carried out at this site.

2.3.3.2 *Industrial Hygiene (Air Quality) Monitoring*

Air quality monitoring for organic vapors was provided on a morning and afternoon basis by an industrial hygienist. The industrial hygienist measured air quality above the borehole opening, above the drill cuttings (when present) and within the general breathing space around the work area. The Industrial hygienist reported all sustainable readings to be below the detectable limits of the organic vapor meter used to measure air quality.

2.3.4 Geophysical Logging

Geophysical logging was performed over two intervals throughout borehole C7021. Geophysical logging systems performed throughout the borehole included; Spectral Gamma Logging System (SGLS). Since logging was performed through casing strings of variable diameters and thicknesses, the technician adjusted the data to account for the changes in casing. Refer to Appendix D.

On March 17, 2009 the borehole was logged through the 16-in. casing from ground surface to 169 ft bgs. On June 15, 2009 the borehole was logged through the 12-in. casing from 169 to 492 ft bgs. The borehole was not logged beyond the 12-in. casing throughout the open borehole.

2.3.5 Well Construction

Well construction began on June 17, 2009 and was completed July 10, 2009. This well was constructed in compliance with WAC 173-160 for constructing resource protection wells to include compliance with WAC 173-160-450 standards for sealing wells. This well was constructed using 8 5/8-in. OD and 8-in ID, schedule-10 type 316 stainless steel casing, sump and continuous wrap v-wire screen. The well has stainless steel welded-tab centralizers positioned every 40 ft throughout its length. The screen is comprised of two sections of 0.045 slot size screens separated by a 20-ft section of solid casing.

The materials used for borehole decommissioning below the well, annular filter pack and annular seals also vary according to depth and use. The borehole below the bottom of the well was decommissioned using 10-20 Css. The lower and upper filter sand packs are of 10-20 mesh Css and are separated by 2 ft of 3/8-in. coated bentonite pellets. The annular seal above the filter pack is of #8 mesh bentonite crumbles. The cement surface seal, placed 32 ft thick, is comprised of type I, II Portland Cement with between 3 percent and, no more than, 5 percent bentonite. See Table 2-10 below for a summary of depths of construction materials.

The well head consist of a 4 ft by 4 ft by 6 in. thick, steel mesh reinforced concrete pad with a 10-inch diameter stainless steel proactive well casing encapsulating the 8 5/8-inch well casing. The protective casing extends three feet above ground surface and one foot above the top of the well and has a lockable cap and a removable access panel on the north side for access to an electrical grounding lug. The well head and pad are also protected by four, three-foot-tall, three-inch diameter protective posts located within on foot of each corner of the well pad. A protective post on the north side of the well is removable for access for maintenance. A brass survey marker bearing the well name, unique well number, and date of completion was installed in the concrete pad on the north side of the well.

Table 2-10. Well 299-W14-73 (C7021) Construction Summary

		Permanent Stainless Steel 8-Inch Diameter Screen and Casing						Annular Materials			
Total Depth Drilled (ft bgs)	Static Water Level (ft bgs)	Upper Screen Interval (ft bgs) [Slot Size (in)]	Screen Blank (ft bgs)	Lower Screen Interval (ft bgs) [Slot Size (in)]	Sump (ft bgs)	Top of Casing (ft ags)	Top of Guard Casing (ft ags)	Upper Sand Pack (ft bgs) [mesh]	Lower Sand Pack (ft bgs) [mesh]	Bentonite Seals {upper} [lower] (ft bgs)	Cement Seals {upper} [lower] (ft bgs)
507	270.4	290.8-390.9 [.045]	390-410	410.9-490.9 [.045]	490.9-500	1.1	2.1	262.5-395 [10/20]	397-503 [10/20]	{32.1-262.5} [395-397]	{0-32.1} [N/A]

Notes:

ID = identification
In = inch
ft ags = above ground surface
ft bgs = below ground surface
N/A = Not applicable

2.3.6 Well Development/Aquifer Testing

Development of this well consisted of sand pack surging and standard well development. Sand pack surging took place over no greater than 15 foot intervals throughout screened intervals. Final well development consisted solely of pumping the aquifer over intervals no greater than 40 feet. Each pumped interval was considered fully developed when the water chemistry had stabilized within 10 percent of three consecutive readings and the turbidity had dropped to or below 5 NTU. Figure 2-3. Summarizes the Borehole Stratigraphy, Total Gamma Response, and Well Construction: Well 299-W14-73 (C7021)

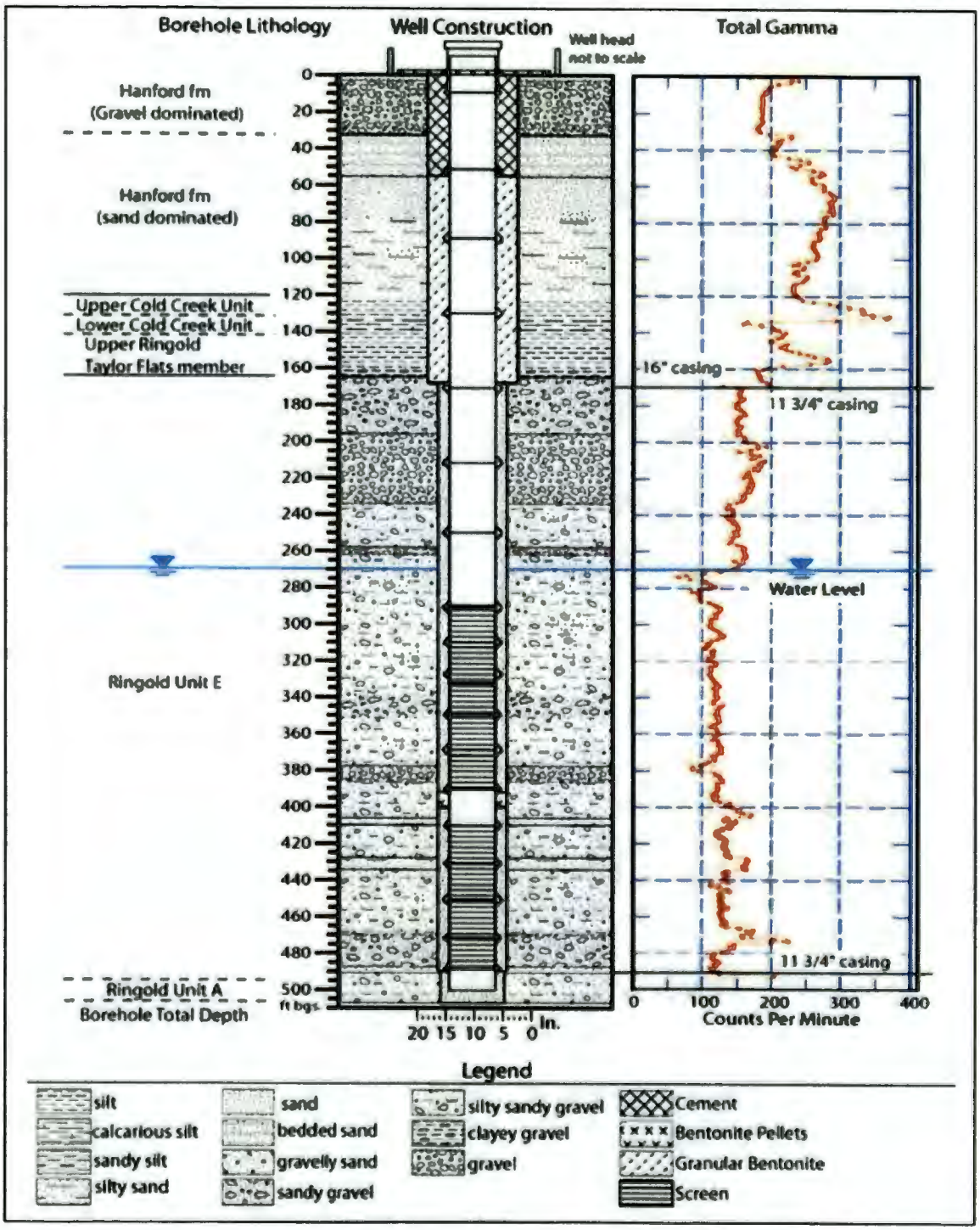

Figure 2-3. Summary of Borehole Stratigraphy, Total Gamma Response and Well Construction: Well 299-W14-73 (C7021)

3 Waste Management

This section presents the management and disposition of waste generated during the drilling, sampling, construction and development of wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021). Waste streams generated include: (1) investigation derived waste (IDW) consisting of vadose zone derived drill cuttings and saturated zone derived drill cuttings; (2) purge water and aquifer water; and (3) miscellaneous solid waste (MSW). Waste streams are fully described and managed in compliance with strategies documented in:

- DOE/RL-2008-57, 2008, Rev.0 Sampling Analysis Plan for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit (DOE/RL-2008-57);
- DOE/RL-2000-40, 2000, Rev. 8. Waste Management Plan for the Expedited Response Action for 200 West Area Carbon Tetrachloride Plume and the 200-ZP-1 and 200-PW-1 Operable Units (DOE/RL-2000-40);
- SGW-39578, 2009, Data Quality Summary Report for the Designation of FY 2009 200-ZP-1 Vadose Zone Investigation-Derived Waste (SGW-39578);
- And SGW-39490, 2009, Data Quality Summary Report for the Designation of FY 2009 200-ZP-1 Saturated Zone Investigation-Derived Waste (SGW-39490);
- WHC-MR-0039, 1990, "Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington." (Izatt, 1990)

3.1 Vadose Zone Derived Drill Cuttings

3.1.1 Well 299-W15-225 (C7017)

According to the, *Waste Inventory Data Lookup* (WIDL) online database well C7017 is located within 100 feet of a waste site that has received radioactive and chemical waste. Therefore drill cuttings (soil) from the top 10 feet of the borehole were continuously monitored for chemical and radiological contamination in compliance with the project Data Quality Objective (DQO) for vadose derived waste (SGW-39578). All vadose zone drill cuttings from this well were placed on 10- and 12-mil plastic sheets at the edge of the drill pad near the point of origin. The cuttings were kept covered to prevent wind, precipitation, and biota from mobilizing any potential radiological and chemical contaminants that may have been associated with the cuttings. After the sediments were determined to pose neither radiological nor chemical risk to the environment the cuttings were returned to the environment near the well site.

3.1.2 Well 299-W14-20 (C7018)

According to the WIDL database, well C7018 is located within 100 feet of two waste sites that have received radioactive and chemical waste. Drill cuttings (soil) from the upper 30 feet of the borehole were continually monitored for chemical and radiological contamination in compliance with the project DQO for vadose derived waste (SGW-39578). All vadose zone drill cuttings from this well were placed on 10- and 12-mil plastic sheets at the edge of the drill pad near the point of origin. The cuttings were kept covered to prevent wind, precipitation, and biota from mobilizing any potential radiological and chemical contaminants that may have been associated

with the cuttings. After the sediments were determined to pose neither radiological nor chemical risk to the environment the cuttings were returned to the environment near the well site.

3.1.3 Well 299-W14-73 (C7021)

According to the (WIDS) online database, well C7021 is not located within 100 feet of a waste site that has received radioactive or chemical waste, therefore continuous chemical and radiological monitoring of sediments from the upper vadose zone were deemed unnecessary (SGW-39578). All vadose zone drill cuttings from the vadose zone were stored on site, near the point of generation, on 10- and 12-mil plastic sheets and were kept covered to prevent precipitation and wind from mobilizing the cuttings and any potential contamination that may have been associated with them. After the sediments were determined to pose neither radiological nor chemical risk to the environment the cuttings were returned to the environment near the well site.

3.2 Saturated Zone Derived Drill Cuttings

Sediments from below the historic high water table are considered to be from the zone of saturation. Because a contaminant plume underlies the 200 West Area, sediments from the zone of saturation throughout the 200 West Area are to be handled as if from an area of known contamination (Izatt, 1990; DOE/RL-2000-40; SGW-39490).

Drill cuttings from the zone of saturation were handled as potentially contaminated material in compliance with the waste management plan for the 200-ZP-1 OU (DOE/RL-2000-40). Drill cuttings from each borehole were removed from the borehole and were placed in temporary containers (e.g. tip dumpsters and slurry troughs) on site. Then excess water was decanted, ladled and/or pumped to a purge water truck (See Section 3.3 for the disposition of purge water). Then the cuttings were reduced of excess moisture by means of evaporation and chemical desiccants and transferred to roll-on/roll-off boxes which were stationed at the drill pad. Upon meeting the Environmental Restoration Disposal Facility (ERDF) waste acceptance criteria, cuttings in all roll off boxes were disposed of at ERDF.

3.3 Purgewater and Aquifer Water

Due to the contaminate plume underlying the 200 West Area, all purgewater from wells within the 200 West Area is to be handled and disposed of as if it were contaminated (Izatt, 1990; DOE/RL-2000-40; SGW-39490).

Purgewater from each well was collected and temporarily stored at the well heads in modular tanks, baker tanks, and/or purgewater trucks. Purgewater produced during all phases of drilling sampling and development of each well -save the extended development of well C7017 was transferred from the site via purge water truck to the on-site Effluent Treatment Facility. Purge water produced during the extended well development phase of well C7017 was pumped through one baker tank to the 200-ZP-1 OU interim pump-and-treat system for treatment.

All purgewater generated during the installation of all three wells covered under this document was handled and disposed of in a manner consistent with guidelines set forth in the waste management plan for the 200 Areas (DOE/RL-2000-40), the project DQO (SGW-39490) as well

as the general guideline for handling and disposing of Hanford site-generated purgewater (Izatt, 1990).

3.4 Miscellaneous Solid Waste

Miscellaneous solid waste (MSW) generated during the installation of each well covered under this document consists of materials that have contacted potentially contaminated media. MSW consisted of disposable sampling equipment and personal protective equipment.

All MSW generated during the installation of all three wells was handled and disposed of in a manner consistent with guidelines set forth in the waste management plan for the 200 Areas (DOE/RL-2000-40). MSW generated at wells C7017 and C7018 was sealed in labeled, depth-discrete bags, and was placed in on-site, roll-on/roll-off canisters to be disposed of at ERDF. MSW generated at well C7021 was placed in both a clearly labeled drum as well as an on-site, roll-on/roll-off canister. MSW placed in the roll-on/roll-off canister was sealed in labeled, depth-discrete bags to be disposed of at ERDF.

MSW placed in roll-on/roll-off canisters and MSW drum were sent to ERDF where their contents met the waste facility acceptance criteria and was disposed.

4 Well Acceptance

Wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021), installed by Blue Star Enterprises-North West, were to be transferred to CHPRC's possession based on meeting acceptance criteria set forth by CHPRC, Ecology and DOE.

An assessment of well acceptance criteria included the following:

- proper well construction
- proper documentation of any and all details pertaining to well installation
- functionality of the well as a pump-and-treat well/monitoring well
- proper well head construction and protective features
- proper well identification
- well-site cleanliness.

Representatives from the accepting entity (CHPRC), the releasing entity (Blue Star Enterprises-North West), and other affiliated entities including; Geosciences, and Quality Assurance were present during the well acceptance meeting for each well. The committee discussed the acceptance criteria of each well and whether or not the conditions of the acceptance criteria were met for each well. All well acceptance criteria for all three wells were met except as noted below.

The final acceptance walk-down of C7017 and C7021 was conducted on July 30th, 2009. The walk-down of C7018 took place on September 24th, 2009. The acceptance of C7017, C7018, and C7022 was documented on QA surveillance number QA-SRGP-SURV-10-001. During the walk-down two field changes were noted. Specifically, they were changes to the size of the surface pad for all three wells and the decision not to install a dedicated sampling pump in C7017.

NCR-09-SGRP-006 R1 was issued documenting and dispositioning a parted screen in C7017. The parted screen was repaired by swedging a stainless steel blank across the gap in the screen. The completed repair was examined by down hole camera survey. The NCR was closed on August 8th, 2009.

NCR-09-SGRP-011 R1 was issued to document and disposition the loss of a 16 inch carbon steel casing shoe in the boring for well C7021. A variance was approved by the Department of Evology to allow completion of the well with the carbon steel shoe left in place. The NCR was closed on February 22nd, 2010.

5 Civil Survey

Locations for wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021) were surveyed by a Washington State licensed Professional Land Surveyor subcontracted under CHPRC on January 30, 2009 prior to well installation. A final survey of well head locations was performed on December 24th 2009. The Horizontal survey was performed using a Trimble[7] 5800 global positioning system receiver under the Washington State Plane Coordinates, WSC83S [91] under the North American Datum of 1991 (NAD83[91]). Elevations were surveyed also using a Trimble 5800 global positioning system receiver under the North American Datum of 1988 (NAVD88). Coordinates have been entered into the *Well Information and Document Lookup* (WIDL) database. Survey data for project wells is summarized in Table 5-1 below.

Table 5-1. Civil Survey Data Summary

Borehole Name	Borehole ID #	Date Surveyed	Northing[a] (m)	Easting[a] (m)	Top of Casing Elevation (m)	Ground Surface[b] Elevation (m)
299-W15-225	C7017	12/04/09	136108.93	566657.35	205.54	204.85
229-W14-20	C7018	12/04/09	136284.47	566909.22	205.16	204.40
299-W14-73	C7021	12/04/09	136204.58	567359.99	217.51	216.73

Notes:

a. Measured at the center of the borehole/well in the Washington State Plane Coordinates, WCS83 (91), *North American Datum of 1983*

b. Ground surface elevation measured to brass survey marker located atop 6-inch tall concrete pad.

ID# = (borehole) Identification Number

M = meter

NA = Not Applicable (survey information not available at the time of publishing)

[7] Trimble is a trademark of Trimble Navigation Limited, Sunnyvale California.

6 Geology

This section presents the structural geology and generalized stratigraphy of the 200 West Area as identified by previous works as well as the geology and hydrogeology of wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021). This section also includes comparisons of borehole geology to borehole geophysical logs for each well.

The stratigraphy and structural geology of the 200 West Area has been described, in detail, in the following documents:

- BHI-01203. Nature and Variability of the Plio-Pleistocene Unit in the 200 West Area of the Hanford Site (Slate 2000).
- DOE/RL-2002-39, 2002, Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin (DOE/RL-2002-39).
- OFR-96-8, The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-central Washington and North-central Oregon (Lindsey 1996).
- PNNL-13858, Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West-Area and Vicinity, Hanford, Washington (Williams et al. 2002).
- PNNL-15955. Geology Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site (Reidel and Chamnes 2002)
- WHC-SA-1764-FP, Late Cenozoic Structure and Stratigraphy of South-Central Washington. (Reidel et al. 1993)

These documents provide a base knowledge for which stratigraphic identifications and correlations are made. Geologic formations and units encountered during the drilling of wells in the 200 West Area includes:

- Hanford formation.
- Cold Creek formation.
- Ringold Formation, Lower units.
- Saddle Mountain Basalt Formation, Elephant Mountain Member.

6.1 Structural Geology

The regional geology of the Pacific-Northwest is detailed in the documents listed above and will not be discussed herein. The Hanford Site is located in the west-central Pasco Basin in south-central Washington. The Basin is bounded to the north, west, and south by a series of east-west-trending, north vergent, anticlines and is bounded to the east by a west-dipping monocline Lindsey (1996) Reidel et al. (1993). The western part of the Pasco Basin is divided by a series of asymmetrical east-west-trending folds that verge to the north. These folds include the Gable Mountain anticline which divides the western part of the Pasco basin into the Wahluke syncline to the north and the Cold Creek syncline to the south. The 200 West Area lies within the Cold Creek syncline

The Wahluke and Cold Creek synclines are filled with Neogene- to Quaternary-aged sediments Lindsey (1996) and Reidel and Chamnes, (2002). These sediments include Pliocene- to Pleistocene-aged alluvium and paleosols associated with fluvial-channel, fluvial-side stream, overbank and lacustrine depositional environs. Pliocene- to Pleistocene-aged sediments also include intertonguing alluvial fan materials. Sediments filling the synclines of the Pasco Basin also include Pleistocene-aged alluvium and lacustrine deposits associated with cyclic cataclysmic flooding and backwater depositional environs associated with the Missoula floods.

6.2 Borehole Geology/Hydrogeology

This section includes detailed descriptions of geologic units and associated sediments as they were encountered throughout the drilling of wells 299-W15-225 (C7017), 299-W14-20 (C7018) and 299-W14-73 (C7021). Sediments were described in the field using grain size percentages, sediment sorting, clast angularity, felsic to mafic composition ratios, degree and type of cementation (using 10 percent dilute hydrochloric Acid [HCl]) and degree of consolidation (based on sample friability and drilling rates). Sediment colors were described using Munsell color chart which provide alphanumeric notation to standardize color descriptions.

Sediments encountered during the drilling of these wells were mostly observed using grab samples of drill cuttings produced from air rotary and cable-hard-tool drilling. These methods of drilling mechanically break down sediments; it should be noted that percentages of grain size, composition, and angularity of samples are estimates. Geologists typically use the radii of broken clasts to estimate original clast sizes, however judgment of sand to gravel ratios and of clast composition ratios remain pragmatic.

6.2.1 WELL 299-W15-225 (C7017)

6.2.1.1 Quaternary-age Deposits/Backfill Materials

- (0.0-15.0 ft bgs): Crushed gravels and silty sands were encountered. These sediments appear to be backfill material associated with the construction of the nearby tank farm and an immediately adjacent buried pipeline. These sediments overlay coarse grained sediments of the Hanford formation (fm).

6.2.1.2 Hanford formation.

Sediments belonging to the Hanford fm. were encountered from 15 to 103 ft bgs. Principal sediments encountered include a rhythmite sequence of silty sandy gravels grading to sandy silts from 15 to 56 ft bgs and a sandy sequence encountered from 56 to 103 ft bgs. These sediments were assigned to the Hanford fm. based on similar findings by Williams et al. (2002) and DOE/RL-2002-39. Hanford fm. sediments have a sharp contact with underlying fine-grained, calcified sediments of the Cold Creek Unit.

- (15.0-20.0 ft bgs): Silty sandy gravel (10 percent silt, 20 percent sand, 70 percent gravel). Gravel is sub-angular to sub-round medium pebbles of 70 percent mafic, 30 percent felsic composition. Sand fraction matches gravel composition (angularity not recorded).

- (20.0-35.0 ft bgs): Sandy silt (15-20 percent sand, 80-85 percent silt). Sand fraction is sub-round, very fine to fine sand. Sediment color is 7.5YR5/2, brown. This interval has a sharp contact with underlying coarser sediments.

- (35.0-36.0 ft bgs): Silty gravel bed (20 percent silt, 80 percent gravel). Gravel fraction is sub-angular, fine to medium pebbles of 35 percent mafic, 65 percent felsic composition. This bed has a sharp contact with above and below intervals.
- (36.0-40.0 ft bgs): Gravelly silt (40 percent gravel, 60 percent silt). Gravel fraction is sub-angular, fine to medium pebbles of 35 percent mafic, 65 percent felsic composition (similar to above interval). This interval grades to the interval below.
- (40.0-43.5 ft bgs): Silty sandy gravel (15 percent silt, 15 percent sand, 70 percent gravel) with sub-angular to sub-round, medium pebbles with fine sand. Gravel size increases at 42 ft (borehole log does not record gravel size) with a change of composition to 50 percent mafic, 50 percent felsic content.
- (43.5-54.5 ft bgs): Sandy silt (40 percent sand, 60 percent silt). Sand exists as stringers comprised of sub-round medium sand of felsic composition (color not recorded).
- (54.5-56.0 ft bgs): Sandy silty gravel bed (10 percent sand, 30 percent silt, 60 percent gravel). Gravel is dominantly felsic, sub-round, very fine pebble to medium pebble sized clasts with a sandy silt matrix. Sand fraction is fine to coarse grained with similar composition to the gravel. Sediment color is 7.5YR5/2 brown, and uncemented.
- (56.0-103.0 ft bgs): Sand (90 percent sand, 10 percent silt). Sand is sub-round, very fine to fine quartz dominant sand. Sediment color is 7/5 YR5/2, brown. Below 83 ft bgs, sediments exhibit a very strong reaction with HCl. Fine to medium grained chips of calcium carbonate were found in samples. Induration (carbonate cementation) increases with depth. This unit has a sharp contact with underlying sediments.

6.2.1.3 Cold Creek Unit

Sediments belonging to the Cold Creek Unit were encountered from 103 to 144 ft bgs. Principal sediments encountered include calcium carbonate cemented silt from 103 to 129 ft bgs grading to sandy silt from 129 to 144 ft bgs. These sediments were assigned to the Cold Creek unit based on similar grain size and gamma response findings by Lindsey, (1996) and Reidel and Chamnes, (2002). Cold Creek sediments share a gradational contact with underlying, coarse-grained sediments of the Ringold Formation (Fm).

- (103.0-129.0 ft bgs): Silt colored 7.5 YR 5/2, brown with up to 10 percent sand. Sediments have a strong reaction with HCl. No chips of caliche were encountered throughout this interval.
- (129.0-144.0 ft bgs): Sandy silt (35 percent sand, 65 percent silt) colored 2.5Y7/1 light gray. Sand fraction is fine to medium sand of 50 percent mafic, 50 percent felsic composition (angularity not noted). Sand fraction increases with depth from 0-35 percent with sparse pebbles present below 133 ft bgs. Sandy silt with sparse pebbles gradually grades to sandy silty gravel.

Spectral analysis of the Cold Creek Unit exhibits 3 spikes between 100 and 130 ft bgs which reveal the presence of at least 3 paleosol horizons previously identified in vicinity wells by Lindsey, 1996 and Reidel and Chamnes, 2007.

6.2.1.4 Ringold Fm, Unit E

Sediments belonging to the Ringold Fm, Unit E were encountered from 144 to 410 ft bgs. Principal sediments encountered include moderately to well sorted sandy silty gravels, from 144 to 219 ft bgs and moderately to poorly sorted silty sandy gravels from 219 to 410 ft bgs with intermittent coarse grained interbeds and fine grained interbeds. These sediments were assigned to the Ringold Fm, Unit E based on similar findings by Williams et al. (2002) and Lindsey (1996). Ringold Fm, Unit E sediments have a sharp contact with underlying fine grained sediments of the Ringold Lower Mud Unit (RLM).

- (144.0-219.0 ft bgs): Moderately to well sorted Sandy silty gravel (10-20 percent sand, 15-45 percent silt, 40-70 percent gravel). Silt content gradually increases with depth, gravel content gradually decreases with depth and sand content remains relatively consistent throughout this interval. Gravels are sub-angular to sub-round fine to medium pebbles with composition ranging from 85 percent to 40 percent mafic basalt with mafic content decreasing with depth. Sandy silty gravel grades to silty sandy gravel below. Sediments below 157 ft bgs are uncemented.
- (219.0-410.5 ft bgs): Moderate to poorly sorted silty sandy gravel (15-20 percent silt, 20-30 percent , 50-60 percent gravel). Gravels are moderately to poorly sorted, sub-round to well-round, fine pebbles to cobbles with silty very fine to very coarse sand matrix. Sediment composition gradually changes throughout this interval from mafic dominant to felsic dominant. This interval contains multiple silty gravel and sandy gravel sub-intervals as follows:
- (223.0-239.0 ft bgs): Sandy gravel (5 percent silt, 30 percent sand, 65 percent gravel). Matrix supported fine pebble to boulder gravel of 40 percent mafic, 60 percent felsic composition.
- (261.0-262.0 ft bgs): Silty gravel (10 percent sand, 30 percent silt, 60 percent gravel). Matrix supported gravels are sub-round pebbles to cobbles with very fine to medium sand.
- (262.0-265.0 ft bgs): Sandy gravel (10 percent silt, 30 percent sand, 60 percent gravel). Matrix supported gravels are sub-round to round, very fine pebbles to boulders of 40 percent mafic, 60 percent felsic composition with sub-angular, fine to very coarse silty sand matrix.
- (316.0-324.0 ft bgs): Gravelly sand (20 percent gravel, 80 percent sand). Sand is very fine to medium sand of 80 percent quartzo-feldspathic, 20 percent basaltic composition with gravel predominantly felsic gravel.
- (353.0-378.0 ft bgs): Gravelly silty sand (20 percent gravel, 20 percent silt, 60 percent sand). Sand is moderately sorted very fine to medium sand of 70 percent quartzo-feldspathic, 30 percent basalt composition with predominantly felsic gravel.

6.2.1.5 Ringold Fm, Lower Mud Unit

Sediments belonging to the RLM were encountered from 410.5 to 458 ft bgs. Principal sediments encountered include clay from 410.5 to 435 ft bgs grading to silty clay from 435 to 458 ft bgs. These sediments were assigned to the RLM based on similar findings by Williams et al. (2002) and Lindsey (1996). The RLM shares a gradual gradational contact with underlying coarse sediments of the Ringold Fm, Unit A

- (410.5-458.0 ft bgs): Clay to silty clay. From 410.5 to 435 ft bgs the unit is dominantly comprised of clay with a small percentage of silt. The interval is light brown and is highly plastic with no reaction with HCl. From 435 to 458 ft bgs silt content gradually increases to 50 percent and consolidation increases with depth. Silty clays are greenish gray colored with rusty brown mottling (color code not noted).

6.2.1.6 Ringold Fm, Unit A

- Sediments belonging to the Ringold Fm, Unit A were encountered from 458 to the total depth of the borehole at 465 ft bgs. These sediments were assigned to the Ringold Fm, Unit A based on similar findings in surrounding wells by Williams et al. (2002); Lindsey (1996) and Reidel and Chamnes (2002). Based on nearby wells, Ringold Fm, Unit A extends to basalt bedrock between 500 and 510 ft bgs.

- (458.0-465.0 ft bgs): Sandy gravel (50 percent sand, 50 percent gravel). Gravels are sub-round (un-noted size) of 50 percent mafic, 50 percent felsic composition with a very fine sand matrix. Matrix color has a slight greenish tint (color classification not noted).

- (465.0 ft bgs): Total depth of the borehole.

6.2.2 Well 299-W14-20 (C7018)

6.2.2.1 Fill Material/Hanford fm.

- (0.0-5.0 ft bgs): Crushed gravel and silty sand of the drill pad. The drill pad is positioned across a topographic low and is 5 ft thick at its deepest point. The drill pad is also positioned about 20 ft north of a waste trench. Sediments below the drill pad extending to 30 ft below the pad surface may have been disturbed by the installation of the nearby trench.

- (5.0-14.5 ft bgs): Sand (5 percent silt, 95 percent sand) Sand is very fine to very coarse grained of 70 percent mafic, 30 percent felsic composition. The sand is unconsolidated but has a strong reaction with HCl. At 13 ft bgs thin bed forms, up to 1/4 in. thick, were encountered.

- (14.4-30.0) ft bgs): Sandy gravel (10 percent silt 36 percent sand, 65 percent gravel). Gravel is sub-angular to well-round very fine to very coarse, pebbles with sparse large cobbles. Sediments are of 60 percent mafic, 40 percent felsic composition. Below 18 ft bgs, sediment composition changes to 80 percent mafic, 20 percent felsic.

- (30.0-31.5 ft bgs): Sandy silty gravel (10 percent sand, 15 percent silt, 75 percent gravel). Sediments are similar to the above interval with the exception that matrix material is 7.5YR6/2, pinkish gray colored. This may be the base level of the nearby trench.

6.2.2.2 Hanford Fm.

Sediments belonging to the Hanford formation were encountered from 31.5 to 90.5 ft bgs. Principal sediments encountered include silty sands and silty gravelly sands Hanford fm. These sediments were assigned to the Hanford fm. based on similar findings by Williams et al. (2002) and DOE/RL-2002-39. Sediments have a sharp contact with underlying fine-grained, carbonate cemented sediments of the Cold Creek Unit.

- (31.5-38.0 ft bgs): Silty sand (25 percent silt, 75 percent sand). Sand is very fine to very coarse with sparse sub-angular to sub-round fine pebbles. Color is 7.5 YR 4/3, brown with no reaction with HCl.
- (38.0-79.0 ft bgs): silty gravelly sand (15-25 percent silt, 15 percent gravel, 70-75 percent sand). Sands are fine to very coarse with sparse sub- to well-rounded fine pebbles. Sediments are 7.5YR4/3 brown colored and are very unconsolidated. Six-inch thick beds of well-rounded medium- to very-coarse-pebble gravels occur periodically throughout the unit. These beds have been identified in nearby pits as basal gravels of large forest beds created by Missoula floods (Chamness and Reidel, 2007). Gravel concentrations of sediments decrease with depth grading to silty sand.
- (79.0-90.5 ft bgs): silty sand (20 percent silt, 80 percent sand). Sand is fine to coarse quartz dominant with sparse sub-angular to sub-round, very fine to fine mafic dominant pebbles. Sediments are 7.5YR4/3 brown and unconsolidated.

6.2.2.3 Cold Creek Unit

Sediments belonging to the Cold Creek Unit were encountered from 90.5 to 127.0 ft bgs. Principal sediments encountered include calcium carbonate cemented silt from 90.5 to 114.0 ft bgs grading to silty sand from 114.0 to 127.0 ft bgs. These sediments were assigned to the Cold Creek unit based on similar grain size and gamma response findings by Lindsey, (1996) and Reidel and Chamness, (2002). Cold Creek sediments share a gradational contact with underlying, coarse-grained sediments of the Ringold Formation (Fm).

- (90.5-114.0 ft bgs): Silt with sparse very fine sand. Silt color is 7.5YR4/3 brown with a weak reaction to 10 percent dilute HCl. At 97.5 ft bgs caliche chips were encountered and sediments have a strong reaction with HCl. This may be fine to medium stringers of caliche that may exist in multiple layers. A spike in total gamma response at 97.5 ft bgs supports the existence of a paleosol carbonate horizon at this depth. Silt grades to silty sand.
- (114.0-127.0 ft bgs): Silty sand (40 percent silt, 60 percent sand). Sand is sub-round, fine to medium grained of 50 percent mafic, 50 percent felsic composition with a weak reaction to 10 percent dilute HCl. One-foot-thick beds of 100 percent silt occur intermittently below 118 ft bgs. Sediments also become well to moderately consolidated below 119 ft bgs. This unit shares a graded contact with underlying silty sandy gravel.

Spectral gamma logs of Cold Creek sediments reveal a saw tooth pattern with spikes at 100, 115 and 120 ft bgs. Based on similar findings by Lindsey, (1996) and Reidel and Chamness, (2002) in surrounding boreholes, at least 3 palio pediment surfaces can be identified within the Cold Creek Unit at this location. Lindsey (1996) and Slate, (2000) also attributed the Cold Creek Unit paleosols to weathered surfaces of Ringold E sediments.

6.2.2.4 Ringold Fm, Unit E

Sediments belonging to the Ringold Fm, Unit E were encountered from 127.0 to 407.0 ft bgs. Principal sediments encountered include moderately to well sorted sandy gravels and sandy silty gravels, from 127.0 to 221.5 ft bgs and poorly sorted silty sandy gravels with occasional sand beds and gravelly silts from 221.5 to 407.0 ft bgs. These sediments were assigned to the Ringold

Fm, Unit E based on similar findings by Williams et al. (2002) and Lindsey (1996). Ringold Fm, Unit E sediments have a sharp contact with underlying fine grained sediments of the Ringold Lower Mud Unit (RLM).

- (127.0-131.0 ft bgs): Moderately to well sorted silty sandy gravel and sandy silty gravel with quartzo-feldspathic dominant silty sand to sandy silt matrix. This interval gradually grades to underlying poorly sorted sediments.
- (127.0-131.0 ft bgs): Silty sandy gravel (30 percent silt, 35 percent sand, 35 percent gravel). Gravel is sub-round to sub-angular coarse- to very coarse pebbles of 60 percent mafic, 40 percent felsic composition with silty sub-round to sub-angular, fine to medium sand of 50 percent mafic, 50 percent felsic composition. Matrix is 7.5YR4/5, brown and is well consolidated with a very weak reaction to 10 percent dilute HCl. This interval grades to underlying sandy silty gravel.
- (131.0-221.5 ft bgs): Sandy silty gravel (10-20 percent sand, 20-40 percent silt, 50-70 percent gravel). Gravels are sub-round, coarse to very coarse pebbles of 80 percent mafic, 20 percent felsic composition with silty quartzo-feldspathic sand matrix (un-recorded grain size). Silt content gradually increases to 40 percent to 180 ft bgs then decreases again below 180 ft bgs.
- (221.5-257.0 ft bgs): Poorly sorted, silty gravel (0-15 percent sand, 35-50 percent silt, 50 percent gravel,). Gravel is sub-rounded to well rounded, very fine pebbles to small cobbles of 30-50 percent mafic, 50-70 percent felsic composition with a slightly sandy silt matrix that is 7.5YR4/3, brown. Mafic content of clasts decreases with depth.
- (257.0-270.0 ft bgs): Poorly sorted, sandy gravel (10 percent silt, 45-50 percent sand, 45-50 percent gravel). Gravel is angular to sub-rounded, very fine pebbles to large cobbles (composition not recorded) with very fine to very coarse sand (unreported composition and angularity) that is 2.5Y5/4 light olive brown colored. This interval has a gradational contact with underlying silty sandy gravels and contains a 2-foot thick sand bed as follows:
- (264.0-266.0 ft bgs): Sand (5 percent silt, 5 percent gravel, 90 percent sand). Sand is fine to medium grained with 5 percent silt and sparse fine to coarse pebbles and is 2.5YR5/2 grayish brown colored with a moderate reaction with HCl.
- (270.0-390.0 ft bgs): Poorly sorted silty sandy gravel to slightly silty sandy gravel (15-30 percent silt, 20-45 percent sand, 40-60 percent gravel). Gravel is angular to well-rounded, very fine pebbles to large cobbles of 15-60 percent mafic, 85-40 percent felsic composition with silty, very fine to very coarse micaceous sand matrix that is 2.5Y5/2, grayish brown in color. Sediments are semi consolidated with no reaction to HCl. Clasts become well rounded and felsic dominant toward the base of the interval. This interval has a gradational contact with underlying sediments and contains a 7.5-foot thick gravelly silty sand interval as follows:
- (280.0-287.5 ft bgs): gravely silty sand (25 percent gravel, 30 percent silt, 45 percent sand). Sand is very fine to very coarse sand (angularity not noted) of 35 percent felsic, 65 percent mafic composition with sub-round to angular, very fine pebbles to small cobbles.

- (390.0-400.0 ft bgs): Gravelly silt (15 percent gravel, 85 percent silt). Silt is micaceous, 5Y5/3, olive colored with discoidal, well rounded, fine pebbles to small cobbles of 100 percent felsic composition. Sediments are moderately consolidated with no reaction to HCl. This interval shares a sharp contact with underlying silty sandy gravel.
- (400.0-407.0 ft bgs): Silty sandy gravel (15 percent silt, 15 percent sand, 70 percent gravel). Gravel is angular to sub-round, very fine pebbles to small cobbles of 20 percent mafic, 80 percent felsic composition with silty, sub-round to round, very fine to coarse sand that is 10YR5/4, yellowish brown colored. This sediment is semi-consolidated, uncemented and shares a sharp contact with underlying clays and silts.

6.2.2.5 Ringold Fm, Lower Mud Unit

Sediments belonging to the RLM were encountered from 407.0 to 430.0 ft bgs. Principal sediments encountered include clay. This sediment was assigned to the RLM based on similar findings by Williams et al. (2002) and Lindsey (1996). The RLM has a gradual gradational contact with underlying coarse sediments of the Ringold Fm, Unit A

- (407.0-430.0 ft bgs): Clay. Color is 5Y5/2 olive gray and is consolidated and uncemented. This interval contains sand interbeds that occur in increasing frequency below 425 ft bgs. The exact depth and thickness of these interbeds is unknown due to poor returns.

6.2.2.6 Ringold Fm, Unit A

Sediments belonging to the Ringold Fm, Unit A were encountered from 430 to the total depth of the borehole at 439.5 ft bgs. These sediments were assigned to the Ringold Fm, Unit A based on similar findings in surrounding wells by Williams et al. (2002); Lindsey (1996) and Reidel and Chamnes (2002). Based on nearby wells, Ringold Fm, Unit A extends to basalt bedrock between 500 and 510 ft bgs.

- (430.0-439.0 ft bgs): Sandy silty gravel (15 percent sand, 20 percent silt, 65 percent gravel). Gravel is sub-angular, very fine to very coarse pebbles of 15 percent mafic, 75 percent felsic composition with sandy silt matrix. Matrix sand is very fine to very coarse grained (unrecorded angularity), is GLEY3/5, very dark grayish green and is semi-consolidated and is uncemented.
- (439.0 ft bgs): Total depth of the borehole.

6.2.3 Well 299-W14-73 (C7021)

6.2.3.1 Quaternary-age Deposits

- (0.0-1.0 ft bgs): Crushed gravel and silty sand of the drill pad.
- (1.0-3.5 ft bgs): Aeolian-silty sand (30 percent silt, 70 percent sand). These sands appear to be aeolian-reworked sediments originating from the underlying Hanford fm. This unit exists as a continuous veneer across the project area producing low dunes and supporting arid shrubs and grasses. Much of the project area surface sediments have been disrupted by construction.

6.2.3.2 Hanford fm.

Sediments belonging to the Hanford fm. were encountered from 3.5 to 123.0 ft bgs. Principal sediments encountered include a poorly sorted sandy gravel sequence and a sand sequence. These sediments were assigned to the Hanford fm. based on similar findings by Williams et al. (2002); DOE/RL-2002-39; and Reidel and Chamnes 2002. Hanford fm. sediments have a sharp contact with underlying fine-grained, calcified sediments of the Cold Creek Unit.

- (3.5-33.0 ft bgs): Poorly sorted sandy gravel (30-40 percent sand, 70-60 percent gravel). The gravel fraction is sub-rounded with a maximum clast size of 4 inches in diameter of 70 percent mafic, 30 percent felsic composition.
- (33.0-53.0 ft bgs): Well sorted sand with sparse pebbles (90 percent sand, 10 percent silt). Sand is coarse to very coarse with un-noted angularity of 75 percent mafic composition. This unit grades downward to silty sand sequence of the Hanford fm.
- (53.0-123.0 ft bgs): Silty micaceous sand (40 percent silt, 60 percent sand). Sand lithology is 50 percent mafic, 50 percent felsic. Sample color is 10YR5/2 brown.

Upon review of borehole logs and their associated-geophysical log reports of surrounding wells and area-geologic cross sections, it was discovered that this well lies atop a large formation of Hanford Gravels. This formation has been described by Williams et al. (2002) and DOE/RL-2002-39 as a large slack water bar produced by the Missoula floods traverse through gable gap.

6.2.3.3 Cold Creek Unit

Sediments belonging to the Cold Creek Unit were encountered from 123.0 to 159.0 ft bgs. Principal sediments encountered include calcium carbonate semi-cemented to cemented silt from 134.0 to 159.0 ft bgs. These sediments were assigned to the Cold Creek unit based on similar grain size and gamma response findings of nearby boreholes by Lindsey, (1996) and Reidel and Chamness, (2002). Cold Creek sediments share a gradational contact with underlying, sandy gravels of the Ringold Formation (Fm).

- (123.0-159.0 ft bgs): Micaceous silt that is 10YR5/2-brown in color with sparse pebbles. The silt has moderate plasticity and has a slight to moderate reaction HCl. Induration increases with depth to 134 ft bgs where a very strong reaction with HCl was reported.
- An increase in gamma response from 123-134 ft bgs and a second increase in gamma response from 134-155 ft bgs supports geologic evidence for the presence of palio pediment surfaces throughout these intervals.

Spectral gamma logs of Cold Creek sediments reveal a saw tooth pattern with spikes at 134 and 155 ft bgs. Based on similar findings by Lindsey, (1996) and Reidel and Chamness, (2002) in surrounding boreholes, at least 2 palio pediment surfaces can be identified within the Cold Creek Unit at this location. Lindsey (1996) and Slate, (2000) also attributed the Cold Creek Unit paleosols to weathered surfaces of Ringold E sediments.

6.2.3.4 Ringold Fm., Unit E.

Sediments belonging to the Ringold Fm, Unit E were encountered from 165 to 435 ft bgs. Principal sediments encountered include clast supported gravel, sandy gravels, and silty sandy

gravels with intermittent gravelly silty sand and sand stringers. Sediments from 409.0 to 480.5 ft bgs are altered. These sediments were assigned to the Ringold Fm, Unit E based on similar findings by Williams et al. (2002) and Lindsey (1996). Ringold Fm, Unit E sediments have a sharp contact with underlying fine grained sediments of the Ringold Lower Mud Unit (RLM).

- (165.0-196.0 ft bgs): Poorly sorted sandy gravel (15 percent sand, 85 percent gravel) belonging to the Ringold Fm. The gravel fraction is sub-round to well-round fine pebble to cobble gravel of 85 percent felsic, 15 percent felsic composition. The sand fraction is sub-angular to sub-round very fine to medium quartzo-feldspathic sand. These sediments are uncemented.
- (196.0-235.0 ft bgs): Clast supported gravel (8 percent sand, 92 percent gravel). Gravel is sub-angular to angular, fine pebbles to very coarse cobbles of 60 percent mafic, 40 percent felsic composition with a sand matrix that is similar to the above interval.
- (235.0-244.0 ft bgs): Sandy gravel (55 percent sand, 45 percent gravel). Gravel is sub-round to sub-angular fine to coarse pebbles of 30 percent mafic, 70 percent felsic composition. Sand is sub-angular to angular very fine to very coarse sand of 30 percent mafic 70 percent felsic composition.
- (244.0-409.5 ft bgs): Moderately to poorly sorted, silty sandy gravel to sandy gravel (10-20 percent silt, 20-30 percent sand, 50-60 percent gravel). Gravel fractions are sub-angular to well-round very fine pebbles to coarse cobbles of 35-25 percent mafic, 65-75 percent felsic composition. Sparse 9-inch boulders are present. Sand fractions are very fine to very coarse sand (unrecorded angularity) of micaceous quartzo-feldspathic sand. Sediment colors range from 10YR7/3 pale yellow brown to 2.5Y5/3 light olive brown with common red iron staining. Carbonate cementation varies throughout this unit. The base of this unit contains clay nodules as well as a 2-foot thick silty sand bed as described below.
- (392.0-407.5 ft bgs): Sparse 4-inch-round clay nodules are present in the gravels. Clay nodules are 10YR5/1, gray in color.
- (407.5-409.5 ft bgs): Sand with fine silt stringers. Sand is 100 percent quartzo-feldspathic. Sediment color is 2.5 Y4/3 olive brown.
- (409.5-480.5 ft bgs): Highly altered, moderately to poorly sorted, silty sandy gravel (20 percent clayey silt, 40 percent sand, 40 percent gravel). Sediment is matrix supported to almost clast supported. Gravel is sub-rounded to well-rounded very fine pebbles, to small cobbles of 20 percent mafic, 80 percent felsic composition with a clayey silty sand matrix. Matrix sand is sub-angular to angular very fine to very coarse grained of 10 percent to 20 percent mafic, 80 percent to 90 percent felsic composition. Larger clasts of gravel have weathering rinds of clayey silt of colors coinciding with clast compositions giving the sediment a mottled black, gray, yellow, white and red coloring. This unit also contains a silty sand lens described below.
- (428.0-435.5 ft bgs): Silty sand interbed with sparse pebbles (5-10 percent clay, 25 percent silt, 75 percent sand) Sand is sub-round to angular, very fine to medium micaceous sand of 90 percent quartzo-feldspathic, 10 percent mafic composition. Sediments are un-cemented,

have no plasticity and contain sparse, sub-round to well-round small cobbles of quartzite. Sediment color is 2.5Y4/4 olive brown. The upper contact of this interval is laterally equivalent to the upper contact of the RLM encountered in surrounding wells 299-W14-72, 299-W14-20 and 299-W11-26.

6.2.3.5 Ringold Fm., Unit A.

Sediments belonging to the Ringold Fm, Unit A were encountered from 480 to the total depth of the borehole at 507 ft bgs. These sediments were assigned to the Ringold Fm, Unit A based on similar findings in surrounding wells by Williams et al. (2002); Lindsey (1996) and Reidel and Chamnes (2002). Based on nearby wells, Ringold Fm, Unit A extends to basalt bedrock between 510 and 520 ft bgs.

- (480.5-507.0 ft bgs): Silty sandy gravel to silty gravel (15-30 percent m, 35 percent sand, 50 percent gravel) Gravel is sub-round to well-round very fine pebbles to small cobbles of 85 percent felsic, 15 percent mafic, composition. Matrix is sub-angular to angular very fine to medium micaceous silty sand. Matrix color is GLEY1,4/5G, grayish green with black mottling. Sediments are slightly cemented with a very mild reaction with HCl. This unit contains a silty sand to sandy silt lens described below.
- (488.6-489.8 ft bgs): Silty sand to sandy silt interbed. This bed of fine grained material was encountered during drilling but was not sampled. The driller and geologist noted a dramatic increase in drill rate through this interval indicating an interval lacking in gravel. The driller also noted that the bit did not stick within the sediments indicating that the sediments were not solely of silt.
- (507.0 ft bgs): Total depth of the borehole.

7 References

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Appendix A

Well Summary Diagrams

Well 299-W15-225 (C7017)

WELL SUMMARY SHEET

Start Date: 01/30/09
Finish Date: 07/16/09
Page 1 of 3

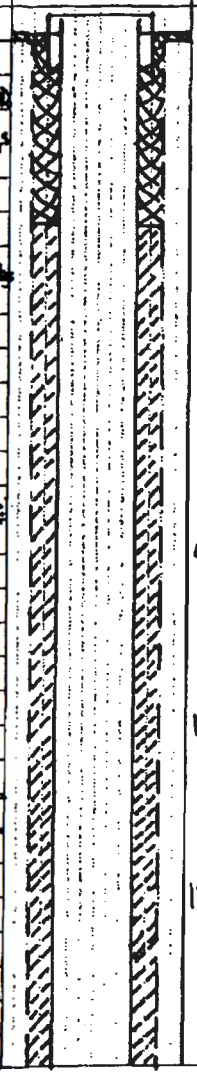
Well ID: C7017
Well Name: 299-W15-225
Location: 20 meters West of TX farm
Project: 200-ZP-1 OU Pump + Treat Wells
Prepared By: J. Thornton
Date: 7/17/09
Reviewed By: L.D. Walker
Date: 8/4/09
Signature:
Signature:

CONSTRUCTION DATA

Description:

Surface Completion:
4'x4'x6" concrete pad with brass survey marker and 10 3/4" OD s.s. protective casing: 3' ags - 3' bgs
Cement Surface Seal:
Type I-II Portland Cement
Ground surface - 33.0 ft bgs
#8 Bentonite Crumbles: 33' - 225.1' bgs
10-20 Colorado Silica Sand:
225.1' - 265.9' bgs
8-16 Colorado Silica Sand:
265.9' - 415' bgs
8-12 Colorado Silica Sand:
415' - 418' bgs
Type I-II Portland Cement Grout:
418' - 456.5' bgs
3/8" Coated Bentonite Pellets:
456.5' - 458' bgs
8-12 Colorado Silica Sand:
458' - 461' bgs
Natural Backfill (stuff):
461' - 465' bgs
8 5/8" OD / 8" ID Stainless Steel Permanent Casing and Screen:
Blank: 2.0' - 245' bgs
0.040 Slot Screen: 245' - 265' bgs
Blank: 265' - 275' bgs
0.055 Slot Screen: 275' - 405' bgs
Sump: 405' - 415' bgs
* Corrugated Sleeve: 36.5' - 36.5' bgs

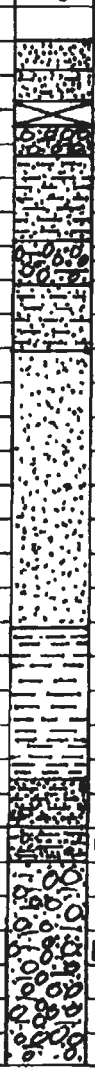
Diagram:



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 30, 60, 90, 120, 150

Graphic Log:



Lithologic Description:

(Ground Surface)
0.0' - 5.0': Sand (S)
5.0' - 10.0': silty Sand (mS)
10.0' - 15.0': No returns
15.0' - 20.0': silty sandy Gravel (mSG)
20.0' - 35.0': sandy Silt (sM)
35.0' - 43.5': silty sandy Gravel (mSG)
43.5' - 54.5': sandy Silt (sM)
54.5' - 103': sand (S)
Hanford Formation: 0' - 103'
103' - 129': silt (M)
Cold Creek Unit: 103' - 129'
129' - 138': sandy silt (M)
Ringold Upper Fines: 129' - 144'
138' - 144': gravely sandy Silt (gsM)
144' - 219': sandy silty Gravel (smG)
Ringold Unit "E": 144' - 410.5

A-6003-843 (03/03)

WELL SUMMARY SHEET

Start Date: 01/30/09
Finish Date: 07/16/09
Page 3 of 3

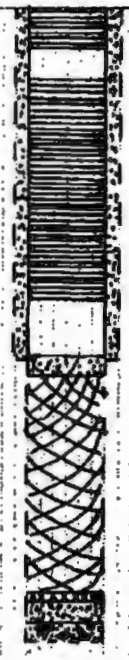
Well ID: C7017
Well Name: 299-W15-225
Location: 2.0 m W of TX farm
Project: 200-ZP-1 Pump + Treat
Prepared By: J. Throelin
Date: 7/17/09
Reviewed By: L.D. Walker
Date: 8/4/09
Signature:
Signature:

CONSTRUCTION DATA

Description

- All temporary casing removed from ground
- All measurements in feet below ground

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 360, 390, 420, 450, 480, 510

Graphic Log

Lithologic Description

- 378'-410.5': silty sandy Gravel (sG)
- 410.5'-458': silty clay (M) "Ringold Lower Mud": 410.5'-458'
- 458'-465': sandy Gravel (sG) "Ringold Unit "A"":

A-8003-843 (03/03)

WELL SUMMARY SHEET	Start Date: 01/30/09	Page 2 of 3
	Finish Date: 07/16/09	

Well ID: C7017		Well Name: 299-W15-225	
Location: 20 m W of TX farm		Project: 200-ZP-1 Pump + Treat	
Prepared By: J. Throelin	Date: 7/17/09	Reviewed By: L. D. Walker	Date: 8/4/09
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description:

Notes: • All temporary casing removed
• All measurements in feet below ground surface (bgs)

Temporary Casing:
16"OD/15"ID, C.S.: 0'-218'
11¾"OD/10¾"ID, C.S.: 218'-415.5'
8½"OD/7⅝"ID, C.S.: 415.5'-446'

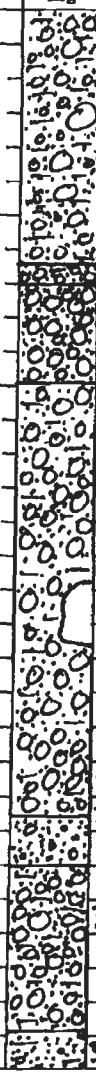
* note: corrugated SS sleeve 361.5'→366.5' is a patch to repair broken screen. (idw) (see diagram on pg. 3)

Diagram:

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 180, 210, 240, 270, 300, 330

Graphic Log:



Lithologic Description:

219'-223': silty sandy Gravel (msG)
223'-239': sandy Gravel (sG)
239'-316': silty sandy Gravel (msG)
316'-324': gravelly Sand (gS)
324'-353': silty sandy Gravel (msG)
353'-378': gravelly silty Sand (gmS)

A-6003-643 (03/03)

Well 299-W14-20 (C7018)

WELL SUMMARY SHEET		Start Date: 1-30-09	Page 1 of 3
		Finish Date: 9-08-09	
Well ID: C7018		Well Name: 299-W14-21	
Location: 200-ZP-1 04; E. of 241 Tx Tank Farm		Project: 200-ZP-1 pump + treat wells	
Prepared By: J. Schulpercoort	Date: 9/29/09	Reviewed By: L. D. Walker	Date: 10-21-09
Signature: Jasian Schulpercoort		Signature: [signature]	

CONSTRUCTION DATA

Description	Diagram
Protective casing with locking well cap: 10" O.D. SS	
Concrete Pad: 4'x4'x6" with wire reinforcement	
Cement Surface Seal: Type I/II portland cement Ground surface - 30.1' bgs	
8 5/8" Stainless Steel: 8 5/8" blank: 21' ags - 244.83' bgs	
8 5/8" S.S. 0.050 slot screen: 244.83' - 374.81' bgs	
8 5/8" blank: 374.81' - 394.78' bgs	
8 5/8" S.S. 0.040 slot screen: 394.78' - 404.78' bgs	
8 5/8" sump: 404.78' - 409.78' bgs	
#8 Bentonite chumbles: 301-303 ft bgs	
8-16 Colorado Sand: 320.8'-379' bgs	
3/8" coated Bentonite pellets 379' - 380' bgs	
10-20 Colorado silica Sand: 380' - 409' bgs	
Type I/II portland cement 409' - 426.5' bgs	
3/8" coated bentonite pellets 426.5' - 429' bgs	
10/20 Colorado silica Sand: 429' - 489' bgs	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		G.S.-5.5': Drill pad Gravel
		5.5'-14.5': Sand
		14.5'-30.0': Sandy Gravel
30		30.0'-38.0': Silty Sand
		38.0'-79.0': Silty Sandy Gravel
60		
		79.0'-90.5': Silty Sand
90		90.5'-114.0': Silt
		114.0'-127.0': Silty Sand
120		
		127.0'-131.0': Silty Sandy Gravel
		131.0'-159.0': Silty Gravel with Sand
150		159.0'-280.5': Silty Gravel with Sand and Sand lenses

A-6003-843 (03/03)

WELL SUMMARY SHEET

Start Date: 1-30-09
Finish Date: 9-08-09
Page 2 of 3

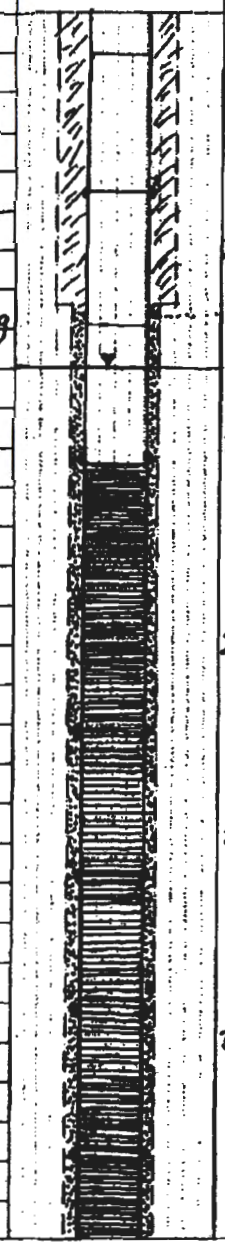
Well ID: C7018	Well Name: 299-W14-20
Location: 200-ZP-1 OU; E. of 241 TX Tank farm	Project: 200-ZP-1 pump & treat wells
Prepared By: J. Schilperoort — Date: 9/28/09	Reviewed By: LD Walker — Date: 10-21-09
Signature: Jessica Schilperoort	Signature: LD Walker

CONSTRUCTION DATA

Temporary Driver Casing:
16" O.D., C.S.: 0.0'-219.05' bgs
11¾" O.D., C.S.: 0.0'-408.7' bgs
10¾ O.D., C.S.: 0.0'-249' bgs
7⅝ O.D., C.S.: 0.0'-439' bgs

All temporary casing removed from the ground

All depths recorded in feet below ground surface



GEOLOGIC/HYDROLOGIC DATA

159.0-230.5: Silty Gravel with Sand

Water level: 228.3' (10/8/09)

230.5-287.5: Gravelly Silty Sand

287.5-327.0': Silty Sandy Gravel with Clay nodules.

327.0-367.0: Slightly Silty Sandy Gravel with Sand lenses.

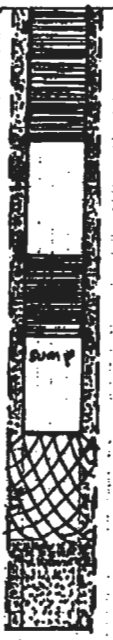
A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 1-30-09
Finish Date: 9-08-09
Page 3 of 3

Well ID: C7018
Well Name: 299-W14-20
Location: 200-ZP1 OU, E of 241 TX Tank farm
Project: 200-ZP-7 pump + treat wells
Prepared By: J. Schilperoort
Date: 9/28/09
Reviewed By: L. D. Walker
Date: 10-21-09
Signature: Jamie Schilperoort
Signature: LD Walker

CONSTRUCTION DATA

Description	Diagram
11 3/4" borehole to → 408.7', then 7 1/2" borehole to TD	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
360		
		367.0'-390': Silty Sandy Gravel
390		390.0'-400': Gravelly Silt
		400'-407': Silty Sandy Gravel
		407'-430': Mud
410		
		430'-439': Silty Gravel
440		TD = 439'
470		
450		

A-6003-643 (03/03)

Well 299-W14-73 (C7021)

WELL SUMMARY SHEET		Start Date: 2/10/09	Page 1 of 3
		Finish Date: 7/21/09	

Well ID: C7021		Well Name: 299 - W14 - 73	
Location: SE of Bridgeport Ave. & 22nd St.; 200-W		Project: 200-ZP-1 OU Pump & Treat Wells	
Prepared By: K. Stiles	Date: 7/13/09	Reviewed By: L. D. Walker	Date: 8/10/09
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
Surface Completion:		0		(Ground Surface)
4' x 4' x 6" concrete pad with				0.0'-1.0': sandy Gravel (sG)
brass survey marker and 10 3/4" O.D.				1.0'-3.5': silty Sand (mS)
s.s. protective casing; 3' ags - 3' bgs				3.5'-33.0': sandy Gravel (sG)
Concrete Surface Seal:				
0.5' ags - ground surface		30		
Cement Surface Seal:				33.0'-53.0': Sand (S)
Type I-II Portland Cement				
ground surface - 32.1 ft bgs				
				53.0'-119.0': silty Sand (mS)
8 3/4" O.D. Stainless Steel		60		
blank: 2.0' ags - 290.73' bgs				
8 3/4" O.D. s.s. 0.045 slot screen:				
290.73 - 390.37' bgs				
8 3/4" O.D. s.s. blank: 390.37-410.86' bgs				
8 3/4" O.D. s.s. 0.045 slot screen:		90		
410.86 - 490.89' bgs				
8 3/4" O.D. s.s. sump w/end cap:				
490.89 - 500.9' bgs				
#8 Bentonite Granules: 32.1-262.5' bgs				
10-20 Colorado Silica Sand:		120		119.0'-123.0': silty Sand (mS)
262.5 - 395' bgs				123.0'-159.0': Silt (M)
3/8" Coated Bentonite Pellets:				
395 - 397' bgs				
10-20 Colorado Silica Sand:				
397 - 503 ft bgs		150		
Temporary Drive Casing:				159.0'-165.0': gravelly Silt (gM)
16" O.D., s.s., 0.0' - 169.1' bgs				165.0'-196.0': gravel KS 7/18/09
11 3/4" O.D., s.s., 0.0' - 490.0' bgs		170		165.0'-196.0': sandy Gravel (sG)
All temporary casing removed * see pg. 2				
All depths in ft "below ground surface" (bgs)				

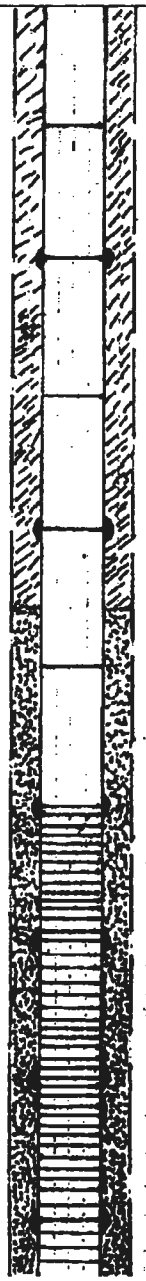
A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 2/10/09
Finish Date: 7/21/09
Page 2 of 3

Well ID: C7021	Well Name: 299-W14-73
Location: SE of Bridgeport Ave. & 22nd St.; 200-W	Project: 200-ZP-1 OU Pump & Treat Wells
Prepared By: K. Stiles — Date: 7/13/09	Reviewed By: L.D. Walker — Date: 8/10/09
Signature: [illegible]	Signature: [illegible]

CONSTRUCTION DATA

Description	Diagram
* Drive shoe on 16" casing broken off casing during drilling - pushed aside at approx. 170' bgs - left in the ground	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
180		
		196.0'-235.0': Gravels (G)
210		
		235.0'-244.0': sandy Gravel (sG)
240		
		244.0'-258.0': silty sandy Gravel (msG)
		258.0'-260.0': gravely Sand (gS)
		260.0-262.5': sandy Gravel (sG)
270		270.7' bgs: Static H_2O Level
		262.5'-340.0': silty sandy Gravel (msG)
300		
330		
		340.0'-351.0': sandy Gravel (sG)
		351.0'-378.0': silty sandy Gravel (msG)

WELL SUMMARY SHEET

Start Date: 2/10/09
Finish Date: 7/21/09
Page 3 of 3

Well ID: C7021	Well Name: 299-W14-73
Location: SE of Bridgeport Ave. & 22nd St.; 200-W	Project: 200-ZP-1 OU Pump & Treat Wells
Prepared By: K. Stiles — Date: 7/13/09	Reviewed By: L.D. Walker — Date: 8/10/09
Signature: [signature]	Signature: [signature]

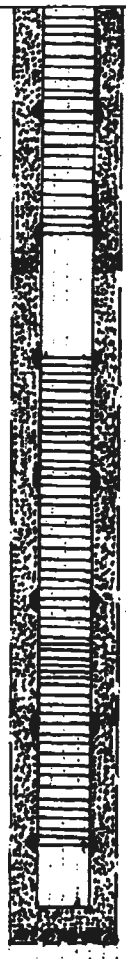
CONSTRUCTION DATA

Description

395-397' bgs: 3/8" coated bentonite pellets (x)

503-507.5' bgs: sluff
507.5'
cw 8-10-09

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 360, 390, 420, 450, 480, 510

Graphic Log

T.D.

Lithologic Description

378.0'-386.5': sandy Gravel (sG)
386.5'-407.5': silty sandy Gravel (msG)
407.5-419.5': silty Sand (mS)
419.5-428.0': silty sandy Gravel (msG)
428.0'-435.5': silty Sand (mS)
435.5'-470.0': silty sandy Gravel (msG)
470.0'-480.5': sandy Gravel (sG)
480.5'-488.6': silty sandy Gravel (msG)
488.6'-489.8': Silt (M)
489.8'-506.3': silty Gravel (mG)

Total Depth = 506.3' bgs
507.5'
cw 8-10-09

A-6003-643 (03/03)

Appendix B

Well Construction Summary Reports

Well 299-W15-225 (C7017)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 01/30/09
Finish Date: 07/16/09
Page 1 of 2

Well ID: C7017	Well Name: 299-W15-225	Approximate Location: 20 m W of TX farm
Project: 200-ZP-1 Pump + Treat Expansion		Other Companies: GRAM, Inc.
Drilling Company: Blue Star Enterprises, N.W.		Geologist(s): Jacob Throolin, Sean Sexton
Driller:	License #:	

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	~~Auger~~	~~Diameter ___ From ___ to ___~~
16" OD / 15" I.D.	0 - 218	16 3/8" / 15"	Cable Tool:	Diameter 13 3/8" From 218 to 280
11 3/4" OD / 10 3/4" ID	218 - 4155	12" / 10 3/4"	Air Rotary:	Diameter 16 3/8 From 0.0 to 218
8 1/2" OD / 7 1/2" ID	4155 - 446	8 1/2" / 7 1/2"	A.R. w/Sonic:	~~Diameter ___ From ___ to ___~~
12 3/4" OD / 12" ID	218 - 278	13 3/8" / 12"	Air Rotary (Reduced)	Diameter 12" From 218 to 4155
	-		Air Rotary (Cased)	Diameter 8 1/2" From 4155 to 446
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design			Air Rotary (Open)	Diameter 7 1/2" From 446 to 465

		Drilling Fluid: water	
Total Drilled Depth: 465	Hole Dia @ TD: 7 1/2"	Total Amt. Of Water Added During Drilling:	
Well Straightness Test Results:		Static Water Level: 228.5	Date: 7/16/09

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
SGLS (Gamma 4)	0 - 215	2/23/09	SGLS (Gamma 1)	446 - 461	5/7/09
SGLS (Gamma 1)	215 - 4101	4/30/09		-	
SGLS (Gamma 1)	4101 - 446	5/11/09		-	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
8 5/8" S.S. Blank	20 ags - 245	Box	N/A	Type I/II Portland Cement	0.0 - 33	88.7	ft³
8 5/8" S.S. "V" wire	245 - 265	Box	0.040	Bentonite Crumbles #8	33 - 225.1	157.7	ft³
8 5/8" S.S. Blank	265 - 275	Box	N/A	10/20 Silica Sand	225.1 - 265.9	88.7	ft³
8 5/8" S.S. "V" Wire	275 - 405	Box	0.055	3/8 - 8/16 Silica Sand	265.9 - 415	185.3	ft³
8 5/8" SS Sump	405 - 415	BOX	N/A	2/12 Silica Sand	415 - 418	2.0	ft³

OTHER ACTIVITIES

Aquifer Test: Multiple tests performed	Date:	Well Decommission:	Yes:	No:	Date:
Description: Standard Development @ 100 gpm; Initial Step Drawdown; Air-lift and surge development; Rawhide and pump development; Final Step Test; EBF Test; Pneumatic Slug Test		Description:			

WELL SURVEY DATA (If applicable)

	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Survey Marker Elevation:

COMMENTS / REMARKS

Reported By:	Title:	Signature:	Date:
J. Throolin	Geologist	[signature]	7/29/09

A-6003-658 (04/03)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 01/30/09
Finish Date: 07/16/09
Page 2 of 2

Well ID: C7017 | Well Name: 299-W15-225 | Approximate Location: 20 m W of TX Farm
Project: 200-ZP-1 Pump+Treat Expansion | Other Companies: GRAM, Inc.
Drilling Company: BSE, NW | Geologist(s):
Driller: | License #:

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger:	Diameter ____ From ____ to ____
	____ - ____		Cable Tool:	Diameter ____ From ____ to ____
	____ - ____		Air Rotary:	Diameter ____ From ____ to ____
	____ - ____		A.R. w/Sonic:	Diameter ____ From ____ to ____
	____ - ____			Diameter ____ From ____ to ____
	____ - ____			Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter ____ From ____ to ____
			Drilling Fluid:	
Total Drilled Depth:	Hole Dia @ TD:		Total Amt Of Water Added During Drilling:	
Well Straightness Test Results:			Static Water Level:	Date:

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
	____ - ____			____ - ____	
	____ - ____			____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
	____ - ____			Type I/II Portland Cement	418 - 456.5	27.0	ft³
	____ - ____			3/8" Bentonite Pellets	456.5 - 458	0.62	ft³
	____ - ____			8/12 Silica sand	458 - 461	1.52	ft³
	____ - ____				____ - ____		
	____ - ____				____ - ____		

OTHER ACTIVITIES

Aquifer Test:	Date:	Well Decommission:	Yes:	No:	Date:
Description:		Description:			

WELL SURVEY DATA (if applicable)

	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Survey Marker Elevation:

COMMENTS / REMARKS

Reported By:	Title:	Signature:	Date:
J. Thrasolin	Geologist	[signature]	7/29/09

A-6003-658 (04/03)

Well 299-W14-20 (C7018)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 01/30/09
Finish Date: 07/16/09
Page 1 of 2

Well ID: C7017 | Well Name: 299-W15-225 | Approximate Location: 20 m W of TX farm
Project: 200-ZP-1 Pump + Treat Expansion | Other Companies: GRAM, Inc.
Drilling Company: Blue Star Enterprises, N.W. | Geologist(s): Jacob Throolin, Sean Sexton
Driller: | License #:

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger:	Diameter ___ From ___ to ___
16" OD./15" I.D.	0 - 218	16 3/8"/15"	Cable Tool:	Diameter 13 3/8" From 218 to 280
11 3/4" OD/ 10 3/4" ID	218 - 415.5	12"/10 3/4"	Air Rotary:	Diameter 16 3/8 From 0.0 to 218
8 1/2" OD/7 1/2" ID	415.5 - 446	8 1/2"/7 1/2"	A.R. w/Sonic:	Diameter ___ From ___ to ___
12 3/4" OD/12" ID	218 - 278	13 3/8"/12"	Air Rotary (Reds)	Diameter 12" From 218 to 415.5
	-		Air Rotary (Cased)	Diameter 8 1/2" From 415.5 to 446
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design			Air Rotary (Open)	Diameter 7 1/2" From 446 to 465
			Drilling Fluid: water	
Total Drilled Depth: 465	Hole Dia @ TD: 7 1/2"		Total Amt. Of Water Added During Drilling:	
Well Straightness Test Results:			Static Water Level: 228.5	Date: 7/16/09

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
SGLS (Gamma 1)	0 - 215	2/23/09	SGLS (Gamma 1)	446 - 461	5/7/09
SGLS (Gamma 1)	215 - 410.1	4/30/09		-	
SGLS (Gamma 1)	410.1 - 446	5/11/09		-	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
8 5/8" S.S. Blank	20 ags - 245	Box	N/A	Type I/II Portland Cement	0.0 - 33	88.7	ft³
8 5/8" S.S. "V" wire	245 - 265	Box	0.040	Bentonite Crumbles #8	33 - 225.1	137.7	ft³
8 5/8" S.S. Blank	265 - 275	Box	N/A	10/20 Silica Sand	225.1 - 265.9	88.7	ft³
8 5/8" S.S. "V" Wire	275 - 405	Box	0.055	8/16 Silica Sand	265.9 - 415	185.3	ft³
8 5/8" SS Sump	405 - 415	BOX	N/A	8/12 Silica Sand	415 - 418	2.0	ft³

OTHER ACTIVITIES

Aquifer Test: Multiple tests peformed | Date:
Description: Standard Development @ 100 gpm; Initial Step Drawdown; Air-lift and swab development; Rawhide end pump development; Final Step Test; EDT Test; Pneumatic Slug Test

Well Decommission: | Yes: | No: | Date:
Description:

WELL SURVEY DATA (If applicable)

Washington State Plane Coordinates:
Protective Casing Elevation:
Brass Survey Marker Elevation:

COMMENTS / REMARKS

Reported By: J. Throolin | Title: Geologist | Signature: [signature] | Date: 7/29/09

A-6003-658 (04/03)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 6/30/09
Finish Date: 07/16/09
Page 2 of 2

Well ID: C7017	Well Name: 299-W15-225	Approximate Location: 20 m W of TX Farm
Project: 200-ZP-1 Pump+Treat Expansion		Other Companies: GRAM, Inc.
Drilling Company: BSE, NW		Geologist(s):
Driller:	License #:	

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger:	Diameter ____ From ____ to ____
	____ - ____		Cable Tool:	Diameter ____ From ____ to ____
	____ - ____		Air Rotary:	Diameter ____ From ____ to ____
	____ - ____		A.R. w/Sonic:	Diameter ____ From ____ to ____
	____ - ____			Diameter ____ From ____ to ____
	____ - ____			Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (F.J) Coupled (C) & Thread Design				Diameter ____ From ____ to ____
			Drilling Fluid:	
Total Drilled Depth:	Hole Dia @ TD:		Total Amt Of Water Added During Drilling:	
Well Straightness Test Results:			Static Water Level:	Date:

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
	____ - ____			____ - ____	
	____ - ____			____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
	____ - ____			Type I/II Portland Cement	418 - 456.5	27.0	ft³
	____ - ____			3/8" Bentonite Pellets	456.5 - 458	0.62	ft³
	____ - ____			8/12 Silica sand	458 - 461	1.52	ft³
	____ - ____				____ - ____		
	____ - ____				____ - ____		

OTHER ACTIVITIES

Aquifer Test:	Date:	Well Decommission:	Yes:	No:	Date:
Description:		Description:			

WELL SURVEY DATA (if applicable)

	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Survey Marker Elevation:

COMMENTS / REMARKS

Reported By:	Title:	Signature:	Date:
J. Throolin	Geologist	[signature]	7/29/09

A-6003-658 (04/03)

Well 299-W14-73 (C7021)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 2-9-09
Finish Date: 7-21-09
Page 1 of 1

Well ID: C7021 | Well Name: 299-W14-73 | Approximate Location:
Project: 200-ZP-1 pump + Treat Expansion | Other Companies: Gam Inc.
Drilling Company: Blue Star Enterprises | Geologist(s): Aaron Lawton
Driller: | License #:

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger:	Diameter ____ From ____ to ____
16"OD/15"ID	0.0 - 169.1	15 3/8"/15"	Cable Tool: ✓	Diameter 11 3/4 From 169.1 to 490.0
11 3/4"OD/10 3/8"ID	169.1 - 490.0	12 3/8"/10 3/8"	Air Rotary: ✓	Diameter 16 7/8 From 0.0 to 169.1
	-		A.R. w/Sonic:	Diameter ____ From ____ to ____
	-			Diameter ____ From ____ to ____
	-			Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (F.J) Coupled (C) & Thread Design				Diameter ____ From ____ to ____

16" casing (W)
12" casing Threaded (FJ) box thread
11 3/4" casing Threaded (FJ) sonic thread attached to 12"

Drilling Fluid: water

Total Drilled Depth: 507.5' | Hole Dia @ TD: | Total Amt. Of Water Added During Drilling:
Well Straightness Test Results: 16": Pass, 12": | Static Water Level: 270.4 | Date: 7-21-09

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
SGLS/~~NGLS~~/~~NMLS~~/~~[illegible]~~	0.0 - 169	3/17/09		-	
SGLS/NMLS/~~[illegible]~~	169 - 492	6/5/09		-	
	-			-	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
8 3/8" S.S. Blank	0.0 - 290.8	Box	-NA-	Portland Cement I, II	0.0 - 32.1	104.0	ft.³
8 3/8" S.S. "V" wire	290.8 - 390.9	Box	.045	Bentonite Crumbles #8	32.1 - 262.5	155.5	ft.³
8 3/8" S.S. Blank	390.9 - 410.9	Box	-NA-	Sand 10-20 mesh SiO_2	262.5 - 395.0	102.2	ft.³
8 3/8" S.S. "V" wire	410.9 - 490.9	Box	.045	Bentonite Pellets 3/8"	395.0 - 397.0	0.7	ft.³
9 3/8" S.S. Sump	490.9 - 500.9	Box	-NA-	Sand 10-20 mesh SiO_2	397.0 - 503.0	51.9	ft.³

OTHER ACTIVITIES

Aquifer Test: See Well Development | Date: -NA- | Well Decommission: NA | Yes: | No: | Date:
Description: Standard well Development 5 stages @ 100 gpm until water chemistry stabilized + NTU < 5 NTU. | Description: NA

WELL SURVEY DATA (if applicable)

136204.21 (m) N, E-566; E. 567357.14 (m)
Washington State Plane Coordinates:
Protective Casing Elevation:
Brass Survey Marker Elevation:

COMMENTS / REMARKS

Reported By: A. Lawton | Title: Geologist | Signature: Aaron Lawton | Date: 7-21-09

A-6003-658 (04/03)

Appendix C
Borehole Logs

Well 299-W15-225 (C7017)

BOREHOLE LOG

Page 1 of 12
Start: 01/26/09
Date: Finish: 02/05/09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20 m West of TX Tank Farm

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0				0 – 8.0': Crushed gravel pad	Air rotary/DH Hammer
				1.0 – 5.0': Sand (S); f.-med. grain; brown; v. sl. moist; mod. sorted; sub rnd to sub ang; <5% gravel	archive g.s. @ 5'; RCT readings < bkgrnd
5	Grab			5-10: silty Sand (mS): sand 85% silt 15%, crs to fine sand, some small (<1mm) pebbles, qtz + mafic grains 50/50 sub-rnd to sub-ang	
10	G.S.			→ inc silt % ~12' to 20-25%	archive @ 10': RCT < bkgrnd
				No Returns 12-15?' bgs	adding water @ 12' to keep dust down
15				?15 – 20: silty sandy gravel (mS(g)): 70% gravel 30% very crs sand 10% silt; gravels: pebbles <1" to 2" 70% mafic 30% other sub-rnd to sub ang.; sand: same lithy as gravels; sample wet from added water; overall color is black - dark gray (5Y 2.5/1 - 5Y 4/1)	copious amounts of water added, very poor returns from 12' to 18?; archive @ ~18'; RCT scan < bkgrnd; added ~350 gals H_2O to formation from 12-20' bgs
	G.S.				
20					
					Tri-cone Bit
25	G.S.			20-25: sandy Silt (sM): silt 80-85% Sand 15-20%; sand fine - v. fine, sub-rnd, color brown (7.5YR 5/2)	archive @ 25', readings <
				25-30: sandy Silt (sM): inc % sand from above to 30-40%; soils pulverized by tri-cone	archive at 35', readings < bkgrnd
30	G.S.			35-36: silty Gravel (mG): gravel 80% silt 20%, some sand from drilling; gravel <1" sub-rnd to sub-ang felsic dom (65%) no rxn HCl, wet & no water added	archive @ 36' readings < bkgrnd
35	G.S.			36-40: gravelly Silt (gM): silt 60% gravel 40%; gravel size dec from above with same lithology, dry, mild rxn HCl	archive @ 40 < background
	G.S.				
	G.S.				

Reported By: J. Throelin / S. Sexton | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] | Date: 2/5/09 | Signature: [signature] | Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Start: 2/05/09 Date: Finish: 2/06/09

Well ID: C7017 | Well Name: 299-W15-275 | Location: 20 m W of TX farm

Project: 200-P-1 Pump & Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
40	G.S.				See pg. 1, Air rotary w/ tri-cone
				40-43.5: silty sandy Gravel (ms(g)): gravel 70% sand 15% silt 15%	
				gravel: <1" mostly felsic/inter., sub rnd to sub-ang; sand: crse to fine,	archive @ 41' < bkgrnd
45	G.S.			may mostly be crushed gravels from bit, same lith. as gravel; dry, no	~5 gal water added 42'
				rxn HCl, gray color overall (GLEY1 5/N)	
				→ inc. gravel size 42', less silt	add ~50 gal water
				%, dec. sand % (g:80 s:10 m:10%)	@ 43' to help cleanout
50	G.S.			inc. mafic lith, now 50/50;	
					archive @ 41' < bkgrnd
				43.5-54.5: sandy Silt (SM): 60% M,	archive @ 45' < bkgrnd
				40% S; sand interm./felsic, med.	RCT no longer on full
	G.S.			grained, sub rnd; no rxn HCl, dry	time basis @ 50'
55				may not be getting gravel returns?	archive @ 50' < bkgrnd
				54.5-56: sandy silty Gravel (sm(g)):	archive @ 54.5
				gravel 60% silt 30% sand 10%;	
				gravel: mostly felsic/inter <1" sub-rnd	
60	G.S.			sand fine to crse, same lith as grav.	archive @ 60
				brown (7.5YR 5/2), no rxn HCl, dry	
					add ~50 gal water total
				56-79: Sand (S): Sand 90% silt	
				<10%; sand v. fine to fine, gtr.	
65	G.S.			dom. sub-rnd brown (7.5YR 5/2),	
				dry, no rxn HCl	archive @ 65'
				→ NOTE: some small gravels recovered	
				when blowing out borehole @ 62'	
				most likely from 55-60' but <10%	
70	G.S.			of total formation	archive @ 70'
75	G.S.				archive @ 75'
					archive @ 80'

Reported By: S. Sexton | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 02/07/09 | Signature: [signature] Date: 8/4/09

A-6003-842 (03/03)

BOREHOLE LOG

Page 2 of 12
Date: 8/4/2009

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20m W of TX farm

Project: ZP-1 Pump & Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Drilling Sampling Tool, Sampler Size, Water Level
80	G.S.				See pg. 1: Air Rot.
				80-103: Sand(S): Sand 90%	w/ tri-cone
				silt < 10%; sand v. fine to fine	
				gr. dom., sub-rnd, brown (7.5YR 5/2)	archive @ 80'
				dry, no rxn HCl	
85				→ poor returns 85-89' bgs, took	
				archive at 89, mix of sand from	
				85-89 ft.: sand size inc. to med.	
				→ small (<1mm) flecks of caliche	
	G.S.			showing up in sands, highly rxn	
90				to HCl, no rocks or pebbles in	archive at 89' bgs
				returns	
				→ split-spoon from 102-105.5 shows	
				mostly silt in formation with some	
				sand 65% silt 35% sand	
95	G.S.			119	archive @ 95'
				103-127: silt (M): >95% silt	HRIS #s: B1YD09,
	B1YD09			with some small (v. fine) sand; brown	B1YC49, B1YD07
	B1YC49			(7.5YR 5/2), slightly damp, strong rxn HCl	Tank farm gravels @
	B1YD07			→ gravels (<1mm) in silt < 10% 117'	95 + 100' bgs
100	G.S.	B1YC45		→ inc. % sand <10% at 124' bgs,	archive @ 100'
		B1YC46		basaltic, fine grained	
		B1YC47			
		B1YC48			Split-spoon taken
		S.S.			102-105.5'
	B1YD08	Full Recov.			archive taken from shoe
105					archive at 105
	B1YD02				
110		G.S.			archive @ 110
	B1YD03				
115		G.S.			archive @ 115

Reported By: S. Sexton | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 8/4/09 | Signature: [signature] Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 4 of 12
Date: 02/12/2009

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20 m W of Tx farm

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	G.S.	BAYDOS			See pg. 1: Air Rot w/ tri-cone bit
	BAYDOS			119-129: silt (M): silt 90% fine sand 10%; sand basalt + felsics 50/50; brown (7.5YR 5/2), dry, strong rxn HCl	archive @ 120'
125		65.		129-138: sandy silt (to M): silt 65% sand 35%; sand fine to medium 50/50 felsic/mafic; dry, brown, strong rxn HCl	archive @ 125'
	BAYDOS			→ color change to light gray (2.5Y 7/1) at 133.5'; silt more pebbly	
130		65		→ poor returns after 142' bgs, gravel increased at 133' but can only tell by how hard drilling is; small gravels occasionally making it to surface, impossible to tell from what depth; gravels are 70-80% mafic;	archive @ 129'
135					archive at 135'
				→ took grab of cuttings from 144-148': sandy silty (gravel) (SM) gravels 80% mafic 20% other, gravels 70% silt 15-20% sand <10%; gravels ~1 inch sub-rnd crushed from tri-cone	
140					archive at 140' added ~150 gals total while cleaning out borehole
145				→ took grab @ 156' bgs, same lithology as before, but exact depth unknown, none to little returns from 148' to 156'	archive at 148?' bgs still adding water ~50 gals
150					
				See pg 5 for Description	
155				~~157.5-159: sandy silt (SM): silt 60% coarse sand 40% sand rnd to sub rnd, may be from crushed rock due to tri-cone; dry, no rxn HCl~~ SMS 02/12/09	archive @ 156?

Reported By: S. Sexton | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 02/12/09 | Signature: [signature] Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 5 of 12
Date: 2/19/09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20m W of Tx farm

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
160	G.S.			SMS 2-17-09	See pg. 1: Air Rot
				~~159 - : sandy silt (SM): silt~~	w/ tri-cone bit
				~~60% coarse sand 40%; sand rnd~~	
	G.S.			~~to sub rnd, may be from crushed~~	archive 160'
				~~gravels due to tri-cone; dry, no~~	
				~~rxn HCl~~	
165				~~→ adding water at 162', getting~~	adding ~200 gal water
				~~returns, mostly gravels, 80% mafic~~	archive @ 163
				~~1-2" diameter~~	change to D.H.
					hammer @ 162
				155.5-163 : sandy silty (gravel	
170	G.S.			(SM)): Gravels 60% silt 30% sand	
				10%; gravels 80% mafic 20% other	archive @ 170'
				sub-angular to sub-rnded, 1-2"	
				diameter; wet, cemented, black	
				sandy silty (gravel (SM)):	
175	G.S.			163 - 179 : ~~sandy silt (SM): silt~~	
				~~70% sand 30%~~; sand range	archive @ 175'
				fine to coarse, sub rnd, mostly	
				mafic; brown (7.5 YR 4/2), damp	
				gravel 40% silt 40% sand 20%	
180	G.S.			gravels predom intermediate to	
				felsic, sub-rnd	archive @ 180'
				→ inc mafic gravel % @ ~175 to 40%	
				→ less gravel in archive due to	
				sorting of sediment by air rotary	
185	G.S.				archive @ 185
190	G.S.				archive @ 190'
195	G.S.				archive @ 195'

Reported By: S. Sexton | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 02/19/09 | Signature: [signature] Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 12
Date: Start: 02/19/09 Finish: 03/04/09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20m W of TX farms

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
200	G.S.				See pg. 1: down-hole hammer w/air rotary
				199-219: sandy silty (gravel (sm(G)): gravel 45% silt 45% sand 10%; gravel up to 2" mostly felsic (100%) sub-rnd; sand fine to coarse, sub-rnd, mostly mafic; matrix brown (7.5YR 4/2), damp no rxn HCl	archive @ 200' added 150 gal water at 200-202 to flush borehole
205	G.S.			→ gravel inc to 55% silt 35 sand 10%	archive @ 205'
				→ sand inc to 20%; 60% gravel; 20% silt	casing much harder to drive after 203'
210	G.S.			219-223: silty sandy GRAVEL (ms(G)) → gravel 55% sand 25% silt 15%, gravel up to 4" mostly basaltic (60%), sub-rnd; sand fine to coarse, moist	archive @ 210'
				223-231: sandy GRAVEL (G) gravel 65%; sand 30%, silt 5%; no rxn to HCl	
215	G.S.			→ 227' bgs: mod cemented, no rxn to HCl	archive @ 215'
	BIYCW4 BIYCW0 BIYCW1 BIYCW2 S.S.	BIYD08		→ Moisture increase slightly @ 229' bgs	
				→ Very moist @ 232.5' bgs	Flushed ~250 gals down hole to clean out @ 218'
220	Fill Recovery	G.S.		→ felsic inc to 60%, 40% mafic	
				→ 234' bgs cobbles up to 6"	Cable tool rig w/drive barrel
				→ 236' poorly cemented, rusty brown when moist	
				→ 238' large cobbles up to 8"	Split spoon 218.7'-221.2' Grab: BIYD08 Archive from s.s. clean out
225	G.S.				archive @ 225'
	BIYCW3 BIYCW4 BIYCW5 BIYCW6 S.S.	BIYD09			228.7-231.2': Split Spoon
230	Fill Recovery	G.S.			archive @ 230' BIYCW3, BIYCW4, BIYCW5, BIYCW6, (BIYD09 grab) then Water table @ 233' bgs
235	G.S.				archive @ 235'

Reported By: S. Sexton | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: for S. Sexton | Date: 3/4/09 | Signature: | Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 7 of 12
Date: Finish: 7-30-09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20m W of TX Farms

Project: ZP-1 Pump + treat | Reference Measuring Point: Ground surface

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
240	G.S.			239-261: silty sandy GRAVEL (ms'G)	cable tool rig w/ 10" drive
				gravel 60%, sand 20%, silt 20%; 60%	barrel
				felsic, 40% mafic, sub-rnd, pr cemented,	
				max cobble 4", no rxn HCl	archive @ 240' bgs
				~~increase silt to 25~~	
245	G.S.			→ decrease silt to 10% @ 248'	archive @ 245'
		Water sample		→ increase silt to 30% @ 255'	
	BIYD74	BIYCY3 BIYCY4 BIYCY5 BIYCY6		decrease silt @ 260'	Water sample interval: 244.5'-246.5'
				increase sand @ 260'	Cobble grab @ 248.5'
				→ max gravel size decrease to ~3" @ 259'	
250	G.S.			~~@ 253'~~	archive @ 250'
				~~261: sandy silty GRAVEL (sm G)~~	
				261-265: silty GRAVEL (m G)	
				gravel 60%, sand 10%, silt 30%	
				sand is vf. to med grained,	
255	G.S.			265-265: sandy GRAVEL (sG)	archive @ 255'
				gravel 60%, sand 30%, silt 10%	added 5 gal water
				sand f to v. crse grained, subang.; gravel	added 1 gal water
				is 40% basalt, 60% felsic, subrnd to rnd	added 3 gal H_2O
				→ max gravel size increase to 8" @ 263'	
260	G.S			~~→ silty gravel lens from 265' to 266'~~	added 20 gal H_2O
				265-270: silty sandy GRAVEL (ms G)	archive @ 260' bgs
				gravel 50%, sand 30%, silt 20%	sieve analysis grab @ 260'
				sand is vf to f grained, gravel ~~same~~	
				as above	
265	G.S.			→ increase gravel to 60% @ 269'	archive @ 265' bgs
				→ increase silt to 20% @ 269'	sieve analysis grab @ 269'
				7/2-2.5Y (light gray) unbending	
270	G.S.			270-316 Silty Sandy Gravel (ms G)	archive and sieve grab @ 270'
				60% G w. rnd f. pebbles to l. cobbs. Dom. Qtz.	
				cobbles are u. rnd, pebbles are sub angular	
	BIYD75			30% m-f. sand qtz-feldspathic	Grab sample @ 272.5'-273'
	G.S.			10-15% silt 2.5Y 7/2 + 7.5YR 4/3 (gray/brown	for chemical analysis.
275				mottling.) ~~w/ [illegible]~~	
				• 270.5: silt increase to 60% 7.5YR 4/3 brown.	Water Sample collection
				• Clasts w/ carbonate rinds strong rxn w/ HCl	271-273' bgs BIYCY3, BIYCY4
				• 271.5: Silt decreases to 20% 7.5YR 4/3 brown	BIYCY5, BIYCY6, BIYCY7,
					BIYCY8, BIYCY9, BIYC-22 FB

Reported By: J. Thrailkill / A. Lanham | Reviewed By: L.D. Walker

Title: Geologist / Geologist | Title: Geologist

Signature: [illegible] Date: 3/30/09 | Signature: [illegible] Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 8 of 12
Date: 4/22/09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20m W. of TX Tank Farm

Project: 200-ZP-1 OU Pump + Treat | Reference Measuring Point: Ground Surface.

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
275	G.S.	BIYD88 (Soil Grab)			archive and sieve analysis
				276': silty gravel lense	grab @ 275'
				276.5': loose sandy Gravel	add 60gal water
				278': return to silty sandy Gravel	
280	G.S.			270 → 316' : Silty Sandy GRAVEL	archive and sieve grab @ 280'
					Begin drilling w/ air rot. rig @ 280'
285	G.S.				archive + sieve grab @ 285'
290	G.S.				archive + sieve grab @ 290'
295	G.S.	Water Sample			G.S. @ 295': BIYD86, BIYD88 archive + sieve grab @ 295' Water sample: 295'-290', BIYC43, BIYC44, BIYC45, BIYC46
300	G.S.			300': increase sand% to 40%; gravel 50% silt 10%	archive + sieve grab @ 300'
305	G.S.				archive + sieve grab @ 305'
310	G.S.				archive + sieve grab @ 310'

Reported By: J. Thomas | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] | Date: 4/22/09 | Signature: [signature] | Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 9 of 12

Date: Finish: 4/23/09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20 m W. of TX Farm

Project: 200-ZP-1 OU Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
315	G.S.	BIYD77		gravel SAND (S)	Air Rot. 12" Threaded casing
		Water Sample		316-320: [illegible], vf - m. grained, brown pr. sorted, saturated, 80% qtz./feld, 20% basalt/other, gravel is predominately basalt, 80% sand, 20% gravel, no rxn to HCl	Grab sample: BIYD77 @ 315
					Archive + sieve grab @ 315
					Water sample: 315'-316': BIYD20
320	G.S.				BIYD21, BIYD22, BIYD23, BIYD62
					Archive + sieve grab @ 320
				324-325: silty sand GRAVEL (msG)	
325	G.S.			gravel 40%, sand 50%, silt 10% pr sorted, saturated, gravel is rounded, no rxn to HCl	Archive + sieve grab @ 325
330	G.S.				Archive + sieve grab @ 330
		BIYD78			Grab sample @ 335': BIYD78
335	G.S.	Water Sample			Archive + sieve grab @ 335
					Water sample 335'-336': BIYD24, BIYD25, BIYD26, BIYD27, BIYD63
340	G.S.				Archive + sieve grab @ 340
345	G.S.				Archive + sieve grab @ 345
350	G.S.			349: decrease gravel % to 30%, sand 50%, silt 20%	Archive + sieve grab @ 350
				353- : gravelly silt SAND (gmS) gravel 20%, silt 20%, sand 60% (see pg 10)	

Reported By: J. Franklin | Reviewed By: L.J. Walker

Title: Geologist | Title: Geologist

Signature: [illegible] | Date: 4/23/09 | Signature: [illegible] | Date: 8/4/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 10 of 12
Date: 4/28/09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20 m W of TX tank farm

Project: 200-ZP-1 OU Pump+Treat Wells | Reference Measuring Point: Ground Surface

Depth (Ft)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
355	G.S.	B1YD19 Water Sample		353- : gravelly silty SAND (gmS)	Air Rotary, 12" Threaded Casing
				(description continued from pg 9)	
				sand is vf-m grained, mod. sorted, saturated, 70% qtz/feld, 30% basalt/other, gravel is predominately felsic, no rxn to HCl	Archive + sieve grab @ 355'
					Grab for chemical analysis @ 355'
					Water sample: 355-356'
360	G.S.				B1YD28, B1YD29, B1YD30, B1YD31, B1YD64
					Archive + sieve grab @ 360'
365	G.S.				Archive + sieve grab @ 365'
				366-367: increase in gravel	
370	G.S.				Archive + sieve grab @ 370'
375	G.S. B1YD62	Water Sample			Archive + sieve grab @ 375'
					Grab for chemical analysis @ 375'
					Water sample: 375-376'
				378-[illegible] silty sandy GRAVEL (mmS) silt 10%, sand 30%, gravel 60% poorly sorted, gravel chips up to 3 inches, 80% felsic, 20% basalt/other	B1YD32, B1YD33, B1YD34, B1YD35, B1YD65
380	G.S.				archive + sieve grab @ 380'
385	G.S.				archive + sieve grab @ 385'
390	G.S.				archive + sieve grab @ 390'
				390: increase sand % to 50%, silt 20%, gravel 30%	
				393: return to 60% gravel, sand 30%, silt 10%	

Reported By: J. Threalin | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 4/28/09 | Signature: [signature] Date: 8/4/09

A-6003-842 (03/03)

BOREHOLE LOG

Page 11 of 12

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20 m. W. of TX tank farm

Project: 200-ZP-1 OU Monitoring Wells | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
395	G.S.	B1YD81			Air rotary-12" Thread casing
		Water Samples			
					Grab for chemical analysis @ 395'
					Archive + sieve grab @ 395'
					Water sample: 395-396'
400	G.S.				B1YD36, B1YD37, B1YD38,
					B1YD39, B1YD66
					Archive + sieve grab @ 400'
				404: Increase sand % to 40%, gravel 40%	
405	G.S.			silt 20%	Archive + sieve grab @ 405'
410	G.S.				Archive + sieve grab @ 410'
	G.S.			410.5-458: clay (M)	Archive grab @ 411'
				lt. brown, wet, no rxn to HCl, high	
				plasticity, small percentage of silt (5%)	
		B1YD82		(Ringold Lower Mud)	
415	G.S.				Archive grab @ 415'
					Downsize casing to 8" @ 415.5'
420	G.S.				Archive grab @ 420'
425	G.S.				Archive grab @ 425'
430	G.S.			430: slight increase in silt	Archive grab @ 430'

Reported By: J. Throelin | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 5/4/09 | Signature: [signature] Date: 8/9/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 12 of 12
Date: 5/5/09

Well ID: C7017 | Well Name: 299-W15-225 | Location: 20m W. of TX tank farm

Project: 200-BP-1 OU Pump+Treat Wells | Reference Measuring Point: Ground surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
435	G.S.			435: increase in silt content; 50% silt, 50% clay; very hard, w/ cemented when silty; change in color to predominately greenish gray, occasionally rusty brown in color	Air rotary - 8" threaded casing; Archive grab @ 435'
440	G.S.				Archive grab @ 440'
445	G.S.				Archive grab @ 445'; Open hole drilling from 446'-465'
450	G.S.				Archive grab @ 450'
455					Archive grab @ 455'
	G.S.				Archive grab @ 458'
460	G.S.			458-465: sandy GRAVEL (sG) 50% sand, 50% gravel, sand is brown with a slight green tint, vf-med grained sand, well sorted sand matrix, gravels are sub rnd, 50% felsic, 50% basalt/other	Archive grab @ 460'; Grab for chemical analysis @ 462'
	B1YD43	Water Sample			Water sample: 461'-465'; HEIS # B1YD44, B1YD45, B1YD46, B1YD47, B1YD68
465	G.S.		TD @ 465'	Total Depth (TD) = 465'	Archive @ 465'
470					

Reported By: J. Threolin | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] | Date: 5/5/09 | Signature: [signature] | Date: 8/4/09

A-6003-642 (03/03)

Well 299-W14-20 (C7018)

BOREHOLE LOG

Page 1 of 11
Date: [illegible] 2-25-09

Well ID: C7018 | Well Name: 299-W14-20 | Location: 200-ZP-1 OU, E. of 241-TX Farm
Project: 200-ZP-1 Pump-And-Treat Wells | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
				(Ground Surface)	(cable tool rig w/ drive barrel)
0				0.0 – 5.5 'bgs: sandy gravel (sG)	
				~75% v.fn to crs., ang. to sub-rnd gr., 25% v.fn to crs s., brn, damp to dry, drill construction gnd. 6% dec. to	
				→ ~65%; s% inc to ~35% @ 5.0' bgs.	
5	Grab			5.5 – 14.5 'bgs: sand (S)	Archive grab @ 5.0' bgs. ← 1-pint jar
				~95% v.fn to v.crs s., 5% om, gry/brn, loose, damp, ~70% bmc(mod), 30% fels, strong rxn w/HCl; grad. contact @ 5.5' bgs	
10	Grab				Archive grab @ 10.0' bgs.
				→ ~13.0' bgs, s appears bedded on drive barrel.	
15	Grab			14.5 – 30' 'bgs: sandy gravel (sG)	Archive grab @ 15.0' bgs
				~65% v.fn to v.crs, well-rnd to sub-ang pebbs, 25% med – v.crs s., 10% om, dark gry/brn, semi-cemented, damp, slt. to no rxn w/HCl; ~60% mafs, 40% fels	
20	Grab			→ ~17.0' bgs, few lg. cobbs (max: 15cm (6" dia))	Archive grab @ 20.0' bgs
				→ ~18.5' bgs, ~80% mafs, 20% fels	Air Rotary w/ 3.4-hammer @ 23'
	Grab				Archive grab @ 23.0' bgs
25	Grab				Archive grab @ 25' bgs.
30	Grab			30.0 – 31.5' bgs, silty sandy gravel (mSG)	Archive grab @ 30.0' bgs.
	Grab			60%G, 25%S, 10%S, 15%M	
				v.fn – v.c. cobbs, of 90% Bslt, 10% felsic/meta.	archive @ 31.5'
				Sand is v.c. – v.fn. sub-well rnd. Bslt dep.	
				largest chip 14". silt color: 7.5YR 5/2 Dk Brown	
35	Grab			31.5 – 38 : silty Sand (mS): sand 75%	
				silt 25%; sand v. crse to fine; some small	archive @ 35' – RCT
	Grab			4 mm, grains sub-rnd to sub-ang;	readings ← bkgrnd
				brown 7.5 YR 4/3; no rxn HCl	

Reported By: T. Bennett / J. Thrailkill / A. Lawson	Reviewed By: L.D. Walker
Title: Geologists	Title: Geologist
Signature: [illegible] Date: 3-25-09	Signature: [illegible] Date: 10/21/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 1 of 1
Date: 9/25/07

Well ID: C7018 | Well Name: 299-W14-20 | Location: E. of 241-TX farms, 200W

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
40	g.s.			39.--79: silty gravelly Sand (mg S); sand 70% gravel 15% silt 15%; sand v. crse to fine, qtz dominant, sub-ang to sub-rnd; gravel mostly intermediate, sub-ang. to sub-rnd up to 1/2" dia.; overall color brown (7.5YR 4/3); no rxn HCl → seds very unconsolidated, hammer does not fire while drilling → lots of gravels in returns @ 49' most likely in formation but not coming up with other seds. → gravel inter beds (6" or less) periodically throughout sand layers, gravels <1" sub-ang. fluvial + fluter. → gravels mostly gone by 70' < 10% of formation (silty Sand)	See pg. 2: Air Rot. w/ D.H. hammer
					archive @ 39'
45	g.s.				RCT readings < bkgrnd
					archive @ 45' - RCT readings < bkgrnd
50	g.s.				archive @ 50' bgs
55	g.s.				archive @ 55' bgs
60	g.s.				archive @ 60' bgs
65	g.s.				archive @ 65' bgs
70	g.s.				archive @ 70'
75	g.s.				archive @ 75'

Reported By: S. Sexton | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 9/25/07 | Signature: [signature] Date: 10/21/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 3 of 11

Well ID: C7018 | Well Name: 299-W14-20 | Location: E. of 240 - TX Farms

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
80	g.s.			79-90.5: silty Sand (mS): sand 80% silt 20% some small gravels: sand fine to coarse, qtz dom (70%) sub-ang to sub-rnd gravels pea-size, mostly mafic/felsic, dry, no rxn HCl, unconsolidated, brown (7.5YR 4/3)	See pg. 1: Air Rot w/ D.H. hammer archive @ 80'
85	g.s.				archive @ 85'
90	g.s.	S.S. 100% Recov.		90.5 - 114: silt (M): brown silt (7.5YR 4/3) dry unconsolidated slight rxn HCl, some plasticity, <10% v. fine sand grains. -> strong rxn HCl @ 97.5' bgs with some caliche pieces in silt sediments	archive @ 90' split-spoon 90-92.5 HCIS# B1YD21 B1YD19, B1YD17, B1YMM9
95	Archive g.s.	NLO			archive @ 95' NLO grab 95' HCIS#: B1YM90, B1YM89
100	Archive g.s.	NLO		114 - 119: silty Sand (mS): sand 60% silt 40%: sand med to fine, 50/50 mafic/felsic, sub-rnd loose, mild rxn HCl, brown (7.5YR 4/3)	archive @ 100' NLO grab 100' HCIS#: B1YMC0
105	Archive g.s.	NLO			archive 105' NLO g.s. 105' HCIS#: B1YMC1
110	Archive g.s.	NLO			archive 110' NLO grab 110 HCIS#: B1YMC2
115	Archive g.s.				archive 115' NLO grab 115 HCIS# B1YMC3

Reported By: S. Sexton | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 3/27/09 | Signature: [signature] Date: 10/21/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 4 of 11
Date: Start: 2/20/09

Well ID: C7018 | Well Name: 299-W14-20 | Location: East of 241-TX Farms, 200 W

Project: ZP-1 Pump & Treat | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	Archive	NCO grab		119-127: silty Sand (mS): 60% sand 40% silt; sand med to fine 50/50 mafic/felsic, sub-rnd, loose no rxn HCl, dry	See pg. 1: Air Rotary w/ D.H. hammer ~ archive @ 120'
				→ drilling becoming harder @ 118' bgs	NCO grab 120 HCl: - B&YMC4
125	Archive	NCO		→ some layers of 100% silt up to 1ft thick	archive @ 125' NCO grab 125 HCl: -
				→ soils damp at 127' bgs	~~B&YMC4~~ B&YMC5
				→ gravels mostly mafic, in returns beginning of 127' bgs, <10% of	sms 1-3"
130	Archive	NCO		formation, causing drilling to slow + be harder, samples still damp, top of cemented gravels?	archive 130' NCO grab 130 HCl: - B&YMC6 begin adding water
				→ gravels mostly mafic/inter	@ 131 ft bgs (600 gals)
135	Archive			subangular to sub-rnd; 1-3" diameter no rxn HCl, % inc to 35%	adding water @ 133', getting no
				127-131: ~~silt~~ silty sandy gravel (ms(G)): gravel 35% sand 35% silt 30%; gravels mostly (60%) mafic/	returns due to lack of air; 1300 gals total archive @ 135'
140	Archive			intermediate 40% other 1-3" max sub-rnd to sub-ang; sand 50/50 mafic/felsic sub-rnd med to fine; overall color brown (7.5YR 4/3) damp, cemented, little to no rxn HCl	archive @ 140'
145	Archive			131-159: sandy silty (gravel) (ms(G)): gravel 70% silt 20% sand 10%; gravels mostly mafic 50%, sub-rnd 1-3" max; most fines (sand + silt) washed from returns; wet from added water;	archive @ 145'
150	Archive				add 150 gals @ 149' archive @ 150'
155	Archive				archive @ 155' drill rate 2 ft/5 min added ~300 gals H_2O

Reported By: S. Sexton | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 2/27/09 | Signature: [signature] Date: 10/21/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 5 of 11
Start: [illegible]
Date: Finish:

Well ID: C7018 | Well Name: 222-W4-20 | Location: East of 241-TX Farm 222-W
Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Drilling Sampling Tool, Sampler Size, Water Level
160	g.S.			159 - 160: sandy silty (gravel) (sm G): gravel 70% silt 20% sand 10%; gravels mostly mafic (80%), sub-rnd 1-3" max; sands mostly qtz (70%); wet from added water, very cemented → sand/silt % increase @ 160' to 20% silt 20% sand (50% gravel)	See pg. 1: Air Rotary w/ D.H. hammer archive @ 160' added ~200 gals H_2O
165	g.S.				archive @ 165' add 250 gals H_2O 165-169' logs
170	g.S.			171': Same as above @ 159' → sand/silt % silt increase 40% @ 175' to 90% silt 10% sand (50% gravel)	archive @ 170' add 250 gals H_2O
175	g.S.				archive @ 175' add 150 gals H_2O
180	g.S.			180': sandy silty gravel (sm G): gravel 50% silt 40% sand 10%; gravels mostly mafic (80%), sub-rnd 1-3" max; sands mostly qtz (70%), wet from water added, very cemented	archive @ 180' add 100 gals H_2O
185	g.S.			185': sand increase to 20%; 30% silt 20% sand (50% gravel)	archive @ 185' add 200 gals H_2O
190	g.S.			189': silt increase to 40%; 40% silt 10% sand 50% gravel	archive @ 190'
195	g.S.			198': sand increase to 20%; 30% silt 20% sand 50% gravel	archive @ 195'

Reported By: S. Sexton / K. Stiles | Reviewed By: L.A. Walker
Title: Env. Engineer | Title: Geologist
Signature: [illegible] | Date: 4/2/09 | Signature: [illegible] | Date: 10/21/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 11

Well ID: C7018 | Well Name: 299-W19-20 | Location: East of 241-TX Farm; 200-W

Project: ZP-1 Pump & Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
200	g.s.			200: sandy silty Gravel (sm G): gravel 50% silt 30% sand 20%: gravels mostly mafic (80%), sub-rnd 1-3" diam, sands mostly qtz (80%), moist, slightly consolidated, no reaction w/ HCl	archive @ 200' add 50 gals H_2O
205	g.s.				archive @ 205'
210	g.s.				archive @ 210'
215	g.s.				archive @ 215'
	S.S. grab				interval 10: grab & split-spoon taken 217.7-219.7' bgs
220	g.s.			→ 221.5': silty Gravel (m G): gravel 50% silt 40% sand < 10%; gravels mostly felsic (100-70%) sub-rnd up to 1" max; silts altered, some fine sand grains; poorly sorted; dry spots of mud; rxn to HCl; somewhat consolidated; Ringold	HCRS #s: B1YD12, B1YD15 B1YD16, B1YM18 (GS.) B1YM19 (grab)
225		4.5 blows 3.5	grab	→ seds @ 230' clump, should be w/in 12" of water	change to cable tool @ 219 ft bgs. archive @ 221.5' bgs archive @ 225.5 split-spoon taken 223.65 - 228.85 ft bgs
230				→ 231: in water, cuttings wet → sand inc @ 235' bgs 30% sand 30% silt 40% gravel; → 237: switch to sand pump, no return due to sands in formation; → sand decr again @ 238' bgs	HCRS #: B1YD13, B1YD14 B1YD19, B1YM19 (all) grab taken @ 228.5: B1YM192 (interval all) archive @ 230' archive @ 235' add 30 gals H_2O @ 238'
235					

Reported By: S. Sexton | Reviewed By: L.A. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 4/13/09 | Signature: [signature] Date: 10-21-09

A-6003-642 (03/03)

BOREHOLE LOG

Page 7 of 11
Date: 10-21-09

Well ID: C7018 | Well Name: 299-W14-20 | Location: East of 241-TX Farms, 200W
Project: ZP-1 Pump & Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
240	g.s.			239-257: silty (gravel) (sub) gravels 50% felsic 50% mafic; rounded up to 4" max; gravels 60% silt 30% sand med. sand grains; brown (7.5YR 4/3); wet, poorly sorted, somewhat consol. clasted; clays modified	See pg. 1: Cable Tool rig w/ drive barrel
245	g.s.			→ inc sand % at ~246 ft to 10-15% gravels 50% silt 35% sand 15% → ~250.0' bgs, g. size inc. to v. fn to lg. cobble	archive @ 240' archive @ 245' added 20 gals H_2O
250	Archive NCO grab I-012	Tool			NCO grab at 250.5 interval 012 HE/S# B1YM93 archive @ 250.5 water sample collected at 250.5 ft bgs
255	g.s.			257-264' bgs: sandy gravel (sG) ~50% v.fn pebs to lg cobbles (sub-rnd to ang), 40% v. fn to v. crs s., 5-10% m, 2.5Y 3/4 "lt. olv. brn", wet, consol. no rxn to HCl, grad contact @ 257	HE/S#s: B1YM89, B1YM90, B1YM39 Archive g.s @ 255' bgs.
260	g.s.			264-266' bgs: sand (S) ~90% fn to med s., 5% fn to crs gr., 5% m, 10YR 5/2 "grayish brn" 2.5Y 5/2 "grayish brn" damp, loose, mod. rxn w/HCl.	Archive g.s @ 260' bgs. Archive g.s @ 264' bgs. Archive g.s @ 265' bgs.
265	g.s.			266-270' bgs: rtn. to sandy (gravel (sG)) ~45% v. fn pebs to sm cobbs (sub-rnd to sub-ang), 45% v. fn to v. crs s., 5-10% m, 2.5Y 5/4 "lt. olv. brn", damp, semi-consol, no rxn w/HCl.	NCO grab @ 267' bgs. HE/S# B1YM94, I-014 @ 0855. Water @ 267' bgs. @1025, 6/1/09
270	NCO grab I-014	Tool		270-280 bgs: 60% f. fn peb to lg cobs 20% f. to v. crs sand, 20% m, (angular to sub rnd) 10YR 5/3 brn, wet, semi-consol no rxn to HCl → ~271' bgs, 5% inc. to ~20%, g. size inc. to 50% 2 lg cobs @ 271' bgs. → comp. change to 80% mafic, 40% felsic, max grain size or clast = 15mm @ 272' bgs.	Hanson B1YM80, B1YM85, B1YM86, B1YM81, B1YM87 (Non), B1YM88, B1YM82, B1YM77 (Tot) Archive G.S. @ 270' bgs. Note: Hard tooling from 272' bgs. Archive G.S. @ 275' bgs.
275	Archive GS	Tool			See pg 8

Reported By: T. Bramwell / J. Schilperport | Reviewed By: L.D. Walker
Title: Geologist | Title: Geologist
Signature: [signature] Date: 10/21/09 | Signature: [signature] Date: 10/21/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 8 of 11
Date: 9/28/09 / 4/20/09

Well ID: 299-W14-20 | Well Name: C7018 | Location: E. of 241 Tx Farm

Project: ZP-1 Pump & treat | Reference Measuring Point: Ground Surface

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
				(see pg. 7)	(see pg. 7)
280	G.S.			280.5'-287.5': gravelly silty sand (gmS)	notes: hand tooling w/
				w 45% v. fn. to v. crs. sand, 20% m, 25% v.fn. pebbles	split spoons about
				to sm. cobbles - subrounded to angular	every 10 ft
		HT		2.5Y 4/2 dk grayish brn, wet, semi-consol.	Archive G.S. @ 280.5' bgs.
285	G.S.			no rxn w/HCl, 65% felsic, 35% mafic	Archive G.S. @ 285' bgs.
				287.5' 300' bgs.: silty sand and gravel (msG)	
	SS-G.S.			40% v. fn. pebbles to sm. cobbles, sub-rounded-angular	NCO G.S. @ 287.5'-290' bgs
				30% v. fn to crs sand, 30% silt/clay (mod. plasticity)	@1500 4/28/2009, H E15 #
				2.5Y 4/3 olive brn, damp, semi-consol. No rxn HCl	B1VM95, B1VM96
290	G.S.	HT		70% felsic, 30% mafic	Archive G.S. @ 290' bgs
					Water sample @ 290' bgs 10:40 6/24/09
					H8SH B1VM72 (VOA), B1VM73
					B1VM72, B1VM78 (TB)
295	G.S.				Archive G.S. @ 295' bgs
					Archive G.S. @ 297 bgs. 4/28/09
				300' - 305' bgs silty sandy gravel (msG)	Archive G.S. @ 305' bgs 6/25/09
300	G.S.			40% v. fn. pebbles to sm. cobbles - sub-rounded to ang. 25% v.fn. to	
				v. crs sand, 15% silt/clay (mod. plasticity) 2.5Y 4/2	
				(dk grayish brn), damp, semi-consol., No rxn to HCl, size	
				v. alt, 75% felsic 25% mafic	
305	G.S.	HT			
				@1321/09	Archive G.S. @ 310' bgs 6/30/09
				→ w 307'-310.5' bgs v. hard drilling	NCO G.S. @ 307'-310' bgs @ 845,
				but same formation	6/24/09 H8SH B1VM97
					NCO water sample @ 310' bgs @ 1551
310		HT			6/24/09 H8SH B1VM77 (VOA),
					B1VM76 (VOA), B1VM78, B1VM72
					B1VM77 (VOA) (TB)
					Archive @ 315' bgs 6/24/09
315	G.S.				
				3/30/09	
				— See pg 9 —	

Reported By: J. Schilperoort | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: J. Schilperoort | Date: 6/30/09 | Signature: LD Walker | Date: 10-21-09

A-6003-842 (03/03)

BOREHOLE LOG

Page 9 of 11

Date: 7/10/09

Well ID: 299-W4-20 | Well Name: C7018 | Location: E. of 241 Tx Farm

Project: 200-ZP-1OU RA Pump-Treat | Reference Measuring Point: G.S.

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description (Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level)
320	G.S.	HT D.P.		See page 8	Archive G.S. @ 320-325' bgs 7/20/09
				Encountered a sandy lense @ ~ 321' bgs. Same formation. 60% v. fn pebbles - cs sand, subrnd, to ang. 25% s fn-crs sand. 15% sil/clay. damp. consol. no rxn to HCl. 100% Fe/Sil. 40% Mafic. SWRH/R	Cable Tool rig
325	G.S.	HT D.P.		@ 7/10/09 327'-332.5' bgs, slightly gravelly sand w/ gS 60% v.f.s. grains to cs. subrnd to ang. 25% v.f.s to v. crs sand: subrnd to ang. 5% m. 25% Fe - dk gray/blk. damp/mst. consol. no rxn to HCl	Archive G.S. @ 327' bgs. 7/06/09 NCO G.S. 325'-330' bgs 7/06/09 NCO H2O 330' bgs @ 1265 7/6/09
330		HT			
					@ 7/8/09 Archive G.S. @ 335' bgs 7/07/09 Archive G.S. @ 340-342.5' bgs 7/7/09
335	G.S.	HT			
340	G.S.	HT D.P.			
				Very micaceous @ 350-353' bgs. Still low silt content	
345	G.S.	HT			Archive G.S. @ 350' bgs 7/8/09
					NCO G.S. 350-352.5' bgs @ 0952, 7/09/09
					NCO H2O 350' bgs @ 1015 7/9/09
350	G.S.	HT D.P.			
		HT			Archive G.S. 355' bgs 7/10/09
355	G.S.	HT		See pg. 10	

Reported By: T. Brunell / J. Schilperoort | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 7/10/09 | Signature: [signature] Date: 10/21/09

A-6003-842 (03/03)

BOREHOLE LOG

Page 10 of 11
Date: 7/20/09 / 7/20/09

Well ID: C7018 | Well Name: 299-W4-20 | Location: E of 241 Tx Farm

Project: 200-ZP-1 OU RI, Pump-&-Treat | Reference Measuring Point: Ground Surface

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
360	G.S.			——— See pg. 9 ———	Archive 360'bgs - [illegible]
				327-367 bgs - slightly silty [illegible] 1mlgS	7/20/09
				60% v.fn to [illegible] sand, [illegible]	Archive 365'bgs 7/20/09
				35% v.fn to crs sand, 5% m, 2.5Y 4/4 dk grayish brn	(Continue H.T.)
				[illegible] HCl, micaceous,	Cable tool drill rig
365	G.S.		(H.T.)	clasts are well rnd. of Qtz. max clast size is	
				2" + clasts of Bslt-subrnd. [illegible], max clast	NWO G.S. @ 369.5-370'bgs 7/20/09
				size is 4". Matrix is Qtz-feldspathic w/	I-024 [illegible]
				gray + black silt laminates w/ iron staining.	7/20/09
	G.S.			367-370: Silty Sandy Gravel (mSG)	Archive [illegible]-371'bgs 7/20/09
370				50% gravel, 30% S, 20% [illegible]-10% m.	
				Matrix supported. Matrix is submangnang,	366-371': Water Sample
				fine sand to silt (15% mSG). 2.5Y 4/2 dk grayish brown.	BYM7F, BYM7K6, BYM7J1,
				Gravel is w/rnd. m.fdn-3.cob. of (90% felsic,	BYM82 (7/13/09)
				microcrystalline, 10% bslt.) Max clast: 4" qtz. sparse.	
375	G.S.			· Sand is Qtz-feldspathic w/ mica.	375: Archive grab (7/13/09)
				· Sed. is poorly indurated. No rxn w/ HCl.	
				[Ringold E]	
					380.0-382.5: Sieve & Archive.
380					Grab
	Sieve		Sieve		
385	G.S.			· increase silt % to 30% Hard Tool	385: Soil Grab Archive
				Drilling. Slurry thickens.	7-14-09
				390.0'-400bgs: Gravelly Silt (GM)	390.1-392.5': NWO G.S.
390	I-026 Chem G.S.			85% m, 15% G. Micaceous silt 5Y 5/2	I-026 HCS#BYM8J 7/17/09
				dolive. w/ well rounded discoid 1-cobs-f.felsic.	390.1-392.5': H2O sample I-026
				Felsic comp. Clasts have random orientation.	I-027 HCS#BYH7F7, BYH77
				Sed. is moist. No rxn w/ HCl and indurated.	BYM7J1, BYM7K7, BYM83
395	G.S.			· Drill rate increase @ 394'	
					Archive G.S. @ 395'(HT) bgs
					on 7/20/09
				——— See Pg. 11 ———	——— See pg. 11 ———

Reported By: J. Schlipmann / A. Lenhart | Reviewed By: C.D. Walker
Title: Geologist | Title: Geologist
Signature: [signature] Date: 7/20/09 | Signature: [signature] Date: 10/21/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 11 of 11
Date: 7-28-09

Well ID: C7018 | Well Name: 299-W4-20 | Location: E. of 241 Tx Farm

Project: 200 ZP-1 Pump-treat wells | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
				SEE PG 10	
400	G.S.	D.B. H.T.		406'-407' bgs: Silty sandy gravel (mG) 70% v.f. cobble to sm. pebbles - subrnd - lng. max size is 5", 15% v.f. to crs. sand - rnd - to subrnd, 15% m., clamp. 10YR 5/4 (yellowish brn) semi-consol. no rxn to HCl 85% Felsic, 15% Mafic.	Archive G.S. @ 400' bgs (D.B.) 7/20/09 - CS sieved. Archive G.S. @ 405' bgs 7/20/09
405	G.S.			407'-430' bgs: Mud (m) 100% m, v. sm. % of silt. 5Y 5/2 olive gray, consol., no rxn to HCl, clamp.	Archive G.S. 405'-410' bgs 7/21/09. NLO sample 406'-410' bgs @ 0896, 7/21/09 [illegible]. Water rxn. test @ 0900, 7/21/09. 405'-410' bgs HESS's: [illegible]
410	G.S.	D.B. H.T.		Dominantly clay w/ interbeds of sand. Light-brown sand encountered @ 415' bgs.	Archive G.S. @ 415' bgs 7/22/09. Archive @ 400, 425' bgs 7/22/09. Not a good return - only enough for chip tray.
415	G.S.				Archive G.S. @ 420' bgs 7/24/09
420	G.S.				Changed casing to 8" @ 408' bgs.
425	G.S.				
430	G.S.			430 - 439' bgs. Silty Gravel (mG) 60% v.f. pebble to v. crs. pebble - subrnd - lng. max size 50mm 20% green m, 15% gm. sand v.f. to crs. clamp. 5Y 5/2 v. dk greenish gry. semi-consol. rxn to HCl 75% Felsic, 15% Mafic.	NLO sample 438-440' bgs 7/24/09 [illegible] NLO H2O [illegible] T.D. = 439' bgs
435					
	Mud Rotary	7:30 AM 7:21			

Reported By: J. Schlipmann | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [illegible] | Date: 7/28/09 | Signature: [illegible] | Date: 10/21/09

A-6003-642 (03/93)

Well 299-W14-73 (C7021)

BOREHOLE LOG

Page 1 of 13
Date: 3/2/2010 [illegible]

Well ID: C7021 | Well Name: 299-W14-73 | Location: 200-ZP-1, SE. Corner of Bridgeport Ave & 22nd St Intersection

Project: 200-ZP-1 Pump and Treat Wells | Reference Measuring Point: Ground Level

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0				0'-1.0': sandy GRAVEL (sG); 60% gravel 40% sand, tr silt. Drill pad gravel/ crushed rock, predom basalt	Cable tool w/ drive barrel
				1.0'-3.5': silty SAND (mS), 30% silt, 70% sand, brown, moist, well sorted, sand subr-subrn, sparse gravel, mod rxn HCl	
5	Grab			3.5'-38': sandy GRAVEL (sG), brown, moist, pr sorted, 70% basaltic, 30% felsic, 60% gravel, 30% sand, 10% silt, max size 4", sand mod rxn to HCl	Archive grab @ 5' bgs
10	Grab			→ gravel increase to 70% @ 8' bgs → gravel decrease to 60% @ 11' bgs → gravel increase to 65% @ 18' bgs	Archive grab @ 10' bgs
15	Grab			38 - 39: sand (S): sand 90% silt 10% sand crse to very crse, mafic 75% 25% other; wet clays to added water; some gravels, due mostly to leftover cobble pieces, drilling very easy from 38' (hammer not firing)	Archive grab @ 15' bgs
20	Grab				Archive grab @ 20' bgs
				→ 22': Switch from cable tool to air rotary	
	Grab				Archive grab @ 23' bgs
25					
30	Grab				Archive @ 30' bgs
					add 250 gals water
35	GS				archive at 36' bgs

Reported By: J. Throslin / S. Sexton | Reviewed By: L.D. Walker
Title: Geologist | Title: Geologist
Signature: [illegible] / [illegible] Date: 3/2/10 | Signature: [illegible] Date: 5/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 2 of 13
Date: 8/10/09

Well ID: C7621 | Well Name: 299-W14-73 | Location: SE of Bridgeport + 22nd St. Inter.

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
40	G.S.				See pg. 1; D.H. hammer
				39-52: Sand (S): sand 90% silt	Air rotary
				10%; sand very crse, to crse mostly	
				mafic (75%); wet due to added	archive @ 40'
				water	
45	G.S.			→ some small pebbles in returns	
				<1" sub-rnd	archive @ 45'
				→ pieces of CaCO3 coming up in	
				cuttings, still no rxn in sand's tho;	
50	G.S.			52-79: silty, sand (wS): silt %	archive @ 50'
				inc to 40% sand 60%, same lith.	
				as above, no rxn HCl, dry, overall	
				color brown, sand color black/white	
				→ dec. sand size, med-crse @	
55	G.S.			63 ft bgs	archive @ 55'
60	G.S.				
					archive @ 60'
65	G.S.				archive @ 65'
70	G.S.				archive @ 70'
75	G.S.				archive @ 75'

Reported By: S. Sexton | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 8/10/09 | Signature: [signature] Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 3 of 13

Well ID: C7021 | Well Name: 299-W19-73 | Location: SE of Bridgeport + 33nd ZP-1 ow

Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
80	G.S.			79 - 119 : Silty Sand (mS): sand 60% silt 40%: sand med to crse, 50/50 mafic/felsic, dry, no rxn HCl, color brown	See pg. 1: Air Rotary w/ D.H. hammer
					archive @ 80'
85	G.S.				archive @ 85'
90	G.S.				archive @ 90'
95	G.S. archive G.S.	B1J8-001			archive @ 95' NCO grab @ 95' for 222-S: HCIS # B1YNH4, B1YNH0
100	G.S. archive	B1J8-002			archive @ 100' NCO grab @ 100' for 222-S: HCIS # B1YNH1
105	archive NCO grab	B1J8-004			archive @ 105' NCO grab @ 105' HCIS # B1YNH2
110	archive NCO grab	B1J8-005			archive @ 110' NCO grab 110': B1YNH3
115	archive NCO grab	B1J8-006			archive @ 115' NCO grab 115: B1YNH4

Reported By: S. Sexton | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 08/04/09 | Signature: [signature] Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 4 of 13
Date: 3/5/09

Well ID: 299-W4-73 | Well Name: C7021 | Location: SE of Bridgeport & 2nd; ZP-1 OU
Project: ZP-1 Pump + Treat | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	G.S.	EW1-007		119 - 123: silty Sand (mS): sand 60% silt 40%; sand med to crse, 50/50 mafic/felsic, dry, no rxn HCl, color brown	See pg. 1: Air Rotary w/ D.H. hammer
		NCO G.S. EW1-025			archive @ 120'
					NCO grab @ 120; B1YNH5
125	G.S.	NCO G.S. EW1-009		123 - 159: Silt (M): brown silt (10YR 5/2) w/ some micas, moderately plastic, slight to moderate rxn HCl — inc small pebble/v. crse sands at 134'; very strong rxn to HCl.	run split-spoon from 121.5' to 123.5 ft bgs. HGS's: B1YNH7, B1YNJ2, B1YNJ5, B1YNJ8, B1YNJ9 for EW1-008
130	G.S.	NCO G.S. EW1-010			
					archive @ 125'
					NCO grab @ 125': B1YNH6
135	G.S.				
					archive @ 130'
					NCO grab @ 130: B1YNH7
					archive at 135'
140	G.S.				
					archive at 140'
					archive @ 145'
145	G.S.				No archive @ 150' due to water in the hopper, sediment are smaller than previous.
					archive @ 155'
150	G.S.				archive @ 160'
155	G.S.				

Reported By: S. Sorton | Reviewed By: L.D. Walker
Title: Geologist | Title: Geologist
Signature: [signature] | Date: 3/5/09 | Signature: [signature] | Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 5 of 13
Date: 3-5-09/3-19-09

Well ID: 299-W4-73 | Well Name: C7021 | Location: SE of Bridgeport + 22nd, ZP-1 area
Project: ZP-1 Pump + Treat | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sample Size, Water Level
160	G.S			160'–165': Gravelly Silt (GM), sl/ft 60% gravel 40%, light brown silt with mostly black (mafic) felsic with quartzite, dry slight reaction w/HCl, gravel size 1-2" 80% black 20% light gravel.	archive @ 160' Air Rotary 163' added water, 250 gallons
165	G.S.			165-170: Silty Sandy Gravel (MSG) (SG) 65%G, 19%S, 5%silt. Med-f. gravel sub rnd clasts & 15% bull. 15% felsic. 2" max size. Sand is f-v.f. sub angular to sub rnd. mainly of felsic & quartz & feldspathic.	165' archive grab Add 250 gal. H_2O 167 Add 250 gal H_2O 168 Add 250 gal H_2O
170	G.S.			170-196: Sandy Gravel (SG) 65%G, 15%S. lithology same as above max clast size 3/4": max size may be larger due to excessive combining mechanical breaking 4" well rounded clast. Slt. rxn w/HCl.	170' Tricone bit Add H_2O: 500 gal Add H_2O: 250 gal 170' archive grab (→175': DH hammer)
175	G.S. archive			→~175' bgs, clast size dec due to excessive drilling. Rln to above descrip ~ 178' bgs. →~178-179' bgs, fels inc to 35%, mafic dec to 65%, dry, v. loose, slt rxn w/HCl.	175' archive grab
180	G.S. archive			→~clast chip size inc. to 1-2" max, more frag @ ~ 183' bgs.	180' bgs archive grab
185	G.S. archive			→clast size dec to 1/4"-1/2" max, @ ~190'	185' bgs archive grab
190	G.S. archive				190' bgs archive grab
195	G.S. archive			235' (TD 3-30-09) 196-235' bgs: gravels (G) ~90% fn to med clasts (sub rnd to rnd) & 10% fn to med sand, dry, v. loose, ø rxn w/HCl, 54% gray, ~40% mafic, 40% fels/felsic/quartz (see pg. 6)	H_2O added to help move clast; flushed. 195' bgs archive grab (see pg. 6) →

Reported By: A. Lanham/T. Buswell | Reviewed By: L.D. Walker
Title: Geologist | Title: Geologist
Signature: [signature] Date: 3/19/09 | Signature: [signature] Date: 3/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 13
Date: 3-19-09/3-20-09

Well ID: C7021 | Well Name: 299-W14-73 | Location: SE of Bridgeport + 2nd, 200-ZP-1 OU

Project: 200-ZP-1 Pump+Treat Wells | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
				(see pg. 5)	(see pg. 5)
200	G.S.			→ Trace Subround gs @ ~197' bgs	200' bgs archive.
				→ ~199' bgs, predom. subround gs, drilled + broken 2 angular	Air Rotary
205	G.S.				205' bgs archive.
					(Note: H_2O still added to hole but pumping out).
210	G.S.				210' bgs archive.
215	G.S.				215' bgs archive.
220	G.S.				220' bgs archive.
225	G.S.				225' bgs archive.
230	G.S.				230' bgs archive
				235-249' bgs: sandy gravel (GG)	
235	G.S.			~55% gravel to crse s, 45% fn. to crse gs (subround to ang), drk gray (10YR 4/1), wet, loose, non rxn w/HCl, 70% felsic (qtz, plag, gran, micaceous, etc.) 30% mafic (g. ma. bas), grad. contact @ 235' bgs. (see pg. 7)	235' bgs archive.

Reported By: T. Buswell | Reviewed By: L.d. Walker

Title: Geologist | Title: Geologist

Signature: Tom Buswell | Date: 3/20/09 | Signature: [illegible] | Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 7 of 13
Date: 7-20-09/4-2-09

Well ID: C7021 | Well Name: 299-W14-33 | Location: SE of Bridgeport + 22nd, ZP-1 OU

Project: 200-ZP-1 OU Pump + Treat Wells | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
				(See pg. 6)	(See pg. 6)
240	G.S. archive			→ w/cable-tool, gs noticed to be mostly gs to lg. cobbles, subrnd; start @ 240.5' bgs, no change in fm. (ms(g))	240' bgs archive. Switched to cable-tool drilling w/hollow drive barrel (2.6) on 3/[illegible]
				244–258' bgs: semi-cem silty sandy gravel (ms(g)) ~40% v.f.s. to v.c.gs, subrnd to subang, 30% v.f.s to v.c.r.s., 30% m., dry, semi-cem, no rxn w/HCl, 10YR 7/2 "pale brown", 65% fels, 35% mafics; good contact @ 244' bgs. HARD drilling.	245' bgs archive. v. hard drilling.
250	G.S. archive				250' bgs archive.
	250-251.5'			→ ~252' bgs, inc. of gs to w/fm to v.c.gs to v.c.r.s. to lg. cobbles, bas (cobbles smooth), felsic (qtzite)	SS @ 251-251.5' bgs @ 0930, HED# B1YND7, B1YN73 (B1), B1YN73, B1YN73, B1YN73, B1YN7(B(B2))
255	G.S. archive			→ ~254' bgs, 1 lg bas. boulder (~9" diam max)	→ Add 2 gal H_2O. 255' bgs archive.
	G.S. archive			→ ~257.5' bgs, s. % dec to ~40%, m. dec to 20%; some "glassy" frs. in semi-cem mat.	→ Add 2 gal H_2O; still v. hard drilling.
260	G.S. archive			258–260' bgs: gravelly sand (gS) ~85% f.s. to c.s. s. (80% mafic, 10% felsic, 10% qtz), ≤15% med to c.gs (subrnd to ang), dry, loose w/some cementation, no rxn w/HCl, 10YR 4/1 "gray", 85% fels, 15% mafic; good contact @ 258'	Archive @ 258' bgs. 260' archive.
				→ ~260' bgs, gs inc. to ~40%, some cobbles.	→ Driller added ~1-2 gal water to borehole @ 265' bgs.
265	G.S. archive			260–262.5' bgs: sandy gravel (s(g)) ~60% v.f.s. to cobbles to lg. cobbles (subrnd to subang), 40% v.f.s to v.c.r.s., dry, loose to semi-cem, no rxn w/HCl, 10YR 5/2 "lt. brownish gray", ~30% fels, 30% mafic.	265' archive. SS @ 267-269.5' bgs @ 0945, 4/1/09 HEZS# B1YN73 (B1), B1YN04, B1YN73 (V.C.A), B1YN73 (V.C.A), B1YN73 (B, V.C.A); 100%
270	G.S. w/ G.S. archive	0.5' of 2.5		262.5–272' bgs: silty sandy gravel (ms(g)) ~50% v.f.s to gs to lg. cobbles (subrnd to ang), 30% f.s. to v.c.r.s., 20% m., all-mixed, loose to semi-cem, no rxn w/HCl, 10YR 5/2 "grayish brown", both fels 40% mafic.	→ 270' bgs archive. GS @ 264.5-270' bgs @ 0945, 4/1/09 HEZS# B1YND5 (FW3-012).
275	G.S. archive	Hand-tooling		→ ~266' bgs, m% inc to 25%, s. dec to 25% @ ~267-267.5' bgs, m% dec to 10%, g. inc to 60%, (~270') s. to 30%; g/s. = 75% fels, 25% mafic. → m% inc. to ~40%, g. inc to 40%, s. to 20%; moisture inc to damp; gs v. weathered.	→ DTW = 270.6' bgs. 275' bgs archive. → Begin hand-tooling @ 275' bgs.
					→ (See pg. 8)

Reported By: T. Bussell | Reviewed By: L.J. Walker

Title: Geologist | Title: Geologist

Signature: [illegible] | Date: 4/2/09 | Signature: [illegible] | Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 8 of 13
Date: 4-1-09 / 4-13-09

Well ID: C7031 | Well Name: 299-W14-73 | Location: S.E. of Bridgeport + 22nd, ZP-1 OU

Project: 200-ZP-1 OU Pump Treat Wells | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
				(see pg. 7)	(see pg. 7)
280	no sample recovery	Hand-tool		272–278.5' bgs: v.well. silty sandy gravel (mSG) ~40% v.fn gr to crs cobbles, [illegible] to well-rnd to sub-ang, 30% v.fn (30%) to v.crs (40%) s., 30% m, multi-color (red, brn, orange, blk, w.), overall color: 10YR 5/3 "yellowish brn"; damp, comp, rxd/gray/blue sebs: non w/HCl, strong 30% fels, 30% mafics v. alt./weathered.	(Note: hard-tooling, collect sieve/grab sam, 10-ft-shot @ ~ 272' bgs, attempt grab recovery 5-ft.)
285	fair archive			275.5' — 295' bgs: v.fn to silty, sandy gravel (mSG) v. similar as 272.0–278.5' bgs: ~50% v.fn gr to lg cobbles, sub-rnd to ang, 30% v.fn to v.crs s., 20% m, mod, sub-comp to loose, no rxn w/HCl, 10YR 5/3 "grayish brn", 65% fels, 35% mafic.	archive @ 285' bgs; sieve grab @ 275'; (note: collect sieve sample every 10' starting @ 290' bgs)
290	G.S. archive; Geo. G.S.; H2O sp	Cable tool G.S. only; water: G.S. only			archive @ 290' bgs; sieve grab @ 290' bgs; add 5 gal H_2O
295	G.S. archive	Hard-tool		295': Same as above @ 275' bgs → 297': increase sand to 40%, decrease to 10% (50% gravel) 298': decrease sand to 20% increase silt to 20% (gravels 50%)	G.S. @ 291-294' bgs 4/2/09 @ 1110; HGES#: BIYND6, EW3-014; → 295' G.S. archive.
300	G.S. archive	Split-spoon		299'–300' bgs: silty sandy Gravel (mSG) gravels 50% v.fn to crs. pebbles, [illegible] sub-ang. to sub-rnd. 30% sand v.fn (20%) to v.crs. (80%) 10YR 5/2 "grayish brown", mod [illegible], no reaction to HCl, 65% felsic, 35% mafic, sub-comp to loose, weathered, 20% m.	H_2O sample @ 297.5' bgs, 4/2/09 @ 0910, HGES#: BIYNK9 (WA), BIYNK1, BIYNK2, BIYNK3 (TB). 300' bgs archive w/ss.
		Hand tool			
305	G.S. archive	S.S.		300–310' bgs: silty sandy gravel (mSG) ~60% v.fn gr to sm cobbles (sub-ang to v.rnd), 25% v.fn (30%) to rnd (10%) s., 15% m, 10YR 5/4 "dark yellowish brn", moist, loose to mod-comp, non w/HCl, 75% fels 25% mafic.	305' bgs archive w/ss.
		Hand tool			
310	G.S. archive; G.S. only	S.S.		310–320' bgs: silty sandy gravel (mSG) ~65% v.fn gr to sm cobbles (sub-ang to sub-rnd) 20% v.fn (50%) to v.crs (10%) s., 15% m 10YR 5/3 "brown", slt. moist, v. comp, slt. rxn w/HCl, 70% fels, 30% mafic	310' bgs archive w/ss. G.S. @ 314.5–318.5' bgs 4/13/09; HGES# BIYND7; EW3-016; 312–313.5: H_2O sample 4/13/09
315	G.S.	Hand-tool			→ 315' bgs archive g.s.
				(see pg. 9)	(see pg. 9)

Reported By: T. Bassett / K. Stiles / A. Anderson | Reviewed By: L.A. Walker

Title: Geologist / Env. Engineer / Geo | Title: Geologist

Signature: [illegible] | Date: 4/13/09 | Signature: [illegible] | Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 9 of 13
Date: 4-14-09 / 4-21-09

Well ID: (7021 | Well Name: 299-W14-33 | Location: SE of Bridgeport + 2nd, ZP-1-OU

Project: 200-ZP-1 OU Pump + Treat Wells | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
				(see pg. 8)	(see pg. 8)
320	G.S. archive	split-spoon; Hand-Tool		320-330 'bgs: silty sandy gravel (mod(s)) ~60% v.fn gr to sm cobbles, subrnd to sub-ang, 20% v.fn (50%) to v.crs (20%) s., 20% m., 10% f/s "brown", 1% moist, v.comp, no rxn w/ HCl, 70% fels, 30% met.	+Still hard-hosting w/as. every ~10 ft. 320' bgs archive sample.
325	G.S. archive			330 — TD 4-15-09	325' bgs archive.
					330' bgs archive.
330	G.S. archive; G.S. archive	S.S. Water: EW3-019; Hand-Tool		330-340 'bgs: silty sandy gravel (mod(s)) ~55% v.fn gr to sm cobbles, subrnd to sub-ang, 30% v.fn (50%) to v.crs (25%) s., 15% m., 2.5Y 5/3 "lt. olive brn", moist, v. comp, no rxn w/ HCl. 75% fels, 25% met.	G.S. @ 330-332.5' bgs @ 0730 4/15/09, HE3s# B1YAV5, EW3-019-G.S. & O sample @ 330.5' bgs @ 1135, 4/15/09, HE3s# B1YAL8, B1YAM8, B1YAN9, B1YAC4 (TB): EW3-019 + EW3-019-TB
335	G.S. archive				335' bgs archive
340	G.S. archive	split-spoon; Hand-Tool		340-351 'bgs: sandy Gravel (SG) 60% gravel 30% sand 10% silt, gravels ~60% v.fine pebbles to large cobbles (60% felsic, 40% mafic), well-rnd to sub-angular, sands 75% v.fn to fn, 15% med. to very coarse (70% felsic, 30% mafic) 2.5Y 5/3 "lt. olive brown", moist, very compacted, no rxn w/ HCl	340' bgs sieve-grab & archive
345	G.S. archive				345' bgs: archive
350	G.S. archive & HCO EW3-020	split-spoon; Water: EW3-020; Hand-Tool		351-360 'bgs: silty sandy gravel (mod(s)) ~50% v.fn gr to sm cobbles (well-rnd to subrnd) 30% v.fn (~40%) to v.crs (20%), 20% m., 2.5Y 6/3 "lt. yellowish brn", dry to damp, semi-comp, violent rxn w/ HCl; 70% fels, 30% met.	351' bgs archive. G.S @ 351.1-353.1' bgs @ 0845, 4/20/09, HE3s# B2YAE3; EW3-020. H2O @ 351.1' bgs, 4/20/09 @ 1450 HE3s# B1YAL2 (VOA), B1YAP6 (SV) B1YAP7, B1YAP8, B1YAV5 (TB): EW3-021. 4-20-09
355	G.S. archive				355' bgs: archive
				(see pg. 10)	(see pg. 10 →)

Reported By: T. Buswell / K. Stiles | Reviewed By: L.D. Walker

Title: Geologist / Env. Engineer | Title: Geologist

Signature: [signature] Date: 4-21-09 | Signature: [signature] Date: 5/10/09

A-6003-842 (03/03)

BOREHOLE LOG

Page 10 of 13
Date: 4-21-09/5-5-09

Well ID: C7021 | Well Name: 299-W9-73 | Location: SE of Bridgeport & 225°, 2P-1-OW

Project: 200-ZP-1 Pump & Treat Expansion | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
360	G.S. archive	4 W.T. Split-spoon		360-370' bgs: silty sandy Gravel (msG)	360' bgs: archive 4/21/09
		Hand-tool		60% gravel (~50%) w/ pebbles to large cobbles (70% felsic, 30% mafic), 20% sand (~85%) v.f.m to fine, ~(15%) med to coarse 20% silt, Hi reaction w/ HCl, gravels sub-angular to well rounded, moist, semi-comp. gravel (~70% felsic, 30% mafic) 2.5Y5/3	
365	G.S. archive			"Hi olive brown"	365' bgs archive: 4/21/09
		Hand-tool			371' bgs archive: 4/22/09
					G.S. @ 370.0-372.8' bgs @ 0855. 4/21/09, HE25"B14WF2: E403-022.
370	G.S.			370-373.0' bgs: silty sandy gravel (msG) ~70% v.f.c gravels to sm. cobbles 25% v.f.m to f.m (mostly med to coarse (50%)), v. crse (10%); 15% mafic, 10% 1/2" bas"; dense to wet, semi-comp., no reaction, sub-angular to rounded; overall 70% felsic, 30% mafic	H.O @ 371.0' bgs @ 1355. 4/22/09, HE25"B14WF3, B14WF4, B14WF5, 4(WA) B14WC6(TD): E403-023.
	Archive trace	2.1 Hammer E403-023			
375	G.S. Archive	Hand-tool			375': Archive grab 4/29/09
				375.0'-384.5' bgs: Sandy Gravel (SG) (80% S, 20% G) 80% f.-v.c. sang-subrang, dominantly felsic mineral fragments (80%) mafic content (20%) gravels of	380-384.5: Sieve Grab 4/29/09
380	S.G.S. Archive	Sieve grab		sang. v.f. pebs to sub-round v.c. pebs of (100% felsic content) (<10%) silt 10YR 3/3 brown. Mild rxn w/ HCl. when dry	384.5= 380.0': Archive Grab 4-29-09
385	G.S. Archive	Hand-tool		384.5-392 bgs: silty sandy Gravel (msG) (40% Sand) v.f.-v.c. subrnd.-sang. ste fellsphthic Sand. (60% Gravel) v.f. pebs to v.c. pebs of Felsic Material (~90%) (~10% mafic): 10YR 3/3 brown. when wet. (10-15% silt)	384.5: Archive grab 4-29-09
390	G.S. Archive	Hand-tool S.S.		392-407.5' bgs: Silty Sandy Gravel (msG) (20% S, 40% S, 40% G) Matrix supported. Gravel is v.c. to sub rnd. f. pebs to s. cobs. 35% mafic. Matrix is silty sand w/ clay nodules. Sand is v.f.-m subrang-sang, micaceous sand w/ 10% v.c. sub-rnd. grains of stre fellsphthic composition. Sand is 10YR 3/3 Yellowish brown color. Clay nodules are 10YR 3/3 gray.	392-394: Split spoon: B14WF3 392-394: Sieve Grab 392-394: Archive Grab 391-392: H2O Sample B14WL6, B14WP5, B14WP6, B14WP7
395	G.S. Archive				

Reported By: E. Stiles / T. Bussell / A. Lanton | Reviewed By: L.D. Walker

Title: Geologist / Geologist / Geologist | Title: Geologist

Signature: [illegible] | Date: 5-5-09 | Signature: [illegible] | Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 11 of 13
Date: 4-28-09 / 5-5-09

Well ID: C7021 | Well Name: 299-W14-73 | Location: SE. of Bridgeport + 22nd, 200-W

Project: 200-ZP-1 OU. Pump + Treat Expansion | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
		(Note Top)		409.5: Silty Sandy Gravel (msG)	400': Archive Grab
400	G.S. Archive	Sieve		20%m, 40%s, 40%G) Matrix supported gravel is	400-402: Sieve Grab
				w sub-rnd f. pebs to 5-cobs. 35% Mafic. Matrix is	
				v.f.-m. subang, heavy micaceous sand w/ 10%	
				v.f. sub-rnd grains of qtz/feldspar. Color is 10YR 5/3	
405	Auger G.S.			Yellowish brown. Sparse clay knobules 4" round	405': Archive Grab Sample.
				10YR 5/4 grays in color. no rxn w/ HCl. weathering	407-409: Soil Grab BIYNT4
				chips present.	409.: Archive Grab
	G.S. Archive	Sieve		409.5-409.5' bgs: Silty Sand (mS) 90%	409: Sieve grab
		Water Sample		Sand w/ silt stringers. Sand is v.f-f	409-410: Water Sample
410				subang. & 100% felsic comp. Color 2.5Y 5/3 olive brown	BIYNP8, BIYNL8, BIYNP9
				409.5-428.0: Silty Sandy Gravel (msG)	
				Matrix supported gravel is well to subrnd. v.f pebs	
				to 3 cobs & 20% mafics. Matrix is silty sand of:	
				v.f. to v.c. ang-subang sand (20% mafic to 10%) w/	415': Archive Grab.
415	G.S. Archive			mottled silts of 10YR 5/4 yellowish brown, 10YR 4/4 dark	
				gray + 2.5YR 3/6 dark red. Total msG% is	
				20%m, 40%s, 40%G. weathering chips present.	
				white cementation present. No rxn w/ HCl	
				matrix is hard to break w/ hands.	420.5-422.0': Archive grab
420					+ Sieve grab.
	G.S. Archive	Sieve		420': Silt content increase to ~30%.	
425		Water Sample			
				428.0-435.5: Silty Sand (mS) v.f (75%,	
430				25-35%m) Sand is v.f-m. ang to subrnd.	
				of 95% micaceous Quartzofeldspathic composition	
				w/ sparse sub-angular to well rnd. small cobs.	432-434: Archive grab
	G.S. Archive	Sieve		of Quartz. Sed. is moist to very moist, no rxn w/ HCl	Sieve grab samples.
				Color: 2.5Y 4/4 olive brown. no plasticity. 10%-5%	434-434: H2O sample
435				clay content.	BIYNM0, BIYNR1, BIYNR2
				435.5- : Silty Sandy Gravel (msG)	BIYNC7
				Sed. similar to 409-428' interval. (20%m, 40%s,	
				40%G) w/ blue clay knobules / saprolitic basalts	
				+ white silica matrices. mod. sorted.	

Reported By: A. Lanham | Reviewed By: L.D. Walker
Title: Geologist | Title: Geologist
Signature: [signature] Date: 5-6-09 | Signature: [signature] Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 12 of 13

Date: 5-6-09

Well ID: C7021 | Well Name: 299-W14-73 | Location: 56' of Bridgeport & 22nd ave. S. of T-Ave, 200 W.

Project: 200-ZP-1 OU, Pump + Treat Expansion | Reference Measuring Point: Ground Surface

Depth (FL)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
440	Sieve			435.5-450: Silty Sandy Gravel (MSG) (20%, 40%S, 40%G) Matrix supported, well rnd. f. to v. c. felsic & mixed lithology, 80% felsic material. Matrix is v.f.-med. angr-subrnd. sand w/silt + trace clay. Sed. is highly weathered w/ clasts with saprolitic rinds + glaze. Bslt. weathers to 2.5GLEY2 5/N black silty clay; Granit weathers to white (GLEY1 8/N) + Quartz weathers to 10YR 8/1 dark yellowish brown. Nonreactive w/HCl	Hard Tool w/ Cable Rig. 440-442: Split spoon, archive + sieve grab samples.
445	G.S.			•445' clay content 0%	445: Archive grab
					441-445: Water Sample: BYNAR3, BYNAR4, BYNAM2.
450	G.S.	Sieve		450-460: Sed. similar to above interval. •Sediments tenacity increase. Cementation increase, moderate w/HCl. •450' clay content ~ 2%	450.5-452.5: Split spoon: Archive + Sieve grab + Lab grab BYNAF6
455	G.S.				455: Archive Grab
460	G.S.	Sieve 0% Recovery 25%		460.0-470.0: Silty Sandy Gravel (MSG) (20% silt, 40-45% Sand, 30-35% Gravel) Matrix sup. Matrix is silty sand w/ angr-subrnd. v.f.-v.f. sand (v.f.-v.f. 10-15% mafic, 30-35% felsic lithophysic comp. Gravel is angr-w.rnd. v.f. pebble to small cobble. Lens. dispersive w/ sparse large cobbles of Bslt. Basaltic content of sed. is more angular than felsic. Color: similar to 435-450' interval, cobbles brown, grayish white. 30% mafic, 70% felsic quartzites.	460-462: Split spoon 0% recovery BYY 5-15-09. 462-464: Split spoon for Sieve + Archive. Foam shoe only. 466.0: Archive grab.
465	G.S.				
470	G.S.	0% 25%		470.0-480.5: Sandy Gravel (SG) (20% S, 80% G) < 10% silt ~ 3% clay. 2.5Y 7/1 Yellow. Sand is v.f.-m. subrnd-subrnd. Gravel unknown size + angularity due to drilling slurry etc. 15% felsic, 85% mafic, 15% mafic, 85% felsic composition. Slow drill rates.	471-473.5: Split spoon for lab BYNAF7, 25% recovery. 467-470: Water Sample. BYNAM4, BYNAR5, BYNAR6, BYNAR7, BYNAD1. 475: Archive Grab
475	G.S.				

Reported By: A. Larson | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [illegible] | Date: 5-21-09 | Signature: [illegible] | Date: 8/10/09

A-6003-642 (03/03)

BOREHOLE LOG

Page 13 of 13
Date: Start: 5-21-09 End:

Well ID: C 7021 | Well Name: 299-W14-073 | Location: SE. of Bridgeport & Dorlone, S. of 7-Mile Rd, 299W.

Project: 200-ZP-1 OU Pump & Treat Expansion | Reference Measuring Point: Ground surface

Depth (Ft)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
480				480.5'-4 : Silty Sandy Gravel (mSG) Matrix Supported (15%m, 35%S 50%G). Matrix is Quartz silty sand w/ v.f.-m. sang-subrang. grains w/ ~2% Mafic content + coarse biotite + Muscovite mica. Color is GLEY1 4/5G grayish green + 25GLEY2 5/N black mottling around both. Clasts. Gravel is sub-rounded v.f. pebs.-5 cobs., 35% both, 15% qtz.	480-482: Archive + Sieve grab (split spoon) 30% recovery.
485	G.S	Water Sample	Basalt Gravel (BG)		485: Archive Grab
				RINGOLD A Unit.	
490				~488.6-489.8: Silt. or v.f. sandy silt, qtz rich. Color GLEY1 4/5G grayish green. washed silt content is qtz rich. See Memo for drilling notes.	488.6-489.6: Drill rate almost free fall. Driller announces not sand, but silt or clay.
	G.S.	100%	S.SG	489.8'-507.0: Silty Gravel (mG) Possibly Tabular base of bedrock. Max chip size 1cm. 5% felsic chips, 95% mafic chips 1% rounded f. peb. to v. Coarse Sand in sample. Color: GLEY2 4/5G, grayish green, v. mild rxn w/ HCl, leaves bright green residue while drying after exposed to HCl. 10% attracted to magnet. Max clast size: boulder. of basalt. Sub-rounded. w/ light weathering.	489.6: Drill Rate returns to previous. 492-499.0: Split spoon BIYAFB, no sieve, no archive. 495-497: HD sample. BIYAF6, BIYAF8, BIYAF7 BIYAD2
495					
500					
		55%		- Clast supported basalt Gravel of sub-rnd. boulders. w/ rounded quartz f.peb.-c.peb. Matrix is v.f. sand to v.c. sand w/ silt. Color is GLEY1 4/5 + 2.5Y 3/3 lt. olive brown. + 10YR 5/4 yellow brown.	502-503': Split spoon Archive + Sieve.
505		T.D.			Bore hole T.D. = 507.5' bgs
510					
515					

Reported By: A. Lanthan | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [illegible] | Date: 6-1-09 | Signature: [illegible] | Date: 8/10/09

A-6003-642 (03/03)

Appendix D

Geophysical Log Data Reports

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HGLP-LDR-390, Rev. 0

299-W15-225 (C7017) EW-1
Log Data Report

Borehole Information:

Borehole:	299-W15-225 (C7017) (EW-1)		Site:	200-ZP-1	
Coordinates (WA St Plane)		GWL[1] (ft):	229.5	GWL Date:	4/30/2009
North (m)	East (m)	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
Unknown	Unknown	2/19/2009	Unknown	462	Cable

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (inch)	Inside Diameter (inch)	Thickness (inch)	Top (ft)	Bottom (ft)
Welded Steel	0.5	16	15 ¼	3/8	-0.5	215
Threaded Steel	4.9	11 7/8	10 3/4	9/16	-4.9	410.1
Threaded Steel	4.4	8 5/8	7 5/8	½	-4.3	446
Threaded Steel	4.2	5 1/2	5	¼	-4.2	461

Borehole Notes:

C7017 corresponds to Phase-I extraction well EW-1 discussed in the Sampling and Analysis Plan for Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit, Fiscal Year 2009 (DOE/RL-2008-57).

The logging engineer measured casing inner diameter and rounded to the nearest 1/16 inch. The depth to water was measured with an e-tape by the logging engineer.

Logging Equipment Information:

Logging System:	Gamma 1 L		Type: Serial No.:	60% HPGe SGLS 47TP32211A
Effective Calibration Date:	03/26/2009	Calibration Reference:	HGLP-CC-030 Rev 1	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	
Logging System:	Gamma 4 L		Type: Serial No.:	60% HPGe SGLS 47TP32211A
Effective Calibration Date:	02/11/2009	Calibration Reference:	HGLP-CC-027, Rev. 2	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2 Repeat	3	4 Repeat
Date	2/23/09	2/23/09	4/30/09	4/30/09
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	0.0	100.0	412.0	236.0
Finish Depth (ft)	217.0	122.0	216.0	216.0
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	DLA21CAB	DLA21CAB	AL037CAB	AL037CAB
Start File	DLA21000	DLA21218	AL037000	AL037197

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Log Run	1	2 Repeat	3	4 Repeat
Finish File	DLA21217	DLA21240	AL037196	AL037217
Post-Verification	DLA21CAA	DLA21CAA	AL037CAA	AL037CAA
Depth Return Error (inch)	0	Low 1 ½"	0	Low 3 1/2"
Comments:	Fine gain adjustment made after files 041, 055, 065, 105 and 174	none	Fine gain adjustment made at bottom of borehole before logging began	none
Log Run	**5**	**6 Repeat**	**7**	**8 Repeat**
Date	05/07/09	05/07/09	05/11/09	05/11/09
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	462.0	458.0	447.0	424.0
Finish Depth (ft)	445.0	454.0	410.0	420.0
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	AL038CAB	AL038CAB	AL039CAB	AL039CAB
Start File	AL038000	AL038018	AL039000	AL039038
Finish File	AL038017	AL038022	AL039037	AL039042
Post-Verification	AL038CAA	AL038CAA	AL039CAA	AL039CAA
Depth Return Error (inch)	NA	Low 1 ½	NA	Low 3
Comments:	Fine gain adjustment made at bottom of borehole before logging began	No fine gain adjustment made	Fine gain adjustment made at bottom of borehole before logging began	No fine gain adjustment made

Logging Operation Notes:

The SGLS data were collected on four separate logging events. The first log (2-23-09) was completed using the Gamma 4, HO 68B-3573 logging system. Data for the remaining three logging events were completed using the Gamma 1, HO 68B-3574. Pre- and post-survey verification measurements were acquired in the Amersham KUTh-115-field verifier. Maximum system logging depth achieved was 462.2 ft before the sonde un-weighted.

Logging data are referenced to the ground surface.

Analysis Notes:

Analyst:	Holloway	Date:	6-4-2009	Reference:	GJO-HGLP 1.6.3, Rev. 0

The SGLS pre- and post-survey verification spectra met acceptance criteria for the established systems.

A casing correction for a 3/8-inch thick casing was applied during analysis for the 0-215 ft log run. A casing correction for a 9/16-inch thick casing was applied during analysis for the 215-410.1 ft log run. A casing correction for a 1/2-inch thick casing was applied during analysis for the 410.1-446 ft log run. A casing correction for a 1/4-inch thick casing was applied during analysis for the 446-461 ft log run.

The SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual peaks and count rates. Concentrations were calculated using EXCEL templates identified as DL20090211.xls (log runs 1 and 2) and AL20090326.xls (log run 3-8) using an efficiency function and corrections for casing, dead time and water as determined by annual calibrations.

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During routine processing of gamma spectra, regions of interest are forced at specific energy levels associated with natural and manmade radionuclides that can be anticipated to be present. This processing approach sometimes results in isolated "detections" near the minimum detection level (MDL) resulting in false-positives. Where these detections occur, individual spectra are scrutinized and determinations are made regarding the validity of the detections. If detection is deemed not representative of a full energy peak, or if confirming peaks are not detected, it is removed from the data set. The integrity of the raw data files and the processed files are maintained should questions arise in the future regarding these determinations.

Results and Interpretations:

The KUT and moisture repeat plots indicate good repeatability.

No manmade radionuclides were detected. Radon was detected from 35-210 ft and 316-410 ft as indicated by elevated 609 keV energy peak as compared to the 1764 keV energy peak.

List of Log Plots:

Depth Reference is ground surface.

Manmade Radionuclides 0-470 feet
Natural Gamma Logs (KUT) 0-160
Natural Gamma Logs (KUT) 150-310
Natural Gamma Logs (KUT) 310-470
Combination Plot 0-160
Combination Plot 150-310
Combination Plot 310-470
Combination Plot 0-480
Total Gamma
Natural Gamma Logs (KUT) Repeat 100-122
Natural Gamma Logs (KUT) Repeat 216-236
Natural Gamma Logs (KUT) Repeat 420-424
Natural Gamma Logs (KUT) Repeat 454-458

[1] GWL – groundwater level
[2] TOC – top of casing

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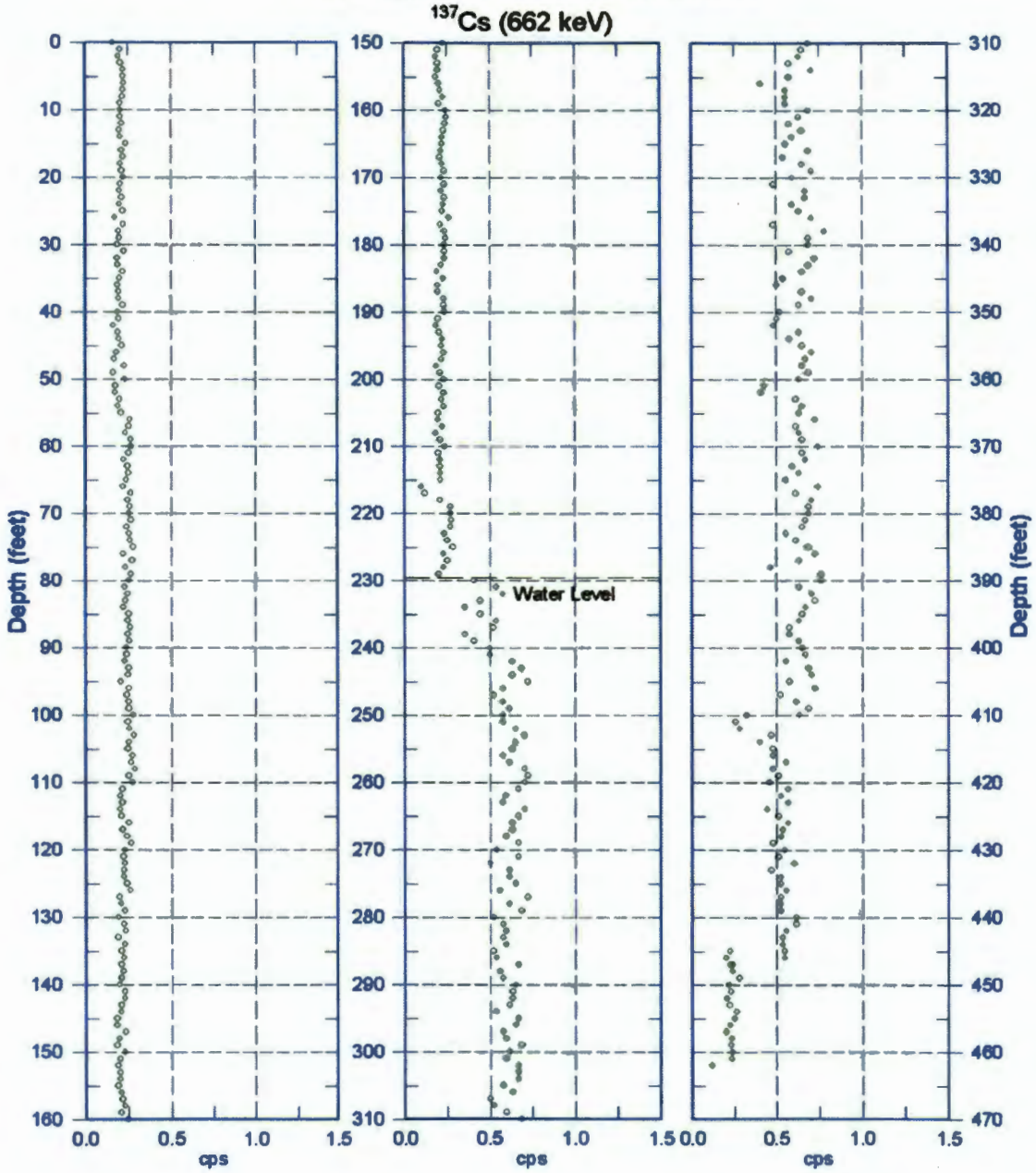
299-W15-225 (C7017 [EW-1])
Manmade Radionuclides



Zero Reference - Ground Surface

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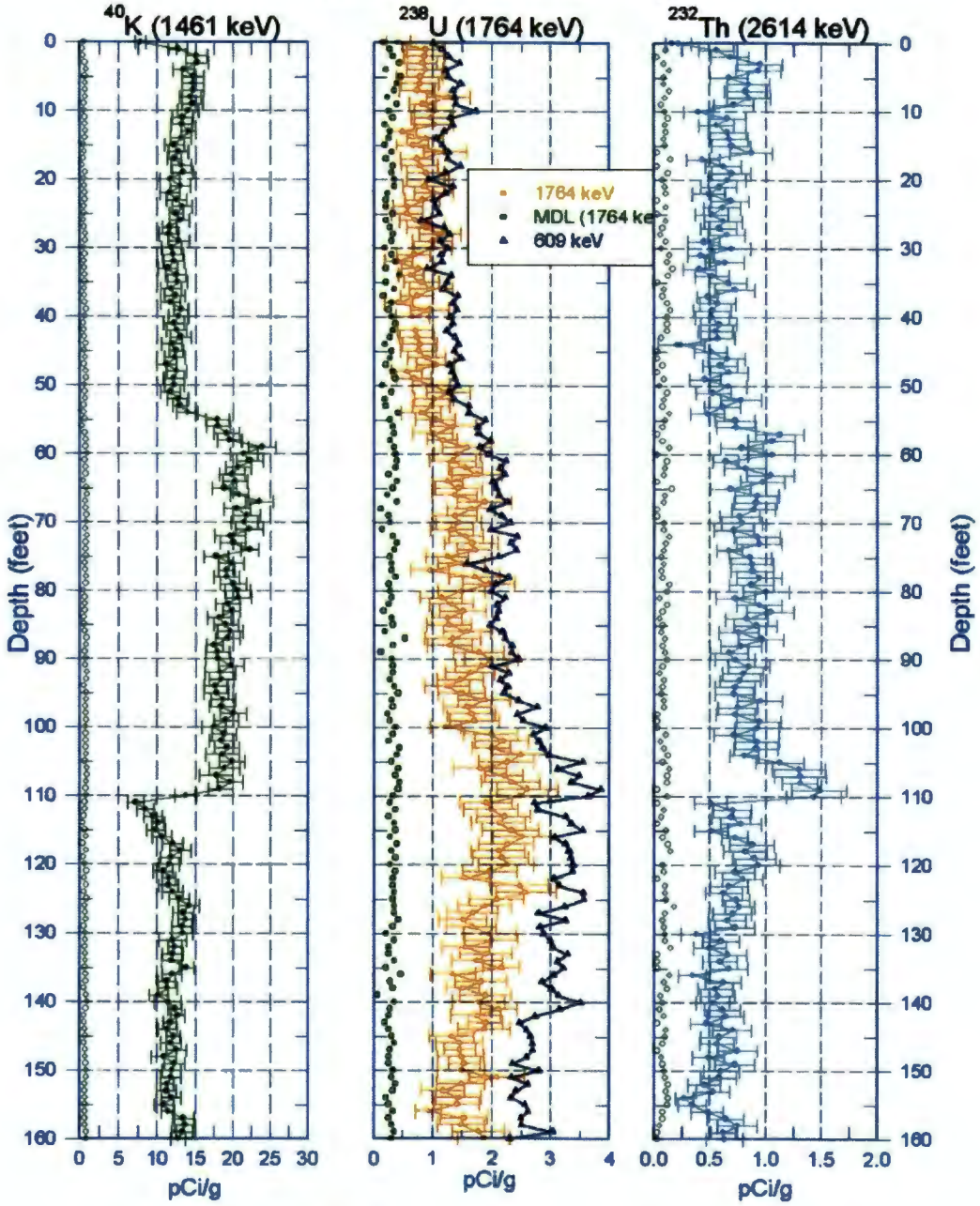
299-W15-225 (C7017 [EW-1])
Natural Gamma Logs



Zero Reference - Ground Surface

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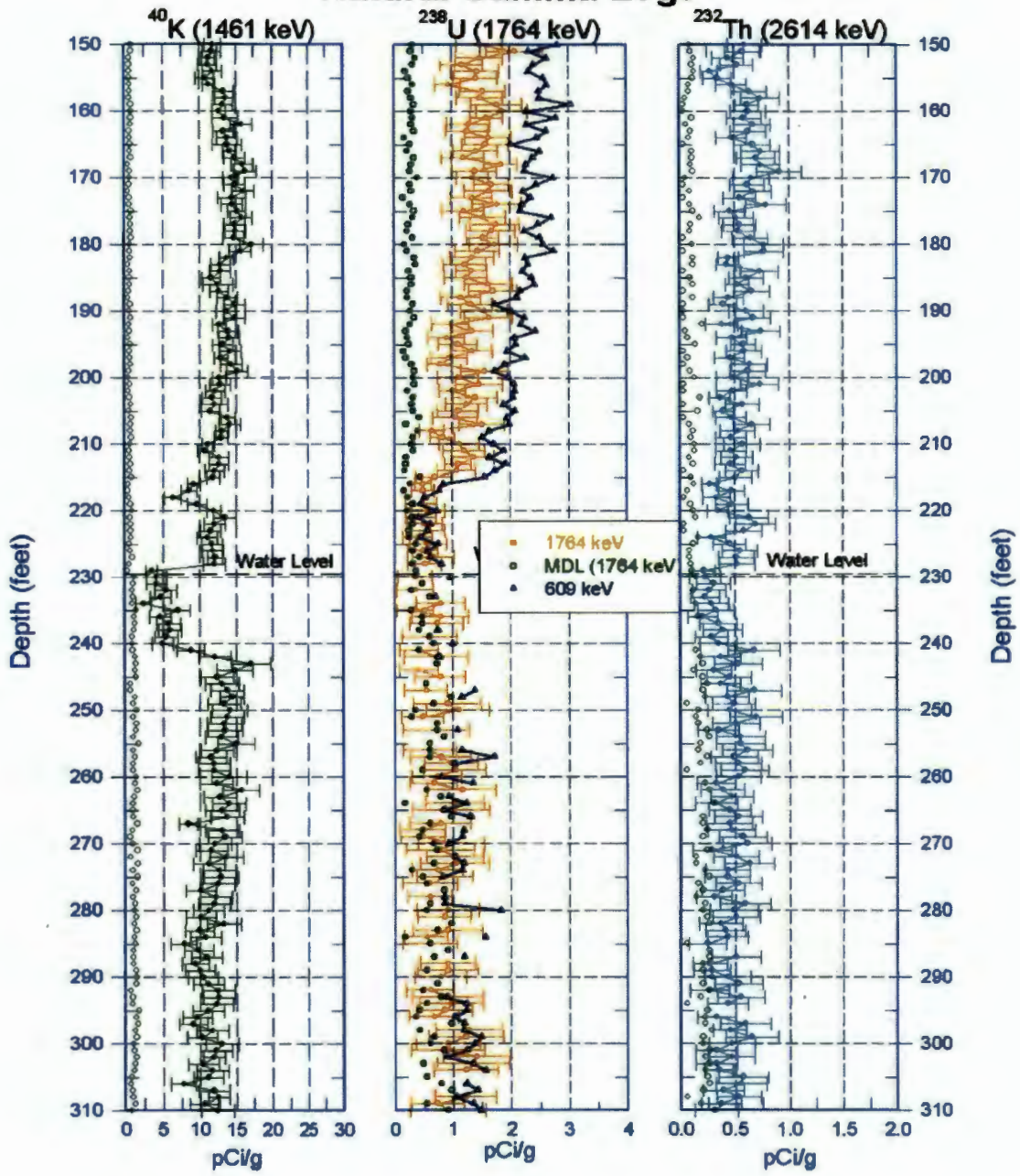
299-W15-225 (C7017 [EW-1])
Natural Gamma Logs



Zero Reference - Ground Surface

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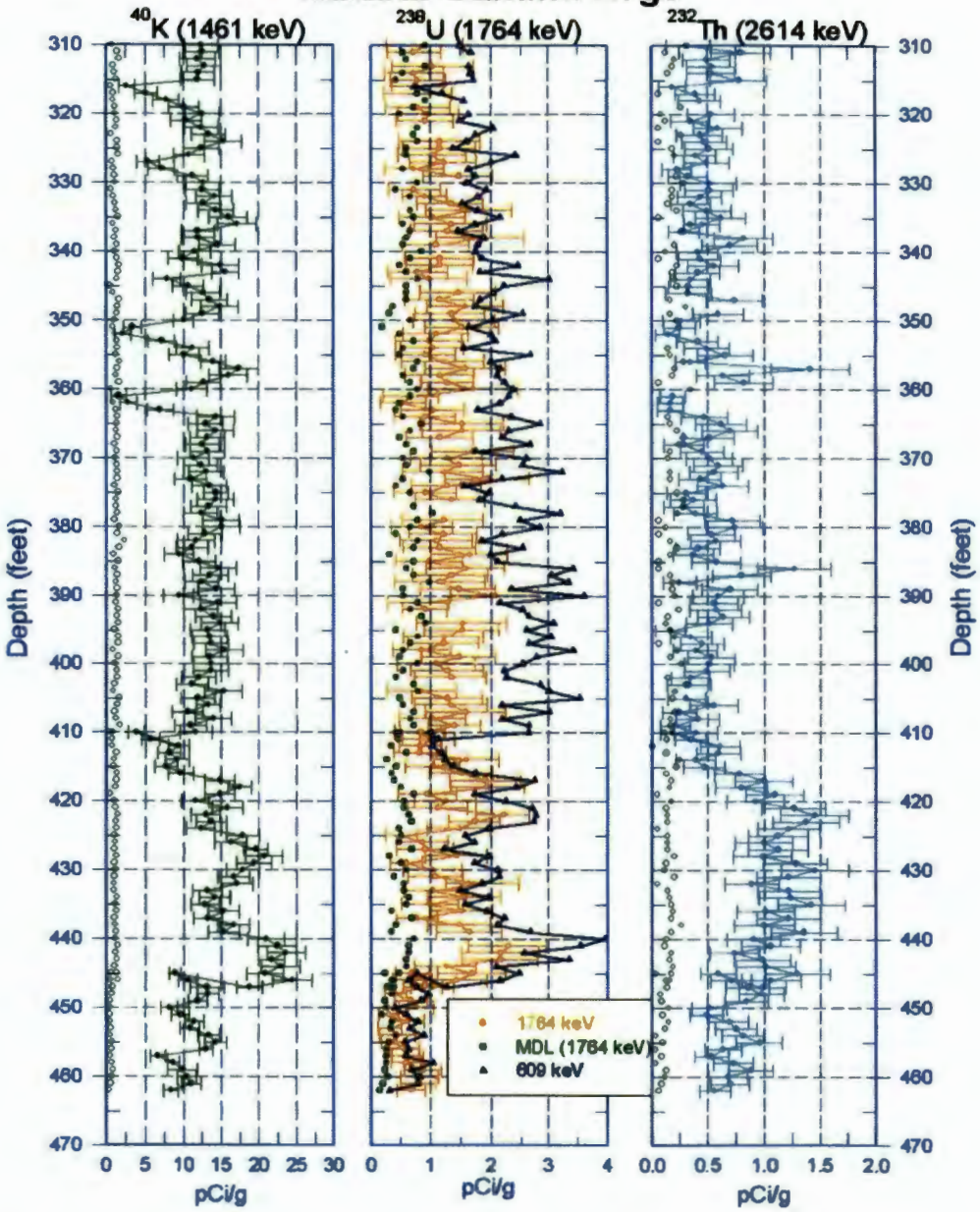
299-W15-225 (C7017 [EW-1])
Natural Gamma Logs



Zero Reference - Ground Surface

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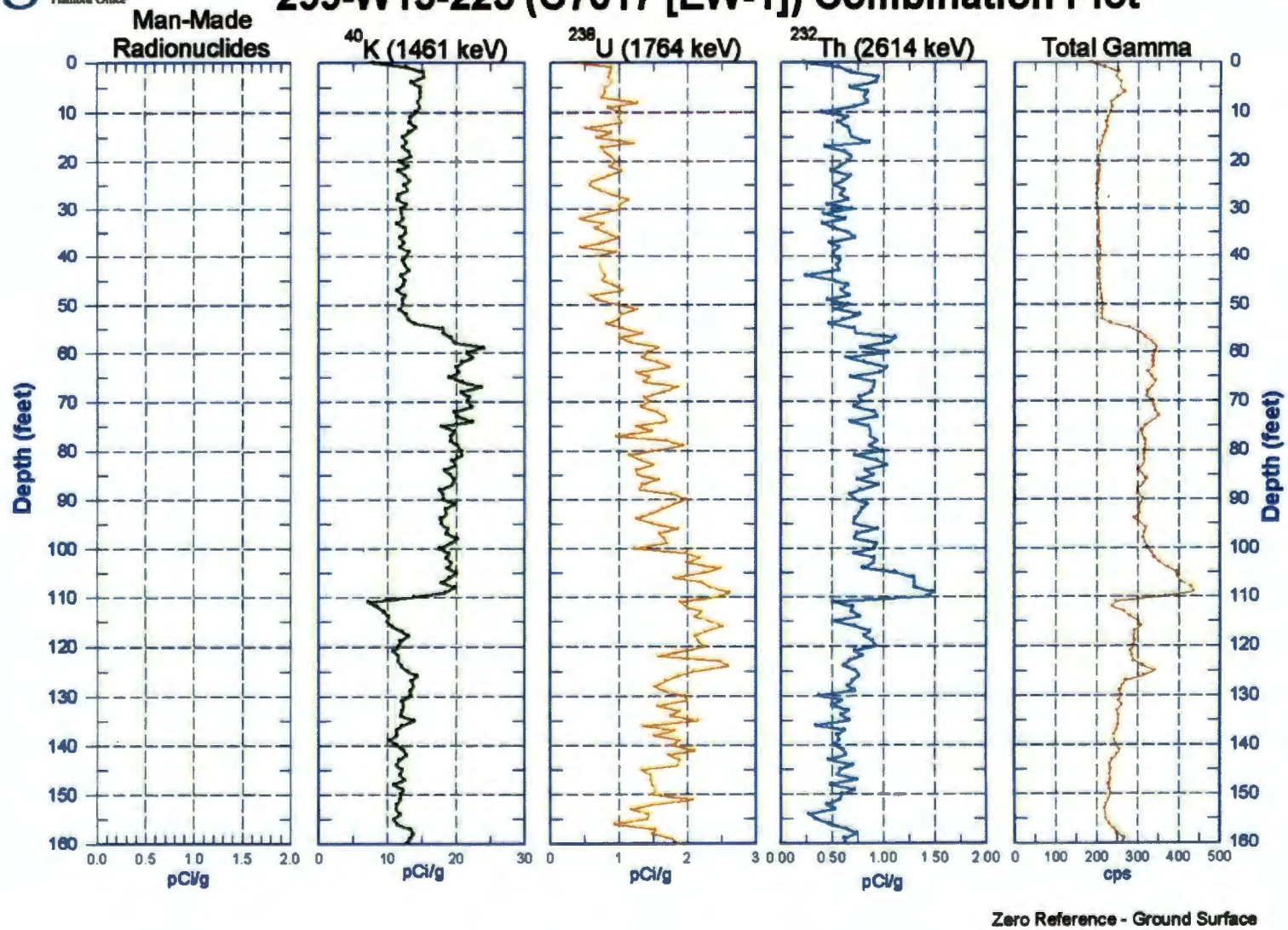
299-W15-225 (C7017 [EW-1]) Combination Plot



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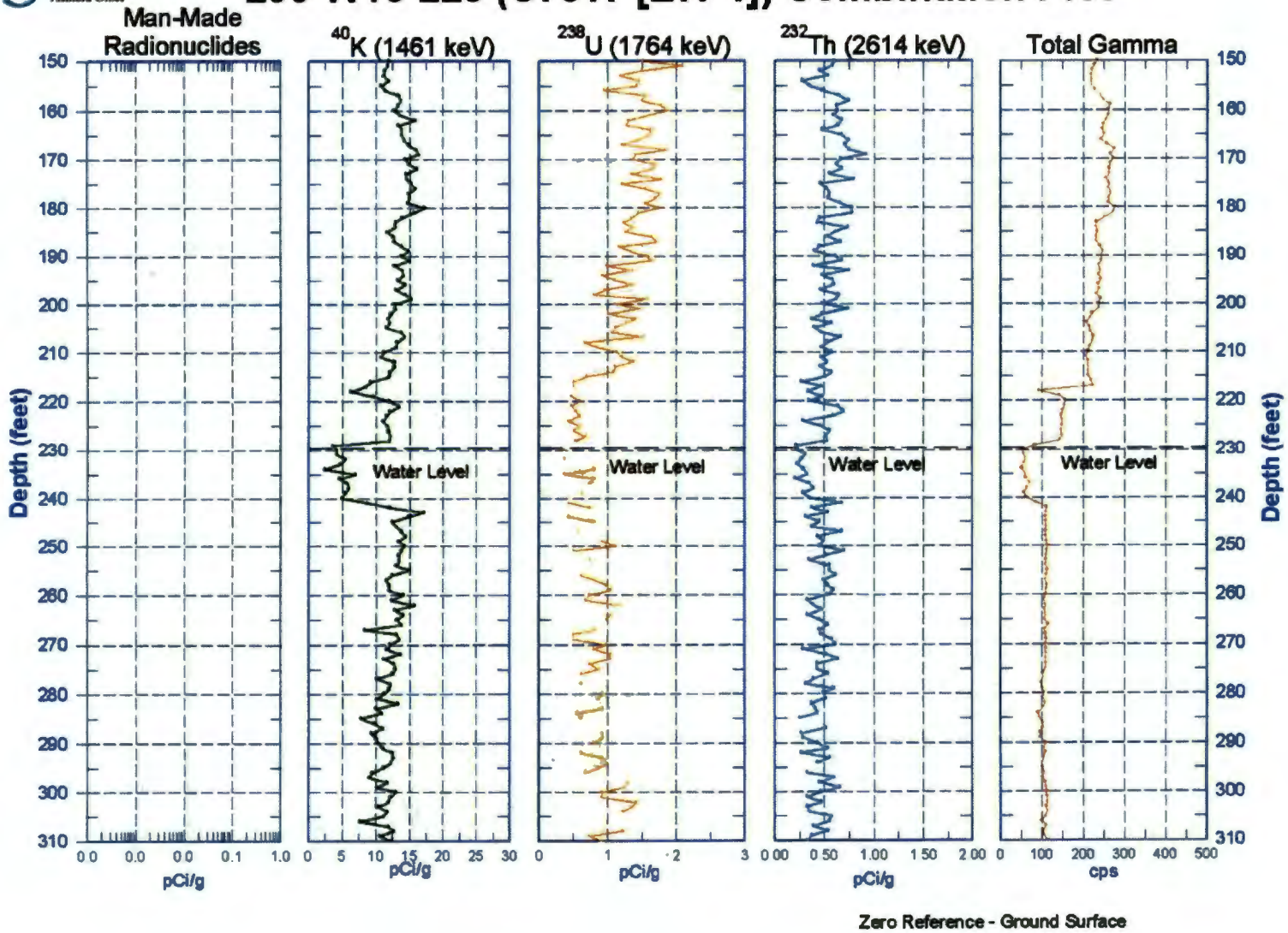
299-W15-225 (C7017 [EW-1]) Combination Plot



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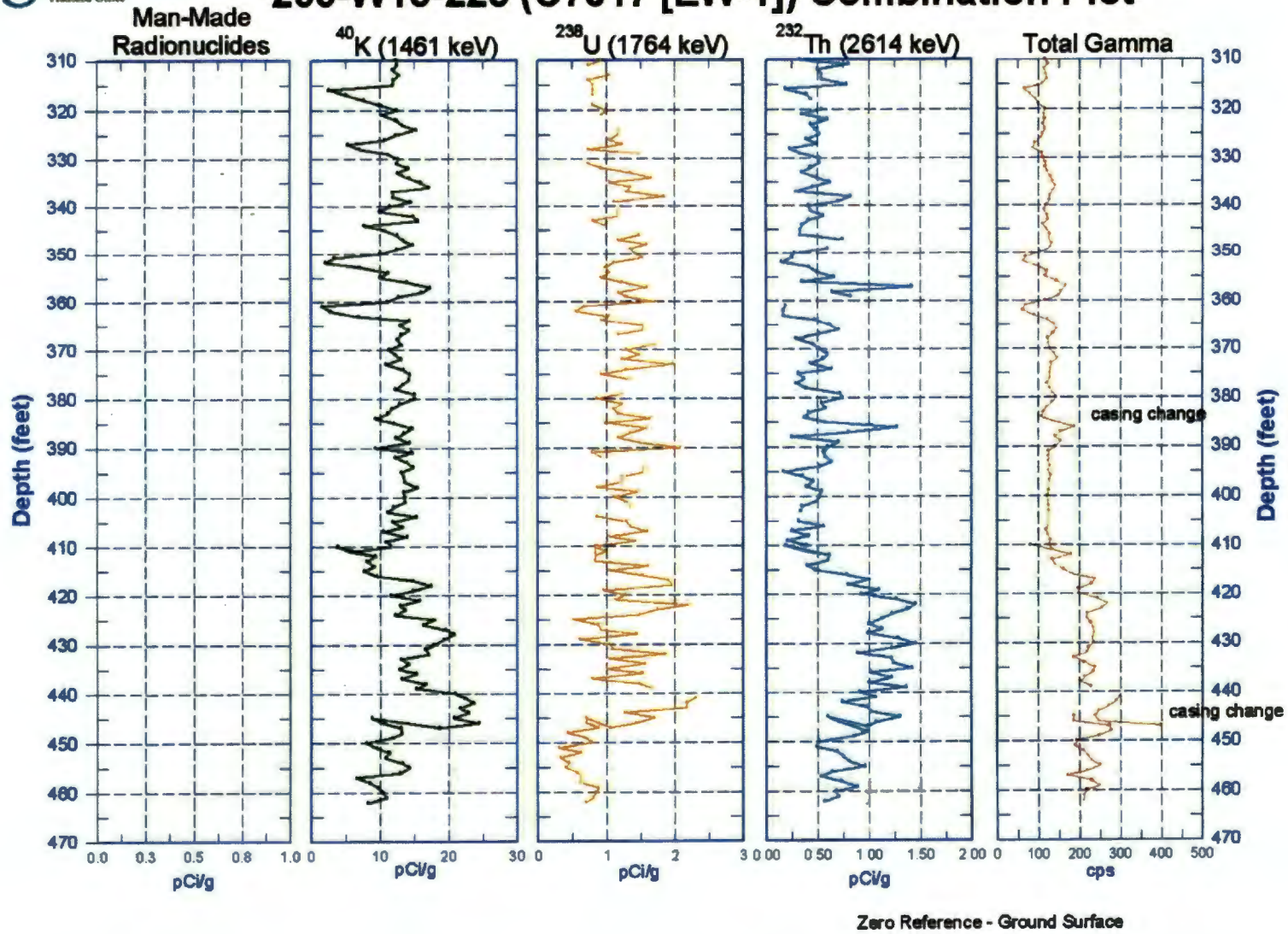
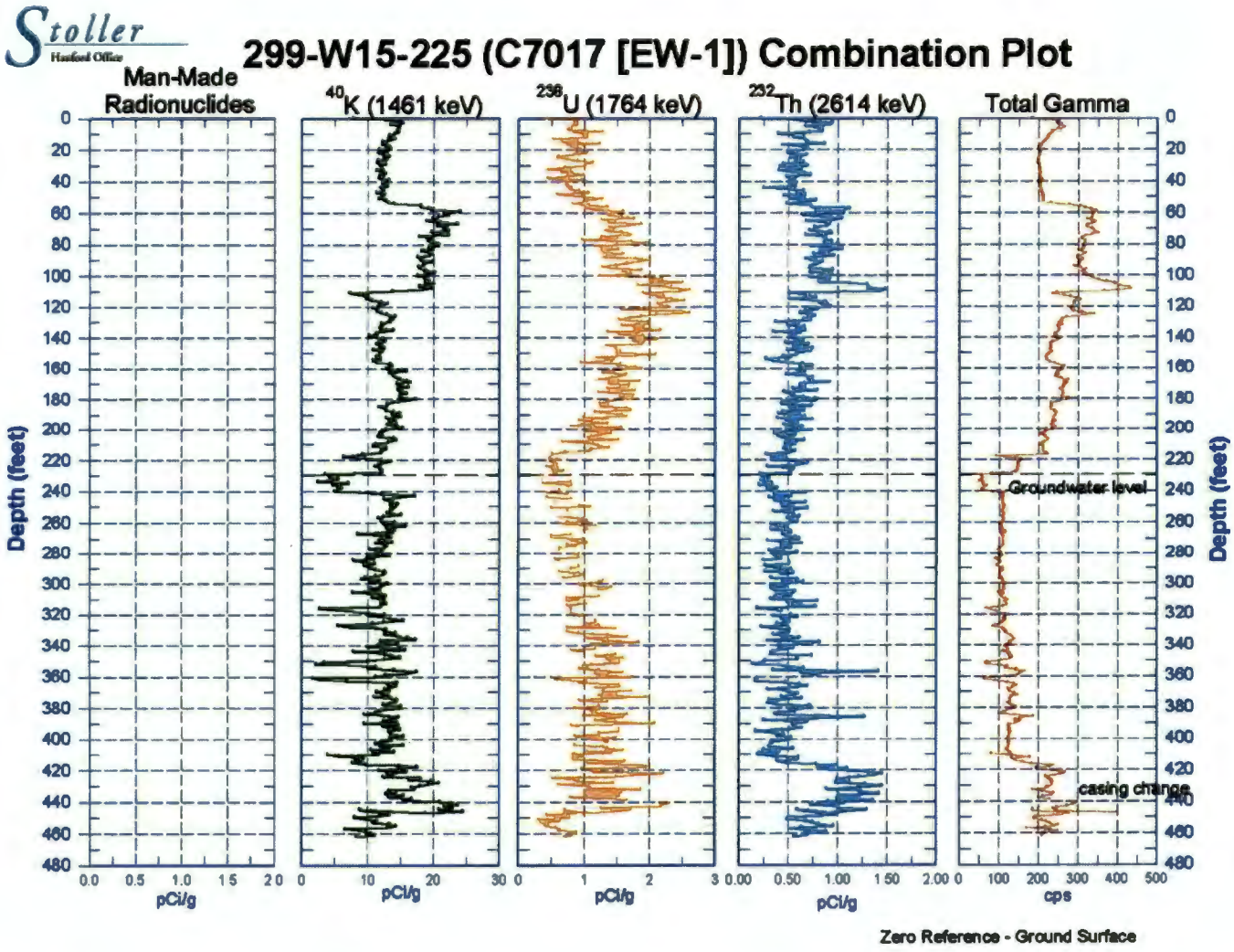
299-W15-225 (C7017 [EW-1]) Combination Plot




Stoller
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299-W15-225 (C7017 [EW-1]) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Depth (feet)
pCi/g
cps
Groundwater level
casing change
Zero Reference - Ground Surface

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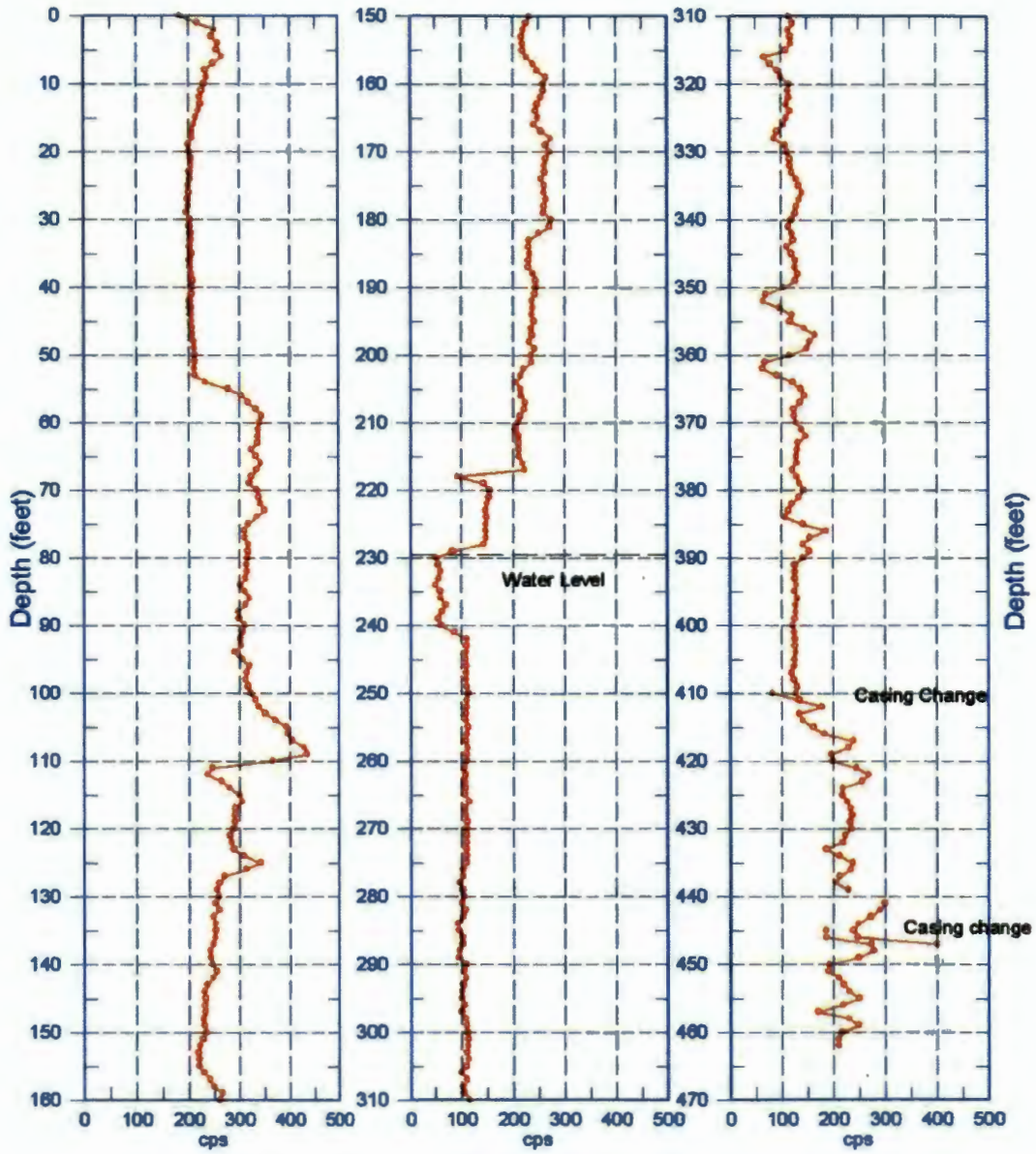
299-W15-225 (C7017 [EW-1])
Total Gamma



Zero Reference - Ground Surface

Stoller
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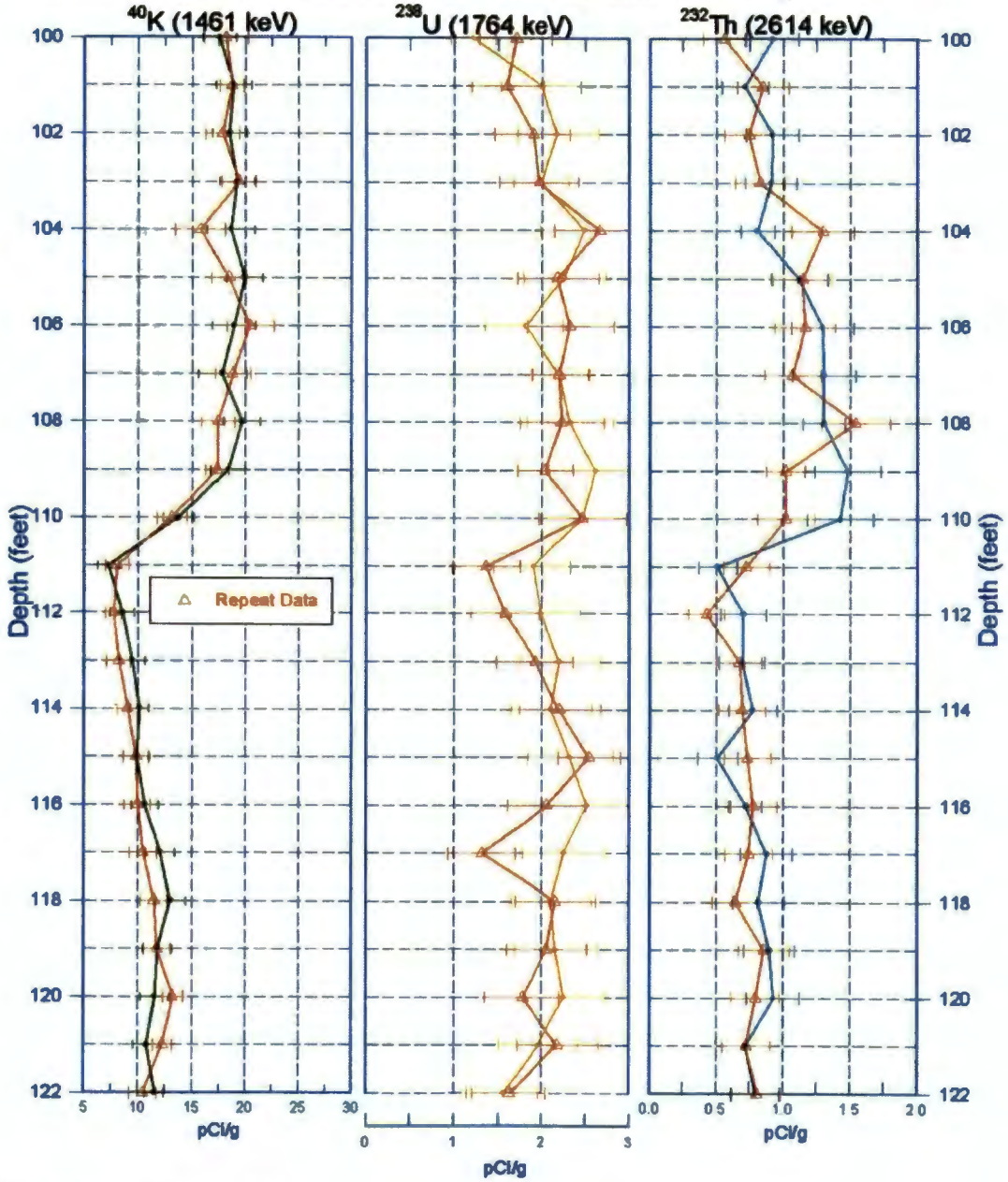
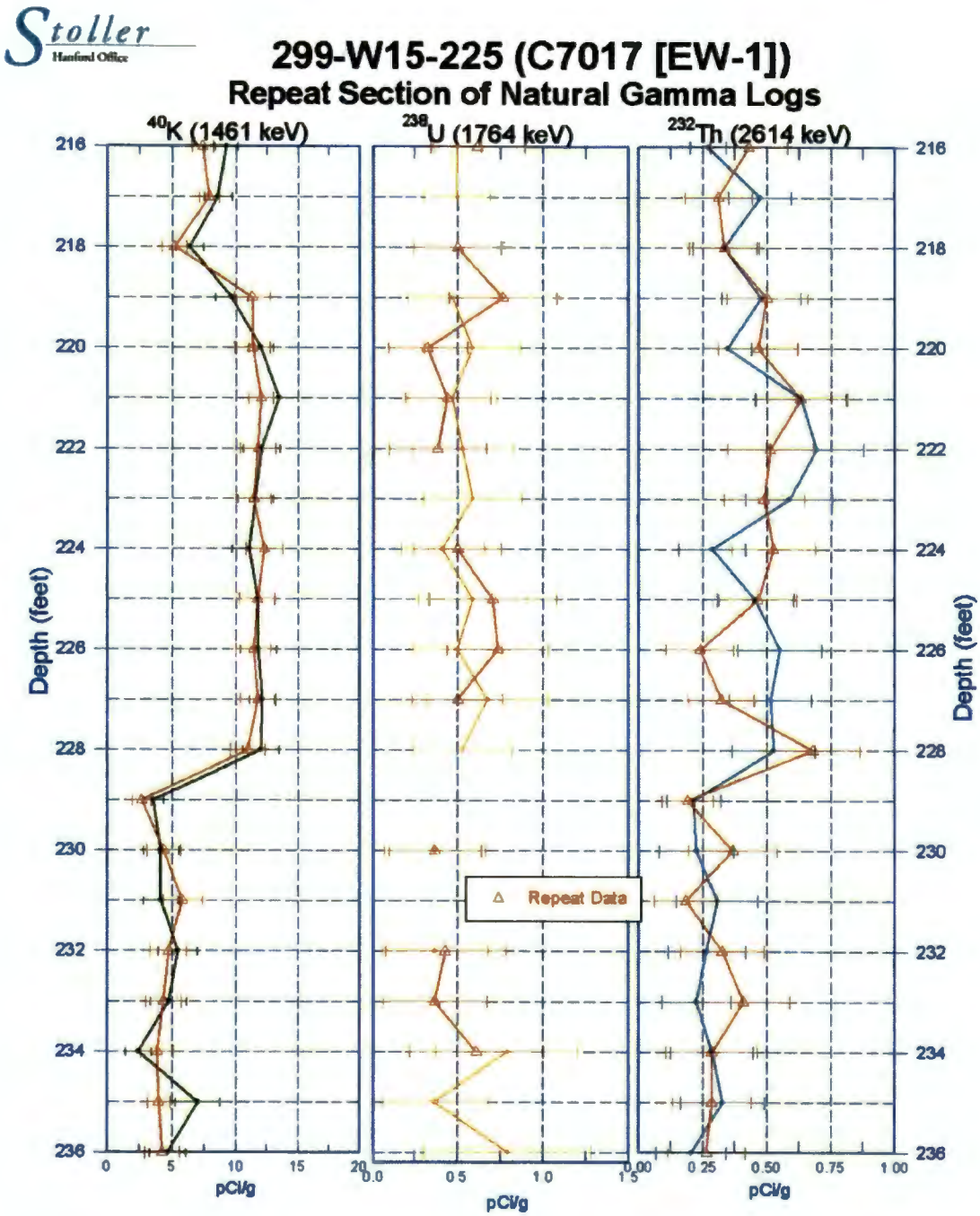
299-W15-225 (C7017 [EW-1])

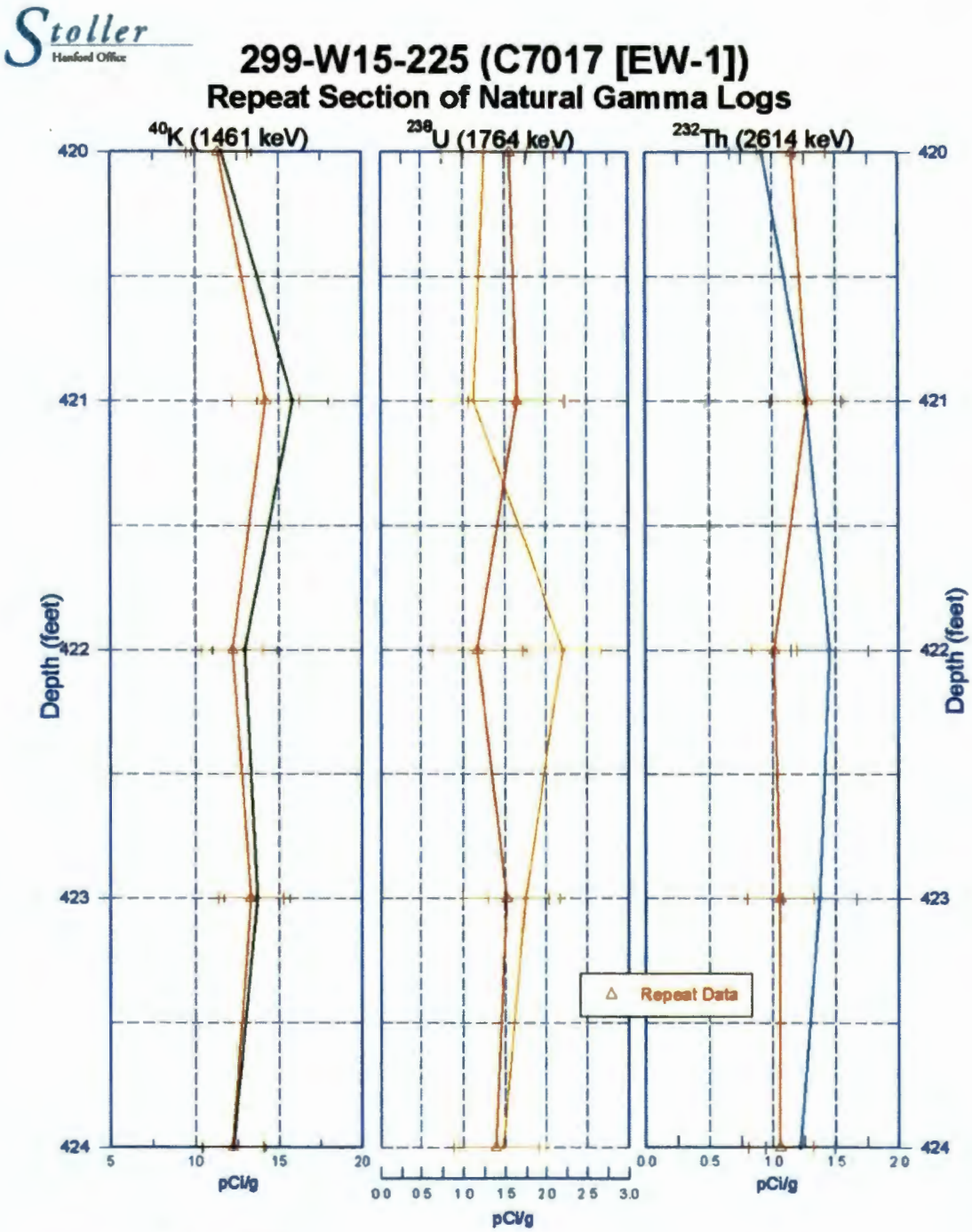
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface



Zero Reference - Ground Surface



Zero Reference - Ground Surface

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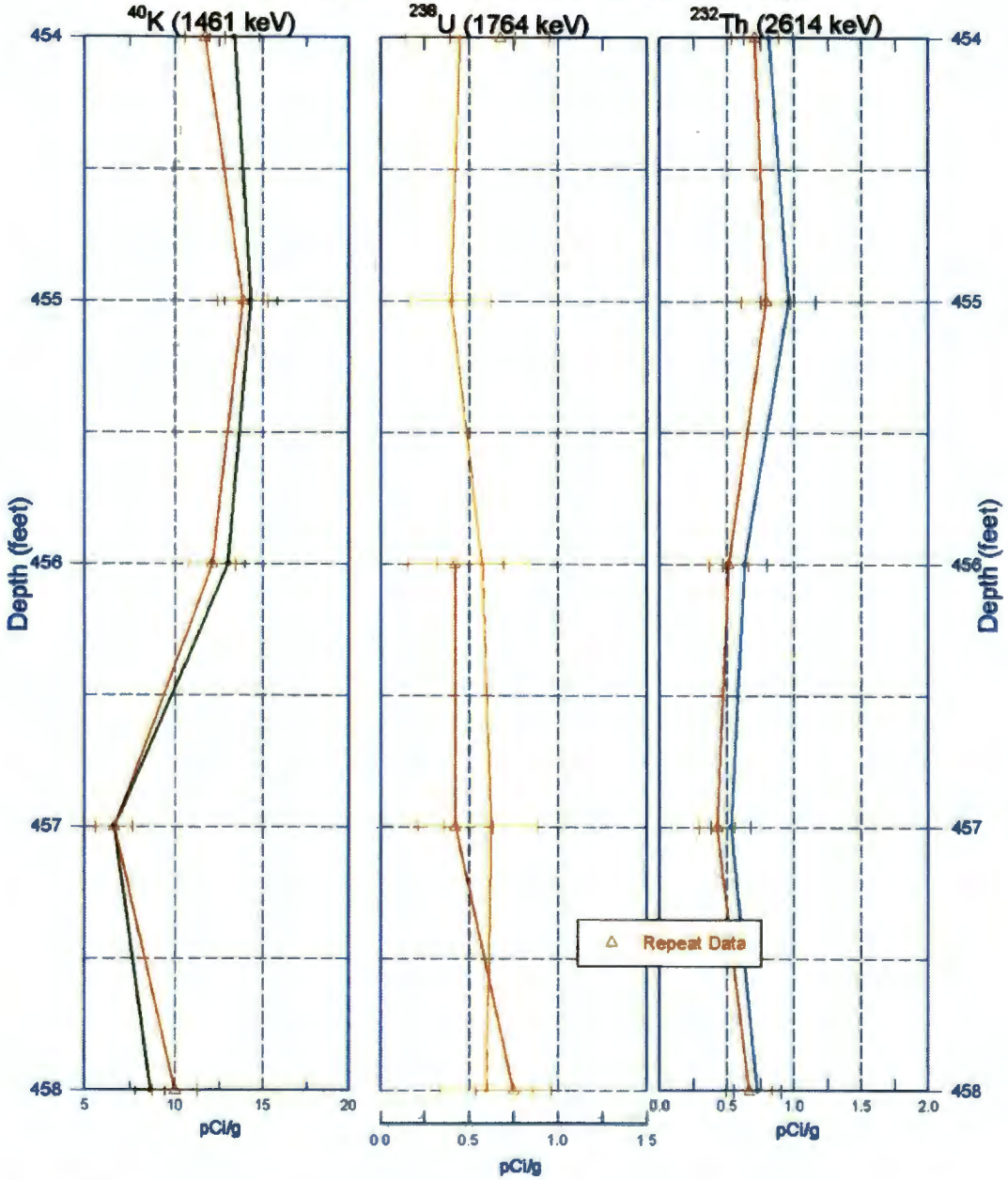
299-W15-225 (C7017 [EW-1])

Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

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HGLP-LDR-396, Rev. 0

299-W14-20 (C7018) EW-2
Log Data Report

Borehole Information:

Borehole:	299-W14-20 (C7018) (EW-2)		Site:	200-ZP-1	
Coordinates (WA St Plane)		GWL[1] (ft):	234	GWL Date:	7/29/2009
North (m)	East (m)	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
Unknown	Unknown	7/29/2009	Unknown	439	Cable/air rotary

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (inch)	Inside Diameter (inch)	Thickness (inch)	Top (ft)	Bottom (ft)
Welded Steel	-0.3	16	15 ¼	3/8	-0.3	218
Threaded Steel	-1.0	11 3/4	10 3/4	1/2	-1.0	408.6
Threaded Steel	-2.0	8 5/8	7 5/8	1/2	-2.0	438

Borehole Notes:

Borehole 299-W14-20 (C7018) corresponds to Phase-I extraction well EW-2 discussed in the Sampling and Analysis Plan for Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit, Fiscal Year 2009 (DOE/RL-2008-57).

The logging engineer measured casing diameter and rounded to the nearest 1/16 inch. The depth to water was measured with an e-tape by the logging engineer.

Logging Equipment Information:

Logging System:	Gamma 4N		Type: Serial No.:	60% HPGe SGLS 45TP22010A
Effective Calibration Date:	2/17/2009	Calibration Reference:	HGLP-CC-022 Rev 2	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3 Repeat	4
Date	4/6/09	4/7/09	4/7/09	7/22/09
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	219.0	125.0	105.0	218.0
Finish Depth (ft)	124.0	0.0	83.0	240.0
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	DNA91CAB	DNB01CAB	DNB01CAB	DNC31CAB
Start File	DNA91000	DNB01000	DNB01126	DNC31000
Finish File	DNA91095	DNB01125	DNB01148	DNC31022
Post-Verification	DNA91CAA	DNB01CAA	DNB01CAA	DNC31CAA
Depth Return Error (inch)	Low 1.5	High 1.5	0	Low 2 3/4

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HGLP-LDR-396, Rev. 0

Log Run	1	2	3 Repeat	4
Comments:	Fine gain adjustment made after files -001 and -026	No fine gain adjustment.	No fine gain adjustment.	No fine gain adjustment.
Log Run	**5**	**6 Repeat**	**7**	**8 Repeat**
Date	7/23/09	7/23/09	7/29/09	7/29/09
Logging Engineer	Spatz	Spatz	Pearson	Pearson
Start Depth (ft)	410.0	238.0	435.0	426.0
Finish Depth (ft)	239.0	218.0	409.0	421.0
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	DNC41CAB	DNC41CAB	DNC51CAB	DNC51CAB
Start File	DNC41000	DNC41172	DNC51000	DNC51027
Finish File	DNC41171	DNC41192	DNC51026	DNC51032
Post-Verification	DNC41CAA	DNC41CAA	DNC51CAA	DNC51CAA
Depth Return Error (inch)	N/A	Low 1 1/4	N/A	Low 3
Comments:	No fine gain adjustment.	No fine gain adjustment.	No fine gain adjustment.	No fine gain adjustment.

Logging Operation Notes:

The SGLS data were collected at three separate times from April to July 2009 so that data could be acquired in a single casing. Pre- and post-survey verification measurements were acquired in the Amersham KUTh-115-field verifier. Maximum system logging depth achieved was 435.0 ft before the sonde un-weighted.

Logging data are referenced to the ground surface.

Analysis Notes:

Analyst:	P.D. Henwood	Date:	8/6/09	Reference:	GJO-HGLP 1.6.3, Rev. 0

The SGLS pre- and post-survey verification spectra met acceptance criteria for the established systems.

A casing correction for a 3/8-inch thick casing was applied during analysis for the 0-219 ft log run. A casing correction for a 1/2-inch thick casing was applied for the remainder of the borehole.

The SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual peaks and count rates. Concentrations were calculated using an EXCEL template identified as DL20090211.xls using an efficiency function and corrections for casing, dead time and water as determined by annual calibrations.

During routine processing of gamma spectra, regions of interest are forced at specific energy levels associated with natural and manmade radionuclides that can be anticipated to be present. This processing approach sometimes results in isolated "detections" near the minimum detection level (MDL) resulting in false-positives. Where these detections occur, individual spectra are scrutinized and determinations are made regarding the validity of the detections. If detection is deemed not representative of a full energy peak, or if confirming peaks are not detected, it is removed from the data set. The integrity of the raw data files and the processed files are maintained should questions arise in the future regarding these determinations.

Results and Interpretations:

No manmade radionuclides were detected.

The KUT repeat plots indicate good repeatability.

List of Log Plots:

Depth Reference is ground surface.

Manmade Radionuclides 0-470 feet
Natural Gamma Logs (KUT) 0-160
Natural Gamma Logs (KUT) 150-310
Natural Gamma Logs (KUT) 310-470
Combination Plot 0-120
Combination Plot 110-230
Combination Plot 220-340
Combination Plot 330-450
Combination Plot 0-480
Total Gamma
Natural Gamma Logs (KUT) Repeat 83-105
Natural Gamma Logs (KUT) Repeat 218-238
Natural Gamma Logs (KUT) Repeat 421-426

[1] GWL – groundwater level
[2] TOC – top of casing

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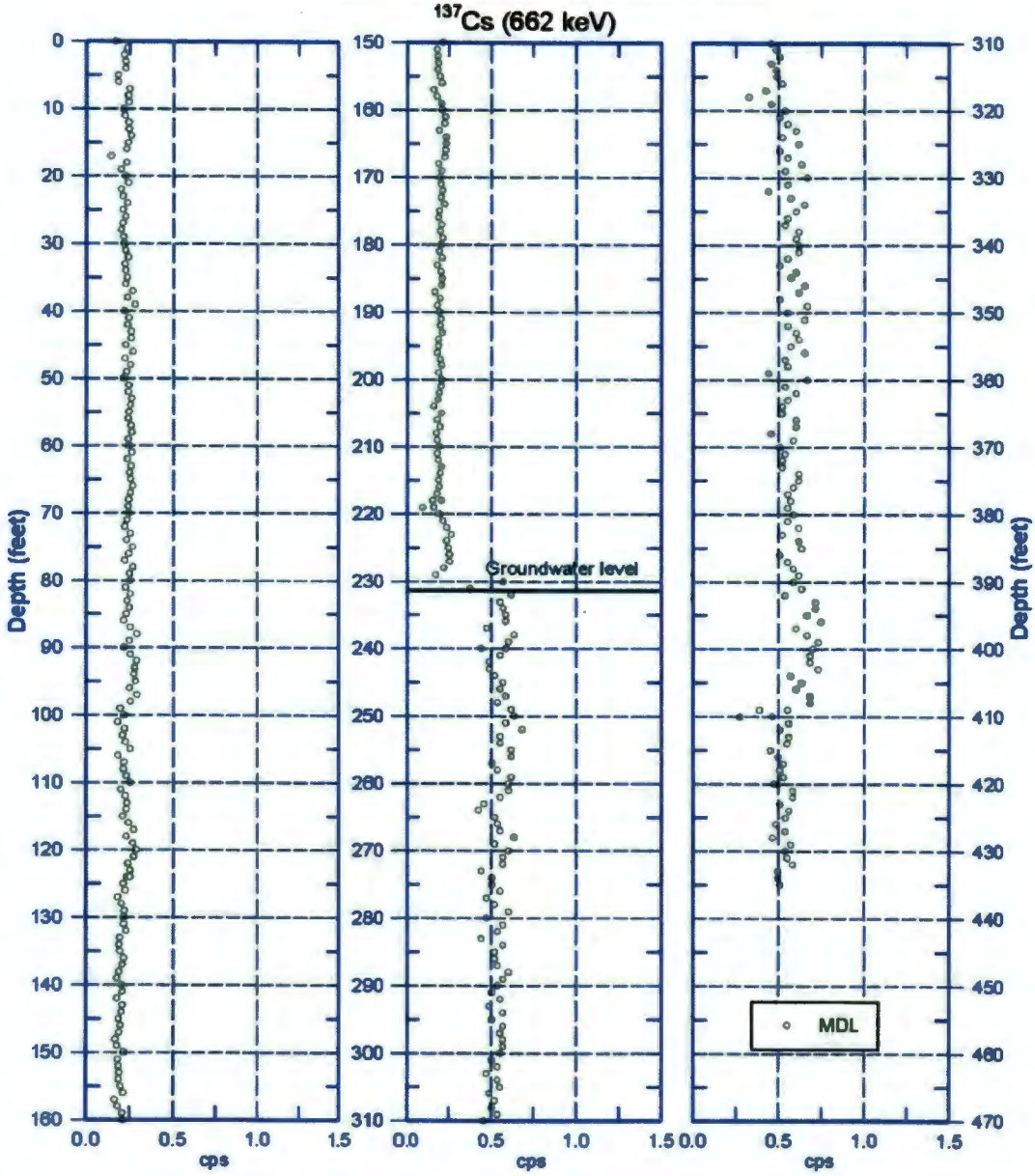
299-W14-20 (C7018 [EW-2])
Manmade Radionuclides



Zero Reference - Ground Surface

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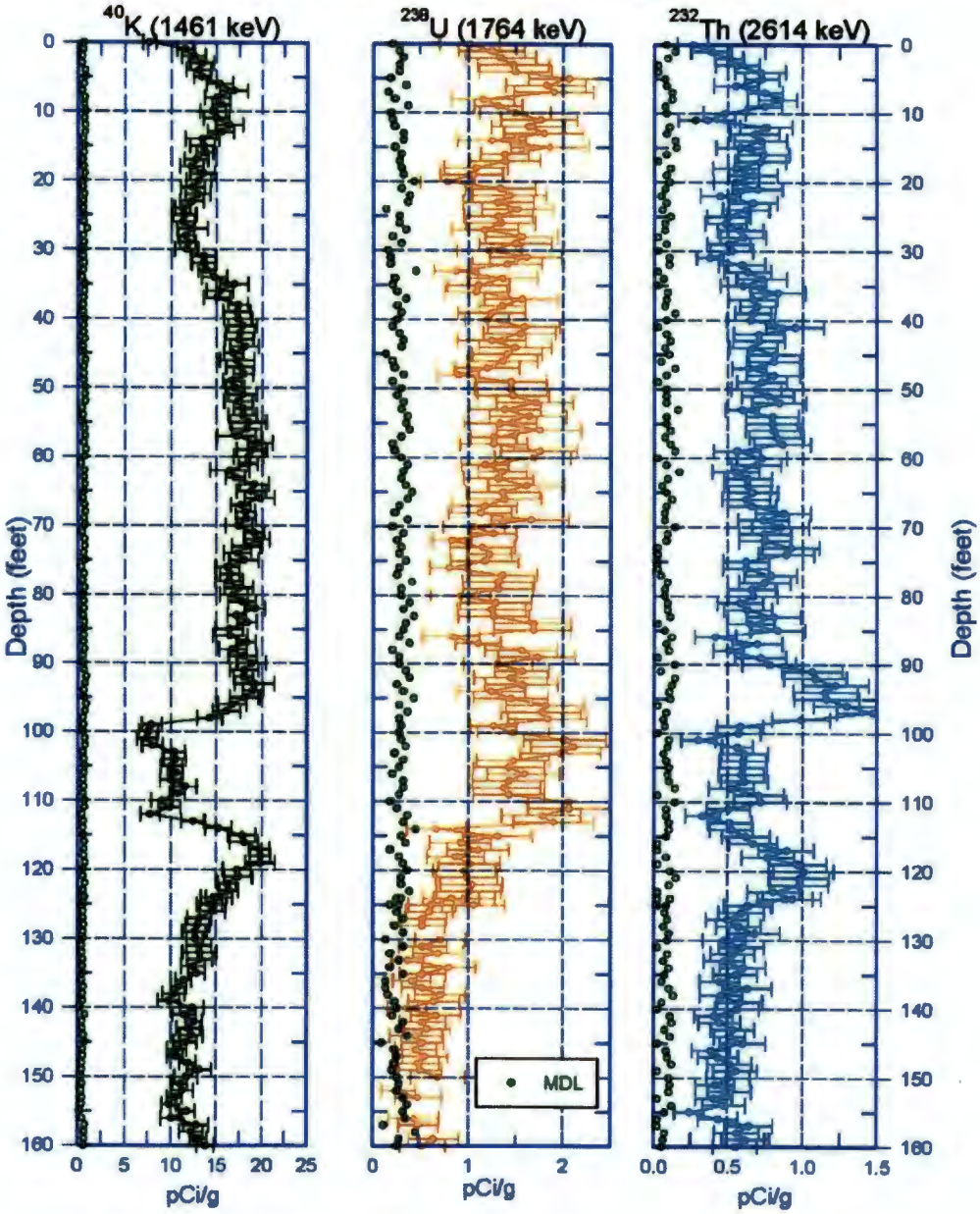
299-W14-20 (C7018 [EW-2])
Natural Gamma Logs



Zero Reference - Ground Surface

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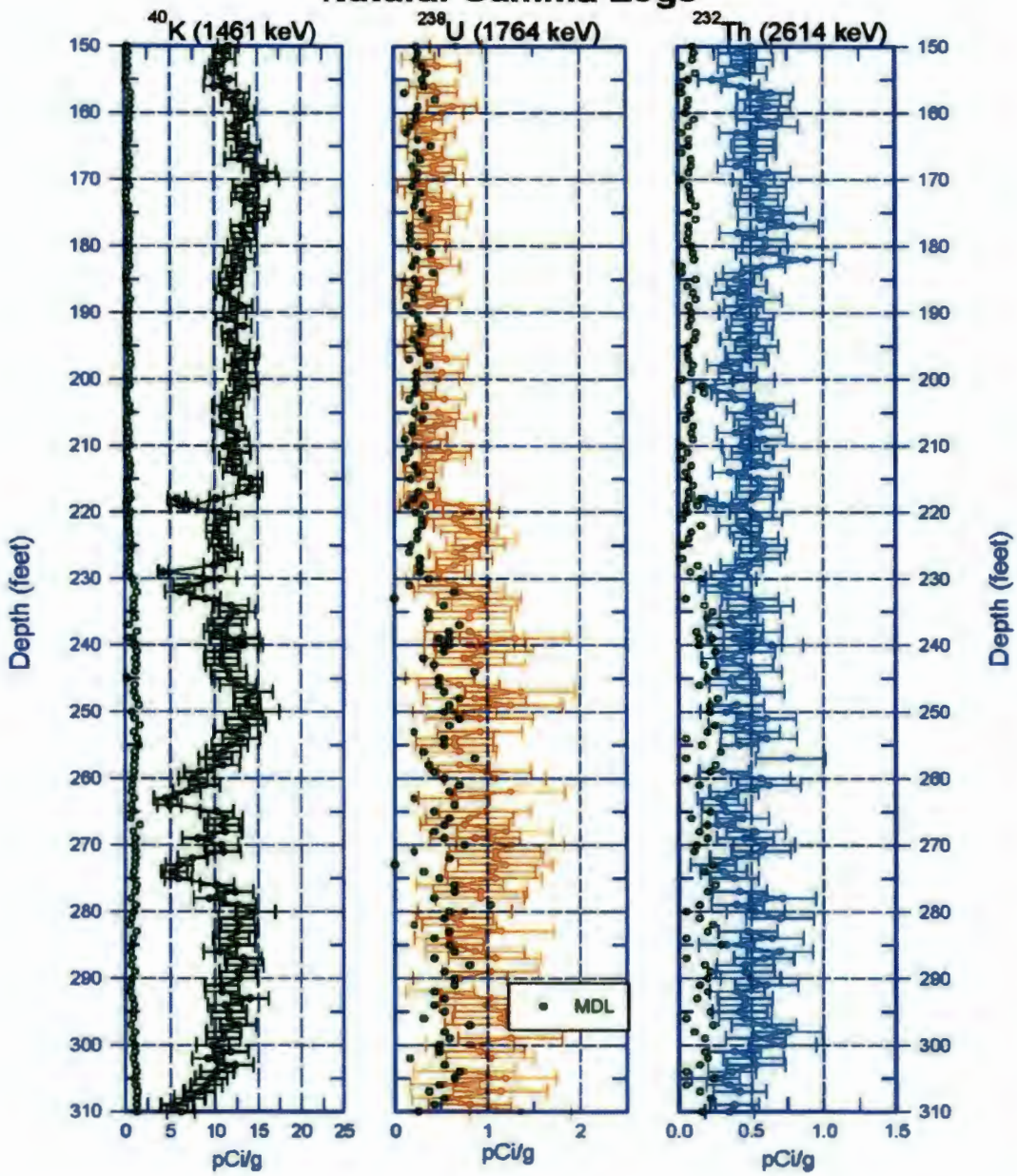
299-W14-20 (C7018 [EW-2])
Natural Gamma Logs



Zero Reference - Ground Surface

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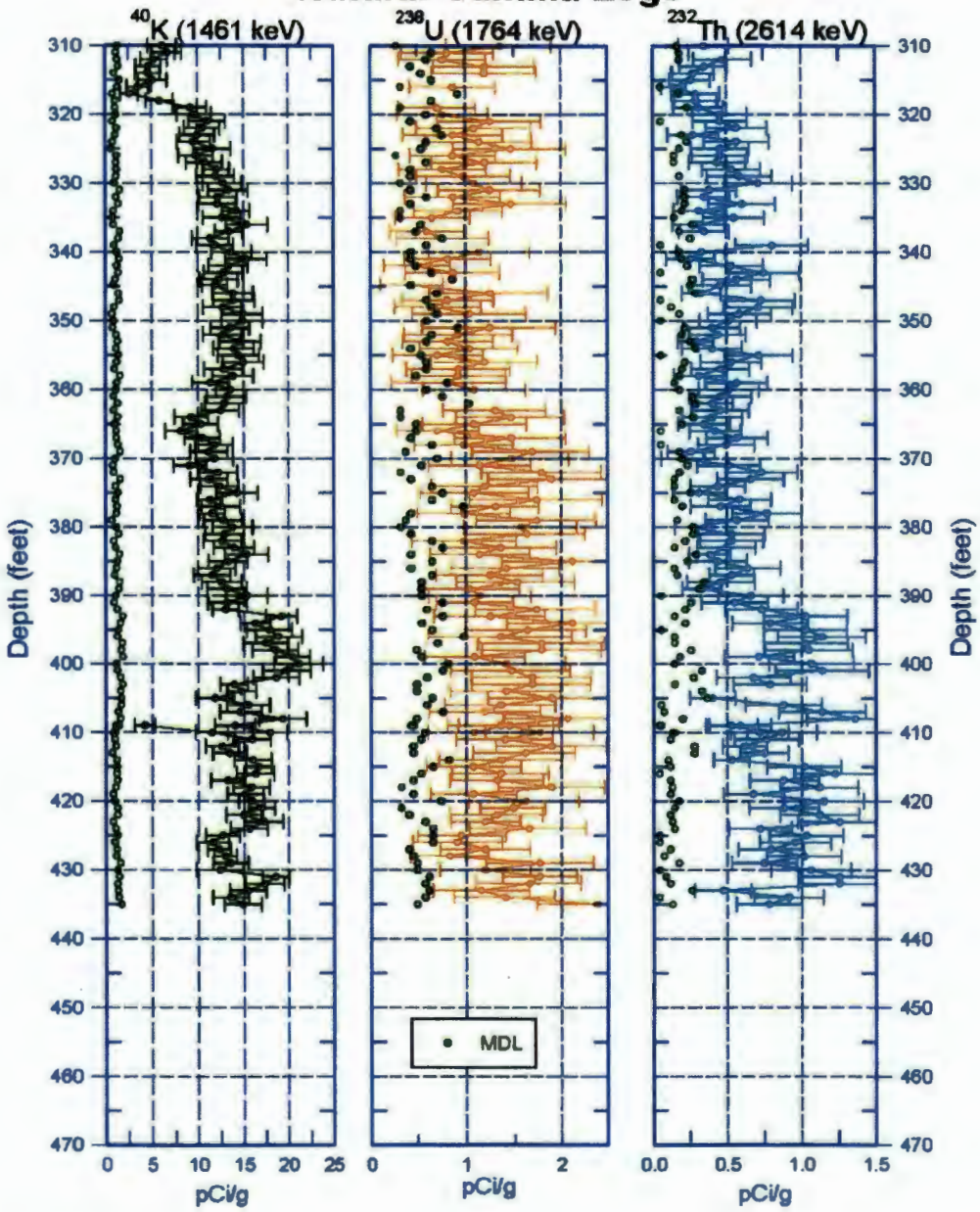
299-W14-20 (C7018 [EW-2])
Natural Gamma Logs



Zero Reference - Ground Surface

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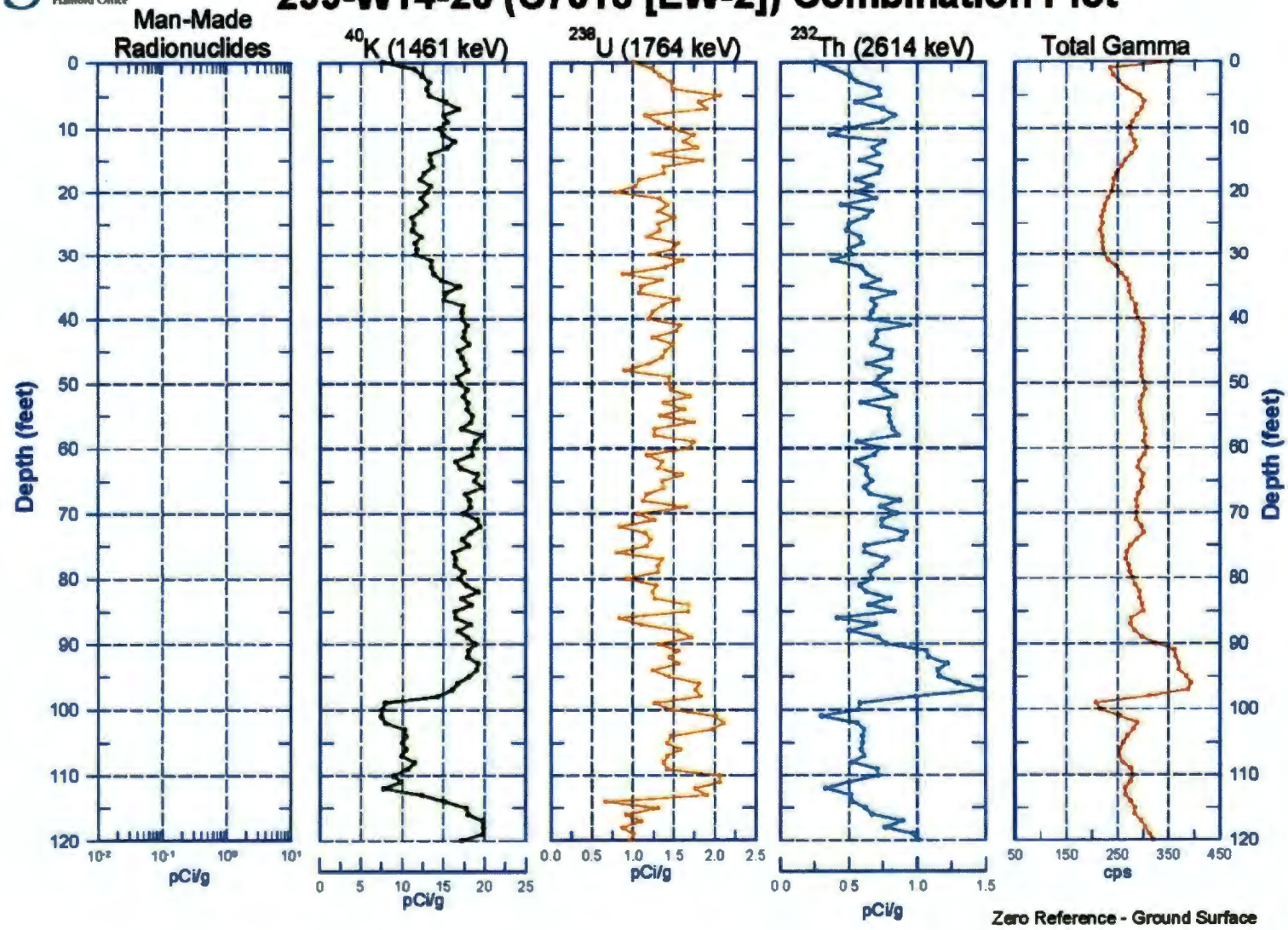
299-W14-20 (C7018 [EW-2]) Combination Plot



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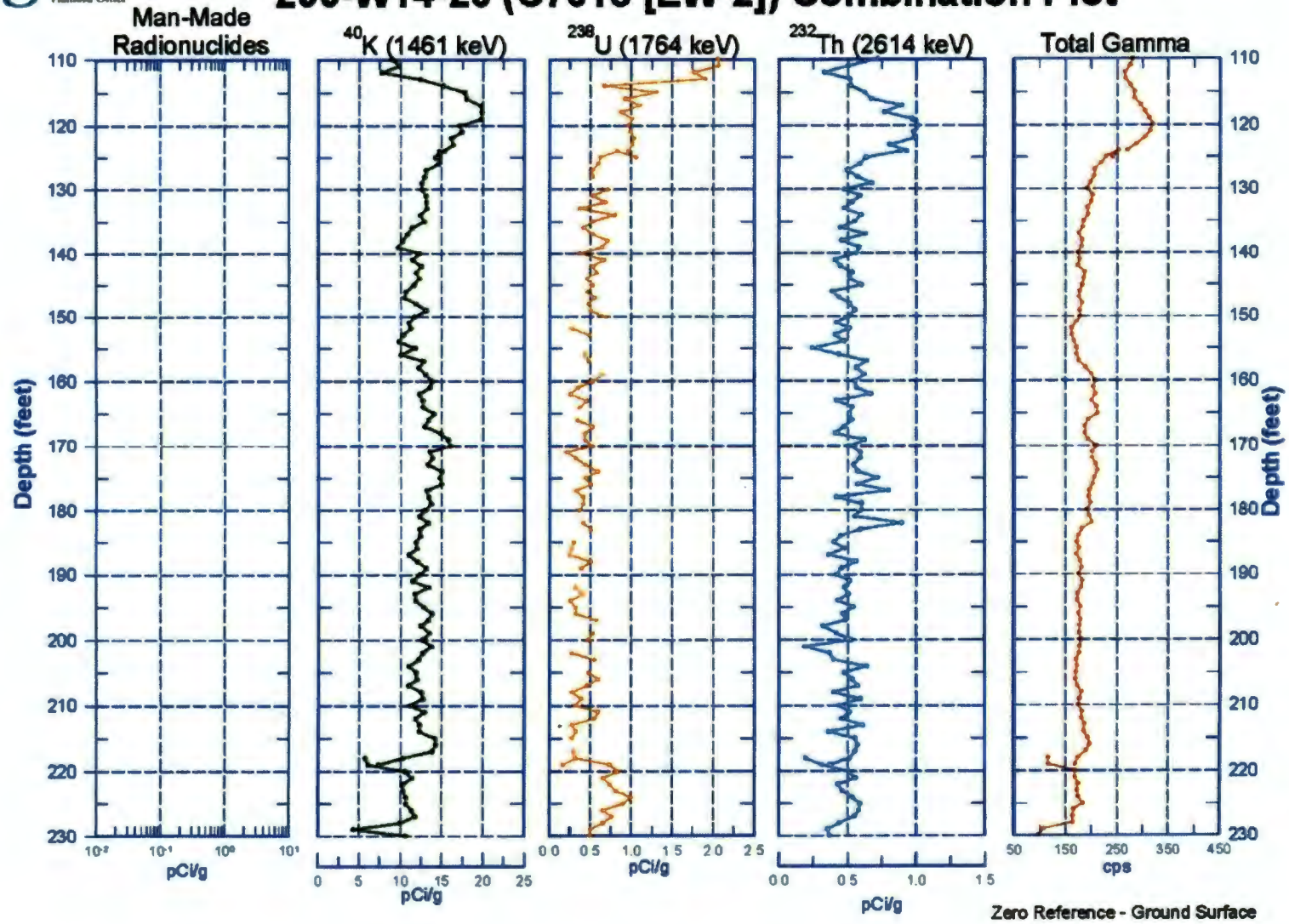
299-W14-20 (C7018 [EW-2]) Combination Plot



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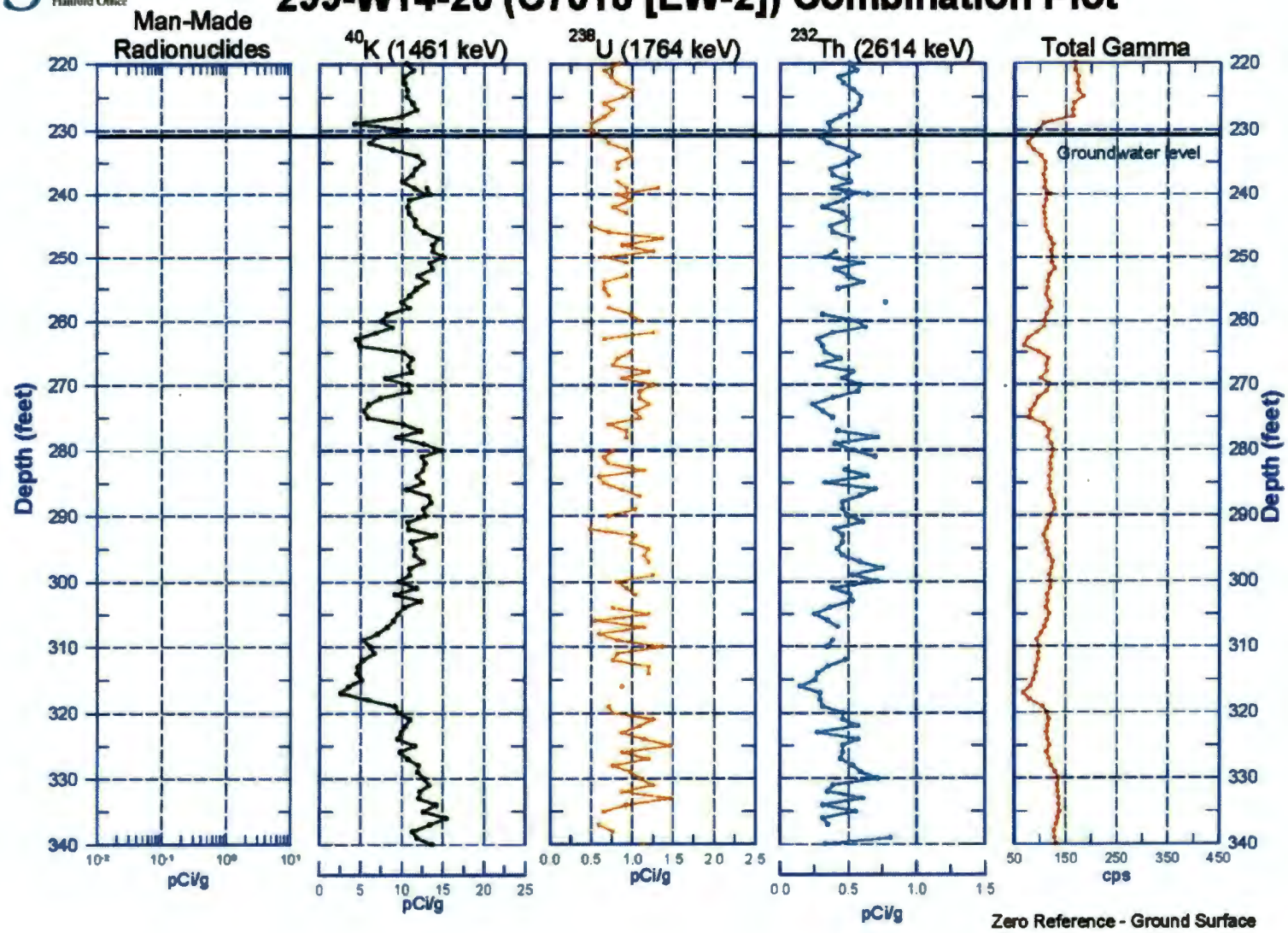
299-W14-20 (C7018 [EW-2]) Combination Plot



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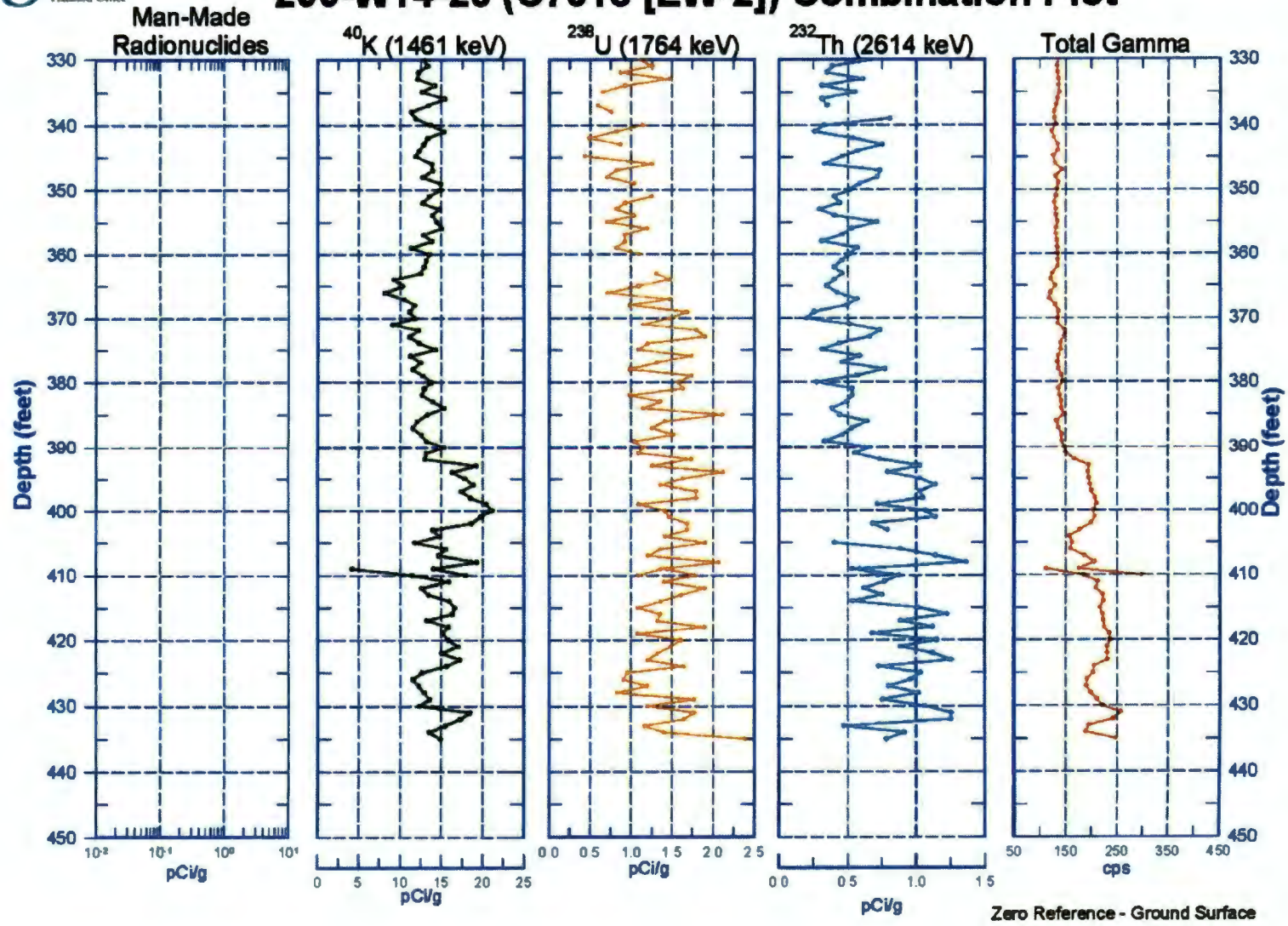
299-W14-20 (C7018 [EW-2]) Combination Plot



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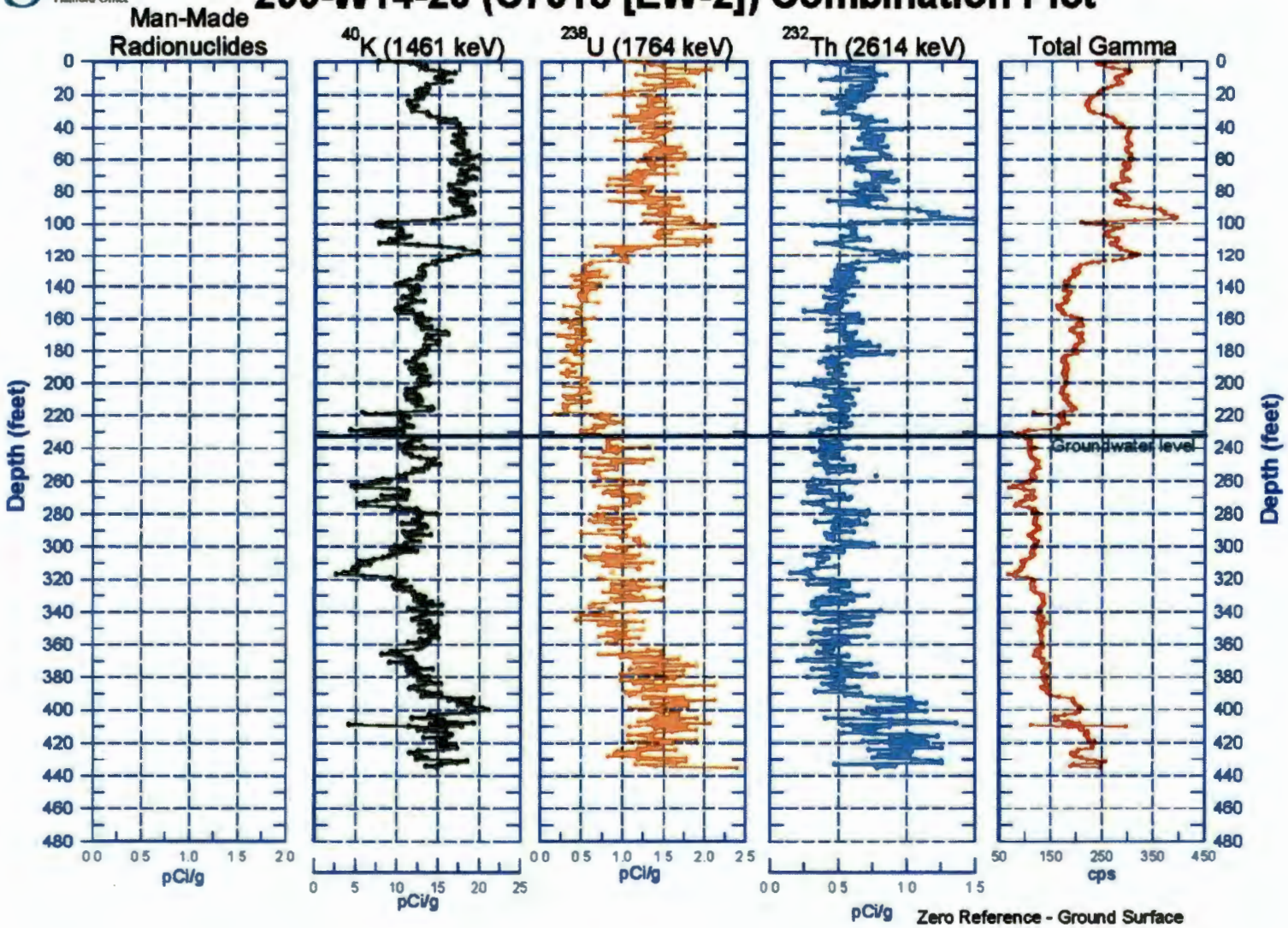
299-W14-20 (C7018 [EW-2]) Combination Plot



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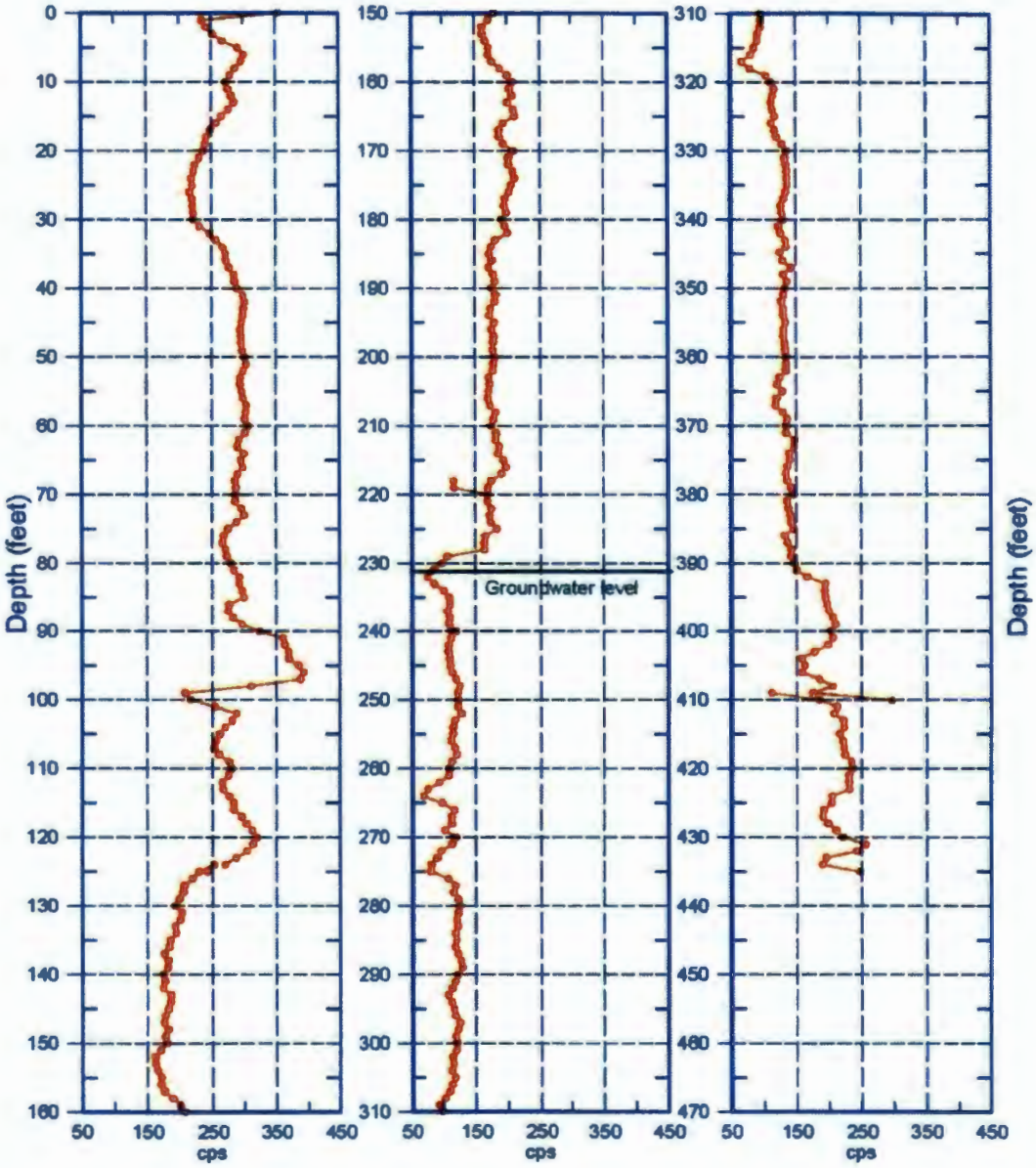
299-W14-20 (C7018 [EW-2])
Total Gamma



Zero Reference - Ground Surface

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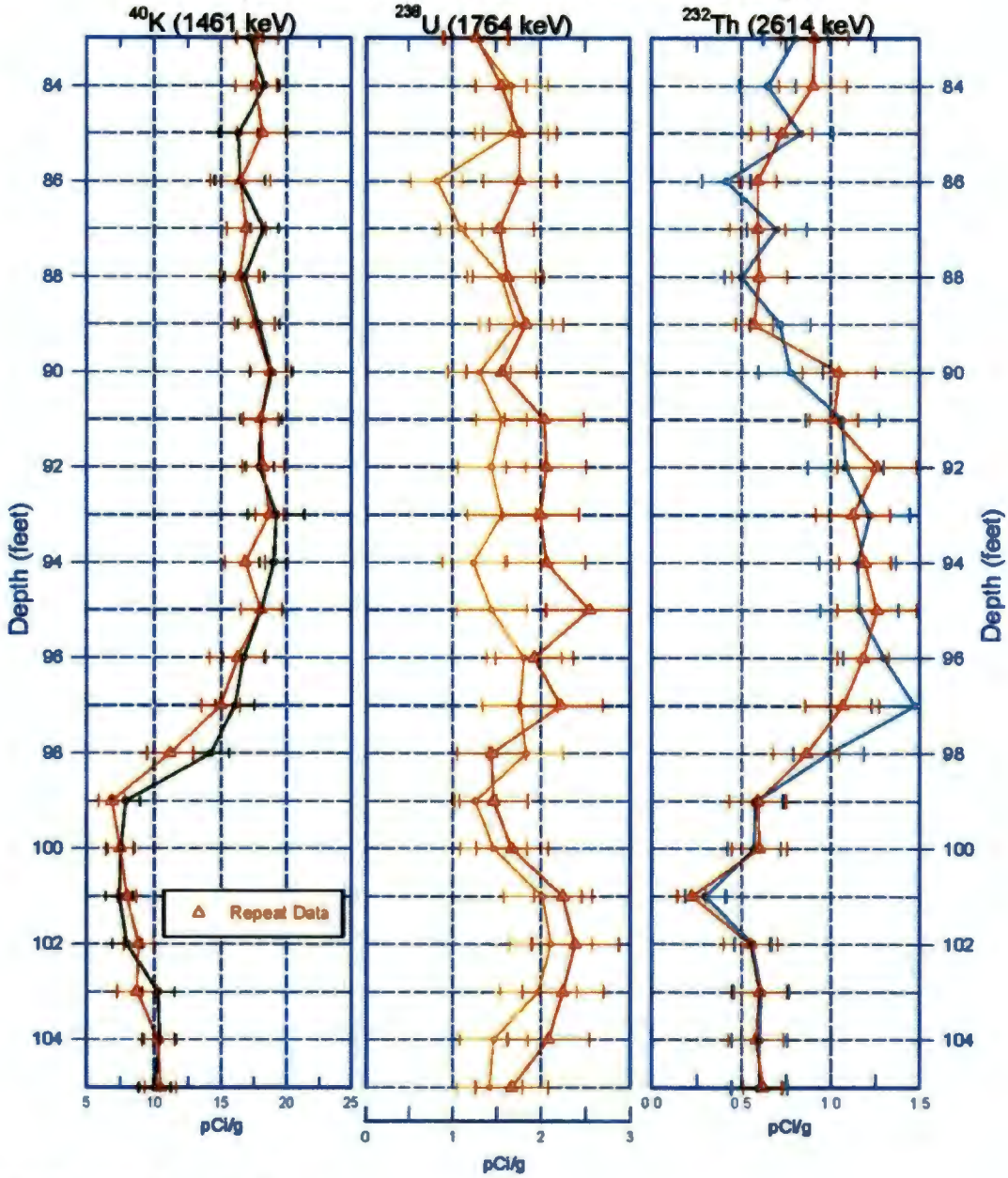
299-W14-20 (C7018 [EW-2])

Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

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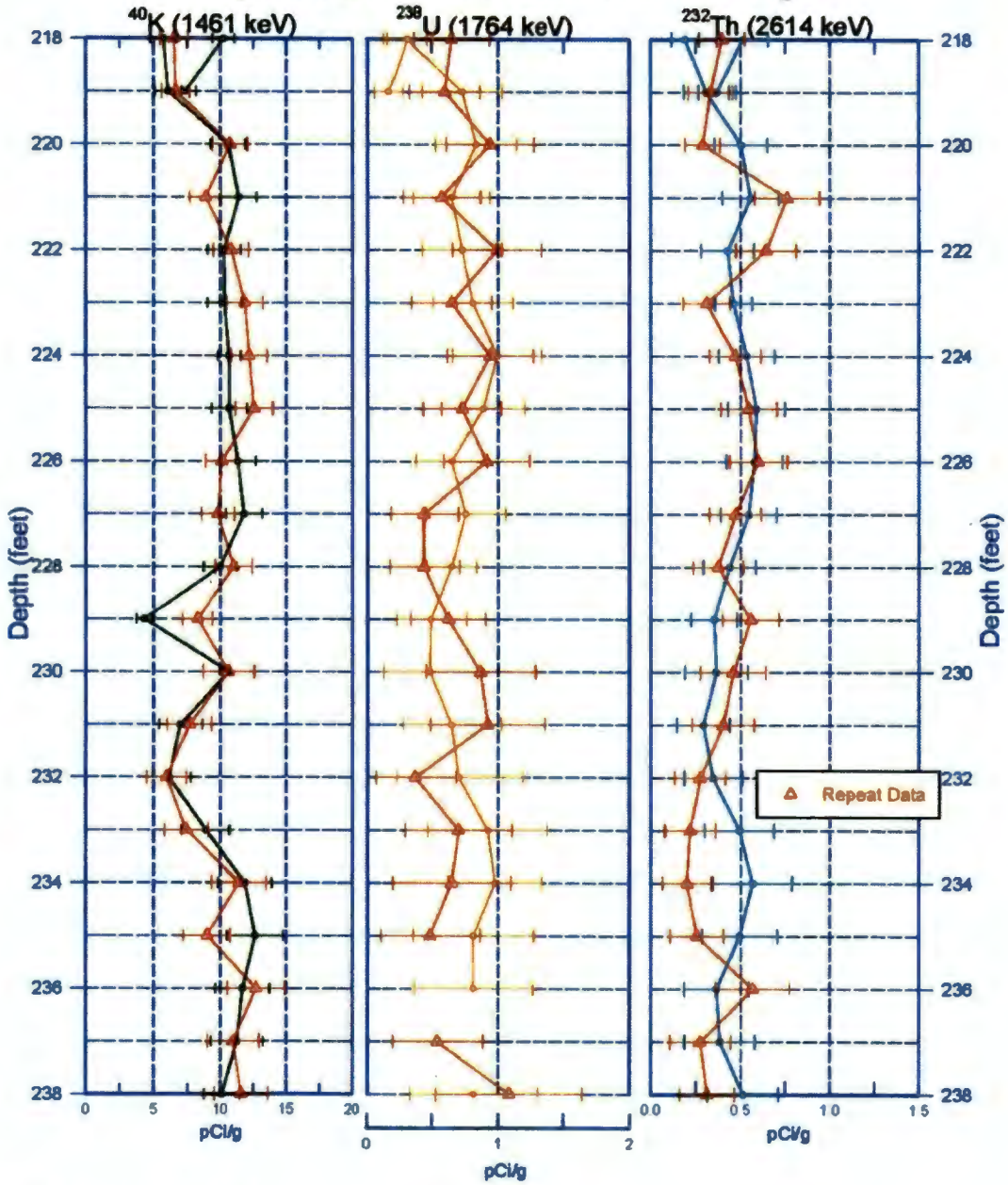
299-W14-20 (C7018 [EW-2])

Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

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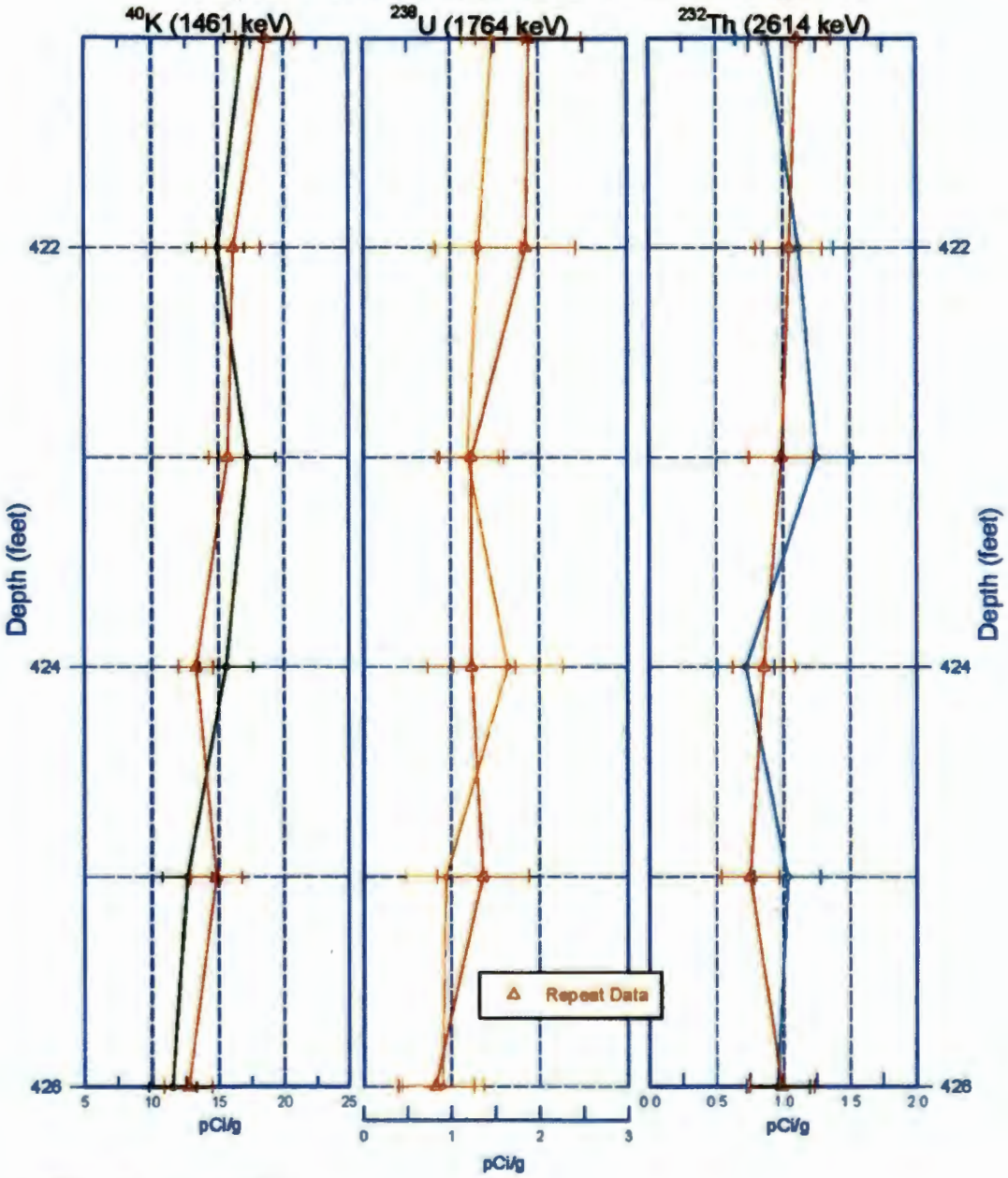
299-W14-20 (C7018 [EW-2])

Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

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299-W14-73 (C7021 [EW-3])
Log Data Report

Borehole Information:

Borehole:	299-W14-73 (C7021) (EW-3)		Site:	200-ZP-1	
Coordinates (WA St Plane)		GWL[1] (ft):	270.4	GWL Date:	6/4/2009
North (m)	East (m)	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
Unknown	Unknown	6/04/2009	Unknown	500	Cable/air rotary

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (inch)	Inside Diameter (inch)	Thickness (inch)	Top (ft)	Bottom (ft)
Welded Steel	0.4	16	15 ¼	3/8	-0.4	170
Threaded Steel	5.0	11 3/4	10	7/8	-5.0	490

Borehole notes:

C7021 corresponds to Phase-I extraction well EW-3 discussed in the Sampling and Analysis Plan for Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit, Fiscal Year 2009 (DOE/RL-2008-57).

The logging engineer measured casing diameter and rounded to the nearest 1/16 inch. The depth to water was measured with an e-tape by the logging engineer.

Logging Equipment Information:

Logging System:	Gamma 1 N		Type: Serial No.:	60% HPGe SGLS 45TP22010A
Effective Calibration Date:	03/28/2008	Calibration Reference:	HGLP-CC-031 Rev 0	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	
Logging System:	Gamma 1 L		Type: Serial No.:	60% HPGe SGLS 47TP32211A
Effective Calibration Date:	03/25/2009	Calibration Reference:	HGLP-CC-030, Rev. 1	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2 Repeat	3	4
Date	3/17/09	3/17/09	6/3/09	6/4/09
Logging Engineer	Pearson	Pearson	Spatz	Spatz
Start Depth (ft)	170.0	137.0	492.0	333.0
Finish Depth (ft)	0.0	120.0	332.0	169.0
Count Time (sec)	100	100	100	100
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	AN125CAB	AN125CAB	AL040CAB	AL041CAB

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Log Run	1	2 Repeat	3	4
Start File	AN125000	AN125171	AL040000	AL041000
Finish File	AN125170	AN125188	AL040160	AL041164
Post-Verification	AN125CAA	AN125CAA	AL040CAA	AL041CAA
Depth Return Error (inch)	1 low	½ low	4 ½ low	N/A
Comments:	none	none	none	none

Log Run	5 Repeat			
Date	06/04/09			
Logging Engineer	Spatz			
Start Depth (ft)	230.0			
Finish Depth (ft)	199.0			
Count Time (sec)	100			
Live/Real	R			
Shield (Y/N)	N			
MSA Interval (ft)	1.0			
Log Speed (ft/min)	NA			
Pre-Verification	AL041CAB			
Start File	AL041165			
Finish File	AL041196			
Post-Verification	AL041CAA			
Depth Return Error (inch)	Low 3			
Comments:	none			

Logging Operation Notes:

The SGLS data were collected on two separate logging events, using the Gamma 1, HO 68B-3574 logging system. Pre- and post-survey verification measurements were acquired in the Amersham KUTh-118-field verifier. Maximum system logging depth achieved was 492.0 ft before the sonde un-weighted.

A centralizer was installed on the sondes.

Logging data are referenced to the ground surface.

Analysis Notes:

Analyst:	Holloway	Date:	7-2-2009	Reference:	GJO-HGLP 1.6.3, Rev. 0

The SGLS pre- and post-survey verification spectra met acceptance criteria for the established systems.

A casing correction for a 3/8-inch thick casing was applied during analysis for the 0-170 ft log run. A casing correction for a 7/8-inch thick casing was applied during analysis for the 170-492.0 ft log runs.

The SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual peaks and count rates. Concentrations were calculated using EXCEL templates identified as G1NMay08.xls for log run 1 and 2 and AL20090326.xls (log runs 3-5) using an efficiency function and corrections for casing, dead time and water as determined by annual calibrations.

During routine processing of gamma spectra, regions of interest are forced at specific energy levels associated with natural and manmade radionuclides that can be anticipated to be present. This processing approach sometimes results in isolated "detections" near the minimum detection level (MDL) resulting in false-positives. Where these detections occur, individual spectra are scrutinized and determinations are made regarding the validity of the detections. If detection is deemed not representative of a full energy peak, or if confirming peaks are not detected, it is removed from the data set. The integrity of the raw data files and the processed files are maintained should questions arise in the future regarding these determinations.

Results and Interpretations:

No manmade radionuclides were detected.

The KUT repeat plots indicate good repeatability.

List of Log Plots:

Depth Reference is ground surface.

Manmade Radionuclides 0-500 ft
Natural Gamma Logs (KUT) 0-170 ft
Natural Gamma Logs (KUT) 160-330 ft
Natural Gamma Logs (KUT) 330-500 ft
Combination Plot 0-120 ft
Combination Plot 110-230 ft
Combination Plot 220-340 ft
Combination Plot 330-450 ft
Combination Plot 440-560 ft
Combination Plot 0-500 ft
Total Gamma 0-500 ft
Repeat Section of Natural Gamma Logs 120-137 ft
Repeat Section of Natural Gamma Logs 199-230 ft

[1] GWL – groundwater level
[2] TOC – top of casing

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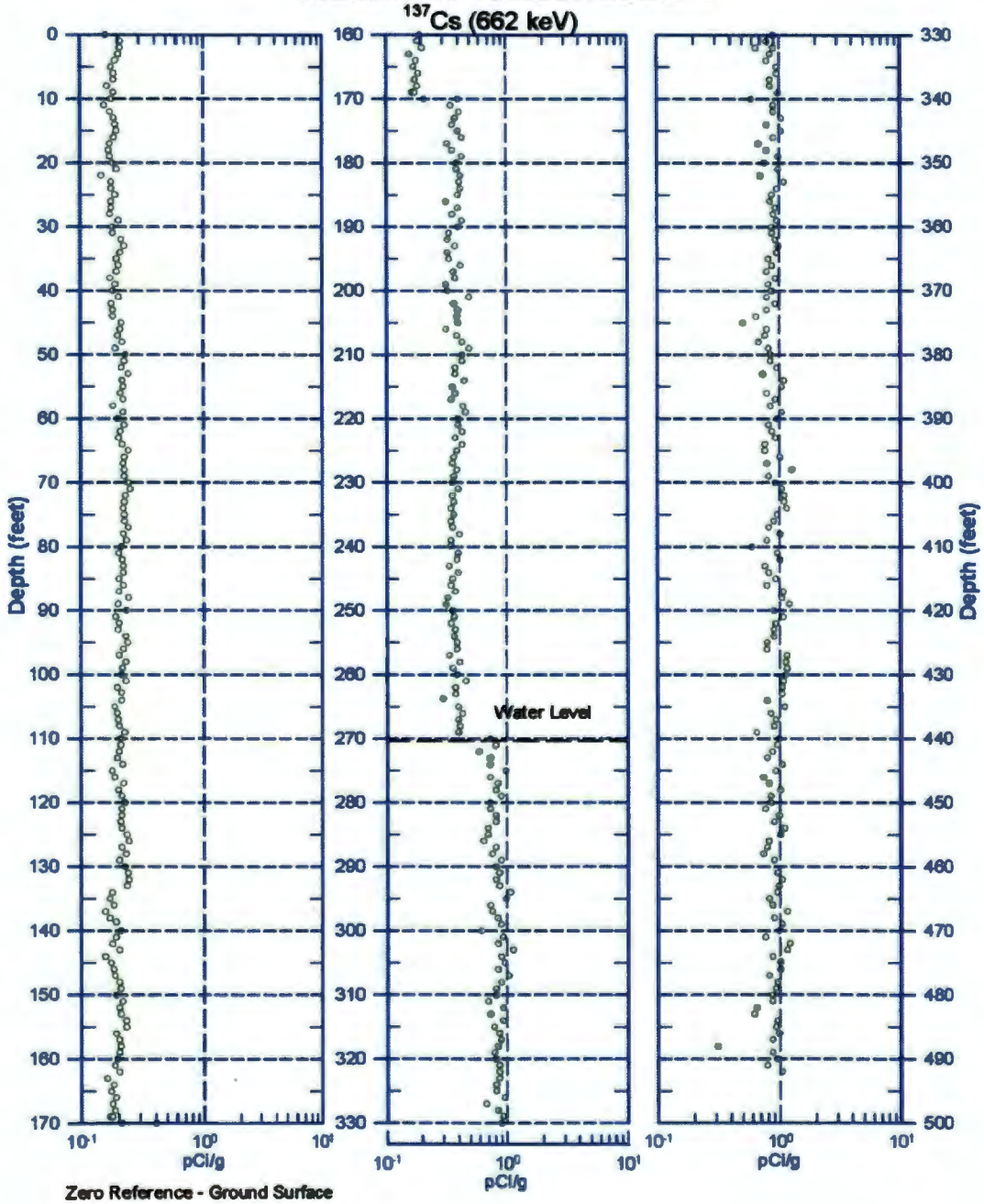
299-W14-73 (C7021 [EW-3])
Manmade Radionuclides



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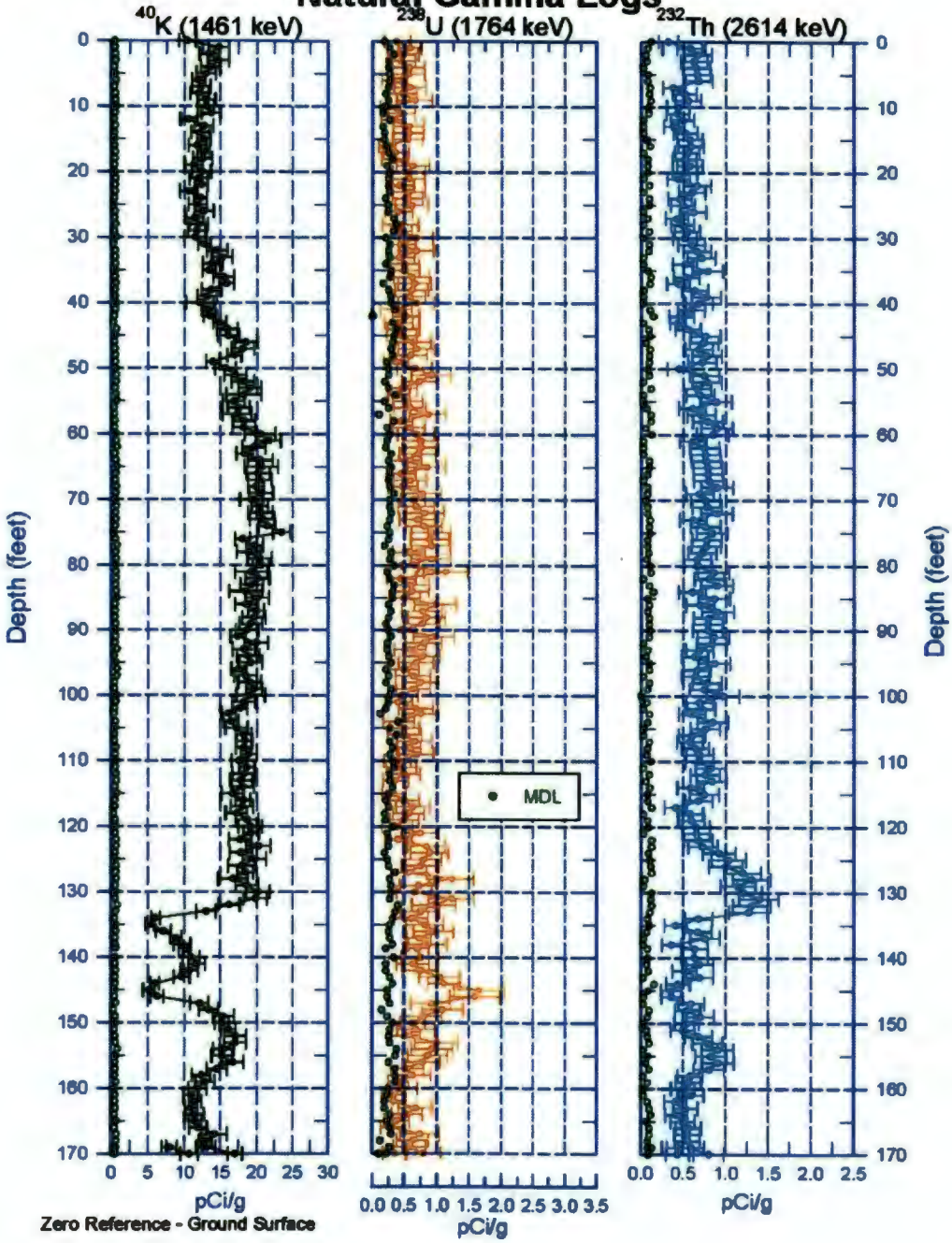
299-W14-73 (C7021 [EW-3])
Natural Gamma Logs



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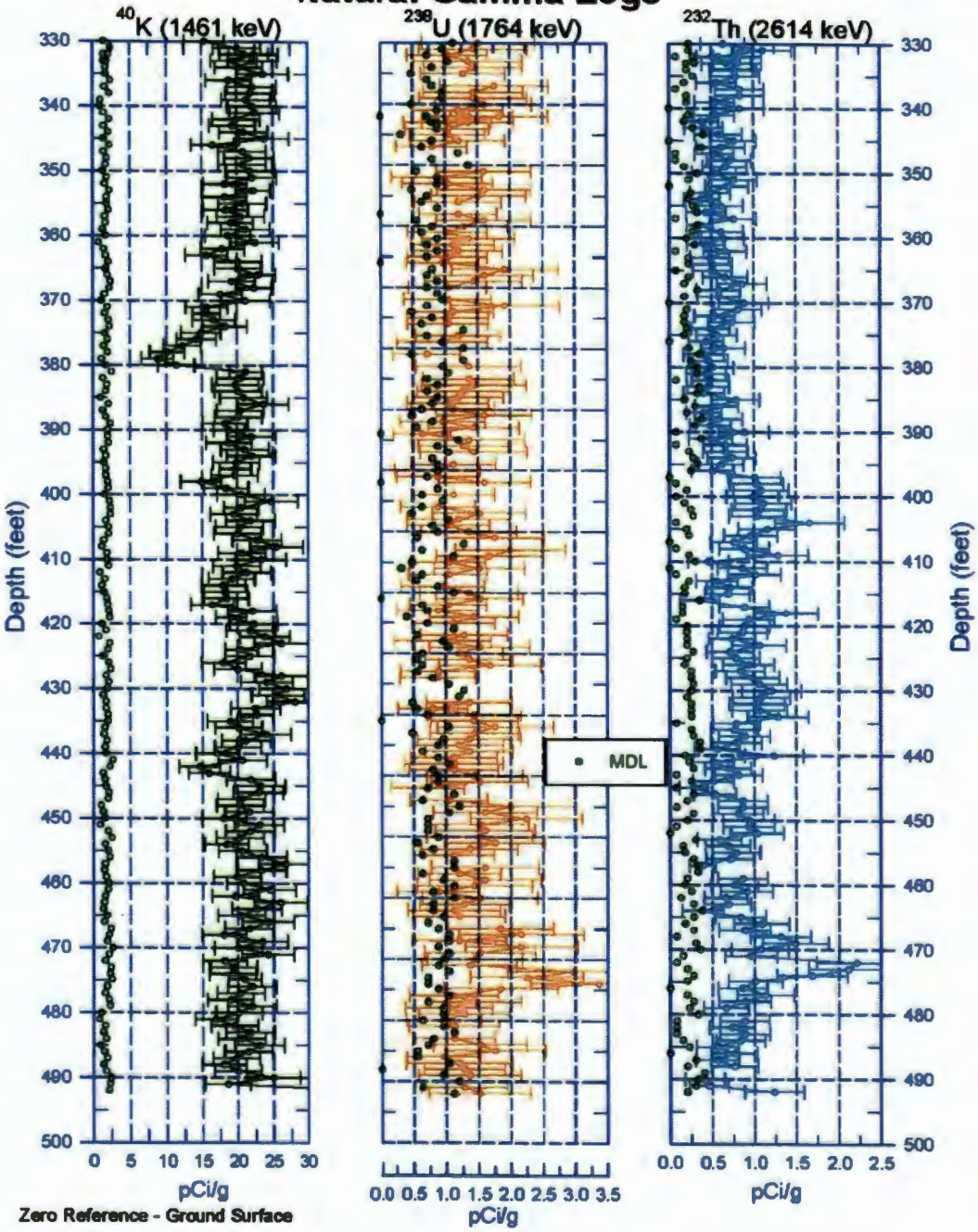
299-W14-73 (C7021 [EW-3])
Natural Gamma Logs



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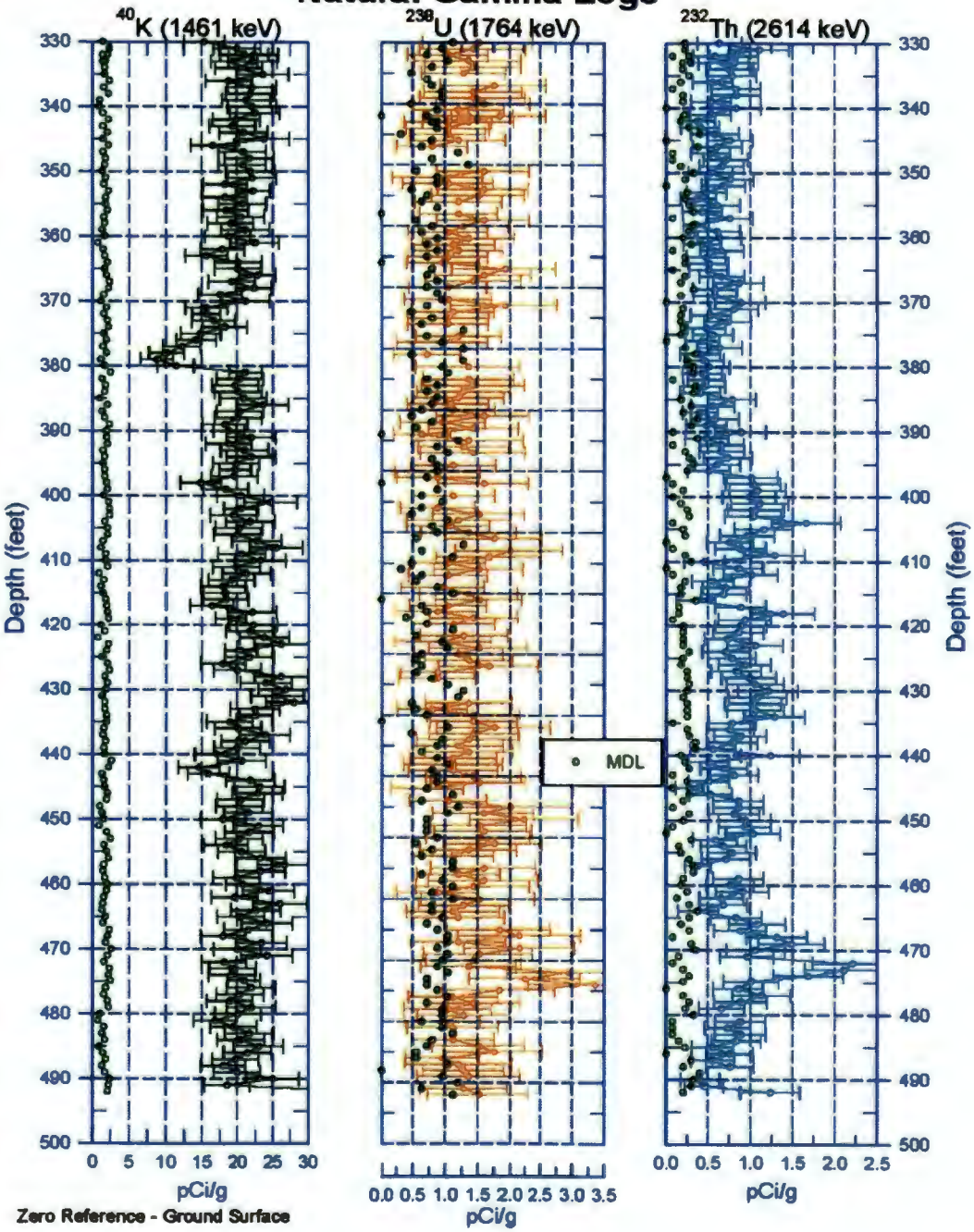
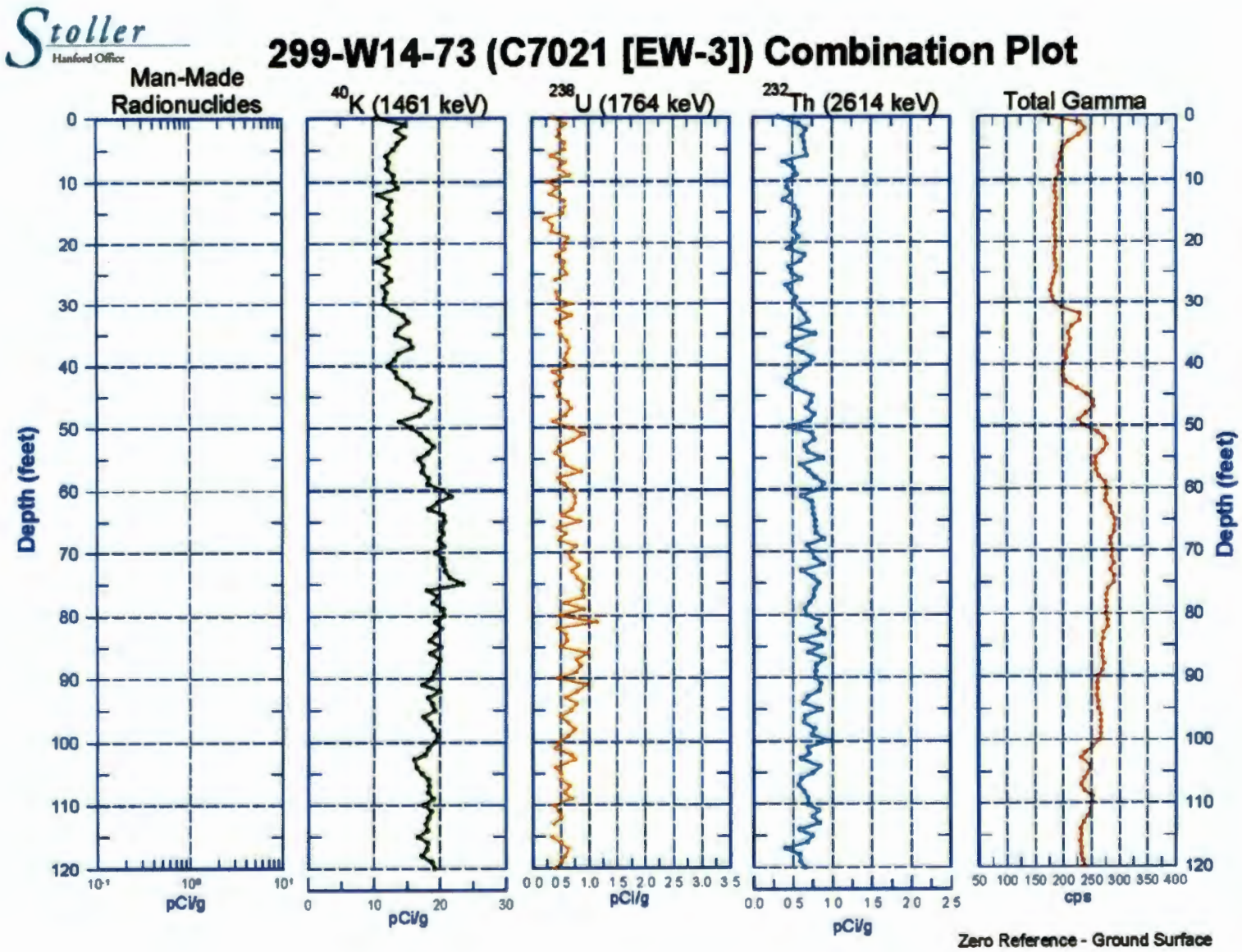
299-W14-73 (C7021 [EW-3])
Natural Gamma Logs

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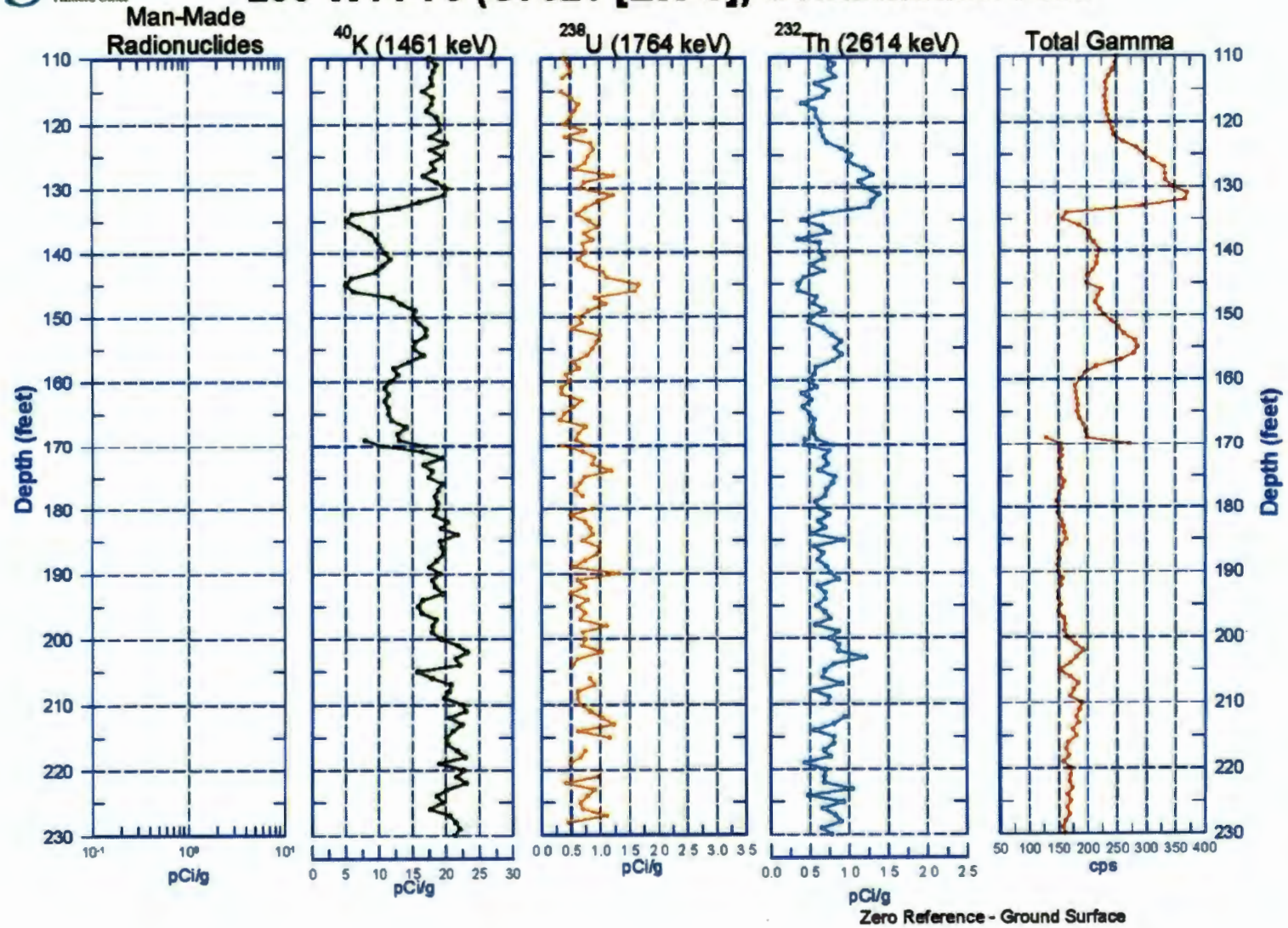
299-W14-73 (C7021 [EW-3]) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Depth (feet)
pCi/g
cps
Zero Reference - Ground Surface

299-W14-73 (C7021 [EW-3]) Combination Plot



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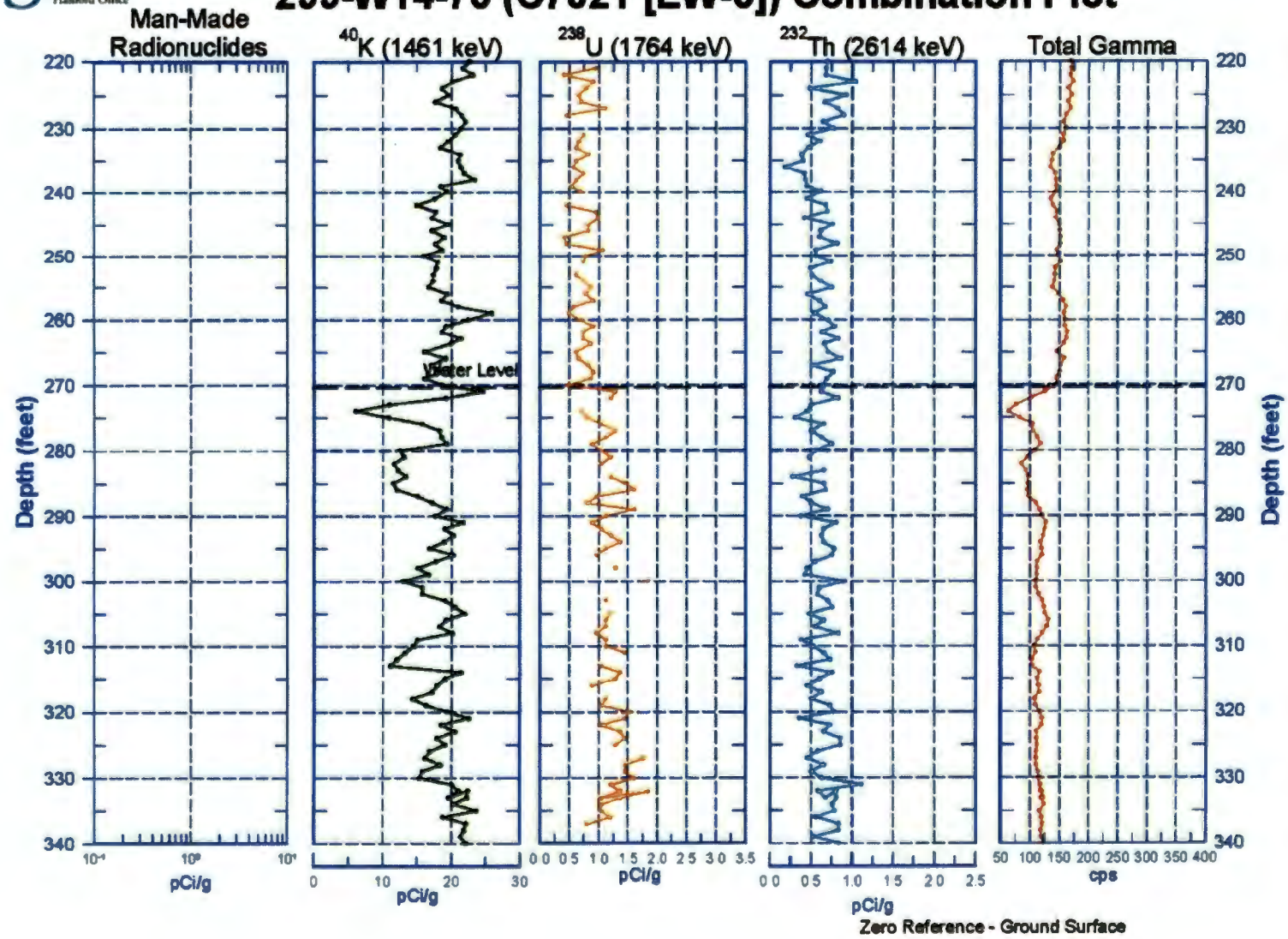
299-W14-73 (C7021 [EW-3]) Combination Plot



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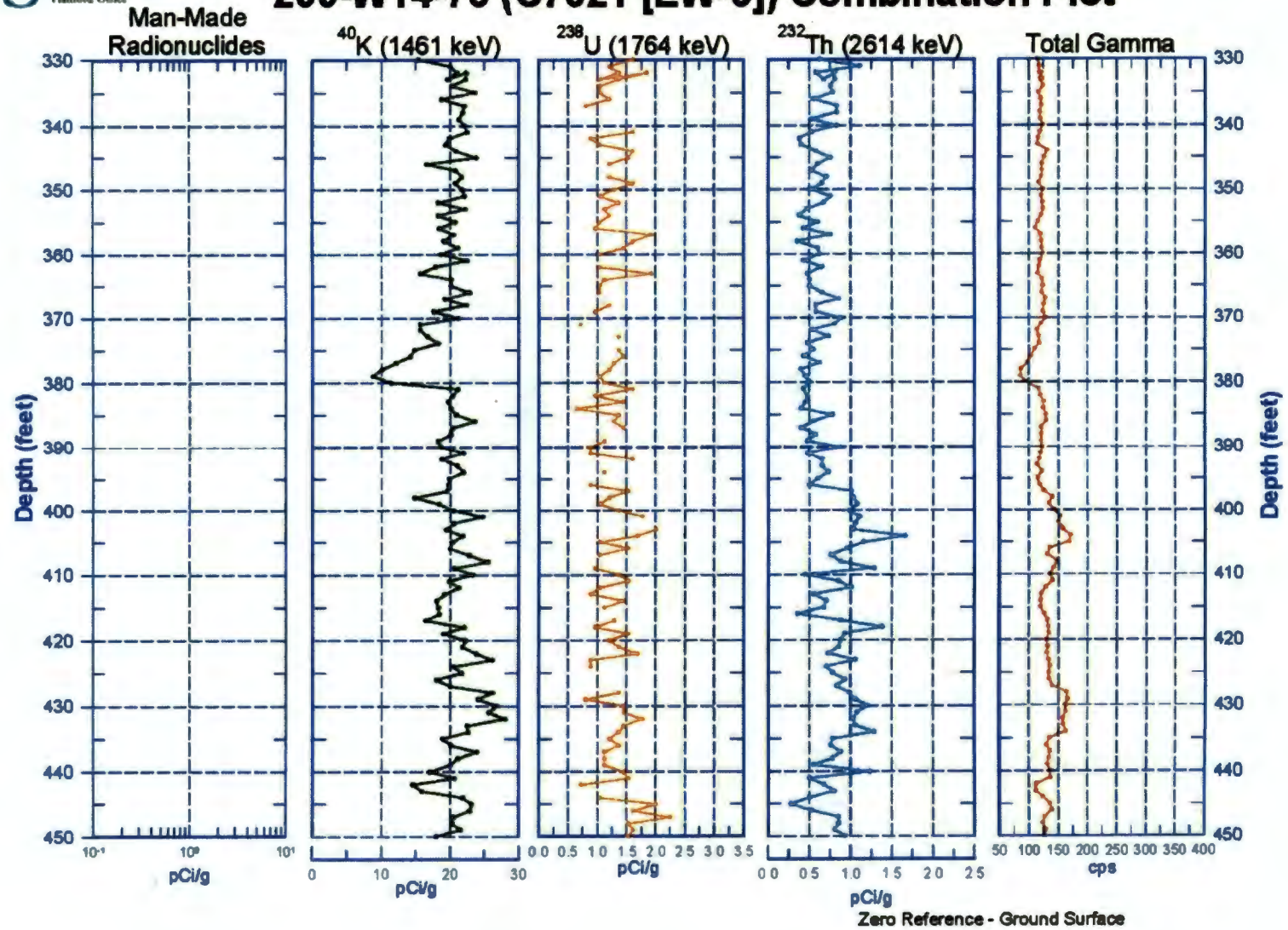
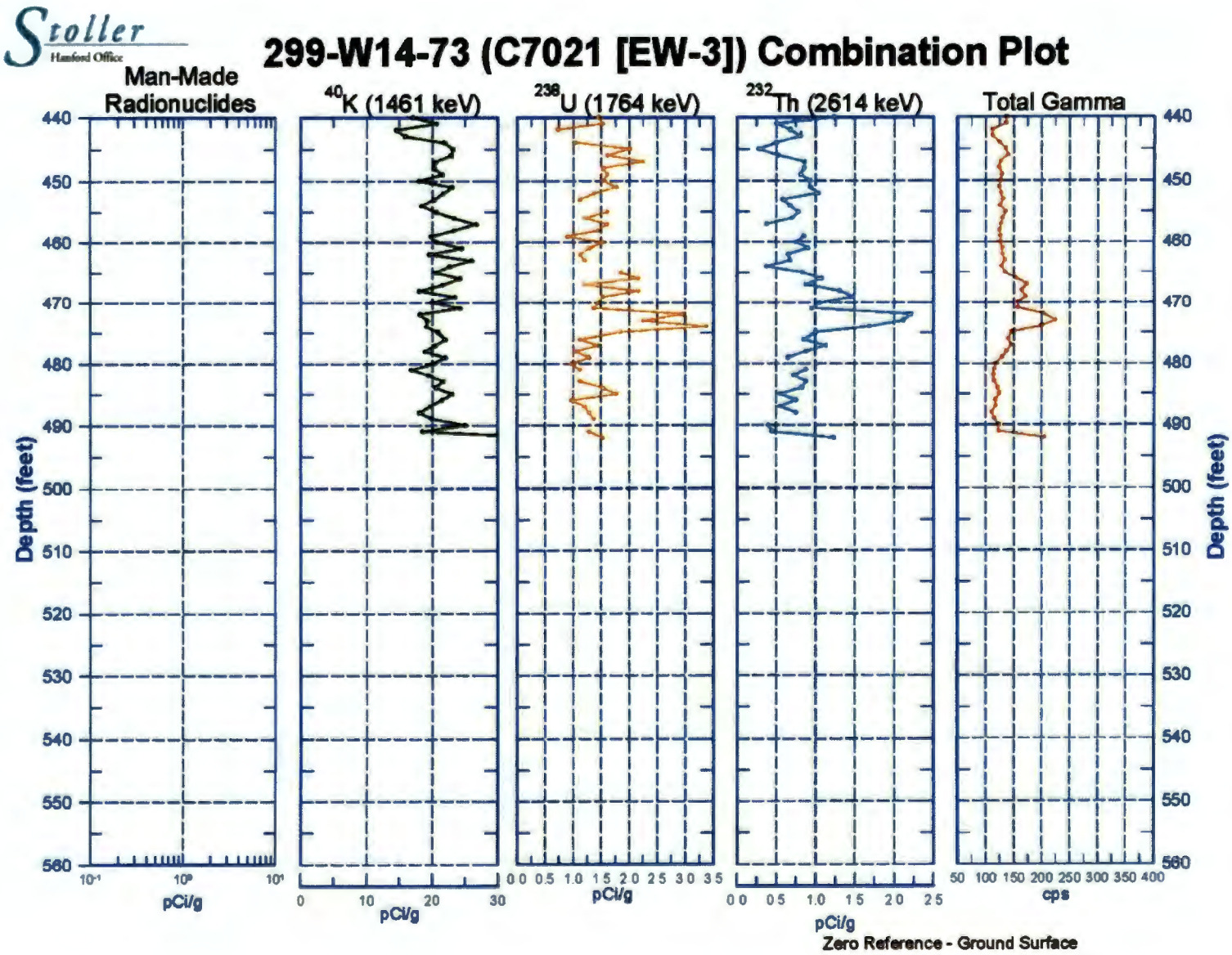
299-W14-73 (C7021 [EW-3]) Combination Plot

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299-W14-73 (C7021 [EW-3]) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Depth (feet)
440
450
460
470
480
490
500
510
520
530
540
550
560
10-1
100
101
pCi/g
0
10
20
30
pCi/g
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5
pCi/g
0.0 0.5 1.0 1.5 2.0 2.5
pCi/g
50 100 150 200 250 300 350 400
cps
Zero Reference - Ground Surface

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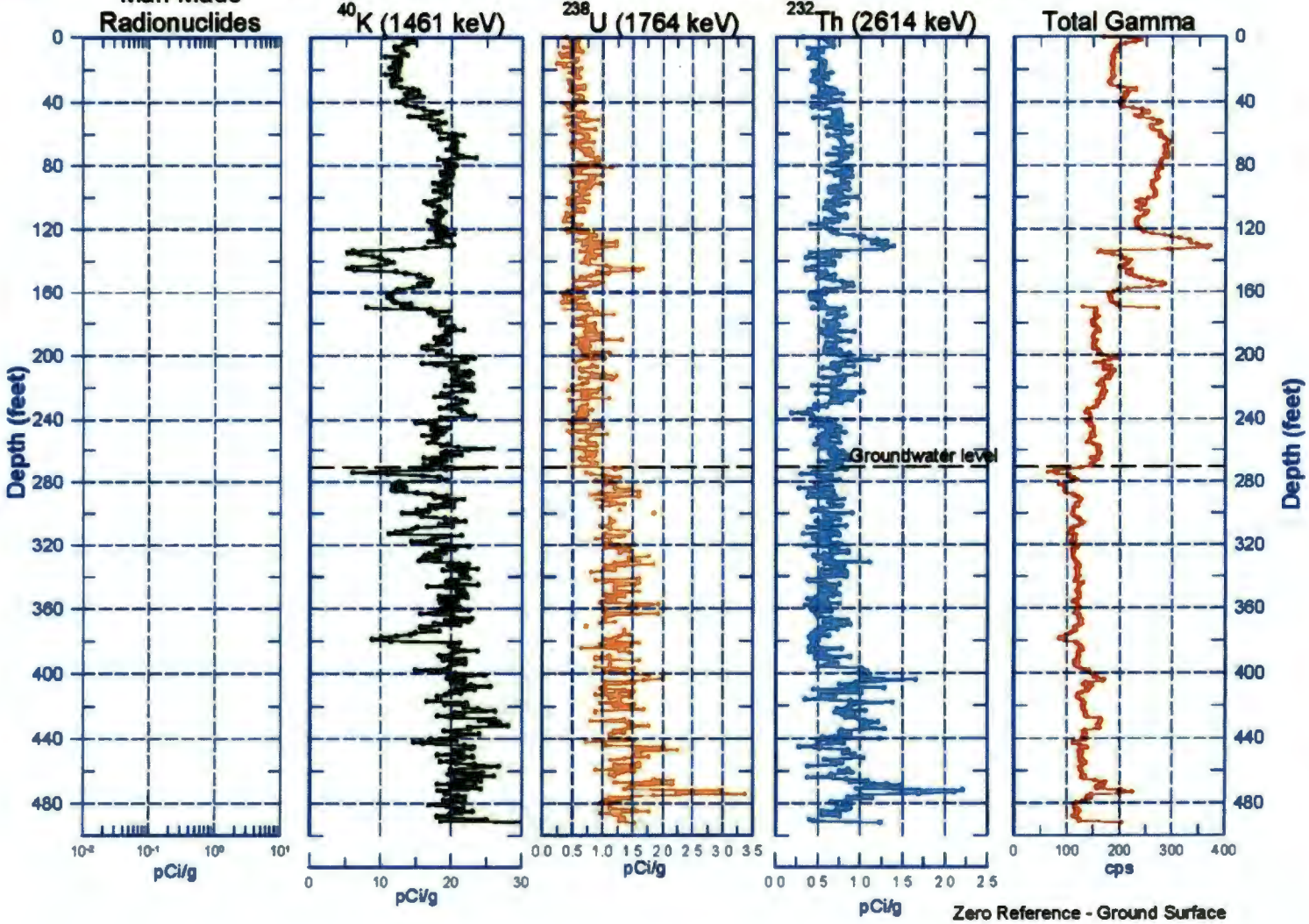
299-W14-73 (C7021 [EW-3]) Combination Plot



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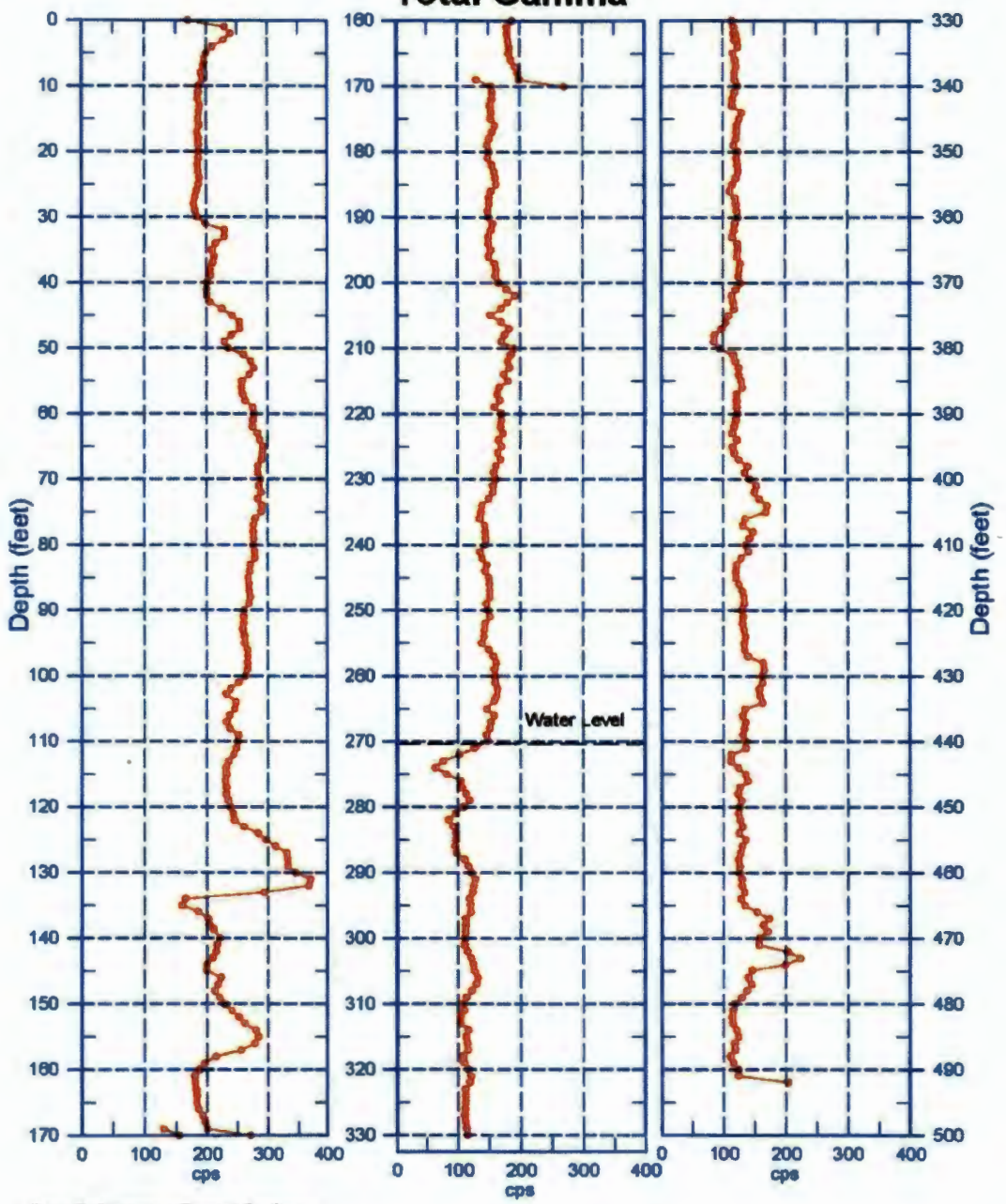
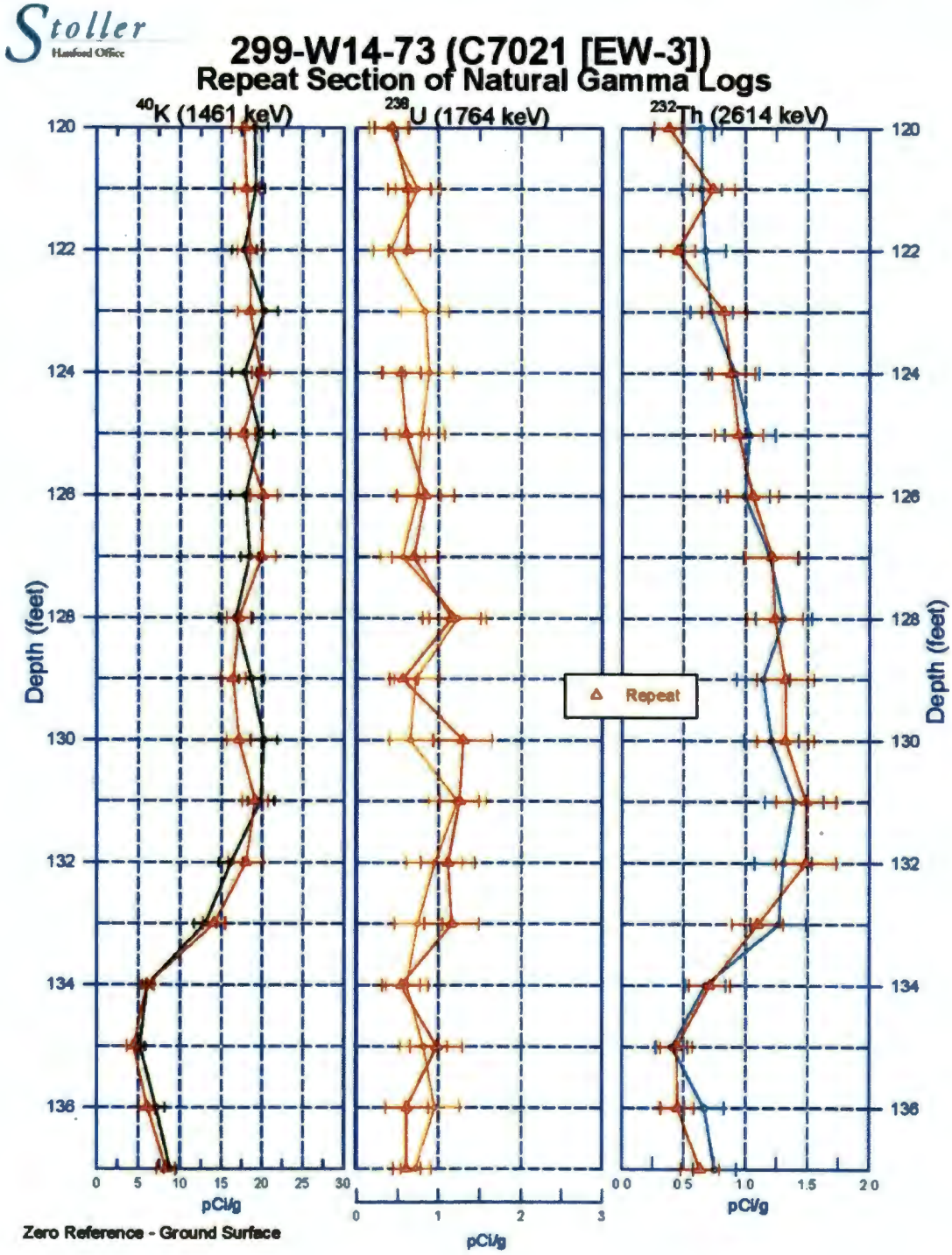
299-W14-73 (C7021 [EW-3])
Total Gamma



Zero Reference - Ground Surface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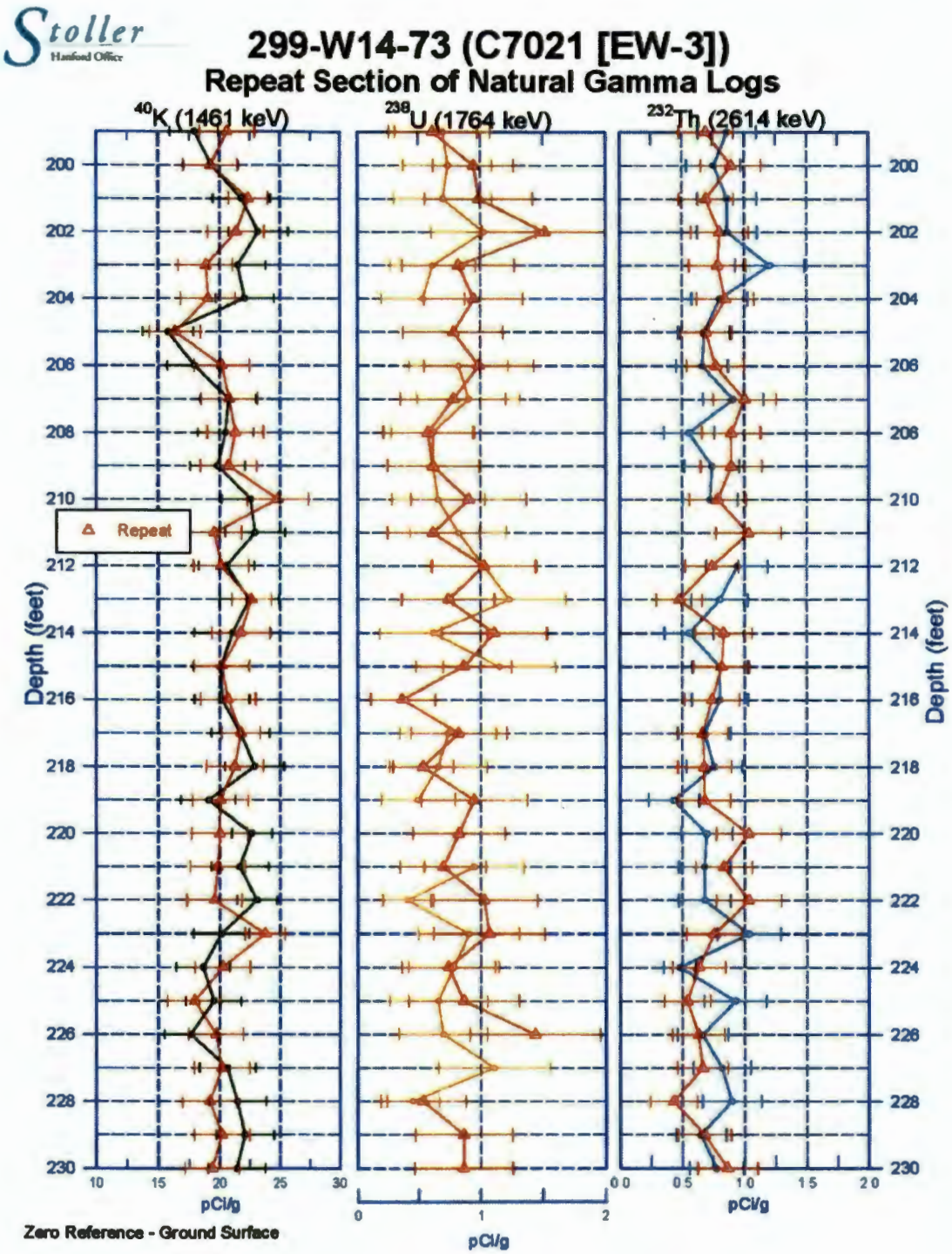
299-W14-73 (C7021 [EW-3])
Repeat Section of Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
120
122
124
126
128
130
132
134
136
0 5 10 15 20 25 30
pCi/g
0 1 2 3
pCi/g
0.0 0.5 1.0 1.5 2.0
pCi/g
Repeat
Zero Reference - Ground Surface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299-W14-73 (C7021 [EW-3])
Repeat Section of Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Repeat
Depth (feet)
pCi/g
Zero Reference - Ground Surface

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