PNNL-14656

Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Borehole Data Package for Four CY 2003 RCRA Wells 299-E27-4, 299-E27-21, 299-E27-22, and 299-E27-23 at Single-Shell Tank, Waste Management Area C, Hanford Site, Washington

B. A. Williams
S. M. Narbutovskih

June 2004

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RL01830

Printed in the United States of America

**Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401.**

**Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161**

PNNL-14656

Borehole Data Package for Four CY 2003 RCRA Wells 299-E27-4, 299-E27-21, 299-E27-22, and 299-E27-23 at Single-Shell Tank, Waste Management Area C, Hanford Site, Washington

B. A. Williams
S. M. Narbutovskih

June 2004

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

Four new Resource Conservation and Recovery Act (RCRA) groundwater monitoring wells were installed at the single-shell tank farm Waste Management Area (WMA) C in fiscal year 2003 to fulfill commitments for well installations proposed in the *Hanford Federal Facility Agreement and Consent Order* milestone M-24-57. Well 299-E27-22, installed upgradient, was drilled through the entire uppermost unconfined aquifer to the basalt and wells 299-E27-4, 299-E27-21 and 299-E27-23 were drilled approximately 40 feet into the uppermost unconfined aquifer and installed downgradient of the WMA. Specific objectives for these wells include monitoring the impact, if any, that potential releases from inside the WMA may have on current groundwater conditions (i.e., improved network coverage) and differentiating upgradient groundwater contamination from contaminants potentially released at the WMA.

This report supplies the information obtained during drilling, characterization, and installation of the four new groundwater monitoring wells. This document also provides a compilation of hydrogeologic and well construction information obtained during drilling, well development, aquifer testing, and sample collection/analysis activities.

Contents

Figures

Tables

1.0 Introduction

Four new Resource Conservation and Recovery Act (RCRA) groundwater monitoring wells were installed at single-shell tank Waste Management Area (WMA) C in fiscal year 2003 to fulfill commitments for well installations proposed in *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement; Ecology et al. 2003) Milestone M-24-57 (Murphy-Fitch 2003).[(a)] The need for increased monitoring capability at this WMA was identified in Narbutovskih and Horton (2001) and during a data quality objectives process for establishing a RCRA/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Atomic Energy Act of 1954 (AEA) integrated 200 West and 200 East Area Groundwater Monitoring Network (Byrnes and Williams 2003).

Four wells have been installed; one located upgradient and three downgradient of the WMA (Figure 1). Specific objectives for these wells are monitoring the impact, if any, that potential releases from the WMA may have on current groundwater conditions (i.e., improved network coverage) and differentiating upgradient groundwater contamination from contaminants potentially released at the WMA. This report provides the information obtained during drilling, characterization and installation of these four new groundwater monitoring wells at the single-shell tank WMA C.

1.1 New Groundwater Monitoring Wells

Four groundwater monitoring wells were installed between July and September 2003. The wells are identified as 299-E27-4 (well ID C4125), 299-E27-21 (well ID C4127), 299-E27-22 (well ID C4124) and 299-E27-23 (well ID C4190) and are shown on the location map in Figure 1. Well 299-E27-20 (C4126) was abandoned due to drilling problems and replaced with 299-E27-23 (C4190), which is located approximately 10 feet to the south from well 299-E27-20. The new wells were constructed to the specifications and requirements described in Washington Administrative Code (WAC) 173-160, the groundwater monitoring description of work for drilling and installation (Williams 2003) and specifications used by Fluor Hanford, Inc. (FHI), Richland, Washington. During drilling and construction of the wells, sampling and analysis activities were conducted to support field screening for radiological and chemical contaminants, to collect sediment grab samples for geologic descriptions, digital photography, and for archival in the Hanford Geotechnical Sample Library (HGSL).

Additional characterization was conducted by the CH2M Hanford Group in borehole 299-E27-22 (C4124), which was drilled through the aquifer to the top of basalt. Intact vadose zone core samples were collected. Although the results of tests on these cores are not reported in this document, depth-discrete aquifer testing and groundwater analyses performed during drilling are included in Sections 6.2 and 9.4.

This document provides a compilation of all available geologic data, spectral gamma ray logs, hydrogeologic data and well information obtained during drilling, well construction, well development, pump installation, aquifer testing, and sample collection/analysis activities. Appendix A contains the

(a) Letter from EJ Murphy-Fitch (Fluor Hanford Inc., Richland, Washington) to Distribution, *"Tentative Agreement on Tri-Party Agreement Negotiations on the Overall Strategy and Approach for Hanford Groundwater Protection, Monitoring, and Remediation (M-024),"* dated September 22, 2003.

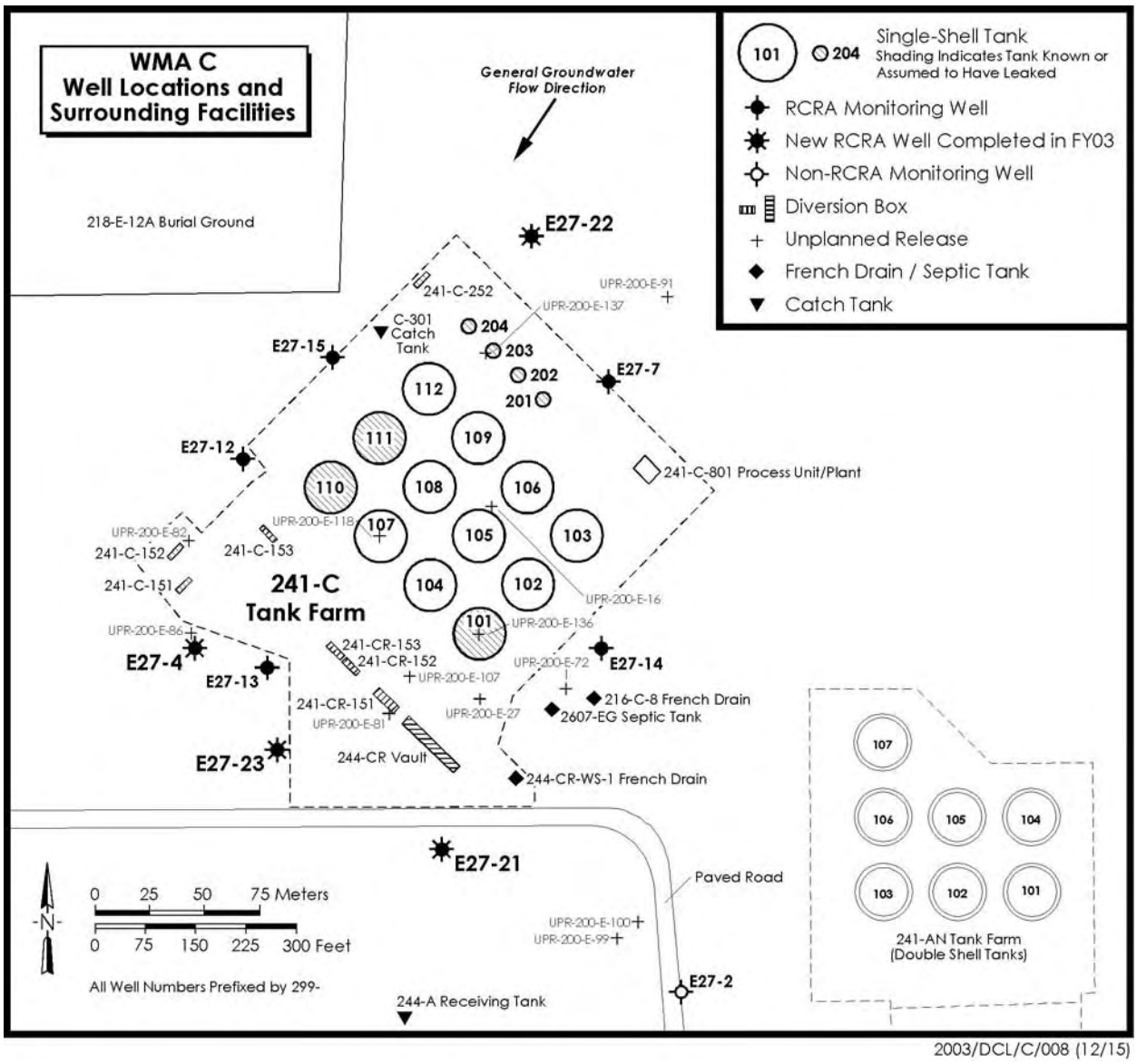


Figure 1. Map of Single-Shell Tank Waste Management Area C and Locations of New and Existing Wells in the Groundwater Monitoring Network

Well Summary Sheets, the Well Construction Summary Report, the geologist's borehole log, well development and pump installation records, well survey results, and a construction variance report. Appendix B contains sediment sieve analysis results, core sample chain of custody forms, the core log for 299-E27-22 (C4124), and selected core sample digital photographs. Appendix C contains complete spectral gamma ray logs and borehole deviation surveys while Appendix D contains the hydrologic test report for well 299-E27-22 (C4124).

Additional well construction documentation is on file with FHI. Drilling, geologic and geophysical logs, and well construction/completion data are presented in Martinez (2003). The Records Management

Information System (RMIS) and the Hanford Well Information System (HWIS) [http://apweb02/cfroot/rapidweb/phmc/cp/hwisapp/] are two electronic databases that also contain drilling and construction records for these four wells.

English units are used in this report to describe drilling and well completion activities because that is the system of units used by drillers to measure and report depths and well construction measurements. Conversion to metric can be done by multiplying feet by 0.3048 to obtain meters or by multiplying inches by 2.54 to obtain centimeters.

2.0 Well 299-E27-22

Well 299-E27-22 is located to the northeast of the WMA C tank farm. The well is upgradient of WMA C and will help differentiate upgradient groundwater contamination from contaminants potentially released at the WMA.

2.1 Drilling and Sampling

Well 299-E27-22 (well ID C4124) was drilled with a dual-wall percussion drill rig (Becker-hammer) from surface to a total depth of 268 feet below ground surface (bgs). The borehole was drilled through the unconfined aquifer to the top of basalt. Temporary 9-inch outside diameter (OD), dual-wall casing was used during drilling to total depth. Drilling began on July 10, 2003 and total depth was reached on September 5, 2003.

Grab samples of sediment for geologic description, digital photography and archives were collected at approximately 5-foot intervals from ground surface to total depth. Sixty-nine continuous split spoon samples were collected from approximately 19 feet bgs to 111.5 feet bgs. The samples were sealed in one-foot long lexan liners and transferred to Pacific Northwest National Laboratory (PNNL) for analysis. These samples were used to define lithology and for physical and chemical characterization of the vadose zone. An additional 45 split spoon samples were collected at approximately 5-foot intervals at two samples per interval from ~114 bgs to ~231.5 feet bgs near the water table, which was located at 230.5 feet bgs. The borehole log in Appendix A provides the sample depths while the composite log in Section 9.5 (Figure 6) summarizes the sampled intervals and graphic results of core descriptions. The chain of custody forms for transfer of the core samples and selected digital photographs of several cores are contained in Appendix B. Two grab samples were collected from drill depths of 233 feet bgs and 268 feet bgs and evaluated for physical property analysis (sieve analysis) to confirm screen selection. The sieve analysis data and distribution curves are in Appendix B.

Sediments encountered during drilling were predominantly unconsolidated sand to gravelly sand of the Hanford formation from ~5 feet bgs to a depth of 185 feet bgs. Above the Hanford formation are recent deposits. The sandy gravel to gravel of the lower Hanford H3 unit comprises the sediments from approximately 185 feet bgs to 268 feet bgs. Although, the Cold Creek unit (CCU), as defined in Wood et al. (2003), may be present, there is no contact within this gravel unit that can be identified between the lower Hanford formation Unit 3 and the CCU. If the CCU is present, it is not clearly defined.

Furthermore hydrologic testing produced hydraulic conductivities ranging from 6,200 to 22,600 feet per day for the gravels in the aquifer. These high values are indicative of the open, highly permeable lower Hanford gravels of the H3. This interpretation is in agreement with Martinez (2003) and Narbutovskih and Horton (2001). There is no indication that Ringold Formation sediments were encountered. The top of basalt is at total borehole depth at 268 feet bgs. The field geologist's detailed borehole log, along with the well construction summary report, as-built diagram, well development and pump installation records, and well survey results are included in Appendix A. A more detailed hydrogeologic interpretation of the borehole sediments is included in Section 9.0.

The borehole and drill cuttings were monitored regularly for organic vapors, ammonia, and radionuclide contaminants (i.e., alpha, beta, and gamma). Radionuclide monitoring indicated the presence of background levels. Ammonia was detected at several intervals (see borehole log in Appendix A). Spectral gamma ray logs were run on September 8, 2003, by Stoller Corporation. A slight amount of cesium-137, near the minimum detection level (MDL, 0.3 pCi/g), was found sporadically throughout the borehole (Appendix C). Section 7.0 provides more details of this logging.

2.2 Well Completion

The permanent casing and screen were installed in well 299-E27-22 in September 2003. A 40-foot long, 4-inch inside diameter (ID), stainless steel, continuous wire-wrap 20 slot (0.02-inch slot) screen was set from 268.02 feet to 228.05 feet bgs. There is no sump below the screen in this well because the design required the screen to be placed directly on top of the basalt to maximize the length of the sample interval. The permanent well casing is 4-inch ID, stainless steel from 228.05 feet bgs to 2 feet above ground surface.

The screen filter pack is composed of 10-20 mesh silica sand placed from 268 to 225.8 feet bgs, and 4-8 mesh filter pack sand placed from 225.8 to 222.5 feet bgs. The annular seal is composed of 1/4-inch bentonite pellets from 222.5 feet to 217.2 feet bgs and granular bentonite crumbles from 217.2 feet to 10 feet bgs. The surface seal is composed of Portland cement grout from 10 feet bgs to ground surface. A 4-foot by 4-foot by 6-inch concrete pad was placed around the well at the surface. A protective well head casing with locking cap, four protective steel posts, and a brass marker stamped with the well identification number and Hanford well number were set into the concrete pad.

Approximately 170 feet of 1/4-inch galvanized carbon steel tremie pipe was lost between the borehole wall and the casing during installation of the bentonite seal material. The well was constructed with the tremie pipe left in the borehole annulus, located from 47 to 217 feet bgs, and sealed in the bentonite. The bottom end of the pipe is approximately 13 feet above the water table. The Washington State Department of Ecology was informed of the nonconformance (NCR # WMP-GPP-03NCR-010) and approved the design. The Well Construction Summary Report, Well Summary Sheet (as-built), construction variance and nonconformance report are included in Appendix A.

A vertical borehole survey was conducted using a downhole gyroscope in the completed well to determine the bottom location relative to the vertical projection. Survey results are discussed in Section 8.0 and located in Appendix C.

The vertical and horizontal coordinates of the well were surveyed by Fluor Federal Services on October 31, 2003. The horizontal position of the well was referenced to horizontal control stations established by the U.S. Army Corps of Engineers (USACE). The coordinates are Washington Coordinate System, South Zone, NAD83(91) datum. Vertical datum is NAVD 1988 and is based on existing USACE bench marks. Survey data are included in Table 1 and Appendix A. The static water level was 230.46 feet bgs on September 10, 2003.

Table 1. Survey Data for Four New RCRA Wells at WMA C

Well Name (Well ID)	Easting (meters)	Northing (meters)	Elevation (meters)	Comments
299-E27-22 (C4124)	575185.10	136685.33		Center of casing
			193.383	Top of casing, N. edge
			192.604	Brass survey marker
			193.389	Top pump base plate, N. edge
299-E27-4 (C4125)	575032.02	136497.92		Center of casing
			205.569	Top of casing, N. edge
			204.685	Brass survey marker
			205.575	Top pump base plate, N. edge
299-E27-21 (C4127)	575145.03	136407.21		Center of casing
			205.728	Top of casing, N. edge
			204.995	Brass survey marker
			205.734	Top pump base plate, N. edge
299-E27-23 (C4190)	575069.46	136452.23		Center of casing
			206.563	Top of casing, N. edge
			205.661	Brass survey marker
			206.569	Top pump base plate, N. edge
NOTES: Horizontal Datum is NAD83 (91); Vertical Datum is NAVD88; Washington State Plane Coordinates (South Zone); surveyed October 31, 2003.				

2.3 Well Development and Pump Installation

Well 299-E27-22 was developed on September 12, 2003 at three different intervals using a temporary, 5-horsepower submersible pump. The depth to water was measured at 233.69 feet below top of casing (btc) prior to development. A pressure transducer was installed above the pump and connected to a Hermit datalogger to monitor water level during development. A total of 3521 gallons of water were pumped. Table 2 contains the well development results, including pump intake depth, pump rate, pump run time, drawdown, recovery time, final turbidity (NTU) and stabilized conductivity and temperature readings.

A dedicated Redi-Flo-2, 0.5-horsepower Grundfos™ submersible sampling pump was installed in well 299-E27-22 on September 19, 2003. The sampling pump intake was set at 240.96 feet (btc), approximately 7.3 feet below the water table, and connected to the surface with 3/4-inch diameter stainless steel riser pipe.

Table 2. Well Development Information for Well 299-E27-22

Pump Rate	Pump Intake Depth (ft btc)	Pumping Run Time	Drawdown (ft)	Final Turbidity Readings	Recovery Test Time
25 gpm	264.5	60 min	0.27	1.08 NTU, 504 µs/cm, 20.7 C	NA
24 gpm	255.5	43 min	0.39	0.97 NTU, 490 µs/cm, 20.3 C	9 min (100%)
23 gpm	243.3	43 min	0.44	2.31 NTU, 476 µs/cm, 20.2 C	12 min (100%)

ft btc = Feet below top of casing.
gpm = Gallons per minute.
NTU = Nephelometric turbidity unit.
µs/cm = micro siemens per centimeter.

3.0 Well 299-E27-4

Well 299-E27-4 (C4125) is located to the southwest of the 241-C tank farm. The well is downgradient of WMA C and will help differentiate upgradient groundwater contamination from potential contaminants released at the WMA.

3.1 Drilling and Sampling

Well 299-E27-4 (well ID C4125) was drilled with a hollow stem auger from 0 to 30 feet bgs and with a Becker-hammer rig from ~30 feet bgs to a total depth of 311 feet bgs. Temporary 9-inch outside diameter (OD), dual-wall casing was used below the 30-foot temporary casing for drilling throughout the borehole to total depth. Drilling began on August 12, 2003, and total depth was reached on August 14, 2003.

Grab samples of sediment for geologic description, digital photography and archives were collected at approximately 5-foot intervals from ground surface to total depth. Also, two grab samples were collected from the proposed screen interval at ~270 feet bgs and ~302 bgs for sieve analysis to confirm screen selection. The sieve analysis data and distribution curves are in Appendix B.

Sediments encountered during drilling were predominantly unconsolidated sands to gravelly sands of the Hanford formation beginning at ~22 feet bgs to about 239 feet bgs. Above the Hanford formation are recent deposits. The sandy gravel to gravel of the lower Hanford H3 unit and possibly the CCU comprise the sediments from approximately 239 feet bgs to 311 feet bgs at total depth. Neither Ringold Formation sediments nor basalt were encountered. The field geologist's detailed borehole log, along with the well construction summary report, as-built diagram, well development data, pump installation records and well survey results are included in Appendix A.

The borehole and drill cuttings were monitored regularly for organic vapors, ammonia, and radio-nuclide contaminants (i.e., for alpha, beta, and gamma). Radionuclide monitoring indicated that alpha, beta and gamma readings were below background levels but ~2 parts per million (ppm) of ammonia were detected at 19 feet bgs (see borehole log in Appendix A). A spectral gamma ray log, run on August 15

and 16, 2003, by Stoller Corporation indicate that a slight amount of cesium-137 near the MDL (0.3 pCi/g) was detected sporadically throughout the borehole (Appendix C). Section 7.0 provides more details of this logging.

3.2 Well Completion

The permanent casing and screen were installed in well 299-E27-4 in August 2003. A 35-foot, 4-inch ID stainless steel, continuous wire-wrap 20 slot (0.02-inch slot) screen was set from 305.33 feet to 270.32 feet bgs with a 2-foot long stainless steel sump placed from 307.76 to 305.33 feet bgs. The permanent well casing is 4-inch ID, stainless steel from 270.32 feet bgs to 1.9 feet above ground surface.

The screen filter pack is 10-20 mesh silica sand placed from 309 to 264.4 feet bgs. The annular seal is composed of 1/4-inch bentonite pellets from 264.4 to 259 feet bgs and bentonite crumbles from 259 to 9.9 feet bgs. The surface seal is composed of Portland cement grout from 9.9 feet bgs to ground surface. A 4-foot by 4-foot by 6-inch concrete pad was placed around the well at the surface. A protective well head casing with locking cap, four protective steel posts, and a brass marker stamped with the well ID number and Hanford well number were set into the concrete pad. During well construction, a stainless steel weight used for tagging and measuring the fill level in the annulus was lost in the borehole at approximately 309 feet bgs. The weight was not recovered and remains in the annulus. The Well Construction Summary Report and Well Summary Sheet (as-built) are included in Appendix A. A borehole deviation survey using a gyroscope was conducted in the completed well to determine the bottom hole location relative to the vertical borehole projection. Survey results are discussed in Section 8.0 and located in Appendix C.

The vertical and horizontal coordinates of the well were surveyed by Fluor Federal Services on October 31, 2003. The horizontal position of the well was referenced to horizontal control stations established by the USACE. The coordinates are Washington Coordinate System, South Zone, NAD83(91) datum. Vertical datum is NAVD 1988 and is based on existing USACE bench marks. Survey data are included in Table 1 and Appendix A. The static water level was 270.65 feet bgs on August 20, 2003.

3.3 Well Development and Pump Installation

Well 299-E27-4 was developed on September 11 and 12, 2003. Development was performed at three different intervals using a temporary, 5-hp submersible pump. The depth to the water was 274.29 feet btc prior to development. A pressure transducer was installed above the pump and connected to a Hermit datalogger to monitor water level during development. Table 3 contains the results of final well development, including pump intake depth, pump rate, pump run time, drawdown, recovery time, final turbidity and stabilized conductivity and temperature readings. A total of 5,100 gallons of water were pumped.

A dedicated Redi-Flo-3, 0.7 hp, Grundfos™ submersible sampling pump was installed in well 299-E27-4 on September 19, 2003. The sampling pump intake was set ~6.9 feet below the water table at 281.11 feet btc and connected to the surface with ¾-inch diameter stainless steel riser pipe.

Table 3. Well Development Information for Well 299-E27-4

Pump Rate	Pump Intake Depth (ft btc)	Pumping Run Time	Drawdown (ft)	Final Turbidity Readings	Recovery Test Time
27 gpm	304.4	70 min	<0.1	3.20 NTU, 516 μs/cm, 19.5 C	10 min (100%)
26 gpm	295.4	50 min	<0.1	0.74 NTU, 452 μs/cm, 20.1 C	10 min (100%)
28 gpm	283.3	70 min	<0.1	1.16 NTU, 403 μs/cm, 18.4 C	15 min (100%)

ft btc = Feet below top of casing.
gpm = Gallons per minute.
NTU = Nephelometric turbidity unit.
μs/cm = micro siemens per centimeter.

4.0 Well 299-E27-21

Well 299-E27-21 (well ID C4127) is located south of the WMA C tank farm. The well is down-gradient of WMA C and will help differentiate upgradient groundwater contamination from potential contaminants released at the WMA.

4.1 Drilling and Sampling

Well 299-E27-21 (well ID C4127) was drilled with a Becker-hammer rig from surface to a total depth of 318 feet bgs. Temporary 9-inch OD, dual-wall casing was used for drilling throughout the borehole to total depth. Drilling began on July 10, and total depth was reached on July 21, 2003.

Grab samples of sediment for geologic description, digital photography and archives were collected at approximately 5-foot intervals from ground surface to total depth. Also, two grab samples were collected from the proposed screen interval from 277 to 280 feet bgs and from 312 to 315 feet bgs for sieve analysis to confirm screen selection. The geologist's borehole log is included in Appendix A. Sieve analysis results and distribution curves are located in Appendix B.

Sediments encountered during drilling were predominantly unconsolidated sand to gravelly sand of the Hanford formation from ~1 feet bgs to about 246 feet bgs. Above the Hanford formation are recent deposits. The sandy gravel to gravel of the lower Hanford H3 unit and possibly the CCU comprises the sediments from approximately 246 feet bgs to 318 feet bgs at total depth. Neither Ringold Formation sediments nor basalt were found in this borehole. The field geologist's detailed borehole log, along with the well construction summary report, as-built diagram, well development and pump installation records, and well survey results are included in Appendix A.

The borehole and drill cuttings were monitored regularly for organic vapors, ammonia and gamma-emitting radionuclides. Radionuclide monitoring indicated that gamma readings were at background levels, and no organics or ammonia was detected (see borehole log in Appendix A). The well was logged with a spectral gamma ray tool on July 21 and 22, 2003, by Stoller Corporation. Logging results showed

a slight amount of cesium-137 near the MDL sporadically throughout the borehole (Appendix C). Section 7.0 provides information on the spectral gamma data collected in the borehole.

4.2 Well Completion

The permanent casing and screen were installed in well 299-E27-21 in July 2003. A 35-foot, 4-inch ID stainless steel, continuous wire-wrap 20 slot (0.02-inch) screen was set from 306.43 feet to 271.37 feet bgs. Below the screen interval there is a 2-foot stainless steel sump extending from 308.83 to 306.43 feet bgs. The permanent well casing is 4-inch ID, stainless steel from 271.37 feet bgs to 2 feet above ground surface.

The screen filter pack is 4-8 mesh silica sand placed from 318 to 314 feet bgs, and 10-20 mesh silica sand placed from 314 to 265.5 feet bgs. The annular seal is composed of 1/4-inch bentonite pellets from 265.5 to 260.4 feet bgs and bentonite crumbles from 260.4 to 10.1 feet bgs. The surface seal is composed of Portland cement grout from 10.1 feet bgs to ground surface. A 4-foot by 4-foot by 6-inch concrete pad was placed around the well at the surface. A protective well head casing with four protective steel posts and a brass marker were set into the concrete pad. The brass marker is stamped with the well identification number and the Hanford well number. The well head has a locking cap. The Well Construction Summary Report and Well Summary Sheet (as-built) are included in Appendix A.

A borehole deviation survey, using a downhole gyroscope, was conducted in the completed well to determine the bottom hole location relative to a vertical borehole projection. Survey results are discussed in Section 8.0 and located in Appendix C.

The vertical and horizontal coordinates of the well were surveyed by Fluor Federal Services on October 31, 2003. The horizontal position of the well was referenced to horizontal control stations established by the USACE. The coordinates are Washington Coordinate System, South Zone, NAD83(91) datum. The vertical datum is NAVD 1988 and is based on existing USACE bench marks. Survey data are included in Table 1 and Appendix A. The static water level was 271.38 feet bgs on July 25, 2003.

4.3 Well Development and Pump Installation

Well 299-E27-21 was developed on August 28, 2003 at three different intervals using a temporary, 5-hp submersible pump. The depth to water was 274.56 feet btc prior to development. A pressure transducer, installed above the pump and connected to a Hermit datalogger, monitored the water level during development. Table 4 contains the data from the well development, including pump intake depth, pump rate, pump run time, drawdown, recovery time, final turbidity and stabilized conductivity and temperature readings. A total of 3,879 gallons of water were pumped.

A dedicated Redi-Flo-3, 0.7 hp, Grundfos™ submersible sampling pump was installed in well 299-E27-21 on September 18, 2003. The sampling pump intake was set at 281.10 feet btc, which is ~6.6 feet below the water table. It was connected to the surface with a 3/4-inch diameter stainless steel riser pipe.

Table 4. Well Development Information for Well 299-E27-21

Pump Rate	Pump Intake Depth (ft btc)	Pumping Run Time	Drawdown (ft)	Final Turbidity Readings	Recovery Test Time
23 gpm	306.7	63 min	<0.1	1.24 NTU, 376 μs/cm, 20.0 C	7 min (100%)
23.5 gpm	297.7	48 min	<0.1	1.64 NTU, 363 μs/cm, 20.2 C	<5 min (100%)
21 gpm	285.6	62 min	<0.1	1.83 NTU, 353 μs/cm, 20.7 C	<5 min (100%)

ft btc = Feet below top of casing.
gpm = Gallons per minute.
NTU = Nephelometric turbidity unit.
μs/cm = micro siemens per centimeter.

5.0 Well 299-E27-23

Well 299-E27-23 (well ID C4190) is located southwest of the WMA C tank farm and south of existing well 299-E27-13. Located downgradient of WMA C, this well will help differentiate upgradient groundwater contamination from potential contaminants released at the WMA. This well was drilled as an offset replacement to the originally proposed well 299-E27-20 (C4126) that was decommissioned after drilling refusal occurred at 278.5 feet bgs. Drilling information on this decommissioned borehole is included in Appendix A.

5.1 Drilling and Sampling

Well 299-E27-23 (well ID C4190) was drilled with a Becker-hammer rig from surface to a total depth of 318 feet bgs. The borehole was drilled approximately 45 feet into the unconfined aquifer. Temporary 9-inch OD, dual-wall casing was used during drilling to total depth. Drilling was completed in one day on August 5, 2003.

Grab samples of sediment for geologic description, digital photography and archives were collected at approximately 5-foot intervals from ground surface to total depth. Also, two grab samples were collected from the proposed screen interval for sieve analysis to confirm screen selection. One sample was from decommissioned borehole 299-E27-20 at ~275 feet bgs, and one was from 299-E27-23 at ~310 bgs. The field geologist's detailed borehole log, along with the well construction summary report, as-built diagram, well development and pump installation records, and well survey results are included in Appendix A. A more detailed hydrogeologic interpretation of the borehole sediments is included in Section 9.0. Sieve analysis results and distribution curves are located in Appendix B.

Sediments found during drilling were predominantly unconsolidated sand to gravelly sand of the Hanford formation from 10 feet bgs to about 245 feet bgs. Above the Hanford formation are recent deposits. The sandy gravels to gravels of the lower Hanford H3 unit and possibly the CCU comprise the sediments from approximately 245 feet bgs to 318 feet bgs, which is the total well depth. Neither Ringold Formation sediments nor basalt were encountered.

The borehole and drill cuttings were monitored regularly for organic vapors, ammonia, and radio-nuclide contaminants (alpha, beta, gamma). Ammonia was detected to a depth of ~110 feet bgs ranging from 0 to 5 ppm. No man-made radiological contamination was detected. The well was logged with a spectral gamma tool on August 7 and 8, 2003, by Stoller Corporation (see Section 7.0 and Appendix C).

5.2 Well Completion

The permanent casing and screen were installed in well 299-E27-23 in August 2003. A 35-foot, 4-inch ID stainless steel, continuous wire-wrap, 20 slot (0.02-inch) screen was set from 308.54 feet to 273.51 feet bgs. Below the screen interval there is a 2-foot stainless steel sump from 310.97 to 308.54 feet bgs. The permanent well casing is 4-inch ID, stainless steel from 273.51 feet bgs to 1.8 feet above ground surface.

The screen filter pack is 10-20 mesh silica sand placed from 318 to 267.8 feet bgs. The annular seal is composed of 1/4-inch bentonite pellets from 267.8 to 263 feet bgs and granular bentonite from 263 to 9.9 feet bgs. The surface seal is composed of Portland cement grout from 9.9 feet bgs to ground surface. A 4-foot by 4-foot by 6-inch concrete pad was placed around the well at the surface. A protective well head casing with a locking cap, four protective steel posts, and a brass marker stamped with the well ID number and Hanford well number were set into the concrete pad. The Well Construction Summary Report and Well Summary Sheet (as-built) are included in Appendix A.

A vertical borehole survey using a gyroscope was conducted in the completed well to determine the bottom hole location relative to a vertical borehole projection. Survey results are discussed in Section 8.0 and located in Appendix C.

The elevation and location coordinates of the well were surveyed by Fluor Federal Services on October 31, 2003. The horizontal position of the well was referenced to horizontal control stations established by the USACE. The coordinates are Washington Coordinate System, South Zone, NAD83(91) datum. Vertical datum is NAVD 1988 and is based on existing USACE bench marks. Survey data are included in Table 1 and Appendix A. The static water level was 273.1 feet bgs on August 12, 2003.

5.3 Well Development and Pump Installation

Well 299-E27-23 was developed on September 2, 2003 at three different intervals using a temporary, 5-hp submersible pump. Depth-to-water level was measured at 276.52 feet btc prior to development. A pressure transducer was installed above the pump and connected to a Hermit datalogger to monitor water level during development. Table 5 contains the results of final well development, including pump intake depth, pump rate, pump run time, drawdown, and recovery time. Final turbidity, electrical conductivity, dissolved oxygen content, pH and temperature readings are also reported. A total of 3,624.5 gallons of water were pumped.

A dedicated Redi-Flo-3, 0.7 hp, Grundfos™ submersible sampling pump was installed in well 299-E27-23 on September 18, 2003. The sampling pump intake was set at 281.11 feet btc, which is about 4.7 feet below the water table. The riser pipe is 3/4-inch diameter stainless steel.

Table 5. Well Development Information for Well 299-E27-23

Pump Rate	Pump Intake Depth (ft btc)	Pumping Run Time	Drawdown (ft)	Final Turbidity Readings	Recovery Test Time
26 gpm	311.3	57 min	0.14	3.93 NTU, 4.46 mg/L DO, 409 µs/cm, 7.86 pH, 20.2 C	15 min (99.6%)
26 gpm	301.3	30 min	0.03	0.74 NTU, NA DO, NA µs/cm, NA pH, NA C	8 min (100%)
6 gpm	291.3	78 min	0.63	3.00 NTU, 3.23 mg/L DO, 381 µs/cm, 7.91 pH, 22.1 C	NA

ft btc = Feet below top of casing. DO = Dissolved Oxygen.
gpm = Gallons per minute. NA = Not available.
NTU = Nephelometric turbidity unit. C = temperature in degrees centigrade.
µs/cm = micro siemens per centimeter.

6.0 Sampling and Analysis During Drilling

This section describes the collection and analysis of sediment and water samples collected during drilling from wells 299-E27-22, 299-E27-4, 299-E27-23, 299-E27-21, and 299-E27-20, which is the decommissioned well.

6.1 Field Screening

The drill cuttings from all the wells were screened in the field for volatile organic and combustible and/or hazardous gas contamination, beta-gamma activity and alpha activity by radiation control technicians (RCT) and site safety staff. Subsurface spectral gamma logs were also evaluated for gamma-emitting contaminants, and details are discussed in Section 7.0.

Radiation screening of drill cuttings from well 299-E25-93 revealed beta and gamma readings slightly above background in a few intervals. Alpha radiation was also detected but determined to be radon. Radiation screening of cuttings from the other wells revealed only background levels. No actions were required. The cuttings were also screened for volatile organics and other potential hazardous gases using an Organic Vapor Monitor (OVM) photo-ionization detector, an Ammonia Monitor, and a Multi Gas / Combustible Gas Monitor. Ammonia was detected sporadically up to 25 ppm in wells 299-E27-22, 299-E27-4 and 299-E27-23. No action was required. Results of field screening for radiation and gases during drilling are indicated on the geologist's borehole logs in Appendix A.

6.2 Sediment and Groundwater Sampling

Sediment samples were collected for geologic description, digital photography, and the soil archives from all four boreholes at 5-foot intervals from ground surface to total depth. The geologic descriptions of these samples are contained in the wellsite geologist's borehole logs in Appendix A. The archive grab samples are contained in 1-pint glass jars, labeled by depth and well number. These jars are stored in the HGSL, which is located at Building 3718A/B in the 300 Area. In addition to the archived jars, sediment

grab samples from each 5-foot depth interval were placed in 1-inch by 2-inch plastic sample trays to create a digital photographic log for each well. These small trays do not include the coarser grain size from the gravels. These digital photographic logs are with the composite logs in Section 9.5. All sediment sample depths and/or intervals are documented in the geologist's borehole logs, located in Appendix A.

Continuous or near continuous core samples were recovered from the vadose zone in borehole 299-E27-22 to provide baseline sediment chemistry data for comparison to potentially contaminated boreholes located inside WMA C tank farm. The core was recovered using a 4-inch ID split spoon sampler that is approximately 2.25 feet long. One hundred and fifteen core samples were collected in one-foot long lexan liners then sealed and labeled. These samples were delivered to the Radiochemical Processing Laboratory in the 325 Building for storage and analysis. The core interval is documented in the borehole log in Appendix A and on the composite log (Figure 6) for well 299-E27-22 in Section 9.5. Chain of custody forms for core transfer to the lab, the detailed core log and selected digital photographs of several cores are located in Appendix B.

Prior to well completion two sediment grab samples were collected from the proposed screen interval in each borehole except for well 299-E27-23. One sample was taken from well 299-E27-23 and another from well 299-E27-20, the nearby well that was not completed because of bit refusal. All of these samples were sieved for particle size distribution to provide data for screen slot size confirmation/ selection. Sieve data and distribution curves are available in Appendix B.

Groundwater samples were collected in borehole 299-E27-22 from five intervals to coincide with depth-discrete aquifer testing as the borehole was drilled below the water table. Water was circulated to the surface for collection from the cuttings return line. Each sample interval was isolated below a packer to isolate the sample interval from the shallower saturated zone within the borehole. The samples were analyzed in the field for conductivity, nitrate (TNT Hach Kit method), technetium-99 (3-M filter disk screening method), and pH. Samples from the same depths were also analyzed by inductively coupled plasma-mass spectroscopy (ICP-MS) for technetium-99 and uranium. Technetium-99 levels for all depths, using the ICP-MS method, were below the lower limit of quantitation of 426 pCi/L (0.025 μg/L). Values less that 80.1 pCi/L were identified with the 3-M filter method. The uranium values for all depths were below the natural background value of 3.43 μg/L reported in Johnson (1993). The analytical results are presented in Table 6 below. The water sample depths are also provided on the composite log of 299-E27-22 in Section 9.0.

Table 6. Depth-Discrete Water Sample Results for Well 299-E27-22 (C4124)

Sample No.	Sample Date	Depth bgs (ft)	Cond μS/cm	pH	nitrate mg/L	Tc-99 (3-M) pCi/L	Tc-99 (ICP-MS) pCi/L	Uranium μg/L
E22-27-22	9/3/2003	239.5-242.5	447	ND	14.2	10.9	U	BG
E36-27-22	9/4/2003	247-250	412	8.11	16.2	U	U	BG
E12-27-22	9/4/2003	252-254	429	7.95	18.4	14	U	BG
E33-27-22	9/5/2003	260	439	7.98	20.1	38.5	U	BG
E14-27-22	9/5/2003	268	563	8.01	31.1	80.1	U	BG
U = undetected. BG = below uranium natural background level of 3.43 μg/L.								

7.0 Spectral Gamma Ray Logging

A high resolution spectral gamma-ray survey was conducted in each borehole by Stoller Corporation to determine the presence and concentration of man-made and naturally occurring gamma-emitting radionuclides in the surrounding sediments. Survey measurements were made at a "move-stop-acquire" mode at a rate of 100 seconds per foot. Neutron-moisture logging was not completed because a dual-wall casing was used during drilling which has a casing thickness that is too large for the calibrated neutron moisture tool. The geophysical logs have been evaluated and correlated to the geologic log data for each borehole and the results are presented in the composite logs in Section 9.5. The full suite of geophysical logs for each well, including the detailed log data reports are provided in Appendix C. The log reports describe calibration requirements, data processing, and log plots.

Well 299-E27-22 (C4124) was logged on September 8, 2003 using the gamma-ray tool from ground surface to 266.45 feet bgs inside temporary dual-wall carbon steel casing with an approximate outside diameter of 9 inches. A repeat section was run from 31.45 to 4.45 feet bgs. As reported by Stoller Corporation, cesium-137 was the only gamma-emitting man-made radionuclide detected during geophysical logging. The cesium-137 was detected at a few sporadic locations in the borehole near the 0.2 pCi/g MDL.

In well 299-E27-4 (C4125), logged on August 15 and 16, 2003, the gamma-ray tool was run from below the 11-inch diameter temporary surface casing from 25 feet bgs to a depth of 301 feet bgs within the nominal 9-inch diameter dual-wall temporary carbon steel casing. A repeat section was run from 121 to 90 feet bgs. As reported by Stoller Corporation, cesium-137 was the only gamma-emitting manmade radionuclide detected during geophysical logging. The cesium-137 was detected at a few sporadic locations in the borehole near the 0.2 pCi/g MDL.

In well 299-E27-21 (C4127), logged on July 21 and 22, 2003, the gamma ray tool was run from ground surface to a depth of 316 feet bgs within the nominal 9-inch diameter dual-wall temporary carbon steel casing. A repeat section was run from 142 to 110 feet bgs. As reported by Stoller Corporation, cesium-137 was the only gamma-emitting man-made radionuclide detected during geophysical logging. The cesium-137 was detected at a few sporadic locations in the borehole near the 0.2 pCi/g MDL.

In well 299-E27-23 (C4190), logged on August 7 and 8, 2003, the gamma ray tool was run from ground surface to a depth of 319 feet bgs within the nominal 9-inch diameter dual-wall temporary carbon steel casing. A repeat section was run from 147 to 115 feet bgs. As reported by Stoller Corporation, cesium-137 was the only gamma-emitting man-made radionuclide detected during geophysical logging. The cesium-137 was detected at 2 feet bgs and from 11 through 13 feet bgs with a maximum concentration of 0.6pCi/g. Cesium-137 was also detected from a few deeper intervals in the borehole near the 0.3 pCi/g MDL.

8.0 Borehole Gyroscope Survey

Downhole deviation surveys using a borehole gyroscope were performed in each well following construction to determine how plumb or vertical the well is and to determine the vertical and horizontal location coordinates of the total depth relative to the borehole surface location. These data are used to determine the extent of borehole deviations created during drilling. For this tool, depths are measured from the top of casing to the top of the tool when it is sitting on the bottom of the well. Three dimensional plots showing a hypothetical vertical well and the true attitude of each deviated well are provided in Figures 2 through 5 below. Further gyroscope information can be found in Appendix C.

In well 299-E27-22 (C4124), results show that at a measured cable depth of 257 feet, the true vertical depth of the well is 256.24 feet, a difference of 0.76 feet. In well 299-E27-4 (C4125), the measured cable depth is 297 feet while the true vertical depth of the well is 295.5 feet, a difference of 1.5 feet. In well 299-E27-21 (C4127), results indicate a measured cable depth of 297.5 feet and a true vertical depth of the well is 296.5 feet, a difference of 1.0 foot. In well 299-E27-23 (C4190), results indicate that at a measured cable depth of 300.5 feet, the true vertical depth of the well is 300.3 feet, a difference of 0.2 feet. Thus deviations from vertical result in depth errors ranging from 1.5 feet to 0.2 feet. These data may be used to correct depths to water levels.

9.0 Subsurface Characterization Results

Results from sediment and water sampling, physical property analysis, geologic logs, spectral gamma logs, well development and aquifer testing for each borehole are correlated to provide an interpretation of the geology at each borehole. This section includes a discussion of the criteria used to evaluate and interpret the data. The composite logs in Figures 6 through 9 illustrate the interpreted hydrogeology developed for each well. These interpretations are consistent with Martinez (2003), Narbutovskih and Horton (2001) and Williams et al. (2000).

9.1 Physical Properties

There was no analysis for physical properties conducted on samples from these wells except sieve analysis for particle size distribution from either grab or split spoon samples collected from the screen interval. Particle size distribution results are provided in Appendix B.

Grab samples collected at 5-foot-depth intervals are described on the geologist's borehole log located in Appendix A. The wellsite geologist's graphic representation of the borehole logs for the four wells are illustrated in composite logs (Figures 6 through 9). The sample quality and formation representativeness of the grab samples, and thus the borehole log descriptions, are limited due to the nature of the drilling. At greater than 250 feet per day, drilling rates were fast. Thus the airlifted return process for cuttings causes gravity separation of sediments based on grain size and density. This process may have mixed the sediment cuttings from different depth intervals before the cuttings reached the surface. When thin beds or sharp contacts were drilled, the returned sediments that were collected could not be completely

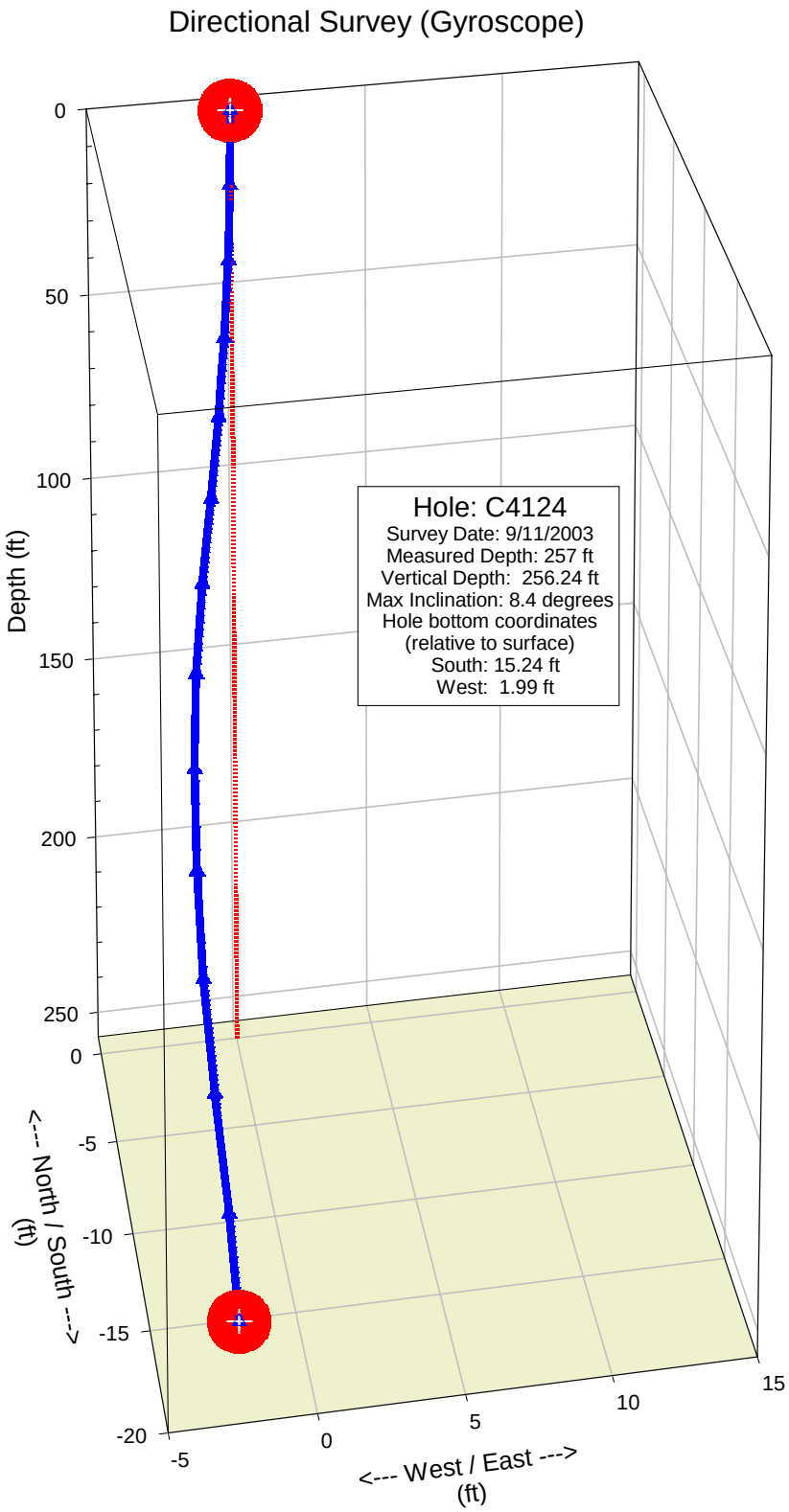


Figure 2. Vertical Profile and Bottom Hole Projections of Well 299-E27-22

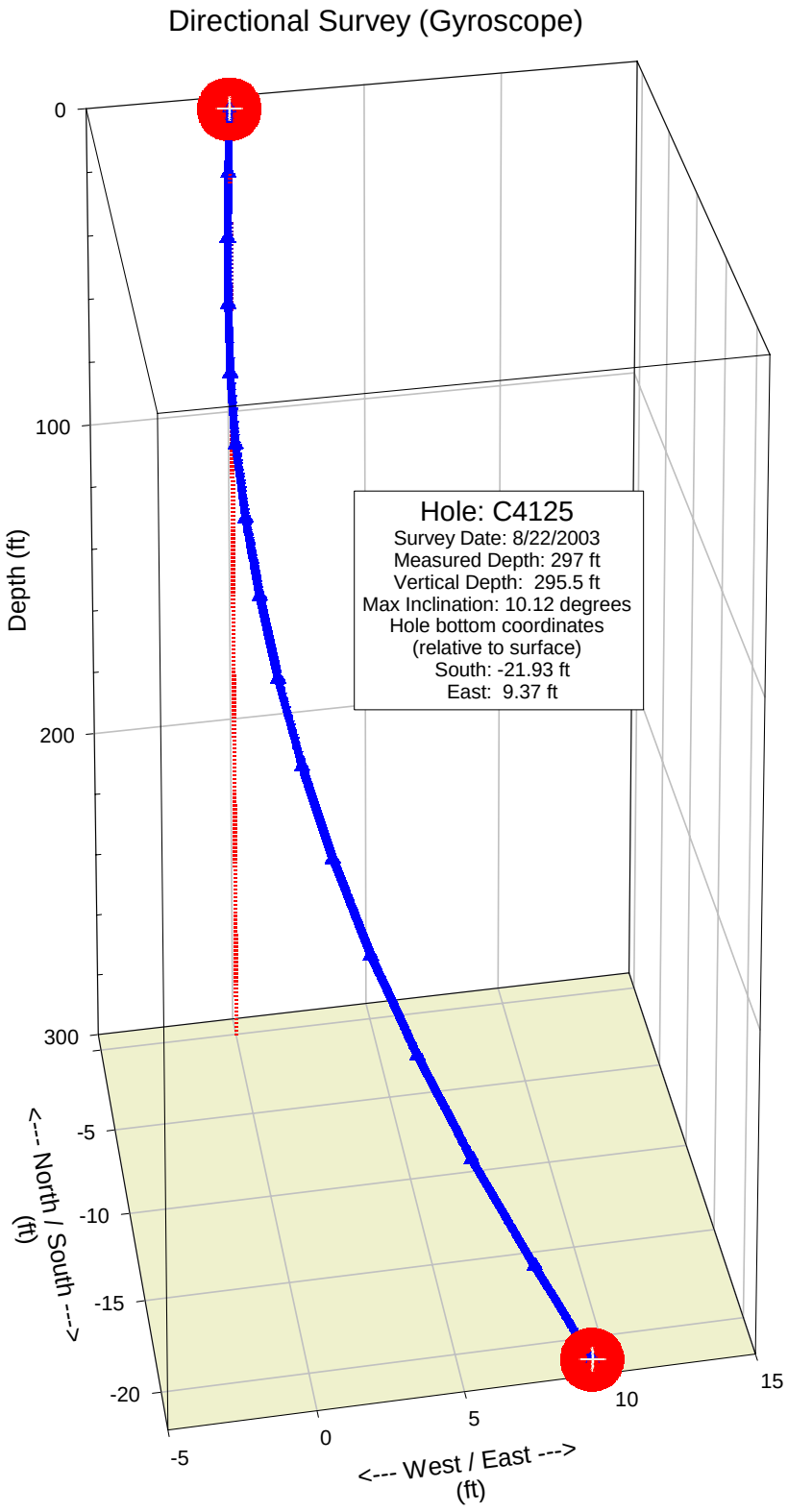


Figure 3. Vertical Profile and Bottom Hole Projections of Well 299-E27-4

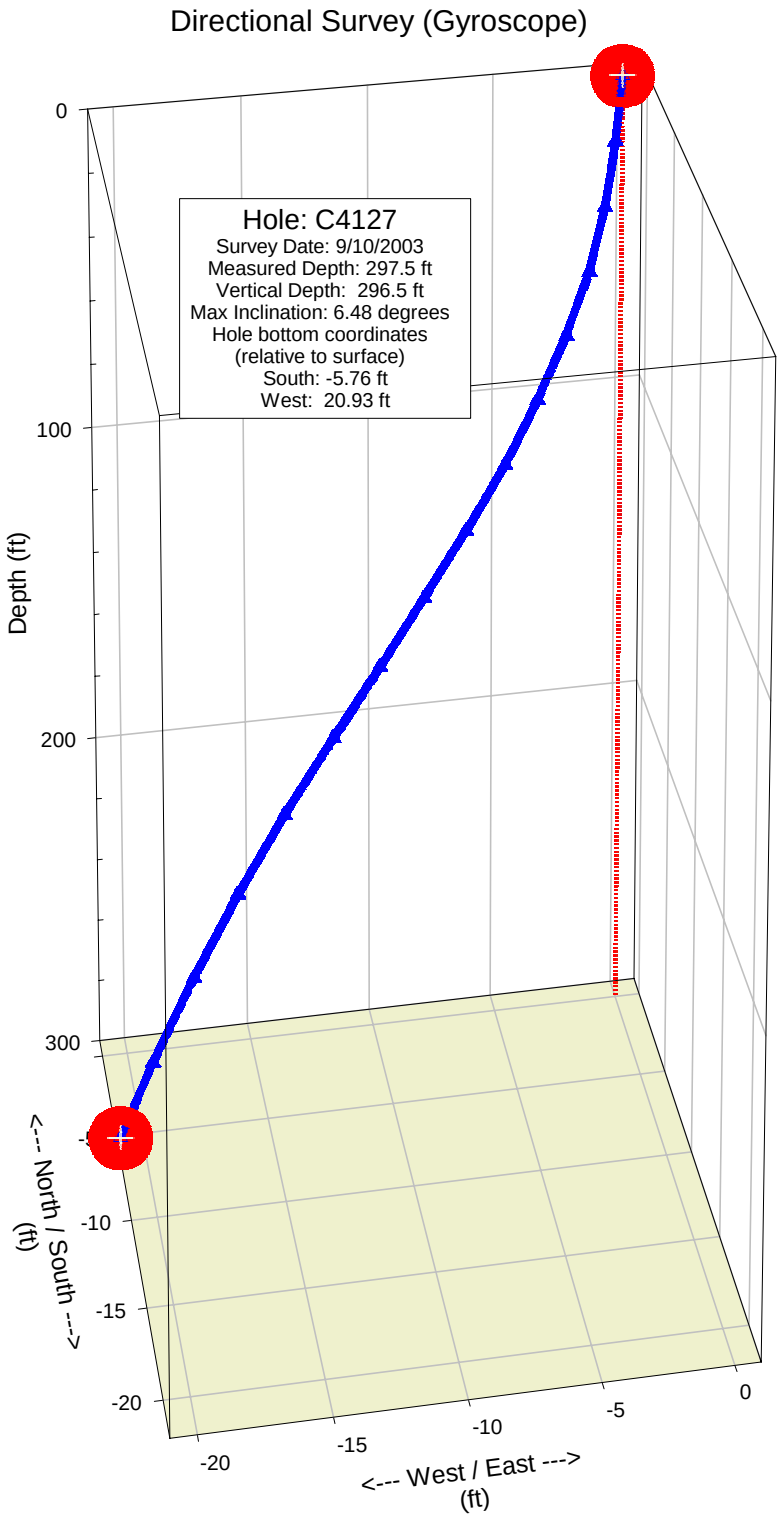


Figure 4. Vertical Profile and Bottom Hole Projections of Well 299-E27-21

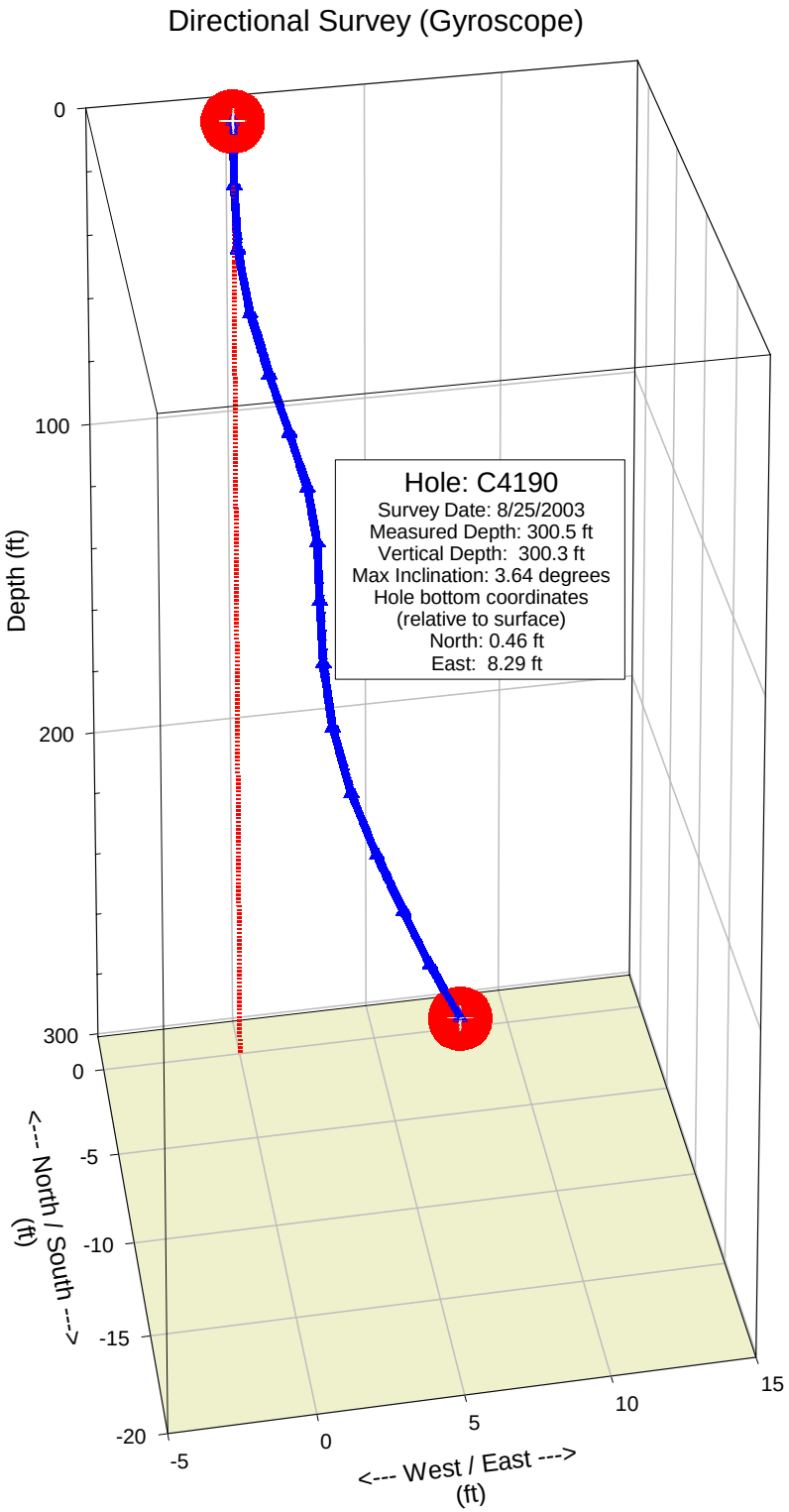


Figure 5. Vertical Profile and Bottom Hole Projections of Well 299-E27-23

correlated to their representative depth intervals. However, near-continuous cored intervals in well 299-E27-22 provide an accurate record of lithology and contacts.

The spectral gamma logs indicate the presence of sharp contacts and/or thin bed intervals that may not have been differentiated in the grab samples from the returned cuttings. Consequently lithologic changes are not always documented in the geologic borehole log for these wells. However, evidence they exist can be seen when comparing data from the vadose zone core recovered from well 299-E27-22 to the spectral gamma ray logs. Figure 6 is the composite log for 299-E27-22. The detailed core description, close-up digital core photographs and a detailed geologist's graphic log of the core illustrate these contacts and thin, or sharp lithologic changes. Detailed core log and digital core photographs are also in Appendix B. These changes are not visible on the graphic log or sample photographs that were generated from evaluating the grab samples from the drill cuttings. The spectral gamma ray logs have proven to be an important tool for identifying and accurately locating contacts and subtle lithologic changes that are important for stratigraphic correlations both within and between boreholes.

9.2 Sediment Digital Photographic Log

A digital photographic log of drill cuttings is included in each composite log for the wells (Figures 6 through 9). Grab samples from the cuttings return line were collected for lithologic descriptions documented in the borehole log in Appendix A, for sediment archives, and for digital photography. These photographic log presentations, compiled from 1-inch by 2-inch chip tray samples, collected at 5-foot depth intervals, provide a qualitative visual tool that reveals changes in major lithologic intervals (i.e., grain size, color, and relative moisture). The digital photographic logs provide a means to illustrate subsurface lithology and related hydrogeologic features. The interpretative value of these logs is limited by the sample collection technique, discussed earlier, and sample container size.

9.3 Spectral Gamma Ray Logging

Based on processing by Stoller Corporation, cesium-137 was the only man-made gamma-emitting radionuclide detected in the four wells (details in Appendix C). This contaminant is mainly near the surface in the boreholes but there are a few sporadic detections, near the MDL of 0.3 pCi/g deeper in the boreholes. In borehole 299-E27-23 (C4190), cesium-137 was detected with a maximum concentration of 0.6 pCi/g at 12 feet bgs. Appendix C provides more details about the cesium-137 detected in the boreholes.

These data are used in the geology interpretation presented in Section 9.5. No discussion of the shallow gamma ray inflections at less than 30 feet bgs is included because these inflections are difficult to correlate, reflecting dramatic changes due to shallow contamination, backfill materials, multiple casing strings, and/or recently deposited loose sediments.

For well 299-E27-22 (C4124), the gamma log plots of the naturally occurring gamma-emitting radionuclides (potassium, uranium, and thorium) indicate there are several distinct activity changes marked by inflection points at depths of ~48, 81, 141, 160, 185, 226, and 230 feet bgs. These major changes correlate to either lithologic features such as bedding contacts and/or thin contrasting lithologic intervals or the water table (Figure 6). The inflections at ~48, 81, 141, 160, 185, and 226 feet bgs

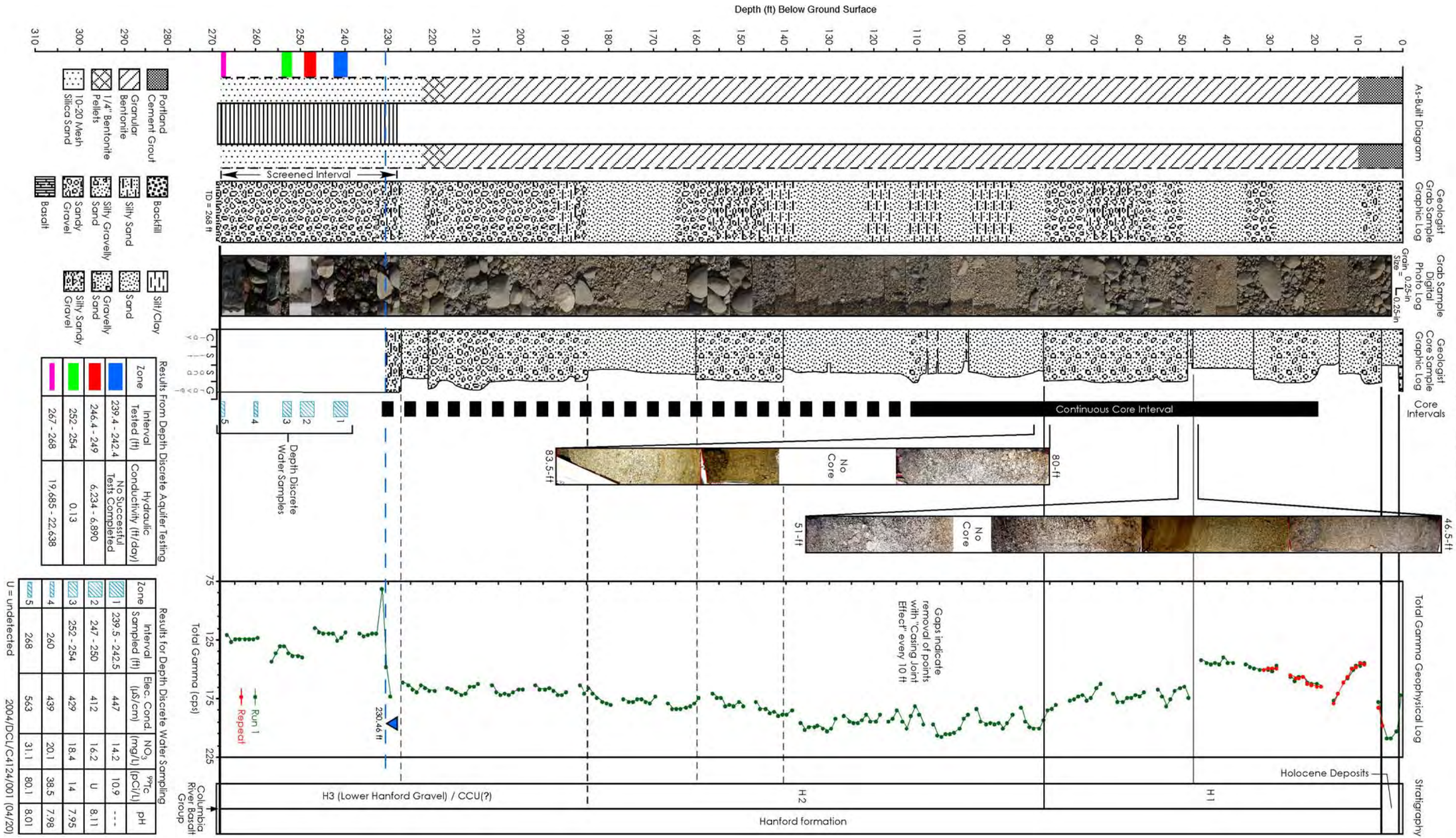


Figure 6. Hydrogeologic Interpretation for Well 299-E27-22 near Single-Shell Tank Farm WMA C

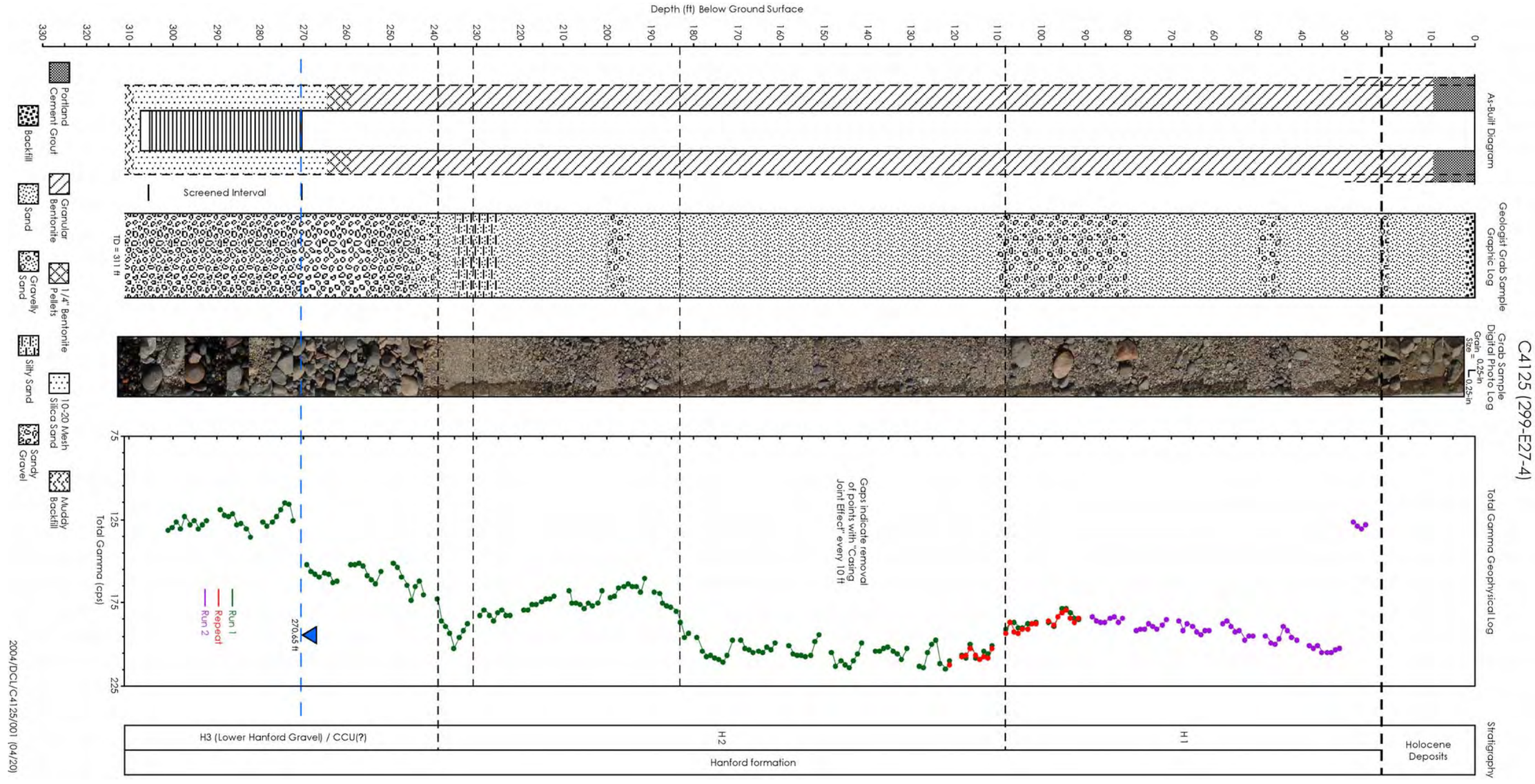


Figure 7. Hydrogeologic Interpretation for Well 299-E27-4 near Single-Shell Tank Farm WMA C

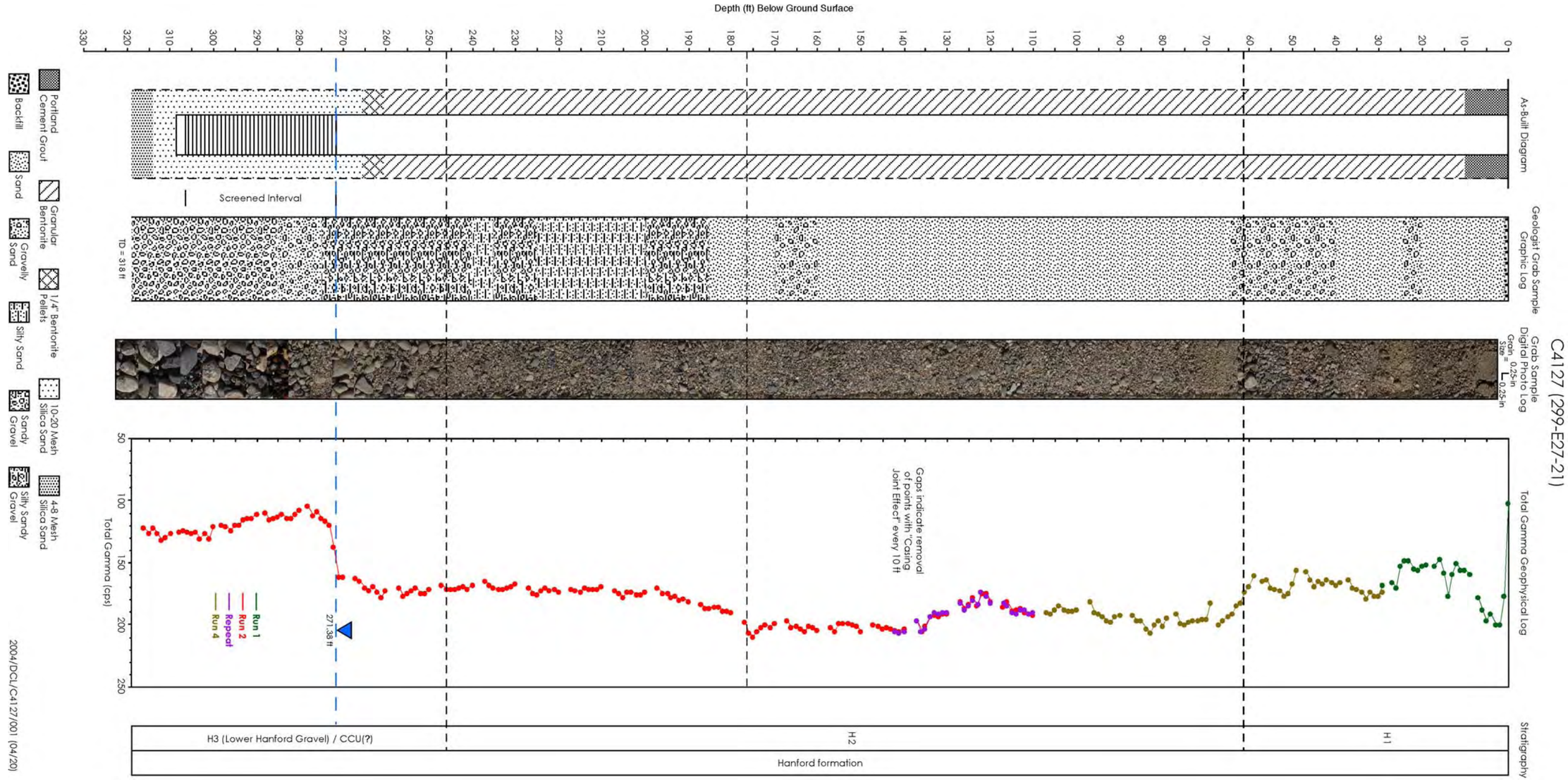


Figure 8. Hydrogeologic Interpretation for Well 299-E27-21 near Single-Shell Tank Farm WMA C

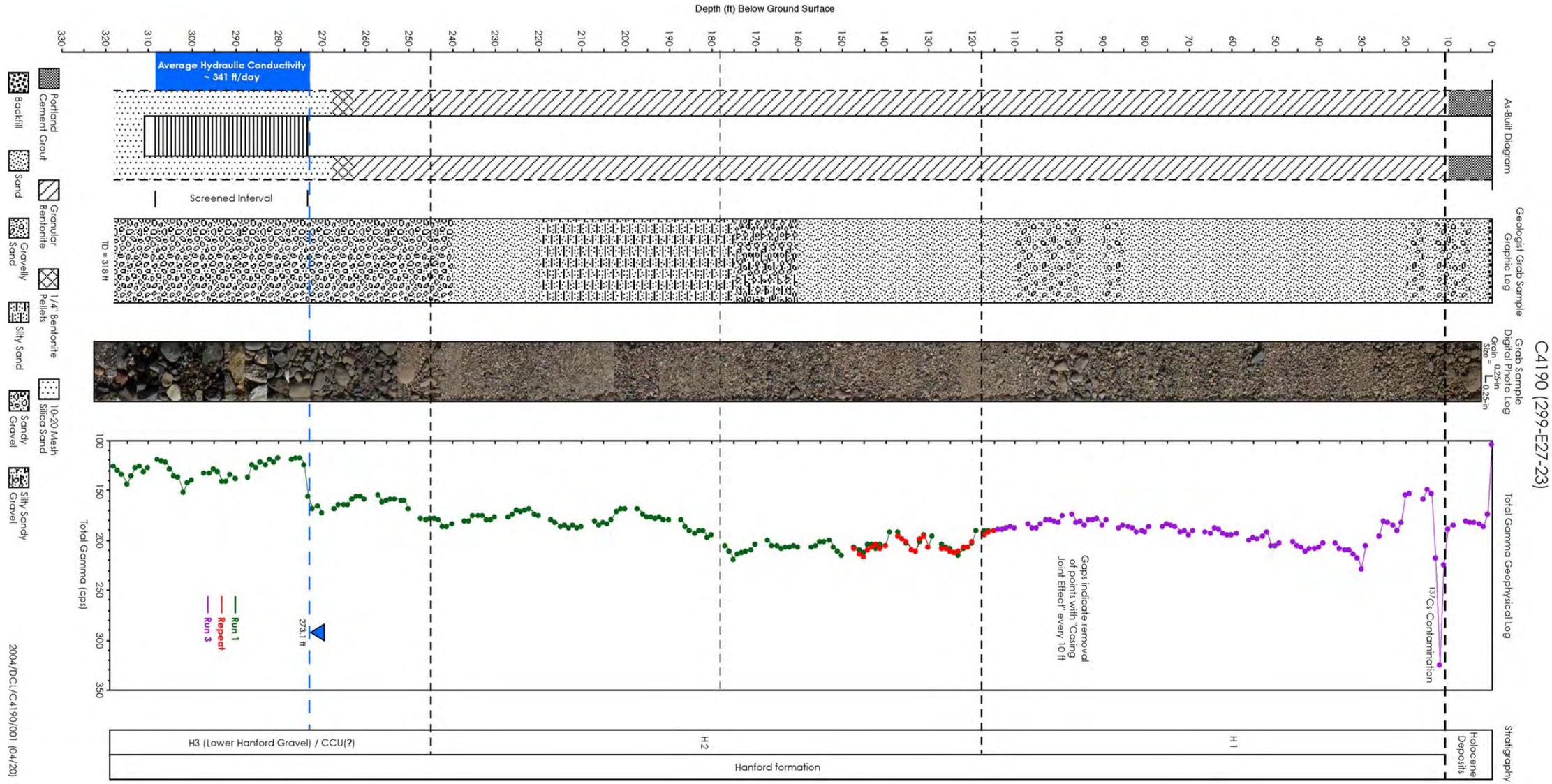


Figure 9. Hydrogeologic Interpretation for Well 299-E27-23 near Single-Shell Tank Farm WMA C

correspond to distinct lithologic changes identified in core samples from the borehole. For example, digital photographs of intact core samples collected from this well are included in the composite log to illustrate the nature of two of the inflections at ~48 and 81 feet bgs (Figure 6 and Appendix B). The cored contact at 48 feet is described as several inches of well-laminated, brown, silty, fine sand between gravelly sand below and grayish sand above. The upper and lower contacts on the finer-grained layer are sharp and distinct. In contrast, the 81-foot contact consists of 0.5 feet of weakly laminated, fine sand between layers of coarser, gravelly sand above and fine to coarse sand below. The upper contact is sharp while the lower contact is gradational. The inflections at 141, 160, 185, and 226 feet bgs reflect other lithologic changes that are visible on the composite log (Figure 6). A graphic log developed from the detailed core descriptions provides an additional comparison to the grab sample derived graphic log.

For well 299-E27-4 (C4125), geophysical log plots of naturally occurring radionuclides indicate several distinct inflection points at depths of ~108, 183, 231, 236, and 270 feet bgs. The inflections at 108 and 183 bgs correspond to changes in lithology similar to those discussed in the paragraph above. The inflections at 231 and 236 feet bgs and a high total gamma peak found at about 238 feet bgs correspond to a thick, fine sand/silt interval approximately 5 feet thick that is recognized in the digital photographic logs at those depths (Figure 7). The water table is located at the inflection at 270 feet bgs.

In the data for well 299-E27-21 (C4127), geophysical log plots of naturally occurring radionuclides indicate several distinct inflection points at depths of ~61, 178, and 271 feet bgs (Figure 8). The inflections at 61 and 178 feet bgs correspond to changes in lithology. The water table is seen at 271 feet bgs. Similarly for well 299-E27-23 (C4190), log plots of naturally occurring radionuclides indicate several distinct inflection points at depths of ~118, 178, and 273 feet bgs. The inflections at 118 and 178 feet bgs correspond to subtle changes in lithology that are not readily apparent in the geology log or digital photographic log (Figure 9). The inflection at 273 feet bgs corresponds to the water table. When details of the geology are correlated to spectra gamma ray logs, it is possible to further define lithologic character within a given well and provide more confidence in correlating geologic units between wells.

9.4 Aquifer Tests

Slug testing was performed in well 299-E27-23 (C4190) following construction and development, and at several different depth intervals during drilling in borehole 299-E27-22 (C4124). The slug tests are performed to provide semi-quantitative estimates of hydraulic conductivity in the unconfined aquifer (i.e., the screen interval). The slug testing results provide an objective method to evaluate the hydraulic properties of the formation. Results also support interpretation of the aquifer system lithology. During slug testing, the aquifer in both wells exhibited highly permeable intervals comparable to other wells completed in the Hanford formation.

Highly permeable conditions are also indicated from well screen development drawdown data collected during constant rate pumping in the wells. Each well was developed at three different depth intervals within the well screen to remove excess sediment and to increase hydraulic communication with the surrounding aquifer. Drawdowns ranged from less than 0.03 to 0.63 feet with pumps rates greater than 20 gallons per minute in all but one interval in all four wells.

9.4.1 Well 299-E27-23

A total of three standard slug tests, one low and two high stress, were conducted on October 7, 2003. Because of the high permeability in the test intervals, no usable test responses were observed for the low stress test where the test response is less than 0.03 feet, with a recovery of less than 3 seconds. As a result, no repeat of the low-stress test was attempted. Consequently, hydraulic conductivity (K) was estimated from high-stress test results. As indicated, similar under-damped, oscillatory responses with rapid recoveries to static conditions within ~7 seconds were exhibited for both tests. The under-damped behavior and rapid recovery are indicative of highly permeable conditions. Slug tests, exhibiting this type of response behavior, cannot be analyzed using standard, over-damped response-based analytical methods such as the Bouwer and Rice or the type-curve methods. The High-K analysis method presented in Butler and Garnett (2000) and Butler et al. (2003) was used to analyze the slug tests at well 299-E27-23. Because the under-damped test responses were very similar, results obtained from the High-K analysis method are quite comparable. Estimates for K ranged between 328 and 354 feet per day for the two tests.

9.4.2 Well 299-E27-22

Multi-stress slug tests were performed at four specific test/depth intervals within well 299-E27-22. Results from testing and analysis are reported in Spane (2003). This letter report is included in Appendix D. The reported hydraulic conductivities have been incorporated into the composite log for well 299-E27-22 (Figure 6). The estimated hydraulic conductivities, ranging from 6,200 to 22,600 feet per day, are well within the permeability range of 3,300 to 1,600,000 feet per day assigned to the Hanford formation (Wurstner et al. 1995). These data support the interpretation that the basalt is overlain by H3 gravels of the Hanford formation at this waste management area. In a small zone from 252 to 254 feet, a low hydraulic conductivity of 0.13 feet per day was estimated. This low value may be related to hole instability since the open hole was not screened during the testing. Alternatively the low conductivity may reflect the in situ conditions in the aquifer at this level or be the result of an artifact left from the drilling process. At this time, the cause of this low value is not known.

9.5 Composite Logs

Composite logs have been assembled for each well using the well as-builts, well development and aquifer testing results, the geologic descriptions of the sediments and representative graphic logs, the digital photographic logs, and the geophysical logs. Stratigraphic contacts and key lithologic changes are identified where possible. The composite logs for the new wells are illustrated in Figures 6 through 9. These interpretations are also consistent with Martinez (2003), Narbutovskih and Horton (2001) and Williams et al. (2000). Recent surficial sediments composed of reworked Hanford, eolian deposits and/or tank farm backfill sediments overlie the area and range in thickness from one foot up to approximately 20 feet bgs.

The Hanford formation comprises most of the thick (~230 to 270 feet) vadose zone in the WMA C, and is composed of unconsolidated sediments ranging in grain size from cobble to pebble gravel, coarse to fine grained sand, silty sand and silt. There are several distinct contacts and thin, fine grain intervals, either silts or soil horizons that separate thicker Hanford formation sedimentary packages or intervals

such as the upper coarse grained gravelly sequence (H1 unit), the sand sequence (H2 unit), and the lower or basal gravelly sequence (H3 unit). More detailed descriptions of these units are in Narbutovskih and Horton (2001). The selection of these contacts is based on dominant grain size intervals and differences identified by the geologist sample descriptions. These changes in lithology are illustrated by the digital photographic logs. Contacts are also identified by the inflections and general curve fitting from the spectral gamma ray logs. For each borehole, the inflections are dashed on the respective composite logs to imply a unit boundary or contact. The contact between H1 unit and H2 unit is readily identified but the H2 and H3 unit contact is more complicated because of large, discontinuous changes in sediment grain size across the lower interval beneath the WMA C. The contact between the Hanford H2 unit and the H3 unit also appears gradational in places and is approximately located on each composite log (Figures 6 thorough 9).

The thickness of the uppermost unconfined aquifer beneath WMA C ranges from about 37.5 feet in the north to 61 feet in the south based on water levels from the new wells and on regional mapping of the top of basalt (Williams et al. 2000). The unconfined aquifer beneath the WMA C is composed mostly of basaltic, uncemented, loose, clean, sandy- to silty-sandy gravels that appears characteristic of the permeable lower Hanford formation gravel (H3 unit). Although the CCU may be present based on Wood et al. (2003), there is not a contact with this gravel unit that can be identified between the lower Hanford formation H3 and the CCU. If the CCU is present, it is not clearly defined.

Ringold sediments have not been identified in these boreholes. Criteria used for determining the presence of Ringold Formation sediments and differentiating them from the younger, overlying H3 gravel include dominantly consolidated silty-sandy gravel, composed of less than 25% basalt, the presence of cementation, including iron staining, micaceous material and comparatively low hydraulic conductivities (< 55 feet per day) in the range of published results for known Ringold Formation sediments (Spane 2002). Sediments of this description were not found in the samples from these wells. Only well 299-E27-22 (C4124) was drilled to basalt, which was encountered in at approximately 268 feet bgs. The top of basalt is defined as the base of the uppermost unconfined aquifer which in well 299-E27-22 is ~37.5-feet thick.

10.0 References

Atomic Energy Act of 1554 (AEA). 1954. As amended, Ch. 1073, 68 Stat. 919, 42 USC 2011 et seq.

Butler, JJ, Jr. and EJ Garnett. 2000. Simple procedures for analysis of slug tests in formations of high hydraulic conductivity using spreadsheet and Scientific Graphics Software. Open-file Report 2000-40, Kansas Geological Survey, Lawrence, Kansas.

Butler, JJ, Jr., EJ Garnett, and JM Healey. 2003. "Analysis of slug tests in formations of high hydraulic conductivity." *Ground Water* 41(5):620-630.

Byrnes ME and BA Williams. 2003. *Data Quality Objectives Summary Report for Establishing a RCRA/CERCLA/AEA Integrated 200 West and 200 East Area Groundwater Monitoring Network*, CP-15329, Rev. 0. Prepared by Fluor Hanford, Inc. for the U.S. Department of Energy, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). 1980. Public Law 96-150, as amended, 94 Stat. 2767, 42 USC 9601 et seq.

Ecology - Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. 2003. *Hanford Federal Facility Agreement and Consent Order*. Document No. 89-10, Rev. 6 (The Tri-Party Agreement), Olympia, Washington

Johnson VG. 1993. *Operational Groundwater Status Report, 1990-1992*. WHC-EP-0595, Westinghouse Hanford Company, Richland, Washington.

Martinez CR. 2003. *Calendar Year 2003 RCRA Groundwater Monitoring Well Summary Report*. WMP-18472, Fluor Hanford, Incorporated, Richland, Washington.

NAD83 (91) North American Datum of 1983 (1991 adjustment).

Narbutovskih SM and DG Horton. 2001. *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*. PNNL-13024, Pacific Northwest National Laboratory, Richland, Washington.

Spane FA. 2002. *Summary of Hydraulic Conductivity Estimates Obtained from Recent Hydrologic Characterization Tests Conducted in the WMA S-SX*. Letter Report to VG Johnson. Pacific Northwest National Laboratory, Richland, Washington.

Washington Administrative Code (WAC). *Minimum Standards for Construction and Maintenance of Wells.* WAC 173-160, Washington Administrative Code, Olympia, Washington.

Williams BA. 2003. *Description of Work for Drilling RCRA Groundwater Monitoring Wells During Calendar Year 2003*. PNNL-SA-38611, Pacific Northwest National Laboratory, Richland, Washington.

Williams BA, BN Bjornstad, R Schalla, and WD Webber. 2000. *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*. PNNL-12261, Pacific Northwest National Laboratory, Richland, Washington.

Wood MI, TE Jones, BN Bjornstad, DG Horton, SM Narbutoskih, and R Schalla. 2003. *Subsurface Conditions Description of the C and A-AX Waster Management Area*. RPP-14430, CH2M Hill Hanford Group, Inc., Richland, Washington.

Wurstner SK, PT Thorne, MA Chamness, MD Freshley and MD Williams. 1995. *Development of a Three-Dimensional Groundwater Model of the Hanford Site Unconfined Aquifer System: FY 1995 Status Report*. PNNL-10886, Pacific Northwest National Laboratory, Richland, Washington.

Appendix A

Geologic Logs, Well Construction and Completion Documentation

Well 299-E27-22

WELL SUMMARY SHEET

Start Date: 08/21/03
Finish Date: 09/10/03
Page 1 of 2

Well ID: c4124
Well Name: 299-E27-22
Location: East of C-Tank Farm
Project: C403 RCRA drilling
Prepared By: Charlene Martinez
Date: 09/11/03
Reviewed By: L.D. Walker
Date: 9/15/03
Signature: Charlene Martinez
Signature: LD Walker

CONSTRUCTION DATA

Description	Diagram
9" OD dual-wall temporary casing used.	
6" ID protective casing set +1.0' above permanent.	
4" ID SS304 sch 10 riser: +2.2' → 228.05'	
Portland Cement Grout: 0' → 10.0'	
Granular Bentonite: 10.0' → 217.2'	
1/4" Bentonite Pellets: 217.2' → 222.5'	
10-20 mesh Silica sand: 222.5' → 2168.0'	
All depths in feet below ground surface:	
All temporary casing removed from ground.	
170' of 1/4" OD pipe remain in ground (bentonite seal) from 47'-20'	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0'-1' Backfill (crushed gravel)
		1'-5' SAND(S)
		5'-10' gravelly SAND(gS)
		10'-29' SAND(S)
		29'-36' sandy GRAVEL(sG)
40		36'-50' SAND(S)
		50'-54' sandy GRAVEL(sG)
		54'-56' SAND(S)
		56'-60' sandy GRAVEL(sG)
		60'-72' silty sandy GRAVEL(msG)
80		72'-81.5' silty gravelly SAND(mgS)
		81.5'-89' SAND(S)
		89'-98' silty SAND(mS)
		98'-105' SAND(S)
		105'-112' silty SAND(mS)
120		112'-116' SAND(S)
		116'-122' silty SAND(mS)
		122'-138' SAND(S)
		138'-145' silty SAND(mS)
		145'-153' gravelly silty SAND(gmS)
160		153'-157' silty sandy GRAVEL(msG)
		157'-165' sandy GRAVEL(sG)
		165'-185' SAND
		185'-188' silty sandy GRAVEL(msG)
		188'-192' silty SAND(mS)
		192'-215' sandy GRAVEL(sG)
200		215'-219' gravelly SAND(gS)
		219'-222' silty sandy GRAVEL(msG)
		222'-227' SAND(S)
		227'-233' silty sandy Gravel (cmsG)

A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 08/21/03
Finish Date: 09/10/03
Page 2 of 2

Well ID: C 4124
Well Name: 299-E27-22
Location: East of C-Tank Farm
Project: C-403 RCRA drilling
Prepared By: Charlene Martinez
Date: 09/11/03
Reviewed By: L.D. Walker
Date: 9/15/03
Signature: Charlene Martinez
Signature: LD Walker

CONSTRUCTION DATA

Description	Diagram
4" ID SS304 sch.10, 0.020-in. slot, cont. wire-wrap wellscreen: 228.05' → 268.02'	
4" ID SS304 sch 10 endcap: 268.02' → 268.10'	
All depths are in feet below ground surface	
All temporary casing removed from ground.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
240		233' - 268' Sandy GRAVEL(GG)
		268' BASALT
280		TD = 268' bgs.
		Static water ⇒ 230.46' bgs (09/10/03)

A-6003-643 (03/03)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 08/21/03
Finish Date: 09/12/03
Page 1 of 1

Well ID: C4124 — Well Name: 299-E27-22	Approximate Location: East of C-Tank Farm
Project: CY03 RCRA drilling	Other Companies: FH, CHG
Drilling Company: Layne Christensen	Geologist(s): C. Martinez, M.J. Hocking
Driller: Paul ("Derry") Lodder — License #: 1628	

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 ___
Dual-wall, carbon steel,	0' - 268'	9"	Cable Tool:	Diameter ___ From ___ to ___
FJ, 9" OD (outer)	-		Air Rotary:	Diameter ___ From ___ to ___
7"/6" (inner)	-		A.R. w/Sonic:	Diameter ___ From ___ to ___
	-		Becker Hammer	Diameter 9" From 0' to 268'
	-		(Reverse Air)	Diameter ___ From ___ to ___
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter ___ From ___ to ___

Drilling Fluid: none

Total Drilled Depth: 268' — Hole Dia @ TD: 9"

Total Amt. Of Water Added During Drilling: —

Well Straightness Test Results: Passed using a 20.4' long, 4.5" OD tool on 09/09/03

Static Water Level: 230.46' — Date: 09/10/03

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Spectral Gamma	0' - 268'	09/08/03		-	
	-			-	
	-			-	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
4" ID SS304, sch.10 riser	+2.2' - 228.05'	F480	N/A	Portland Cement (94# bag)	0' - 10.0'	5 bags	N/A
4" ID SS304 sch.10 wellscreen	228.05' - 268.02'	"	0.020"	Granular Bentonite (50# bag)	10' - 217.2'	102.5 bags	N/A
4" ID SS 304 sch10 endcap	268.02' - 268.1'	"	N/A	Bentonite Pellets (50#)	217.2' - 222.5'	2 buckets	1/4"
	-			Colorado silica sand (50#)	225.8' - 222.5'	3.5 bags	4-8
	-			Colorado silica sand (50#)	225.8' - 268.0	82 bags	10-20

OTHER ACTIVITIES

Aquifer Test: well development	Date: 09/12/03	Well Decommission:	Yes:	No:	Date:
Description: Franklin 5HP submersible pump. 3 stages. Intake @ 264.5 (B) / 255.5' (M) / 243.3' (T). 23-25 gpm. Final turbidity: 1.08 (B) / 0.97 (M) / 2.31 (T) (NTU's.)		Description:			

WELL SURVEY DATA (if applicable)

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

COMMENTS / REMARKS

Vol. calcs: P.C. => 5 bags * 1.285 ft^3/bag = 6.43 ft^3; Granules => 102.5 bags * 0.71 ft^3/bag = 72.78 ft^3; pellets => 2 buckets * 0.62 ft^3/bucket = 1.24 ft^3; 10-20 sand => 82 bags * 0.535 ft^3/bag = 43.87 ft^3; 4-8 sand => 3.5 bags * 0.663 ft^3/bag = 2.32 ft^3.

Reported By:	Title:	Signature:	Date:
Charlene Martinez	Geologist	Charlene Martinez	09/18/03

A-6003-658 (04/03)

BOREHOLE LOG

Page 1 of 7

Date: 08/21/03

Well ID: C4124 | Well Name: 299-C27-22 | Location: n.E. of C-Tank Farm

Project: C403 RCRA Drilling | 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	BH9"	N/A		0'-1' Backfill material. Crushed gravel.	Becker Hammer using 9" OD dual-wall casing
				1'-5' SAND(S). 100% sand, well sorted, vfn-fn, non basaltic, micaceous. 2.5Y5/3 light olive brown (moist) no rxn HCl.	
5	Grab GW9"				Collect 5' archive
				5'-10' gravelly SAND(gS) 20% gravel, 75% sand, 5% silt. Gravel mod. sorted. SR-R, 65% basalt, 35% qtz/other. Sand, poorly sorted, pred. vcse grained. vfn-vcse, SR-SA, 80% basalt, 20% qtz/other. 10YR3/1, v. dark gray moist. no rxn HCl.	
10	Grab BH9"				Collect 10' archive @ 10' NH_3 = 25ppm
				10'-29' SAND, 95% sand, 5% silt. Sand. SR-SA, v poorly sorted, SR-SA, 80% basalt, 20% qtz/other, vfn-vcse, pred v.cse grained. 10YR3/1 v. dark gray (moist) no rxn HCl.	Collect 15' archive
15	Grab BH9"				@ 20' NH_3 = 17ppm
		SS#1 100%			SS#1 19.5'-21.5' bgs
20	Grab BH9"	SS#2 100% rec.		@ 15' sand graded to vfn-fn, v. well sorted, micaceous, 40% basalt, 60% qtz/other no rxn HCl. 2.5Y4/2, dark grayish brown. Rounded	Collect 20' archive SS#2 21.5'-24.0' bgs
		SS#3 100% recovery			SS#3 24.0-26.5' bgs
25	Grab BH9"	SS#4 80% recovery		@ 20' sand graded to v. poorly sorted vfn-vcse, 40% basalt, 60% qtz/other SR-SA.	Collect 25' archive. T.D.S. @ 26.5' bgs (8/21/03) Start 08/22/03 SS#4 26.5'-29.0' bgs 4ppm NH_3
		SS#5 95% recovery		@ 22' trace poorly sorted gravel (<8%) mps ~ 4". Basaltic, SA-R	SS#5 29.0'-31.5' bgs 5ppm NH_3
30	Grab BH9"	SS#6 100% recovery		@ 24.5 basalt cobbles w/ poorly sorted gravel. Sand grading to poorly sorted, SR-SA, vfn-vcse	Collect 30' archive SS#6 31.5'-34.0' bgs
35	GRAB BH9"	SS#7 100% recovery		29'-36' Sandy Gravel (sG) 30% gravel, 65% sand, 5% silt. Gravel, mod. sorted, pea-size-med pebbles, basaltic. Sand, poorly sorted	Collect 35' archive. SS#7 34.0'-36.5' bgs
		SS#8 100% recovery			SS#8 36.5'-39.0' bgs

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 08/21/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03

BOREHOLE LOG

Date: 08/22/03

Well ID: C4124 | Well Name: 299-E27-22 | Location: N.E. of C-Tank Farm

Project: C403 RCRA drilling | 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	BH 9-11	SS# 8		(29' cont.) sand, SR-SA, vfn-vcse, 50% basalt, 50% qtz/other. 10YR4/2 dark grayish brown, moist, no rxn HCl.	Becker Hammer using 9" OD dual wall casing. Collect 40' archive. SS# 9 39'-41.5' bgs. SS# 10 41.5'-44.0' bgs.
	Grab BH 9-11	SS# 9 100% recovery			
		SS# 10 100% recovery			
45	Grab BH 9-11	SS# 11 100% recovery		36'-50' SAND(s) 95% sand, 5% silt. Sand, vfn-fn, R, well sorted, non-basaltic no rxn HCl. 2.5Y 5/3, light olive brown (moist)	Collect 45' archive. SS# 11 44.0-46.5' bgs.
		SS# 12 100% recovery			SS# 12 46.5'-49.0' bgs
50	Grab BH 9-11	SS# 13 100% recovery		48'-48.5' compact sand lens, laminer bedding, vfn-fn grain. Rounded, non-basaltic.	Collect 50' archive. SS# 13 49.0'-51.5' bgs.
		SS# 14 100% recovery		@ 48.5' vcse-vfn grain sand. poorly sorted, basaltic.	SS# 14 51.5'-54.0' bgs. SS# 15 54.0'-56.5' bgs. Collect 55' archive.
55	Grab BH 9-11	SS# 15 100% recovery		50'-54' sandy GRAVEL (sG) 50% gravel, 40% sand, 10% silt. Gravel, poorly sorted, pred. pea-size - sm. cobbles. SA-R. Sand: poorly sorted, SR-SA, 60% basalt, 40% qtz/other, vfn-vcse grained higher % csel/vcse grain. 10YR4/1, dk gray (moist), no rxn HCl.	SS# 16 56.5'-59.0' SS# 17 59.0'-61.5' (0% rec.) Collect 60' archive. SS# 18 61.5'-64.0' bgs. SS# 19 64.0'-66.5' bgs.
		SS# 16 100% recovery			
60	Grab BH 9-11	SS# 17 NO returns			
		SS# 18 100% recovery			
65	Grab BH 9-11	SS# 19 50% recovery		54'-56' SAND(s) 90% silt 10% sand, mod-sorted, SR-SA vfn-med, non-basaltic, 2.5Y 4/3 olive brown, moist. no rxn HCl.	Collect 65' archive. SS# 20 66.5'-69.0' bgs. SS# 21 69.0'-71.5' bgs (0% rec.) Collect 70' archive.
		SS# 20 95% recovery			
70	Grab BH 9-11	SS# 21 NO Returns		56'-60' sandy GRAVEL (sG) 65% gravel, 30% sand, 5% silt. Gravel, basaltic, SA-R, poorly sorted, mps - 2". Sand, poorly sorted SR-SA, 60% basalt, 40% qtz/other, vfn-vcse, 10YR4/1 dk gray (moist) no rxn HCl.	E.O.S. @ 71.5' bgs (08/22/03) 9am 08/25/03 SS# 22 71.5'-74.0' bgs. Collect SS# 23 74.0-76.6' bgs. Collect 75' archive. SS# 24 76.5'-79.0' bgs.
		SS# 22 100% recovery			
75	Grab BH 9-11	SS# 23 100% Recovery			
		SS# 24 100% Recovery		60' — 72' Silty sandy GRAVEL (msG) 65% gravel, 25% sand, 10% silt	

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 08/22/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03

BOREHOLE LOG

Page 3 of 7

Date: 08/25/03

Well ID: C4124 | Well Name: 299-E27-22 | Location: n.E. of C-Tank farm

Project: C-103 RCRA drilling | 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	BH 9" Grab BH 9"	SS#25 80% recovery		(80' cont.) Gravel, poorly sorted, SA-R, pea-size to med cobbles, 45% basalt, 55% qtz/other. Sand, poorly sorted, SR-A, 50% qtz / 50% basalt, fn-vcse grained 10YR 5/3 brown (dry), no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 80' archive.
		SS#26 65% recovery			SS#25 79.0'-81.5' bgs. SS#26 81.5'-84.0' bgs.
85	Grab BH 9"	SS#27 85% recovery		72'-81.5' Slightly silty gravelly SAND (mgS) 15% gravel, 73% sand, 12% silt. Gravel, mod-sorted, SA-R, 50% basalt 50% qtz/other, mps ~ 3". Sand, poorly sorted, SR-A, fn-vcse grained, 50% basalt, 50% qtz/other, 10YR 5/2, grayish brown (moist). no to weak rxn HCl.	Collect 85' archive. SS#27 84.0'-86.5' bgs.
		SS#28 100% recovery			SS#28 86.5'-89.0' bgs.
90	Grab BH 9"	SS#29 100% recovery			SS#29 89.0'-91.5' bgs. Collect 90' archive.
		SS#30 100% recovery			SS#30 91.5'-94.0' bgs. SS#31 94.0'-96.5' bgs.
95	Grab BH 9"	SS#31 100% recovery		81.5'-89' SAND (s) 95% sand, 5% silt. Sand, R, v. well sorted, vfn-fn grained, non-basaltic, trace mica, 2.5Y 5/3 light olive brown (moist). weak rxn HCl. @ 84' sand grading to v. cse-vfn grained, basaltic, poorly sorted. @ 85' sand, grading to vcse-med grained, mod. sorted, basaltic, trace well-sorted gravel, basaltic.	Collect 95' archive. E.O.S. @ 96.5' bgs (08/25/03). Start 08/26/03.
		SS#32 100% recovery			SS#32 96.5'-99.0' bgs.
100	Grab BH 9"	SS#33 100% recovery			SS#33 99.0'-101.5' bgs. Collect 100' archive.
		SS#34 100% recovery			SS#34 101.5'-104.0' bgs.
105	Grab BH 9"	SS#35 100% recovery		89'-98' Silty SAND (mS) 85% sand, 15% silt. Sand, SR-SA, poorly sorted, fn-vcse grained, 35% basalt, 65% qtz/other, 2.5Y 4/3 olive brown (moist), micaceous, no rxn HCl.	SS#35' 104.0'-106.5' bgs. Collect 105' archive.
		SS#36 90% recovery			SS#36 106.5'-109.0' bgs.
110	Grab BH 9"	SS#37 95% recovery		98'-105' SAND (s) 95% sand, 5% silt. Sand, R, vfn-fn grain, compact matrix, micaceous, non basaltic, v. well sorted 2.5Y 5/2 grayish brown (moist). No rxn HCl. @ 99.5', sand-poorly sorted, vfn-vcse, SR-SA, 35% basalt, 65% qtz/other, increase in silt (~10%), unconsolidated. @ 101.5' increase in basalt content (45%)	SS#37. 109.0'-111.5' bgs. Collect 110' archive.
		n/a			
115	Grab BH 9"	SS#38 100% recovery			SS#38 114'-116.5' bgs. Collect 115' archive.
		n/a			

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/25/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 4 of 7

Date: 08/26/03

Well ID: C4124 | Well Name: 299-E27-22 | Location: East of ~~SST~~ S-Tank Farm

Project: C403 RCRA drilling | 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	BH 9 11 Grab BH 9 11	SS# 39 100% recovery n/A		105'–112' SILTY SAND(mS) 85% sand, 15% silt, trace gravel. Gravel, basaltic, med pebbles. Sand, v. poorly sorted, SR-SA. 20% basalt, 80% qtz/other, vfn-vcse grained, micaceous 2.5Y 5/3 light olive brown, (moist) no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 120' archive. SS# 39 119'–121.5' bgs. Collect 125' archive. SS# 40 124'–126' bgs. Collect 125' archive.
125	Grab BH 9 9 Grab BH 9 8	SS# 40 100% recovery n/A			
130	Grab BH 9 4 Grab BH 9 7	SS# 41 100% recovery n/A		112'–~~118'~~ 116' SAND(S) 95% sand, 5% silt. Sand, SR-SA, mod. sorted, pred fn-med grained, vfn-vcse, grains present, non-basaltic, micaceous, 2.5Y 5/4, light olive brown (moist), no rxn HCl.	Collect 127' archive. SS# 41 129'–131.5' bgs. Collect 130' archive.
135	Grab BH 9 7 Grab BH 9 6	SS# 42 100% recovery n/A		116'–122' silty SAND (mS). similar to description from 105'–112'.	Collect 133' archive. SS# 42 134'–136.5' bgs. Collect 135' archive.
140	GRAB BH 9 7 Grab BH 9 4	SS# 43 100% recovery n/A		122'–138' SAND(S) 95% sand, 5% silt. Sand, vfn-vcse, SR-SA, poorly sorted, 45% basalt, 55% qtz/other, micaceous 10YR 5/2, grayish brown, moist, no rxn HCl. @127' silt increasing to ~10%. Sand, moderately sorted, SR-SA, pred. med-cse grained. Some fn & vcse (small %'s). @130' sand grading to well-sorted, vfn-med grained. @133' sand graded to poorly sorted, vfn-vcse. silt <5%.	Collect 138' archive. SS# 43 139.0'–141.5'. Collect 140' archive. @139' 1 ppm NH_3 in borehole 9 ppm NH_3 in spoils. Collect 143' archive. SS# 44 144.0'–146.5' bgs. Collect 145' archive.
145	Grab BH 9 4 Grab BH 9 11	SS# 44 100% recovery n/A			E.O.S. @ 146.5' bgs (08/26/03)
150	Grab BH 9 11 Grab BH 9 8	SS# 45 80% recovery n/A		138'–145' silty SAND(mS) 85% sand, 15% silt. Sand, SR-SA, mod. sorted, vfn-cse, pred. Med grained, micaceous, 20% basalt, 80% qtz/other. 2.5Y 6/2 light brownish gray (moist). no rxn HCl.	Start 08/27/03. SS# 45 149'–151.5' bgs. Collect 150' archive.
155	Grab BH 9 8 Grab BH 9 11	SS# 46 50% recovery n/A		145'–~~153'~~ 154' gravelly silty SAND(gmS) 15% gravel, 70% sand, 15% silt. Gravel, basaltic, mod. sorted, SR-SA, pea-size to sm. pebbles. Sand, poorly sorted, SR-SA, 60% qtz/other, 40% basalt, vfn-vcse grained, pred. cse-vcse. 10YR 5/3 brown (dry). non-	Collect 155' archive. SS# 46 154'–156.5' bgs. Collect 155' archive. Collect 157' archive.

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/26/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 08/27/03

Well ID: C4104 | Well Name: 299-E27-22 | Location: East of C-Tank Farm

Project: C4103 RCRA drilling | 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	BH 9 11 Grab BH 9 V	55 #47 95% recovery		153'-157' Silty sandy GRAVEL(ms6) 70% gravel, 20% sand, 10% silt. Gravel, SA-R, mod. sorted, basaltic. Sand, SR-A, poorly sorted, vfn-vcse grained, mod. cse-vcse. 40% basalt, 60% qtz/other. 10YR 5/3 brown (dry). No rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 160' archive 55 #47 159.0'-161.5' bgs
	Grab BH 9 V	n/a			Collect 163' archive
165	Grab BH 9 V	55 #48 100% recovery			55 #48 164'-166.5' bgs Collect 165' archive
	Grab BH 9 V	n/a		157'-160' Sandy GRAVEL(sG) 40% gravel, 55% sand, 5% silt. Gravel, basaltic, well-sorted, pea-size - sm. pebbles SA-R. Sand SR-SA. 65% basalt, 35% qtz/other, vfn-vcse grained, mod-vcse. Trace mica. 10YR 5/1 gray (moist). no rxn HCl.	Collect 167' archive
170	Grab BH 9 V	55 #49 100% recovery			55 #49 169'-171.5' bgs Collect 170' archive
	Grab BH 9 V	n/a			Collect 173' archive
	Grab BH 9 V	55 #50 75% recovery			55 #50 174'-176.5' bgs
175	Grab BH 9 V	n/a		160'-185' SAND(S) 7% gravel, 88% sand, 5% silt. Gravel, v. well sorted, SR-SA, pea-sized, basaltic. Sand, v. poorly sorted, SR-A, vfn-vcse grained. 65% basalt, 35% qtz/other, micaceous. 10YR 5/1 gray (moist). No rxn HCl.	Collect 175' archive
	Grab BH 9 V	55 #51 100% recovery			Collect 177' archive RCT sk. of B8@ background 55 #51 179'-181.5' bgs
180	Grab BH 9 V	n/a		@ 170' only trace pea-size gravel.	Collect 180' archive
	Grab BH 9 V	55 #52 75% recovery		@ 175' silt increasing to 10%.	Collect 182' archive 55 #52 184'-186.5' bgs
185	Grab BH 9 V	n/a		185'-188' Silty sandy GRAVEL(ms6) 45% gravel, 43% sand, 12% silt. Gravel, mod-sorted, basaltic, pea-size - mod pebbles, SA-R. Sand, poorly sorted, SR-A, vfn-vcse grained, 25% basalt, 75% qtz/other 2.5Y 4/3, olive brown (moist). no rxn HCl.	Collect 185' archive Collect 187' archive
	Grab BH 9 V	55 #53 100% recovery			55 #53 189'-191.5' bgs. T.O.S. @ 191.5' bgs (08/27/03) Start (09/02/03)
190	Grab BH 9 V	n/a			Collect 190' archive
	Grab BH 9 V	55 #54 100% recovery		188'-192' Silty SAND(ms) 5% gravel, 83% sand, 12% silt. Gravel, pea-size to sm. pebbles, RCRA, well-sorted, basaltic. Sand, mod-sorted, med-vcse, SR-SA, 30% basalt, 70% qtz/other. 2.5Y 5/2 grayish brown (moist). no rxn HCl.	Collect 192' archive 55 #54 194'-196.5' bgs
195	Grab BH 9 V	n/a			Collect 195' archive
	Grab BH 9 V				Collect 197' archive

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/27/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 7
Date: 09/02/03

Well ID: C4124 | Well Name: 299-E27-22 | Location: East of C-Tank Farm
Project: C403 RCRA drilling | 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	BH 9-11 Grab BH 9-10	SS#55 100% recovery N/A		199'-215' Sandy GRAVEL (SG) 45% gravel, 50% sand, 5% silt. Gravel, SA-R, well sorted, basaltic, pea-size to sm. pebbles, Sand, SR-SA, poorly sorted, vfn-vcase grained, 40% basalt, 60% qtz/other, trace mica, 2.5 Y 4/2 dk. grayish brown (moist), no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. SS#55 199'-201.5' bgs collect 200' archive
205	Grab BH 9-9 Grab BH 9-8 Grab BH 9-7	SS#56 100% recovery N/A		@194' gravel increasing to lg-pebbles-sm. cobbles. Poorly-sorted. @199' gravel content decreasing to ~30%, pea-size to med-pebbles, silt increasing to 10%.	SS#56 204'-206.5' bgs collect 205' archive collect 207' archive
210	Grab BH 9-6 Grab BH 9-5 Grab BH 9-4	SS#57 60% recovery N/A		@205' gravel content increasing to ~50%, silt decreasing to ~7%. Gravel, mod-sorted, pea-size to med pebbles.	SS#57 209'-211.5' bgs collect 210' archive. collect 212' archive.
215	Grab BH 9-3 Grab BH 9-2 Grab BH 9-1	SS#58 100% recovery N/A		@209' gravel, v. poorly sorted, pea-size to med cobbles, mps ~ 6", 45% basalt, 55% felsics.	SS#58 214'-216.5' bgs collect 215' archive collect 217' archive.
220	Grab BH 8-10 Grab BH 8-9 Grab BH 8-8	SS#59 10% Rock recovery N/A		215'-219' gravelly SAND (gS) 20% gravel, 92% sand, 8% silt. Gravel, mod-sorted, pea-size to med pebbles, SR-A, 40% basalt, 60% qtz/other. Sand, vfn-vcase, SR-A, poorly sorted, pred. pea-vcase, 40% basalt, 60% qtz/other, micaceous, 10YR 5/3, brown (moist), no rxn HCl.	SS#59 219'-228.6' bgs collect 220' archive collect 222' archive SS#60 224'-226.5' bgs collect 225' archive collect 227' archive
225	Grab BH 8-7 Grab BH 8-6 Grab BH 8-5	SS#60 75% recovery N/A			
230	Grab BH 8-4 Grab BH 8-3	SS#61 10% rocks recovery Collect sieve sample @233'-235' (approx.)		219'-222' silty, sandy GRAVEL (msG) Gravel 55%, sand 35%, silt 10%. Gravel, poorly-sorted, SR-A, 50% basalt, 50% qtz/other. Sand, SR-SA, poorly sorted, vfn-vcase grained, 35-40% basalt, 60-65% qtz/other, trace mica. 2.5Y 4/2, dk. grayish brown (moist). no rxn HCl.	E.O.S. @ 229' bgs (09/02/03) Spuds 09/02/03 SS#61 229'-231.5' bgs collect 230' archive collect 233' archive sieve sample (233'-235')
235	Grab BH 8-2 Grab BH 8-1			222'-227' SAND (S), trace gravel, well sorted, sm. pebbles. Sand, SR-SA, poorly sorted, vfn-vcase, trace mica, 80% basalt, 20% qtz/other, no rxn HCl.	collect 235' archive

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 09/02/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03

BOREHOLE LOG

Page 7 of 7

Date: 09/03/03

Well ID: C4124 | Well Name: 299-E27-23 | Location: East of C-Tank Farm

Project: C403 RCRA Drilling | 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	BH9II Grab BH9II	n/a		225 – 233' Silty sandy GRAVEL (mSG) 55% gravel, 33% sand, 12% silt. Gravel, v. poorly sorted, SR-A, pea-size to med. cobbles, 20% basalt, 80% qtz/other. Sand, R-A, v. poorly sorted, vfn-vcse grained, 15% basalt, 85% qtz/other. 2.5Y5/2 grayish brown (dry). No rxn HCl.	Beckerhammer drilling using 9" OD dual-wall casing. Collect 240' archive
245	Grab BH9II				Collect 245' archive
250	Grab BH9II			233' – 268' Sandy GRAVEL (sG) 40% gravel 55% sand, 5% silt. Gravel, mod-sorted, pea-size to sm. pebbles, 55% qtz/other, 45% basalt, SR-SA. Sand, SR-SA, poorly sorted, vfn-vcse grained, grad. cse-vcse, 65% basalt, 35% qtz/other. No rxn HCl.	E.O.S. @ 249' bgs (09/03/03) Start 09/04/03 Collect 250' archive
255	Grab BH9II			@ 237' gravel increasing in size 4 %. Poorly sorted, sm pebbles - med cobbles, basaltic. Gravel, 60%, sand 35%, silt 5%.	E.O.S. @ 254' bgs (09/04/03) Start 09/05/03. Collect 255' archive.
260	Grab BH9II			268' Basalt. weathered surface, iron oxide staining, vesicular surface, visible fractures, quartz streaks, chloride, "peacock" iridescence	Collect 260' archive
265	Grab BH9II			TD @ 268' bgs.	Collect 265' archive
	Grab	Steve sample			Collect 268' archive (TD)
270					
275					

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 09/03/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

WELL DEVELOPMENT AND TESTING DATA

Report # 1 : Page 1 of 2

Well Name:	Well ID:	Well Location:	Date:
299-E27-22	C4124	East of C-Tank Farm	09/12/03

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

Has the well been surveyed? ☐ Yes ☒ No | Does the well have a cement pad? ☐ Yes ☒ No

PART 1

STATIC WATER LEVEL:

Start of Job 233.69'

End of Job —

DEPTH TO BOTTOM:

Start of Job 271.3'

End of Job —

PART 2

WELL DEVELOPMENT DATA

Pump Model Franklin 5 Hp submersible

	B	M	T
Intake Depth	264.5'	255.5'	243.3'
Starting Turbidity	30.9	24.7	111

Pump Start	Stop	Flow Rate
(60 mins) 1158	(1500 gals) 1258	25 gpm
1312 (43 min) 1412	1355 (1032 gals) 1455 (989 gals)	24 gpm 23 gpm
1500 + 1032 + 989 = 3521 gals.		

Total Pumped 3521 gals.

	B	M	T
Final Turbidity	1.08	0.97	2.31

XD SN/Range (PSI) 20.0

PART 3

INSTANTANEOUS SLUG TEST

Static Water Level (TOC)

Transducer Depth

Baseline Start

Injection Start

Baseline Start

Withdrawal Start

Slug Volume

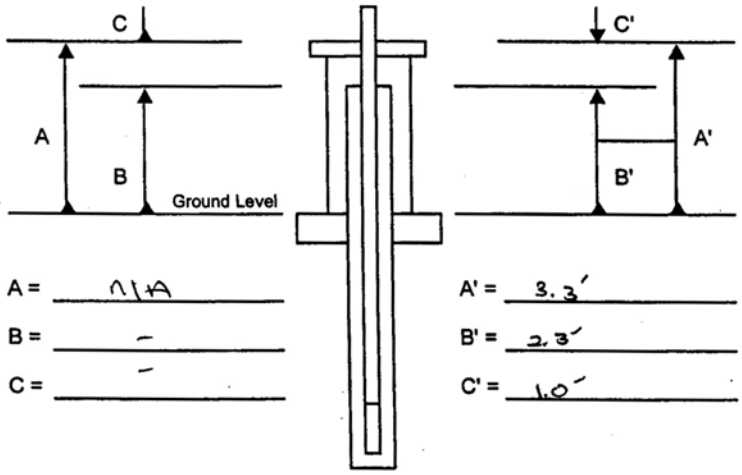
XD SN/Range (PSI)

Changed batteries in data logger 09/12/03

PART 4

Last Recorded Measurements Date: N/A

Current Measurements Date: 09/12/03



A = N/A

B = —

C = —

A' = 3.3'

B' = 2.3'

C' = 1.0'

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

COMMENTS:

1016 Pump setting rig on site from decon.

1018 Setting up rig.

1025 Tagged g.w. ⇒ 233.69' (TOC)

Tagged bottom ⇒ 271.3' (TOC) No fill.

1100 Trippin in pump & tremmie pipe.

1145 Intake set 264.5' TOC

1157 Ready to run test (#4 on data logger). XD = 26.761'

1158 Begin test. Initial readings: XD = 26.365'; Turb 30.9 NTU; Cond ⇒ 974 µs/cm; T = 20.7 °C. 25 gpm

See page 2 for readings.

1258 Start recovery test (#5 on data logger)

1306 Stop test. Final XD = 26.698'. 99.8 % recovery

Prepared by (print name): Charlene Martinez	Signature: Charlene Martinez	Date: 09/12/03
Reviewed by (print name): L.D. Walker	Signature: L.D. Walker	Date: 9/30/03

A-6003-644 (03/03)

FIELD ACTIVITY REPORT - DAILY DRILLING
Continuation Page

Date: 09/12/03

Well Name: 299-E27-22 | Well ID: C4124

Location: East of C Tank Farm | Continuation of Report No.: 1 (well development)

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth
		well development
		Readings for 264.5' interval (test #4)

Time	XD(ft)	NTU Turb	µS/cm cond	T°C	Drawdown
1224	26.494	3.37	498	20.6	0.267'
1235	26.344	2.08	508	20.2	0.417'
1248	26.470	2.69	508	20.6	0.291'
1254	26.491	1.08	504	20.7	0.270'

1307 — Resetting intake @ 255.4' TOC. Initial XD = 17.809'

1312 — Begin test @ 255.4' TOC (test #6). Initial readings: XD = 17.545'; cond 491 µS/cm; T = 21.1°C; Turb: 24.7 NTU; 24 gpm.

Readings for 255.4' interval (test #6) on datalogger

Time	XD(ft)	NTU Turb	µS/cm cond	T°C	Drawdown
1322	17.629	2.96	488	20.4	0.18'
1338	17.605	1.49	490	20.3	0.204'
1348	17.584	2.06	484	20.8	0.225'
1354	17.422	0.97	490	20.3	0.387'

← 1355 — Shut pump off. Begin recovery test (#7). (Purge water truck full)

1404 — Stop recovery test (#7) Final XD = 17.806'; 100% recovery

1400 — 2nd purge water truck on site. 1st truck off site.

1405 — move intake to next interval (243.3' TOC). XD = 5.901'

1412 — Begin test @ 243.3' TOC (Test #8) Initial readings: XD = 5.446'; ~~21.8°C~~ (cm) T; T = 21.4°C; cond = 459 µS/cm; Turb = 111 NTU; 23 gpm.

Readings for 243.3' TOC (Test #8)

Time	XD(ft)	NTU Turb	µS/cm cond	T°C	Drawdown	
1428	5.425	4.26	470	20.9	0.476'	1455 Stop test. Begin recovery test
1438	5.478	2.64	475	20.1	0.423'	1507 Stop rec. test. Final XD = 5.901. 100%
1448	5.583	2.67	475	20.3	0.318'	1500 Drill crew securing site. Purge
1453	5.457	2.31	476	20.2	0.444'	water truck off site. Generator off site.
						Will pull pump on Monday or Tuesday.

Reported By: Charlene Martinez | Title: Geologist | Date: 09/12/03

Signature: Charlene Martinez

Reviewed By: L.D. Walker | Title: Geologist | Date: 9/30/03

Signature: L.D. Walker

A-6003-652 (04/03)

FIELD ACTIVITY REPORT
WELL SERVICES

Page 1 of 1

Date	Well No.	Rig Type/Model	Rig No.	Contract/Work Order No.	Report No.
09/19/03	299-E27-23	Pump setting rig			1

Purpose: Install pumps in C403 RCRA wells

Reference:

Location: East of C-Tank Farm

HISTORICAL DATA

Construction Depth: 268.1' bgs

Casing Size	Type	Set At
4" ID SS304, Sch. 10	+2.3' –	228.05'

Casing Perforations Schedule — Interval:

Well Screen(s) Type — Interval:
0.020" slot
4" ID SS Sch 10 — 228.05' – 268.03'

Last Recorded Depth-to-Water	Last Recorded Depth-to-Bottom
233.69' (TOC)	271.3' (TOC)

Current Depth-to-Water	Current Depth-to-Bottom
233.6' (TOC)	271.3' (TOC)

PUMP SYSTEM CONFIGURATION

	Pre-Maintenance	Post-Maintenance
Pump Type: 0.5 HP	Grundfos Rediflo2	
Pump Model	model 1A1060-03	
Tubing Size/Type		
Length-Bottom of Tubing to Pump Intake	0.96'	
Tubing Length	240.0'	
Length-Top of Tubing to Reference Point		
Pump Intake Set at (Depth)	240.96'	

Reference/Measuring Point (TOC): TOP of CASING

Start Time: 0810
End Time:
Time:
Contract Time:
Total Time:

Personnel: Layne Christensen
- Dave DeWitt
- Ken Jones

Fluor Hanford
- Tim Hotwell

CH2m Hill (CHG)
- Charlene Martinez

Materials Used: 24 x 10' long, SS304, sch. 40, 0.75" OD tremmie pipe.

0.5 HP Grundfos

Description of Operations/Remarks

0810 On site from C4125. Drill crew dropped off pump setting rig. off site to get 0.75" OD SS304, schedule 40 tremmie pipe & 0.5 HP Grundfos Rediflo2 pump.

0848 Drill crew on site. Setting up rig. Prepare to install pump.

0848 FHOS (T. Hotwell) off site to get pump.

0904 missing an adapter (SS coupler from 3/4" to 1/2") to attach pump to tremmie pipe. FHOS (T. Hotwell) & driller (D. DeWitt) working on problem.

0910 T. Hotwell off site looking for an adapter.

0918 Drill crew off site looking for an adapter.

0933 Adapter located, drill crew back.

0934 Begin installing Rediflo2 pump (0.5 HP Grundfos)

1022 Done.

1025 Mast down on pump setting rig. Off site to C4122 to begin testing pumps.

1105 Testing pump. Control box not working. End of shift. off site.

* Note: Pump tested (09/24/03). Worked @ 400hz on control box.

Report By: Charlene Martinez
Title: Geologist
Signature: Charlene Martinez

Reviewed By: L. D. Walker
Title: Geologist
Date: 9/30/03
Signature: L D Walker

DISTRIBUTION: White-Field File Custodian Yellow-Group Files Pink-Project Coordinator Goldenrod-Team Leader BC-6000-278 (04/91)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend **Company:** Fluor Federal Services
Date Requested: 9/29/03	**Requestor:** Chris S. Wright (FH)
Date of Survey: 10/31/03	**Surveyor:** Fluor Federal Services Survey Dept.
ERC Point of Contact:	**Survey Co. Point of Contact:** Grant F. Brazil, P.L.S.
Description of Work: Civil Survey of Groundwater Monitoring Well C4124 (299-E27-22).	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 200E

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
2E-127 (FFS) and 2E-134 (FFS)

Vertical Control Monuments:
2E-33 (FFS) and 2E-115 (FFS)

Well ID	Well Name	Easting	Northing	Elevation	
C4124	299-E27-22	575185.10	136685.33		Center of Casing
				193.383	Top Casing, N. Edge
				192.604	Brass Survey Marker
				193.389	Top Pump Base-plate, N. Edge

Notes:

Surveyor Statement:
I, Grant F. Brazil, a Professional Land Surveyor registered in the State of Washington (Registration No. 22326), hereby certify that this report is based on a field survey performed in October, 2003 under my direct supervision, and that the data contained here is true and correct.

Original to:
Distribution by DIS:

Waste Management Project

NONCONFORMANCE REPORT DISTRIBUTION COVERSHEET

From: Quality Assurance	***MSIN:*** T3-02	***Date:*** 10/1/03
NCR No.: **WMP-GPP-03NCR-010**	***STATUS:*** **Initiation [ ] Disposition [ ] Closure [X]**	

TO:		***MSIN***
Responsible Individual	R. L. Biggerstaff	E6-35
Cognizant QA Engineer	W. R. Thackaberry	E6-35
Originator	W. R. Thackaberry	N/A
QA Manager	D. G. Farwick	T3-02
Facility Manager (if applicable)	N/A	N/A
Facility Department Manager/Lead (if applicable)	N/A	N/A
Authoritative Source	D. B. Wegner	N/A
PAAA Compliance Officer	D. J. Riel	N/A
QA NCR Coordinator	S. L. Day	T3-02
OTHER: (if applicable)		***MSIN***
FH QA Programs	D. D. Volkman	H7-28
Contract Specialist	J. D. Phillips, FFS	H7-10
	C. S. Wright	E6-35
	T. L. Hottell	R4-02
	R. J. Fabre	R4-02
	B. A. Williams, PNNL	K6-81
	D. A. Myers, CH2M *(Closed copy only)*	E6-35

NONCONFORMANCE REPORT

NCR No. WMP-GPP-03NCR-010 Page 1 of 8

1. P.O./W.O./Job Control No.	2. Responsible Program, Project, Facility, or SSC
Contract No. 18618	GPP/RCRA/WMA C

3. Item or Material I.D. No./Catalog No./Other	4. Dwg./Spec./Other No./Rev.	5. Safety Classification
Annular Seal	SOW for Req 100395	GS

6. Lot/Heat/Serial No.	7. Lot Size/Sample Size/Quantity Accepted	8. ASME Code Item?
Well C4124/299-E27-22	N/A	☐ Yes ☒ No (If yes, notify authorize inspector.)

9. Supplier Name/Address	10. Suspect / Counterfeit Item?	11. Procurement Related?
Layne Christensen Company 9001 Pacific Ave Bldg B Tacoma, WA 98444	☐ Yes ☒ No (If Yes, Occurrence Report Required)	☒ Yes ☐ No (If Yes, Notify Contract Specialist)

DESCRIPTION OF NONCONFORMANCE

12. Description of Nonconformance

(a) Required Condition/Origin of Requirement

Contract 18618 Statement of Work figure 3, The CY03 RCRA Groundwater Monitoring Well Diagram shows bentonite granular seal occupying the annular space between the 4 inch diameter permanent casing and the borehole wall in the interval between the Bentonite pellet seal (above the filterpack) and the cement grout (surface) seal.

(b) Actual Condition

A 170 ft. segment of 1/4" galvanized carbon steel pipe was lost within the granular bentonite annular seal. The bottom of the pipe is reported to be at 217.2 feet below ground surface. This just is above the 5 foot bentonite pellet seal. The top of the lost pipe is 47 feet below ground surface. It is entirely contained within the annular seal and is neither wetted nor in contact with sand pack/screened interval. The 1/4" pipe was being used to measure depth to top of permanent meterials being placed in the hole during well completion when a coupling failed and the segment was lost. At the time the pipe was lost the 4 inch permanent casing was encircled by a 6 in ID inner casing and a 9 inch OD outer casing. The presence of these two casings would cause the lost pipe to be isolated from the formation (borehole wall) by at least 2.5 inches of bentonite crumbles. See attached sketch

Contract Specialist Acknowledgement

John Phillips	[signature]	9/11/03
Print Full Name	Signature	Date

NCR IDENTIFICATION / VALIDATION

13. NCR Initiator

WR Thackaberry	[signature]	9-10-03
Print Full Name	Signature	Date

14. NCR Validation. Initiating Organization QA Manager or designee

DG Farwick	[signature]	9/10/03
Print Full Name	Signature	Date

A-7310-104 (05/03

NONCONFORMANCE REPORT (continued)

NCR No. WMP-GPP-03NCR-010 Page 2 of 8

DISPOSITION

15. Interim Disposition (Check One) ☒ N/A (See Final Disposition) ☐ Conditional Accept/Use ☐ Other

Use only if actions are needed prior to determining final disposition or to facilitate continued work or testing on a conditional and controlled bas

Technical Justification, USQ or CX No. _____, required for "Conditional Accept/Use" disposition. Include the extent and any required instructions.

APPROVAL

15.1 Design Authority or ☐ N/A if not applicable

Print Full Name	Signature	Date

15.2 Responsible Organization's QA Representative or Manager or ☐ N/A if not applicable

Print Full Name	Signature	Date

15.3 ASME Authorized Code Inspector or ☐ N/A if not applicable

Print Full Name	Signature	Date

15.4 Other or ☐ N/A if not applicable

Organization/Discipline Represented _____

Print Full Name	Signature	Date

INTERIM DISPOSITION COMPLETION

16. Interim Disposition Complete (Check One) ☐ Complete ☐ N/A if not applicable

Responsible Organization QA or QC Representative

Print Full Name	Signature	Date

FINAL DISPOSITION

17. Final Disposition (Check One)

☒ Accept-As-Is ☐ Reject ☐ Repair ☐ Rework

(a) Technical Justification or Engineering Document Change (EDC), Facility Modification Package (FMP), or Design Change Notice (DCN) Number N/A See 17(b) (required for "Accept-As-Is" and "Repair" dispositions.) If EDC, FMP, or DCN Number is not required, explain why and perform USQ screening in accordance with applicable procedure. USQ or CX No. _____

Use N/A for "Reject" or "Rework" dispositions.

The 1/4" diameter tube (170 ft long) was encapsulated within bentonite backfill. The conical shape of the shoe of the working string forced the tube to lay up against the 4" SS risor. This resulted in a minimun of 2 1/4" of bentonite sealant between the tube and the formation wall. This is consistant with WAC 173-160 regulations, and was approved by Ecology (oral conversation, followed by E:mail message. Water quality sampling will not be affected by the presence of the tube since the bottom of the tube is 11 ft above the water table.

NONCONFORMANCE REPORT (continued)

NCR No. WMP-GPP-03NCR-010 Page 3 of 8

(b) Instructions for Completion. For "Repair" and Rework," include Inspection Criteria. For "Reject," identify method of disposal, e.g., scrap, return to vendor or other.

Use N/A for "Accept-As-Is."

This well will be as-built on a Well Summary Sheet which will be entered into RMIS. Assure that the presence of the pipe is documented on the Well Summary Sheet for C4124.

APPROVAL

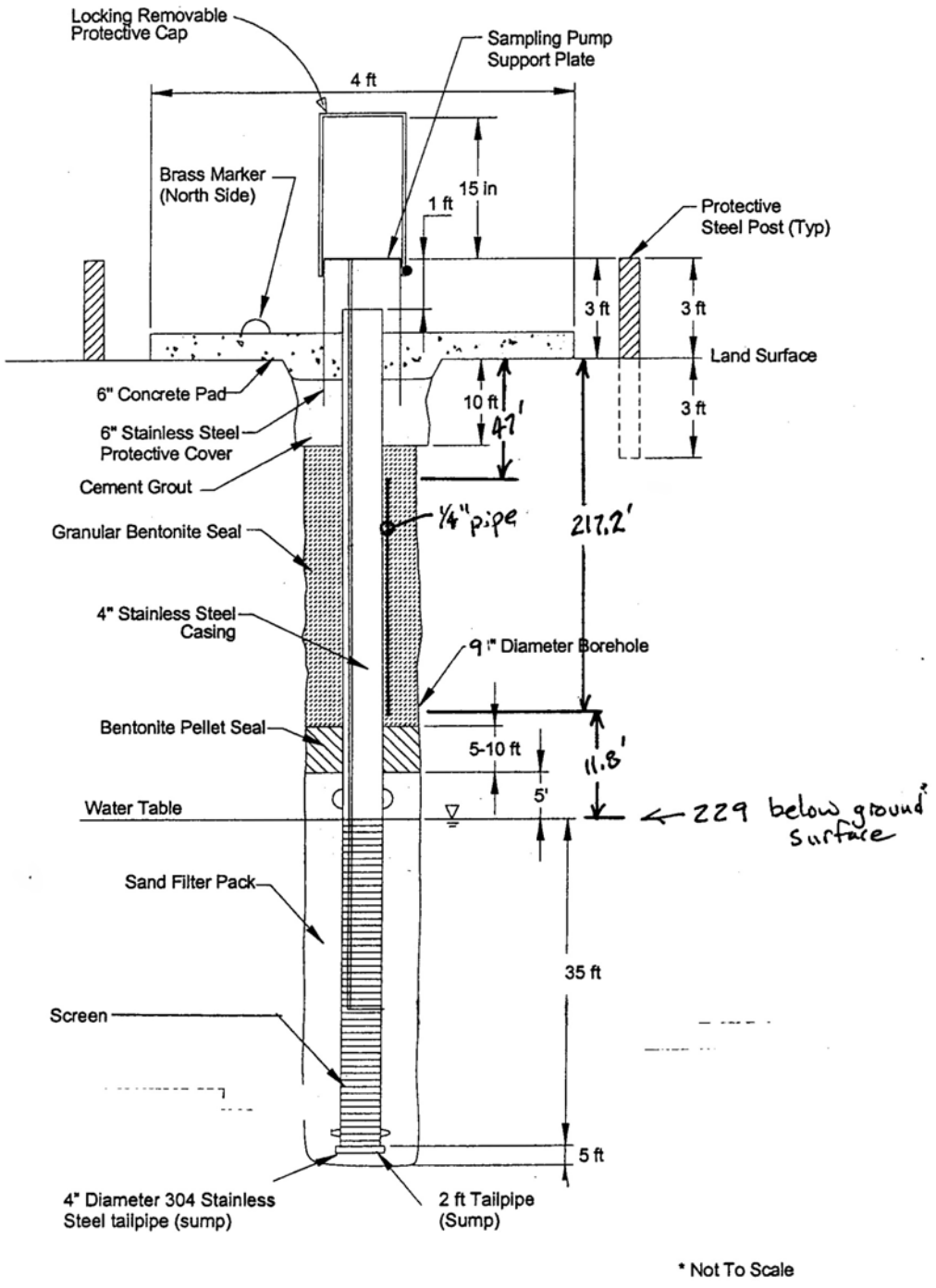
	Print Full Name	Signature	Date
17.1 Design Authority	Richard L. Biggerstaff	Richard L Biggerstaff	9/15/03
17.2 Responsible Organization's QA Representative or Manager	WR Thackaberry	W R Thackaberry	9-15-03
17.3 ASME Authorized Code Inspector or ☒ N/A if not applicable			
17.4 Other or ☐ N/A if not applicable Organization/Discipline Represented Manager Groundwater Remediation	Jane Borghese	Jane V Borghese	9-15-03

CLOSURE

	Print Full Name	Signature	Date
18. NCR Closure ☒ Approved Disposition Actions Complete and Verified ☐ Follow-on NCR QA or QC Representative	W. R. Thackaberry	W R Thackaberry	9-29-03

Figure 3. CY03 RCRA Groundwater Monitoring Well Diagram.

C4124



Thackaberry, W R (Bill)

From: Caggiano, Joseph [Jcag461@ECY.WA.GOV]
Sent: Wednesday, September 10, 2003 3:30 PM
To: 'Biggerstaff, Dick L'
Cc: Wright, Christopher S; Thackaberry, W R (Bill); Fruchter, Jonathan S
Subject: FW: well C4124 lost 1/4" pipe
Importance: High

I copied your message into a Word file, turned on the Track Changes feature, and made a few changes to clarify meaning.

Please proceed as we agreed and as stipulated below. If there are changes from this plan, please contact me. Please be sure to include the tremie pipe in the as-built drawing of the well to be entered into HWIS and, as always, include paper copy of this electronic correspondence in the construction report for this well.

Please conduct an investigation into this accident and correct field procedures to guard against future occurrences of this type.

-----Original Message-----
From: Biggerstaff, Dick L [mailto:Dick_L_Biggerstaff@RL.gov]
Sent: Wednesday, September 10, 2003 11:32 AM
To: Caggiano, Joseph
Cc: Wright, Christopher S; Thackaberry, W R (Bill); Borghese, Jane V; Williams, Bruce A; Fruchter, Jonathan S
Subject: well C4124 lost 1/4" pipe
Importance: High

Joe--This is to confirm our telecom earlier this morning concerning well 299-E27-22 (C4124). The rig on this well is a dual wall percussion type with limited space between the 4" SS and the 6" ID inner casing. Approximately 170 feet of 1/4" galvanized pipe (being used to tag backfill) was lost (coupling unscrewed) in the hole with the top at ~47 ft and the base at 217.2 ft bgs, just above the 5 ft bentonite pellet seal placed over the sand pack. The groundwater is at 229 ft bgs, or 11.8 ft below the bottom of the pipe. Multiple attempts have been made to fish the pipe out of the hole; however, there is just no annular space to work in, and all attempts have been futile. The plan we discussed is to place bentonite crumbles through the zone and to within 10 ft of the surface, thus encapsulating the pipe within the bentonite crumbles between the 4" SS completion and the formation. Because of the down-hole working system, the 1/4" pipe will be pressed up against the side of the 4" SS as the backfill operation continues. Since the outer temporary casing is 9" OD, there will be sufficient bentonite to provide an adequate seal after it is removed. The upper 10 ft of the hole will be cemented consistent with the prior-approved drilling plan. Please confirm your understanding and approval of this communication by return E-mail

Joe--This is to confirm our telecom earlier this morning concerning well 299-E27-22 (C4124). The rig on this well is a dual wall percussion type with limited space between the 4" SS and the 6" ID inner casing. Approximately 170 feet of 1/4" galvanized pipe (being used to tag backfill) was lost (coupling unscrewed) in the hole with the top at ~47 ft and the base at 217.2 ft bgs, just above the 5 ft bentonite pellet seal placed over the sand pack. The groundwater is at 229 ft bgs, or 11.8 ft below the bottom of the pipe. Multiple attempts have been made to fish the pipe out of the hole; however, there is just no annular space to work in, and all attempts have been futile. The plan we discussed is to place bentonite crumbles through the zone containing and including the galvanized tremie pipe (i.e., 47 to 217.2 ft. bgs) and to within 10 ft of the surface, thus encapsulating the pipe within the bentonite crumbles between the 4" SS completion and the formation. Because of the down-hole working system, the 1/4" pipe will be pressed up against the side of the 4" SS as the backfill operation continues. Since the outer temporary casing is 9" OD, there will be sufficient bentonite to provide an adequate annular seal after it is removed. The upper 10 ft of the hole will be cemented consistent with the prior-approved drilling plan. Please confirm your understanding and approval of this communication by return E-mail

WELL SUMMARY SHEET

Start Date: 08/21/03
Finish Date: 09/10/03
Page 1 of 2

Well ID: c4124
Well Name: 299-E27-22
Location: East of C-Tank Farm
Project: C403 RCRA drilling
Prepared By: Charlene Martinez Date: 09/11/03
Reviewed By: L.D. Walker Date: 9/15/03
Signature: Charlene Martinez
Signature: LD Walker

CONSTRUCTION DATA

Description

9" OD dual-wall temporary casing used.

6" ID protective casing set +1.0' above permanent.

4" ID SS304 sch 10 riser:
+2.2' → 228.05'

Portland Cement Grout:
0' → 10.0'

Granular Bentonite:
10.0' → 217.2'

1/4" Bentonite Pellets:
217.2' → 222.5'

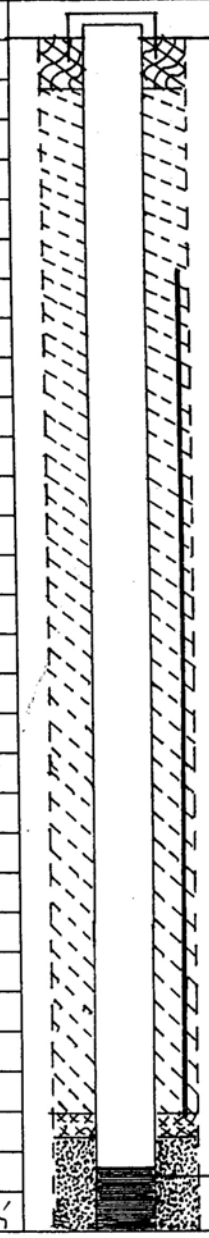
10-20 mesh Silica sand:
222.5' → 268.0'

All depths in feet below ground surface.

All temporary casing removed from ground.

170' of 1/4" OD pipe remain in ground (bentonite seal) from 47'-217'

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0'-1' Backfill (crushed gravel)
		1'-5' SAND(S)
		5'-10' gravelly SAND(gS)
		10'-29' SAND(S)
		29'-36' sandy GRAVEL(sG)
40		36'-50' SAND(S)
		50'-54' sandy GRAVEL(sG)
		54'-56' SAND(S)
		56'-60' sandy GRAVEL(sG)
		60'-72' silty sandy GRAVEL(msG)
80		72'-81.5' silty gravelly SAND(mgS)
		81.5'-89' SAND(S)
		89'-98' silty SAND(mS)
		98'-105' SAND(S)
		105'-112' silty SAND(mS)
120		112'-116' SAND(S)
		116'-122' silty SAND(mS)
		122'-138' SAND(S)
		138'-145' silty SAND(mS)
		145'-153' gravelly silty SAND(gmS)
160		153'-157' silty sandy GRAVEL(msG)
		157'-165' sandy GRAVEL(sG)
		165'-185' SAND
		185'-188' silty sandy GRAVEL(msG)
		188'-192' silty SAND(mS)
		192'-215' sandy GRAVEL(sG)
200		215'-219' gravelly SAND(gS)
		219'-222' silty sandy GRAVEL(msG)
		222'-227' SAND(S)
		227'-233' silty sandy Gravel (msG)

A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 08/21/03
Finish Date: 09/10/03
Page 2 of 2

Well ID: C4124
Well Name: 299-E27-22
Location: East of C-Tank Farm
Project: CY03 RCRA drilling
Prepared By: Charlene Martinez Date: 09/11/03
Reviewed By: L.D. Walker Date: 9/15/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
4" ID SS304 sch.10, 0.020-in. slot, cont. wire-wrap wellscreen: 228.05' → 268.02'	
4" ID SS304 sch 10 endcap: 268.02' → 268.10'	
All depths are in feet below ground surface	
All temporary casing removed from ground.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
240		233' - 268' Sandy GRAVEL(GG)
		268' BASALT
280		TD = 268' bgs.
		Static water => 230.46' bgs (09/10/03)

A-6003-643 (03/03)

Well 299-E27-4

WELL SUMMARY SHEET

Start Date: 08/12/03
Finish Date: 08/20/03
Page 1 of 2

Well ID: C4125
Well Name: 299-E27-4
Location: West of C-Tank Farm
Project: C403 RCRA Drilling
Prepared By: Charlene Martinez
Date: 09/05/03
Reviewed By: L.D. Walker
Date: 9/5/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
ID 5 1/8" OD casing to 30' bgs	
9" OD dual-wall temporary casing to 311' bgs.	
6" ID ss protective casing set + 1.0' above permanent.	
4" ID SS 304 schedule 10 riser: +1.9' → 270.32'	
Portland Cement Grout: 0' → 9.9'	
Granular Bentonite: 9.9' → 259.0'	
All temporary casing removed from ground:	
All depths in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0'-2' Backfill (Crushed Gravel)
		2'-20' SAND(S)
		20'-22' Sandy GRAVEL(sG)
		22'-45' SAND(S)
40		45'-50' gravelly SAND(gS)
		50'-80' SAND(S)
80		80'-110' gravelly SAND(gS)
		110'-195' SAND(S)
120		
160		
200		195'-200' Sandy GRAVEL(sG)
		200'-225' SAND(S)
		225'-235' Silty SAND(mS)
		235'-240' SAND(S)

A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 08/12/03
Finish Date: 08/20/03
Page 2 of 2

Well ID: C4125
Well Name: 299-E27-4
Location: West of C-Tank Farm
Project: C-403 RCRA drilling
Prepared By: Charlene Martinez Date: 09/05/03
Reviewed By: L.D. Walker Date: 9/5/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
1/4" Bentonite Pellets: 259.0' → 264.4'	
10-20 mesh silica sand: 264.4' → 309.0'	
4" ID SS 304 schedule 10 0.020-in. slot cont. wire-wrap well screen: 270.32' → 305.33'	
4" ID SS 304 schedule 10 sump end cap 305.33' → 307.76'	
muddy backfill 309.0' → 311.0'	
All temporary casing removed from ground.	
All depths in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
240		240'-245' gravelly SAND (gS)
		245'-255' sandy GRAVEL (sG)
		255'-272' GRAVEL (G)
		272'-311' sandy GRAVEL (sG)
280		
		TD = 311' bgs
320		static water = 270.65' bgs (08/20/03)

A-6003-643 (03/03)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 08/12/03
Finish Date:
Page 1 of 1

ID: C4125	Well Name: 299-E27-4	Approximate Location: West of C-Tank Farm
Project: C403 RCRA drilling		Other Companies: F H, CH G
Drilling Company: Layne Christensen		Geologist(s): C. Martinez, M.J. Hocking
Driller: Paul "Derry" Lodder	License #: 1628	

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in.) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger: Hollow Stem	Diameter 9" From 0' to 30'
Dual-wall carbon steel, FJ	0' - 311	9"	Cable Tool:	Diameter ____ From ____ to ____
9" OD (outer); 7"/6" Inner	____ - ____		Air Rotary:	Diameter ____ From ____ to ____
	____ - ____		A.R. w/Sonic:	Diameter ____ From ____ to ____
10 5/8" / 10", Carbon	0 - 30'	10 5/8" / 10"	Becker Hammer	Diameter 9" From 30' to 311'
steel, FJ	____ - ____		(Reverse Air.)	Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter ____ From ____ to ____

Drilling Fluid: none

Total Drilled Depth: 311'	Hole Dia @ TD: 9"	Total Amt. Of Water Added During Drilling: N/A	
Well Straightness Test Results: Passed using a 20.4' long, 4.5" OD tool on 08/18/03		Static Water Level: 270.65'	Date: 08/20/03

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Spectral Gamma	0' - 309'	08/15 & 08/16 2003		____ - ____	
	____ - ____			____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
4" ID SS 304, Sch. 10 riser	+1.9' - 270.32'	F480	N/A	Portland Cement (94#)	0 - 9.9'	6 bags	N/A
4" ID SS 304 Sch. 10 wellscreen	270.32' - 305.33'	"	0.020"	Granular Bentonite (50#)	9.9' - 259.0'	99 bags	N/A
4" ID SS 304 sump	305.33' - 307.76'	"	N/A	Bentonite Pellets (50#)	259.0' - 264.4'	2 buckets	1/4"
	____ - ____			Colorado Silica Sand (50#)	264.4' - 309.0'	23 bags	10-20
	____ - ____				____ - ____		

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

vol. calcs: P.C. => 6 bags * 1.285 ft^3/bag = 7.71 ft^3; Granules => 99 bags * 0.71 ft^3/bag = 70.29 ft^3.
Pellets => 2 buckets * 0.62 ft^3/bucket = 1.24 ft^3; 10-20 sand => 23 bags * 0.535 ft^3/bag = 12.31 ft^3

Reported By:	Title:	Signature:	Date:
Charlene Martinez	Geologist	Charlene Martinez	09/09/03

A-6003-658 (04/03)

WELL ATTRIBUTES REPORT

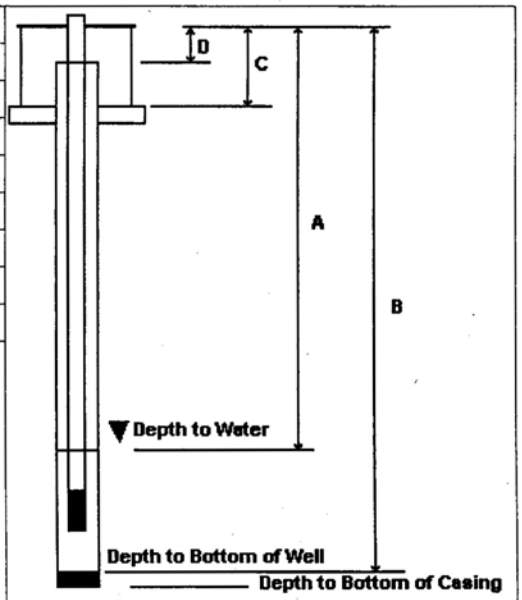
FIELD ORDER NO
WELL ID: C4125
WELL NAME: 299-E27-4
HOST WELL ID

DRILL DATE: 08/12/03
CONST DATE: 08/18/03
CONST DEPTH: 307.76'

LAST INSPECTION
NORTHING
EASTING
ELEVATION

MEASUREMENT INFORMATION

		LAST	CURRENT
A	DEPTH TO WATER(ft)	274.21' (TOC)	274.19' (TOC)
	DEPTH TO WATER DATE	09/19/03	09/29/03
B	DEPTH TO BOTTOM(ft)	311.35' (TOC)	n/a
	DEPTH TO BOTTOM DATE	09/19/03	n/a
C	STICK UP(ft)	2.88'	2.88'
D	REFERENCE MARK(ft)		
	REFERENCE MARK IS TOC	☒ YES ☐ NO ☐ ND*	☒ YES ☐ NO



A DEPTH TO WATER FROM TOP OF CASING
B DEPTH TO BOTTOM OF WELL FROM TOP OF CASING
C TOP OF CASING TO GROUND SURFACE/PAD
D TOP OF CASING TO SURVEY REFERENCE MARKER

PERFORATION INFORMATION

CASING SIZE	TOP	BOTTOM	CUTS/FT/ROUND

CHANGES

g.w. => 274.21' - 0.02' (landing plate) = 274.19' TOC

CASING INFORMATION

SIZE	TOP	BOTTOM	MATERIAL	TYPE	CONNECTION	THICKNESS
4" ID	+1.9'	270.32'	stainless steel	304; sch. 10		

CHANGES

SCREEN INFORMATION

SIZE	TOP	BOTTOM	MATERIAL	TYPE	SLOT SIZE
4" ID	270.32'	305.33'	stainless steel	304; schedule 10	0.020-inch

CHANGES

ND* - Not Documented
BHI-EE-231 (02/20/02)

1/10/2003

BOREHOLE LOG

Page 1 of 8

Date: 08/12/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	H.S.	N/A		0-2' Backfill. Crushed basaltic gravel	med-risk 0-30' bgs.
					Hollow-stem auger used
				2'-20' sand(s) 100% sand, R, v. well sorted, vfn-fn grained, non-basaltic. 2.5Y 4/3 olive brown, moist. Strong rxn HCl.	to 30' bgs. 10 5/8" OD single-wall casing used to 30' bgs. E.O.S. 08/12/03 Start 08/13/03
5	Grab H.S.				Collect 5' archive
				20'-22' Sandy GRAVEL (sG) 65% gravel, 35% sand. Gravel, poorly sorted, SR-SA, 2m pebbles-2m cobbles basaltic. Sand, vfn-fn grain, R. trace mica, non-basaltic, 2.5Y 4/3 olive brown, moist. Med rxn HCl.	
10	Grab H.S.				Collect 10' archive
				22'-45' SAND (s) 85% sand, 6% silt, 9% gravel. Gravel, well-sorted, pea-size, SR-R, basaltic. Sand, mod-sorted, vfn-med grain, SR-SA, 2.5Y 4/2, dark grayish brown, moist. No rxn HCl. Trace mica.	
15	Grab H.S.				Collect 15' archive
20	Grab H.S.				Collect 20' archive
25	Grab H.S.				Collect 25' archive
					Cont. RCT/IH coverage 1st 30': α, β, γ @ background NH_3 => 2 ppm @ 19' bgs.
30	Grab BH 9"				Collect 30' archive Becker Hammer using 9" OD dual-wall casing 30'-TD'.
35	Grab BH 9"			@ 35' Sand, poorly ~~sorted~~ sorted vfn-vcse grained, SR-SA, 65% qtz/other, 35% basalt silt content down. No gravel. 2.5Y 5/2 grayish brown, moist, no rxn HCl.	Collect 35' archive

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date:

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 2 of 8

Date: 08/13/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH9" Grab BH9"	N/A		@ 40' trace basaltic gravel, mes ~3"	Becker Hammer using 9" OD dual-wall casing. Collect 40' archive
45	Grab BH 9"			@45'–50' GRAVELLY SAND(gS) 15% gravel, 80% sand, 5% silt, Gravel, well-sorted, pea-size to 3m pebbles, basaltic, R-SR. Sand, poorly sorted, fn-vcse grained, micaceous, 55% qtz/other, 45% basalt. No rxn HCl.	Collect 45' archive
50	Grab BH 9"			50'–~~55'~~ 60' SAND(S) 95% sand, 5% silt. Sand, poorly sorted, SR-SA, vfn-vcse, 55% qtz/other, 45% basalt, micaceous. No rxn HCl.	Collect 50' archive
55	Grab BH 9"				Collect 55' archive
60	Grab BH 9"				Collect 60' archive
65	Grab BH 9"			@65' trace of pea-size basaltic gravel.	Collect 65' archive
70	Grab BH 9"			@70' trace of pea-size basaltic gravel	Collect 70' archive
75	Grab BH 9"			@75' ~2% pea size basaltic gravel	Collect 75' archive

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/13/03 | Signature: LD Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 08/13/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH9" Grab BH9"	N/A		80'-110' gravelly SAND (gS) 20% gravel 75% sand, 5% silt. Gravel, well sorted, SR-R, 65% basalt, 35% qtz) other, pea-size-sm pebbles. Sand, poorly sorted, SR-SA, vfn-vcse, 45% basalt, 55% qtz/other, no rxn HCl, micaceous	Becker Hammer using 9" OD dual-wall casing collect 80' archive
85	Grab BH9"			@85' gravel down to 15%. Pred. pea-size, basaltic, SR-R	collect 85' archive
90	Grab BH9"				Collect 90' archive
95	Grab BH9"			@95' gravel increasing to 20%, mod-sorted, increasing to 3cm pebbles	collect 95' archive
100	Grab BH9"			@100' sand mod sorted, basalt content decreasing to 45%. Gravel decreasing to 12%.	collect 100' archive
105	Grab BH9"			@105 gravel decreasing to 10%	collect 105' archive
110	Grab BH9"			110' - 115' SAND(S) 94% sand, 6% silt. Sand, mod-sorted, med-vcse, SR-SA 40% basalt, 60% qtz/other, micaceous 2.5Y 5/2 grayish brown, dry, no rxn HCl.	collect 110' archive
115	Grab BH9"			@115' sand grading to poorly sorted, vfn-vcse, SR-SA.	collect 115' archive

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/13/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 08/13/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: C-103 RCRA drilling | 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	BH 9" Grab BH 9"	N/A		@120' Sand, v poorly sorted, vfn-vcse grained, pred. cse-vcse. Trace gravel sm pebbles, mps ~0.5". Silt ~ 6%.	Becker Hammer using 9" OD dual-wall casing. Collect 120' archive.
125	Grab BH 9"			@125' Increase in basaltic, pea-size gravel (~ 8%) Sand. 50% basalt, 50% qtz/other. 6-7% silt.	Collect 125' archive
130	Grab BH 9"			@130' pea-size basaltic gravel. Sand, poorly sorted, SR-SA, vfn-vcse 6-7% silt.	Collect 130' archive
135	Grab BH 9"			@135' still pea-size basaltic gravel	Collect 135' archive
140	Grab BH 9"			@140' pea-size gravel, basaltic. Sand vfn-vcse grain, poorly sorted, SR-SA, silt ~ 6%. 50% qtz/other 50% basalt. no rxn HCl.	Collect 140' archive
145	Grab BH 9"			@145' Sand grading to mod-sorted med-vcse grain. no gravel.	Collect 145' archive
150	Grab BH 9"			@150' ~8% basaltic, pea-size gravel. Sand, SR-SA, med-vcse grained, 50% basalt, 50% qtz/other. no rxn HCl.	Collect 150' archive
155	Grab BH 9"				Collect 155' archive

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/13/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 5 of 8

Date: 08/13/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH 9" Grab BH 9"	n/a		@160' trace pea-size gravel (< 5%), basaltic. Sand, SR-SA, poorly sorted, fn-vcse., 50% qtz/other, 50% basalt	Becker Hammer using 9" OD dual-wall casing. Collect 160' archive
165	Grab BH 9"				Collect 165' archive
170	Grab BH 9"			@170' trace pea-size basaltic gravel.	Collect 170' archive
175	Grab BH 9"			@175' sand grading to mod-sorted, SR-SA. 50% qtz/other, 50% basalt, med-vcse	Collect 175' archive
180	Grab BH 9"			@ 180' sand grading to poorly-sorted, SR-SA vfn-vcse grained, 50% basalt, 50% qtz/other	Collect 180' archive
185	Grab BH 9"			@ 185' pea-size basaltic gravel (~ 8%)	Collect 185' archive
190	Grab BH 9"			@190' pea-size to small pebbles (~ 8%) pred. basalt. sand, v. poorly sorted, vfn-vcse grain, SR-SA. Silt 6-7%.	Collect 190' archive
195	Grab BH 9"			195' — 200' Sandy GRAVEL (SG) 45% gravel, 50% sand, 5% silt. Gravel, v. well-sorted, SR-R, basaltic, pea-size. Sand, mod-sorted, m-vcse grained, 40% basalt, 60% qtz/other, SR-SA, no rxn HCl	Collect 195' archive

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 08/13/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 8

Date: 08/13/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: CY 03 RCRA drilling | 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	BH 9" Grab BH 9"	n/a		200'–225' SAND (S) 5% gravel, 90% sand, 5% silt. Gravel, SR-SA basaltic, peg-size, well sorted. Sand, poorly sorted, vfn-vcse, SR-SA, 40% Basalt, 60% qtz/other. no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 200' archive. P.M. RCT ck. All okay
205	Grab BH 9"				Collect 205' archive
210	Grab BH 9"				Collect 210' archive
215	Grab BH 9"			@ 215' no trace gravel. silt content same. sand, SR-SA, poorly sorted.	Collect 215' archive
220	Grab BH 9"			@ 220' sand, grading to mod-sorted, vfn-med grain, few coarse grains. 40% basalt, 60% qtz/other.	Collect 220' archive
225	Grab BH 9"			225'–235' silty SAND (mS) 88% sand, 12% silt. Sand, SR-SA, mod-sorted, vfn-cse, 40% basalt, 60% qtz/other. no rxn HCl. micaceous	Collect 225' archive
230	Grab BH 9"			@ 230' sand grading to well-sorted, vfn-fn, silt same.	Collect 230' archive
235	Grab BH 9"			235'–240' SAND (S) 95% sand, 5% silt. Sand, vfn-fn, v. well sorted, R, non-basaltic, micaceous, 2.5Y 6/2 light brownish gray (dry) no rxn HCl.	Collect 235' archive

Reported By: Charlene Martiner | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martiner | Date: 08/13/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 08/13/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH 9" Grab BH 9"	N/A		240'– 245' gravelly sand (gs) 15% gravel, 80% sand, 5% silt. Gravel, well-sorted, basaltic, sm-pebbles, SR-R, sand, poorly sorted, SR-SA, vfn-vcse, 40% basalt, 60% qtz/other	Becker Hammer using 9" OD dual-wall casing. Collect 240' archive
245	Grab BH 9"			245'– 255' Sandy GRAVEL (sG) Gravel 45%, sand 50%, silt 5%. Gravel well sorted, SR-SA, 45% basalt, 35% qtz/other, sm. pebbles. Sand, poorly sorted, SR-SA, vfn-vcse, 45% basalt, 55% qtz/other. no rxn HCl. micaceous.	Collect 245' archive
250	Grab BH 9"			@250' gravel, mod-sorted, mps ~2"	Collect 250' archive. p.m. I_H ct. $\wedge H_2$ ▼ organics < detect.
255	Grab BH 9"			255'–272' GRAVEL (G) 85% gravel, 10% sand, 5% silt. Gravel, mod-sorted, SR-SA 80% basalt, 20% qtz/other, pea-size (predominant) occassional med-pebble, mps ~2.5". Sand, poorly sorted, vfn-vcse, SR-SA. 45% basalt, 55% qtz/other. no rxn HCl.	Collect 255' archive
260	Grab BH 9"				Collect 260' archive
265	Grab BH 9"			272'–311' Sandy GRAVEL (sG) 55% gravel, 40% sand, 5% silt. Gravel, mod-sorted, SA-R, 45% basalt, 55% qtz/other, mps ~ 3". Sand, poorly sorted, pred. csse-vcse grained, SR-SA, increase in basalt content, 80% basalt, 20% qtz/other	Collect 265' archive. RCT performed thorough survey of spoils. 9x 3,5 @ background (0'–270')
270	Grab BH 9"	sieve sample			Collect 270' archive. Collect sieve analysis sample (from cyclone) between 270'–271' bgs
275	Grab BH 9"				Collect 275' archive

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 08/13/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: LD Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 8 of 8

Date: 08/13/03

Well ID: C4125 | Well Name: 299-E27-4 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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
280	BH 9"	N/A			Becker Hammer using 9" OD dual-wall casing
	Grab BH 9"				collect 280' archive
285	Grab BH 9"			@ 285' gravel size decreasing, sm-med pebbles, some sm. cobbles. Increased basalt content	collect 285' archive
290	Grab BH 9"				Collect 290' archive
295	Grab BH 9"			@ 295' gravel, poorly sorted, pea-size to med. cobbles. Basalt 60%, qtz/other 40%.	Collect 295' archive
300	Grab BH 9"	sieve analysis sample N/A			Collect 300' archive; collect sample for sieve analysis (from cyclone) @ 301'-303' bgs
305	Grab BH 9"			@ 305' gravel, mod-sorted, SA-R basaltic.	Collect 305' archive
310	Grab BH 9"				collect 309' archive.
	TD => 311' bgs			TD => 311' bgs.	
315					

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/13/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

WELL DEVELOPMENT AND TESTING DATA

Report 1: Page 1 of 1

Well Name:	Well ID:	Well Location:	Date:
299-E27-4	C4125	West of C-Tank Farm	09/10/03

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

Has the well been surveyed? ☐ Yes ☒ No

Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:

Start of Job 274.29'

End of Job

DEPTH TO BOTTOM:

Start of Job 311.35'

End of Job

PART 2

WELL DEVELOPMENT DATA

Pump Model Franklin 5 HP submersible

Intake Depth ~~273.0~~ B

Starting Turbidity

Pump Start	Stop	Flow Rate
—	—	—

Total Pumped

Final Turbidity

XD SN/Range (PSI) 20.0 psi

PART 3

INSTANTANEOUS SLUG TEST

Static Water Level (TOC)

Transducer Depth

Baseline Start

Injection Start

Baseline Start

Withdrawal Start

Slug Volume

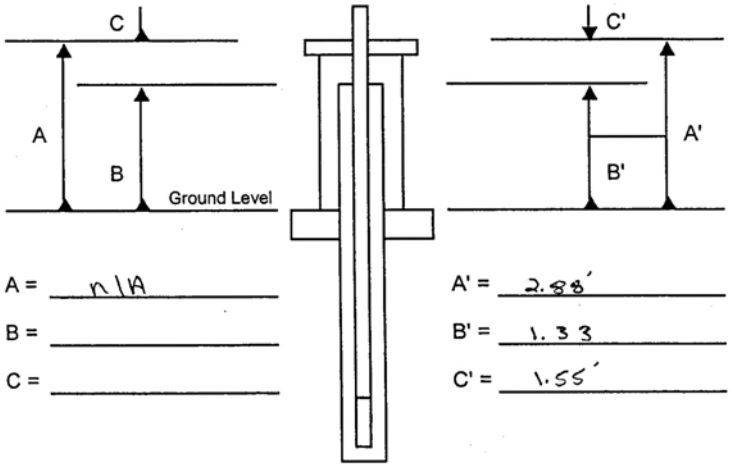
XD SN/Range (PSI)

~~Not used Charlene Martinez 09/10/03~~

PART 4

Last Recorded Measurements Date: —

Current Measurements Date: 09/10/03



A = n/A

B =

C =

A' = 2.88'

B' = 1.33

C' = 1.55'

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

COMMENTS: 1200 On site. Waiting for drill crew to finish securing C4124.

1235 Initial measurements ⇒ gw = 274.29' TOC

TD = 311.35' TOC. No fill in well.

1245 Setting up pump setting rig.

1320 Tripping in pump + tremmie pipe.

1330 Calibrating instruments

1415 Pipe in. Lowering transducer.

1430 Goofy readings from Hermit. Pulled transducer up. Stuck. Trip out tremmie pipe. Tape transducer to above pump. Trip in pipe. Done. Resume in A.r

1545 Goofy readings from Hermit. will take to office.

Prepared by (print name):	Signature:	Date:
Charlene Martinez	Charlene Martinez	09/10/03
Reviewed by (print name):	**Signature:**	**Date:**
L.D. Walker	L.D. Walker	9/30/03

A-6003-644 (03/03

WELL DEVELOPMENT AND TESTING DATA

Report # 2. Page 1 of 2

Well Name:	Well ID:	Well Location:	Date:
299-E27-4	C4625	West of C-Tank Farm	09/11/03

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

Has the well been surveyed? ☐ Yes ☒ No | Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:

Start of Job 274.29'

End of Job 274.30'

DEPTH TO BOTTOM:

Start of Job 311.35'

End of Job N/A

PART 2

WELL DEVELOPMENT DATA

Pump Model Franklin 5 HP submersible

Intake Depth B 304.4' | M 295.4 | T —

Starting Turbidity B 26.6 | M 6.23 | T —

Pump Start	Stop	Flow Rate
0845 (70 mins)	0955 (1840 gals)	26-27 gpm
1000 (50 mins)	1050 (1300 gals)	26 gpm
1840 + 1300 = 3,140 gals		

Total Pumped 3,140 gals.

Final Turbidity B 3.20 | M 0.74 | T —

XD SN/Range (PSI) N/A

PART 3

INSTANTANEOUS SLUG TEST

Static Water Level (TOC)

Transducer Depth

Baseline Start

Injection Start

Baseline Start

Withdrawal Start

Slug Volume

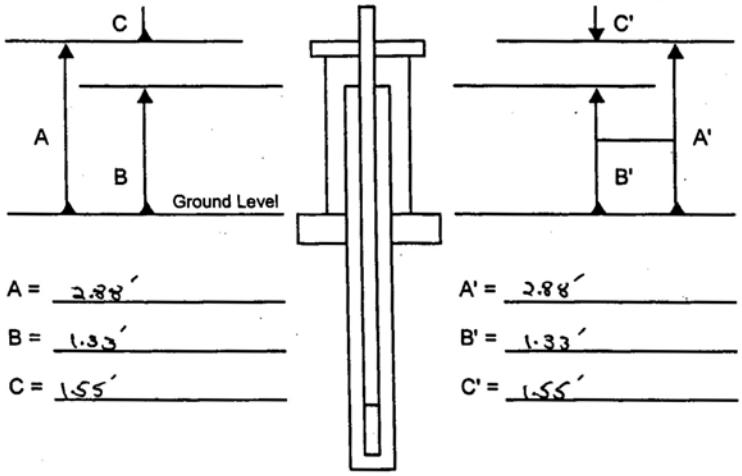
XD SN/Range (PSI)

Wax used on chain pulley 09/11/03

PART 4

Last Recorded Measurements Date: 09/10/03

Current Measurements Date: 09/11/03



A = 2.88'

B = 1.33'

C = 1.55'

A' = 2.88'

B' = 1.33'

C' = 1.55'

Are there any reference marks on the casing strings? ☐ Yes ☐ No

PART 5

COMMENTS:

0600 P.O.D./Safety meeting

0615 On site. Prepare to develop well. old-fashioned development.

0630 Trying to get E-tape into well. Troubles lowering e-tape.

0651 Raising/lowering pump to try to get E-tape in well.

0653 Calibrating instruments.

0800 Geologist miscalculated where pump was to be set. Tripped in more tremmie pipe.

0830 Running in E-tape. Trying again.

0842 Ready to go. Hooking up hoses & valves. XD = 274.29' TOC.

0845 Turn on pump. Initial measurements: T 19.2°C | COND 530 | Turb mu 24.6 ; XD = steady @ 274.33' below TOC. 27 gpm.

See page 2 for measurements.

Prepared by (print name):	Signature:	Date:
Charlene Martinez	Charlene Martinez	09/11/03
Reviewed by (print name):	**Signature:**	**Date:**
L.D. Walker	L.D. Walker	9/30/03

A-6003-644 (03/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Date: 09/10/03

Well ID: C4125 | Well Name: 299-E27-4

Location: West of C-Tank Farm | Report No.: 2 (well development)

Start	Finish	Total
Time 0600	Time 1115	Time 5.25 hrs
Hole Depth/Csg n/a / n/a	Hole Depth/Csg n/a / n/a	Hole Depth/Csg n/a / n/a

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Test #1, Intake set @ 304.4' TOC.

Time	XD (ft)	NTU TURB	µS/cm Cond.	T °C	
0906	274.33	8.19	522	19.3	0945 Pump shut off. Recovery test.
0910	274.33	4.04	522	19.2	0955 Stop test. 274.29' 100% recovery.
0916	274.33	3.50	522	19.2	0955 move intake up 9'. Intake set @ 295.4' TOC.
0925	274.31	3.19	516	19.6	
0930	274.30	3.00	513	19.7	1000 Start 2nd test (295.4' TOC) XD = 274.29' TOC.
0935	274.30	2.85	516	19.7	Holding steady XD => 274.3' (TOC)
0940	274.30	3.20	516	19.5	Initial readings: XD = 274.31, TURB 6.23 NTU; COND 478 µS/cm

Test #2 (295.4' TOC) T = 21.0°C ; 2½ gpm

Time	XD (ft)	NTU TURB	µS/cm COND	T °C	
1010	274.31	2.65	462	19.9	1050 Stop test. Purge water truck full.
1030	274.31	1.62	452	20.0	1050 Begin recovery test.
1040	274.31	0.96	451	19.9	1100 Recovery complete. XD = 274.30' TOC.
1050	274.31	0.74	452	20.1	100% recovery.

1115 Geologist off site, site shut down early due to F-H. shingdig. Driller/helper to go to Tacoma for supplies/equipment. Be back to resume well development in A.M. using Hermit 3000 data logger.

Charlene Martinez 09/11/03

Reported By: Charlene Martinez | Title: Geologist | Date: 09/11/03 | Signature: Charlene Martinez

Reviewed By: L.D. Walker | Title: Geologist | Date: 9/30/03 | Signature: L.D. Walker

A-6003-651 (04/03)

WELL DEVELOPMENT AND TESTING DATA

Report #3: Page 1 of 2

Well Name:	Well ID:	Well Location:	Date:
299-E27-4	C4125	West of C-Tank Farm	09/12/03

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

Has the well been surveyed? ☐ Yes ☒ No | Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:

Start of Job 274.29'

End of Job 274.35'

DEPTH TO BOTTOM:

Start of Job 311.35'

End of Job 311.35'

PART 2

WELL DEVELOPMENT DATA

Pump Model Franklin 5 HP

Intake Depth 283.3'

Starting Turbidity 35.6

Pump Start	Stop	Flow Rate
(70 mins) 0647	0757 (1960 gals)	28 gpm

Total Pumped 1960 gallons

Final Turbidity 1.16 NTU

XD SN/Range (PSI) 20.10

PART 3

INSTANTANEOUS SLUG TEST

Static Water Level (TOC)

Transducer Depth

Baseline Start

Injection Start

Baseline Start

Withdrawal Start

Slug Volume

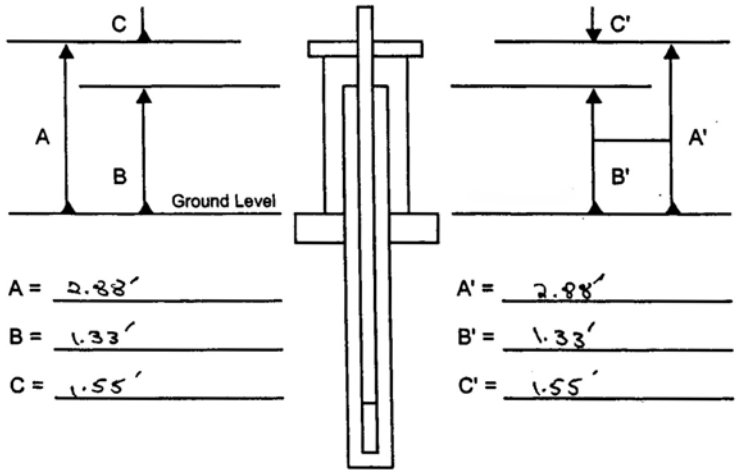
XD SN/Range (PSI)

not used Charlene Martinez 09/12/03

PART 4

Last Recorded Measurements Date: 09/11/03

Current Measurements Date: 09/12/03



A = 2.88'

B = 1.33'

C = 1.55'

A' = 2.88'

B' = 1.33'

C' = 1.55'

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

COMMENTS:

0600: P.O.D.I. Safety meeting. Discuss well development.

0612 on site. Prepare for stage 3, using Hermit data logger.

0615 Calibrating instruments

0620 Setting intake. Remove 2' pipe. Add 9' pipe.

0645 Ready for test #1 (intake @ 283.3'). Initial XD = 8.31

(test #2 on data logger)

0647 Begin test. Initial readings: XD = 8.233'. Cond = 407 µS/cm

T = 18.3°C, TURB = 35.6 NTU. measurements listed below

Time	XD (ft)	NTU TURB	µS/cm Cond	T°C	28 gpm => flow rate.
0658	8.272'	6.46	402	18.2	
0719	8.253	1.70	403	17.4	
0730	8.247	1.28	402	18.0	

Prepared by (print name):	Signature:	Date:
Charlene Martinez	Charlene Martinez	09/12/03
Reviewed by (print name):	**Signature:**	**Date:**
L.D. Walker	L.D. Walker	9/30/03

A-6003-644 (03/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Date: 09/12/03

Well ID: C4125 | Well Name: 299-E27-4

Location: West of C-Tank Farm | Report No.: 3 (well development)

Start	Finish	Total
Time 0600	Time 0930	Time 3.5 hrs
Hole Depth/Csg — / —	Hole Depth/Csg — / —	Hole Depth/Csg — / —

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:

See Report No. 1 well development

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
		Readings (cont.)
	Time	XD(ft) / NTU Turb / µS/cm Cond / T°C
	0744	8.244 / 1.45 / 405 / 18.0
	0757	8.244 / 1.16 / 403 / 18.4
0758		Pump shut off. Begin recovery test (#3 on data logger). End Test. Final XD
	0863	= 8.310'. 100% recovery
0825	0900	Tripping out trommie pipe & pump.
0832		Purge water truck off site to be emptied.
0902	0918	Cleaning site. Prepare to go decon & move to C4124, off site.
0925		Tagged g.w. => 274.35' TOC
		Tagged TD => 311.35' TOC

Charlene Martinez 09/12/03

Reported By: Charlene Martinez | Reviewed By: L. D. Walker

Title: Geologist | Date: 09/12/03 | Title: Geologist | Date: 9/30/03

Signature: Charlene Martinez | Signature: LD Walker

A-6003-651 (04/03)

FIELD ACTIVITY REPORT
WELL SERVICES

Page 1 of 1

Date	Well No.	Rig Type/Model	Rig No.	Contract/Work Order No.	Report No.
09/19/03	299-E27-4	Pump setting rig			1

Purpose	Reference	Location
Install pumps in CY03 RCRA wells		West of C-Tank Farm

HISTORICAL DATA

Construction Depth	307.76' bgs
Casing Size / Type / Set At	4" ID SS 304 sch 10 / +1.9' – 270.32'
Casing Perforations Schedule / Interval	
Well Screen(s) Type (4" ID) / Interval	0.020" slot SS 304 sch 10 / 270.32' – 305.33'
Last Recorded Depth-to-Water	274.29' (TOC)
Last Recorded Depth-to-Bottom	311.35' (TOC)
Current Depth-to-Water	274.21' (TOC)
Current Depth-to-Bottom	311.35' (TOC)

PUMP SYSTEM CONFIGURATION

	Pre-Maintenance	Post-Maintenance
Pump Type (0.7 HP)	Grundfos Redi.flo3	
Pump Model	Prod # 96030139 model A	
Tubing Size/Type	0.75" OD SS 304 sch 40	
Length-Bottom of Tubing to Pump Intake	1.11'	
Tubing Length	280.0'	
Length-Top of Tubing to Reference Point		
Pump Intake Set at (Depth)	281.11'	

Reference/Measuring Point: (TOC) Top of Casing

Start Time	0600
End Time	0810
Time	
Contract Time	
Total Time	2.25 hrs

Personnel:
Layne Christensen
- Dave DeWitt
- Ken Jones

FLUOR Hanford
- Tim Hottell

CH2M Hill (CCHG)
- Charlene Martinez

Materials Used: 28 x 10' long sections SS 304 sch. 40, 0.75" OD tremmie pipe w couplers (ss)
0.7 HP Grundfos Redi.flo3 pump.

Description of Operations/Remarks

0600 P.O.D. / Safety meeting
0615 Drill crew off to get ss tremmie pipe.
0630 Drill crew on site. Setting up rig.
0640 Tagged g.w. => 274.21' (TOC)
Tagged TD => 311.35' (TOC)
0650 Tripping in 0.7 HP Grundfos Redi.flo3 pump w 0.75" OD SS 304, schedule 40 tremmie pipe.
0806 Done. Lowering mast. Preparing to move to C4124.
0900 Drill crew + rig off site. Geologist tagging along.
11 22 Pump tested. Works. (cm)

not used
Charlene Martinez 09/19/03

Report By	Charlene Martinez
Title	Geologist
Signature	Charlene Martinez
Reviewed By	L.D. Walker
Title	Geologist
Date	9/30/03
Signature	L.D. Walker

DISTRIBUTION: White-Field File Custodian Yellow-Group Files Pink-Project Coordinator Goldenrod-Team Leader BC-6000-278 (04/91)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend **Company:** Fluor Federal Services
Date Requested: 9/29/03	**Requestor:** Chris S. Wright (FH)
Date of Survey: 10/31/03	**Surveyor:** Fluor Federal Services Survey Dept.
ERC Point of Contact:	**Survey Co. Point of Contact:** Grant F. Brazil, P.L.S.
Description of Work: Civil Survey of Groundwater Monitoring Well C4125 (299-E27-4).	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 200E

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
2E-127 (FFS) and 2E-134 (FFS)

Vertical Control Monuments:
2E-33 (FFS) and 2E-38 (FFS)

Well ID	Well Name	Easting	Northing	Elevation	
C4125	299-E27-4	575032.02	136497.92		Center of Casing
				205.569	Top Casing, N. Edge
				204.685	Brass Survey Marker
				205.575	Top Pump Base-plate, N. Edge

Notes:

Surveyor Statement:
I, Grant F. Brazil, a Professional Land Surveyor registered in the State of Washington (Registration No. 22326), hereby certify that this report is based on a field survey performed in October, 2003 under my direct supervision, and that the data contained here is true and correct.

Original to:
Distribution by DIS:

Well 299-E27-20

Decommissioned due to bit refusal

Not completed

WELL SUMMARY SHEET

Start Date: 07/28/03
Finish Date: 08/05/03
Page 1 of 2

Well ID: C 4126
Well Name: 299-E27-20
Location: West of C-Tank Farm
Project: C403 RCRA drilling
Prepared By: Charlene Martinez Date: 08/08/03
Reviewed By: L.D. Walker Date: 8/12/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
9" OD Dual-wall temporary casing used:	
Quick-Crete Cement: 0' → 10.3'	
Granular bentonite: 10.3' → 262.8'	
10-20-mesh silica sand: 262.8' → 278.5'	
All ~~temporary~~ temporary casing removed from ground.	
All depths are in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

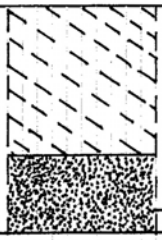
Depth in Feet	Graphic Log	Lithologic Description
0		0'-1' Backfill. Crushed gravel.
		1'-5' SAND(S)
		5'-13' gravelly SAND(gS)
		13'-16' SAND(S)
		16'-20' gravelly SAND(gS)
40		20'-85' SAND(S)
80		85'-90' gravelly SAND(gS)
		90'-95' SAND(S)
		95'-110' gravelly SAND(gS)
		110'-160' SAND(S)
120		
160		160'-175' silty Sandy GRAVEL (msG)
		175'-220' silty SAND(mS)
200		
		220'-240' SAND(S)

A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 07/28/03
Finish Date: 08/05/03
Page 2 of 2

Well ID: C4126
Well Name: 299-E27-20
Location: West of C-Tank Farm
Project: CY03 RCRA drilling
Prepared By: Charlene Martinez Date: 08/08/03
Reviewed By: L.D. Walker Date: 8/12/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
9" OD Dual-wall casing used.		240		240 - 278.5' Sandy GRAVEL (GP)
		274		STATIC WATER @ 273.5' bgs (07/29/03)
				Refusal @ 278.5' bgs
		280		Borehole decommissioned
		320		
All temporary casing removed from ground.				
All depths are in feet below ground surface.				

A-6003-643 (03/03)

BOREHOLE LOG

Page 1 of 7

Date: 07/28/03

Well ID: C4126 | Well Name: 299-E27-20 | Location: W. of S-Tank Farm

Project: FY 03 RCRA drilling | 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	BH94	n/a		0'-1' Backfill material. Crushed basaltic gravel.	Becker Hammer using 9" OD dual-wall casing
				1'-5' SAND (S) 95% sand, 5% silt. Sand, R, v. well sorted, vfn-med grained, non-basaltic. 2.5Y5/3 light olive brown (dry). micaceous no rxn HCl.	Aeolian sand
5	Grab BH94				Collect 5' archive
				5'-13' gravelly SAND (gS) 15% gravel, 80% sand, 5% silt. Gravel, mod-sorted, SR-A, basaltic, mps ~ 1.5", Sand, v. well sorted, R, vfn-med, non-basaltic. 2.5Y3/3 dark olive brown (moist). micaceous strong rxn HCl.	Hanford fmtn @ 5' bgs.
10	Grab BH94				Collect 10' archive
15	Grab BH94				Collect 15' archive
				13'-16' Sand (S) 5% gravel, 87% sand, 8% silt. Gravel, poorly sorted, basaltic, SR-SA, mps ~ 3".	
20	Grab BH94			Sand, poorly sorted, vfn-vcse, 85% basalt, 15% qtz/other, SR-SA 2.5Y3/2, v. dark grayish brown (moist). mod. rxn HCl.	Collect 20' archive. NH3 => 20 ppm in borehole. RCT surveying spoils. Background @ 2200 ppm (Sodium Iodide) spoils @ 3000+ ppm
25	Grab BH94			16'-20' gravelly sand (gS) 10% gravel, 82% sand, 8% silt. Gravel, poorly sorted, SR-SA, sm pebbles-med cobbles, mps ~ 4", basaltic. Sand, poorly sorted, SR-SA vfg-vcse grained, 85% basalt, 15% qtz/other, trace mica. 2.5Y3/2 v. dark grayish brown (moist) mod. rxn HCl.	Collect 25' archive
30	Grab BH94				Collect 30' archive
35	Grab BH94			20'-85' SAND (S) 95% sand, 5% silt. Sand, poorly sorted, SR-SA fn-vcse grained, 40% basalt, 60% qtz/other. 2.5Y5/2 grayish brown (moist) no rxn HCl.	Collect 35' archive. trace gravel @ 35'

Reported By: Charlene Martinez | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/28/03 | Signature: L D Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 07/28/03

Well ID: C4126 | Well Name: 299-E27-20 | Location: west of C-Tank Farm

Project: C403 RCRA drilling | 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	3@9" Grab BH9"	n/a		@20' sand, cse-vcse, mod sorted, basalt increase to 60%, 40% qtz/other. 2.5Y 4/3 olive brown (moist) no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 40' archive
45	Grab BH9"			trace w. sorted gravel (basalt) @45' 25'-50' same sand description as 20' interval.	Collect 45' archive
50	Grab BH9"				Collect 50' archive @50' NH_3 => 9 ppm
55	Grab BH9"			@55' increase in pea-size basaltic gravel (~5%), well sorted, SR-R sand, same as before.	Collect 55' archive
60	Grab BH9"				Collect 60' archive @60' NH_3 => 18 ppm
65	Grab BH9"			@65' increase in pea-size basaltic gravel (~8%) sand, poorly sorted, fn-vcse grained, pred. cse-vcse, SR-SA, 50% basalt, 50% qtz/other. no rxn HCl.	Collect 65' archive
70	Grab BH9"				Collect 70' archive @70' NH_3 => 14 ppm
75	Grab BH9"			@75' trace of pea-size gravel (~5%) sand same as above	Collect 75' archive

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/28/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 3 of 7

Date: 07/28/03

Well ID: C4126 | Well Name: 299-E27-20 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH94 Grab BH94	N/A			Becker Hammer using 9" OD dual-wall casing. Collect 80' archive. NH_3 = 18 ppm (80')
				85'-90' gravelly SAND (gS)	
86	Grab BH94			12% gravel, 85% sand, 3% silt. gravel, basaltic, SR-R, well-sorted, pea-size-3cm pebbles (mps = 0.3") sand, poorly sorted, fn-vcse, SR-SA, 55% basalt, 45% qtz, other. 2.5Y 4/2 dark grayish brown (moist) no rxn HCl.	Collect 85' archive
90	Grab BH94				Collect 90' archive NH_3 = 18 ppm (90')
				90'-95' SAND (S) 95% sand, 5% silt, sand, SR-SA, v. poorly sorted, vfn-vcse grained, 55% basalt, 45% qtz, other. 2.5Y 4/2 dark grayish brown (moist) no rxn HCl.	
95	Grab BH94				Collect 95' archive
100	Grab BH94				Collect 100' archive @ 100' 20 ppm NH_3 RCT reports slight elevation of α, β, γ, but below action levels.
105	Grab BH94				Collect 105' archive
110	Grab BH94			95'-110' gravelly SAND (gS), 15% gravel, 80% sand, 5% silt gravel, well sorted, SR-R, basaltic, pea-size-3cm pebbles. Sand, poorly sorted, SR-SA, vfn-vcse 55% basalt, 45% qtz/other, 2.5Y 4/2, dark grayish brown (moist) no rxn HCl.	Collect 110' archive.
115	Grab BH94				Collect 115' archive
				110' (see next page) SAND (S)	

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 07/28/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 07/28/03

Well ID: C4126 | Well Name: 299-E27-20 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH9" Grab BH9"	N/A		110' – 160' SAND(s) 95% sand, 5% silt. Sand, 45% basalt, 55% qtz/other, poorly sorted, SR-SA, 2.5Y 4/2 dark grayish brown (moist), no rxn HCl	Becker Hammer using 9" OD dual-wall casing. Collect 120' archive. @120' O,S,R levels dropping @120' NH_3 => 2.0 ppm
125	Grab BH9"			@120' Sand, v. well sorted, non-basaltic, SR-R, v.fn-med. micaceous 2.5Y 5/3, light olive brown (moist) no rxn HCl.	Collect 125' archive
130	Grab BH9"			@125' sand as described @110' trace basaltic gravel	Collect 130' archive @130' 19 ppm NH_3
135	Grab BH9"			@130' sand as @125', trace gravel pea-size, basaltic, dry	Collect 135' archive.
140	Grab BH9"			@135' trace gravel. (pea-size) basaltic, dry	collect 140' archive @140' NH_3 => 4 ppm. O,S,R slight elevation between 130'-140' bgs.
145	Grab BH9"			@145' trace gravel, pea-size basaltic, dry	Collect 145' archive
150	Grab BH9"				Collect 150' archive @150' NH_3 = 8 ppm. O,S,R steady (Sodium Iodide readings between 2400-2900 cpm). Background => 2200 cpm.
155	Grab BH9"			@155' trace pea-size gravel	Collect 155' archive

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/28/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 5 of 7

Date: 07/28/03

Well ID: C4126 | Well Name: 299-E27-20 | Location: west of C-Tank Farm

Project: C403 RCRA drilling | 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	BH 9" Grab BH 9"	N/A		160'- 175' silty sandy GRAVEL (mSG) 30% gravel, 60% sand, 10% silt. Gravel, SR-R, well-sorted, basaltic, pea-size, 3m. pebbles, mps=2", Sand, mod-sorted, SR-SA, 60% qtz/other, 40% basalt, med-vcse grained. 10YR5/1, gray, dry, no rxn HCl. micaceous	Becker Hammer using 9" OD dual-wall casing. Collect 160' archive @160' NH_3 = 19ppm
165	Grab BH 9"				Collect 165' archive
170	Grab BH 9"				collect 170' archive @170' NH_3 = 11ppm R.B.R still steady.
175	Grab BH 9"			175' - 220' silty SAND (mS) sand, 85% silt 15%. Sand, 40% basalt, 60% qtz, poorly sorted, SR-SA, vfn-vcse grained, trace mica. dry, 10YR5/1, dry (gray) no rxn HCl.	collect 175' archive
180	Grab BH 9"			@180' sand grading to well-sorted sand, vfn-med grain. no rxn HCl. 40% basalt, 60% qtz/other	Collect 180' archive. @180' NH_3 = 9ppm
185	Grab BH 9"				collect 185' archive
190	Grab BH 9"			@190' sand, mod-sorted, fn-vcse grain.	collect 190' archive @190' NH_3 = 14ppm R.B.R steady
195	Grab BH 9"			@195' sand, poorly sorted, vfn-vcse, SR-SA, silt decreasing.	Collect 195' archive.

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/28/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 7
Date: 07/28/03

Well ID: C-4126 | Well Name: 299-E27-20 | Location: West of C-Tank Farm
Project: C403 RCRA drilling | 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	BH 94 Grab BH 94	n/a		@200' increase in pea-size basaltic gravel, sand, poorly sorted, vfn-vcse. Silt same	Becker Hammer using 9" OD dual-wall casing. collect 200' archive. @200' NH_3 = 12 ppm. ~~BT~~ steady ⇒ RCT off-site.
205	Grab BH 9"			@205' sand, grading to well-sorted, v fn-med grain, 40% basalt, 60% qtz lother, dry, no rxn HCl. Silt same.	collect 205' archive
210	Grab BH 9"			@ 210', sand, mod. sorted, med-cse grained, dry. Silt same.	collect 210' archive. @210' NH_3 = 8 ppm
215	Grab BH 9"			@215 trace gravel, pea-size, basalt. dry.	collect 215' archive
220	Grab BH 9"			~~220'~~ 220'–240' SAND(S) ~~95%~~ 95% sand, 5% silt. Sand, poorly sorted SR-SA, vfn-vcse. 40% basalt, 60% qtz lother.	collect 220' archive. @220' NH_3 = 21 ppm
225	Grab BH 9"				collect 225' archive
230	Grab BH 9"			@230' sand grading to well-sorted, SR-SA, med-cse grained, silt increase to ~8%.	collect 230' archive. @230 NH_3 = 8 ppm
235	Grab BH 9"				collect 235' archive.

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 07/28/03
Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 07/28/03

Well ID: C 4126 | Well Name: 299-E27-20 | Location: west of C-Tank Farm

Project: C403 RCRA Drilling | 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	BH 9" Grab BH 9"	n/a		@240' sand, v. well sorted, vfn-med grained, SR-R, 40% basalt, 60% qtz/other, micaceous, dry, no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 240' archive. @240' nH_3 = 22 ppm
245	Grab BH 9"			240'-~~255~~ 278.5' sandy GRAVEL (GW) 35% gravel, 60% sand, 5% silt. Gravel, mod-well sorted, SR-SA, 45% basalt, 55% qtz/other. Sand, well sorted, SR-SA, med-vcse grained, 40% basalt, 60% qtz/other, 10YR5/2 grayish brown, dry, no rxn HCl.	Collect 245' archive.
250	Grab BH 9"				Collect 250' archive. @250' nH_3 = 3 ppm
255	Grab BH 9"			@255' gravel increased to 70%, sand 20%, silt 10%. Gravel, poorly sorted, 3m-pebbles-5m. cobbles.	Collect 255' archive.
260	Grab BH 9"			@260' gravel, mod-sorted, pea-size-5m pebbles. Sand, poorly sorted, vfn-vcse. Basalt, 55%, qtz/other 45%. 10YR4/1 dark gray, dry. No rxn HCl.	Collect 260' archive. @260' nH_3 = 3 ppm
265	Grab BH 9"			@265' gravel, well sorted, trace moisture. 55% gravel, 40% sand, 5% silt.	Collect 265' archive.
270	Grab BH 9"			@270' gravel, 60%, 35% sand, 5% silt. Gravel, poorly sorted, SR-SA, basalt, 50%, qtz/other 50%, v. moist. Sand, poorly sorted, SR-SA, vfn-vcse, 65% qtz/other, 35% basalt.	Collect 270' archive. Collect sample from cyclone (275'-277') sieve analysis. Collect 275' archive.
275	Grab BH 9"	sieve analysis sample n/a		@275' gravel, increasing in size, max ~4", poorly sorted, pea-size-med cobbles. Sand, poorly sorted, SR-SA, same as above.	E.O.S. @278' (07/28/03) Start 07/29/03. v. hard drilling @278' bgs. Refusal @278.5' bgs. TD = 278.5'

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 07/28/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 07/28/03
Finish Date: 08/04/03
Page 1 of 1

ID: C4126	Well Name: 299-E27-20	Approximate Location: West of C-Tank Farm
Project: C403 RCRA drilling		Other Companies: FH, CH6
Drilling Company: Layne Christensen		Geologist(s): C. Martinez, M.J. Hocking
Driller: Chris Dean/Paul Lodder	License #: 2554 / 1628	

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 ____
Dual-wall carbon steel, FJ, 9"OD(outer) 7"/6" (inner)	0' - 278.5'	9"	Cable Tool:	Diameter ____ From ____ to ____
	____ - ____		Air Rotary:	Diameter ____ From ____ to ____
	____ - ____		A.R. w/Sonic:	Diameter ____ From ____ to ____
	____ - ____		Becker Hammer	Diameter 9" From 0' to 278.5'
	____ - ____		(Reverse Air)	Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter ____ From ____ to ____

Drilling Fluid: n/a

Total Drilled Depth: 278.5'	Hole Dia @ TD: 9"	Total Amt. Of Water Added During Drilling: —	
Well Straightness Test Results: n/a		Static Water Level: 273.15'	Date: 07/29/03

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
n/a	____ - ____		n/a	____ - ____	
	____ - ____			____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
	____ - ____			Quick-Crete Cement (80#)	0' - 10.3'	14 bags	n/a
n/a	____ - ____			Granular Bentonite (50#)	10.3' - 262.8'	141.5 bags	n/a
	____ - ____			Colorado Silica Sand (50#)	262.8' - 278.5'	11 bags	10-20
	____ - ____				____ - ____		
	____ - ____				____ - ____		

OTHER ACTIVITIES

Aquifer Test:	Date:	Well Decommission:	Yes: ✓	No:	Date:
Description: n/a		Description: Decommissioned on 08/04/03. Hit refusal @ 278.5' bags => ~5' into water table.			

WELL SURVEY DATA (if applicable)

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

COMMENTS / REMARKS

Vol. calcs: Quick-crete => 80#/94# * 1.285 ft³/bag * 14 bags = 15.31 ft³; granular bentonite => 141.5 bags * 0.71 ft³/bag = 100.47 ft³; 10-20 sand => 11 bags * 0.535 ft³/bag = 5.89 ft³.

Reported By:	Title:	Signature:	Date:
Charlene Martinez	Geologist	Charlene Martinez	09/08/03

A-6003-658 (04/03)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend **Company:** Fluor Federal Services
Date Requested: 9/29/03	**Requestor:** Chris S. Wright (FH)
Date of Survey: 10/31/03	**Surveyor:** Fluor Federal Services Survey Dept.
ERC Point of Contact:	**Survey Co. Point of Contact:** Grant F. Brazil, P.L.S.
Description of Work: Civil Survey of Groundwater Monitoring Well C4126 (299-E27-20).	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 200E

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
2E-127 (FFS) and 2E-134 (FFS)

Vertical Control Monuments:
2E-33 (FFS) and 2E-38 (FFS)

Well ID	Well Name	Easting	Northing	Elevation	
C4126	299-E27-20	575067.36	136455.88		Center of Brass Cap in Concrete
					Top Casing, N. Edge
				205.447	Brass Survey Marker
					Top Pump Base-plate, N. Edge

Notes:
Brass cap in concrete only. No Well Casing.

Surveyor Statement:
I, Grant F. Brazil, a Professional Land Surveyor registered in the State of Washington (Registration No. 22326), hereby certify that this report is based on a field survey performed in October, 2003 under my direct supervision, and that the data contained here is true and correct.

Original to:
Distribution by DIS:

Well 299-E27-21

WELL SUMMARY SHEET

Start Date: 07/21/03
Finish Date: 07/25/03
Page 1 of 2

Well ID: C4127
Well Name: 299-E27-21
Location: South of CR-vault
Project: C403 RCRA drilling
Prepared By: Charlene Martinez
Date: 08/07/03
Reviewed By: L.D. Walker
Date: 8/11/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
9" OD Dual-wall temporary casing used	
6" ID ss protective casing set +1.0' above permanent	
4" ID ss304 sched. 10 riser: + 2.0' → 271.37' (Em)	
Portland Cement Grout: 0' → 10.1'	
Granular Bentonite: 10.1' → 260.4'	
1/4" Bentonite Pellets: 260.4' → 265.5'	
All temporary casing removed from ground:	
All depths are in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0'-1' Backfill (crushed gravel)
		1'-20' SAND(s)
		20'-25' gravelly SAND(gS)
		25'-40' SAND(s)
40		40'-65' gravelly SAND(gS)
		65'-160' SAND(s)
80		
120		
160		160'-170' gravelly SAND(gS)
		170'-185' SAND(s)
		185'-200' silty sandy GRAVEL (msG)
200		200'-225' silty SAND(mS)
		225'-235' silty sandy GRAVEL (msG)
		235'-240' silty SAND(mS)

A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 07/21/03
Finish Date: 07/25/03
Page 2 of 2

Well ID: C4127
Well Name: 299-E27-21
Location: South of CR-Vault
Project: C403 RCRA drilling
Prepared By: Charlene Martinez
Date: 8/10/03
Reviewed By: L.D. Walker
Date: 8/11/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
10-20 mesh silica sand: 265.5' → 314.0'	
ss 304 (4" ID) schedule 10 0.020-in. cont. wire-wrap well screen: 271.37' → 306.43'	
4" ID ss 304 schedule 10 sump/endcap: 306.43' → 308.83'	
4-8 mesh silica sand: 314.0' → 318.0'	
All temporary casing removed from ground:	
All depths are in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
240		240'-275' silty sandy GRAVEL (msG)
		275'-285' gravelly SAND (gS)
280		285'-318' sandy GRAVEL (sG)
		TD = 318' bgs
320		Static water 271.38' bgs (07/25/03)
360		

A-6003-643 (03/03)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 07/21/03
Finish Date: 08/28/03
Page 1 of 1

ID: C4127	Well Name: 299-E27-21	Approximate Location: South of CR-Vault
Project: C403 RCRA drilling		Other Companies: FH, CHG
Drilling Company: Layne Christensen		Geologist(s): C. Martinez, M.J. Hocking
Driller: Paul ("Derry") Lodder	License #: 1628	

TEMPORARY CASING AND DRILL DEPTH

*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.
Carbon Steel, dual-	0' - 318'	9"
wall casing, FJ.	____ - ____	
Outer=9" O/D	____ - ____	
Inner 7"/6"	____ - ____	
	____ - ____	

*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design

DRILLING METHOD

Auger:	Diameter ____ From ____ to ____
Cable Tool:	Diameter ____ From ____ to ____
Air Rotary:	Diameter ____ From ____ to ____
A.R. w/Sonic:	Diameter ____ From ____ to ____
Reverse Air (Becker Hammer)	Diameter 9" From 0' to 318'
	Diameter ____ From ____ to ____
	Diameter ____ From ____ to ____

Drilling Fluid: N/A

Total Drilled Depth: 318'	Hole Dia @ TD: 9"
Total Amt. Of Water Added During Drilling: -0-	
Well Straightness Test Results: Passed using 4.5" OD, 20.4' long tool on 07/23/03	Static Water Level: 271.38' Date: (07/25/03)

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Spectral Gamma	0' - 318'	07/21 & 07/22 2003		____ - ____	
	____ - ____			____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
4" ID SS304, sched 10 casing	+2.0' - 271.37'	F480	N/A	Portland Cement (94#)	0' - 10.1'	4 bags	N/A
4" ID SS 304 sched 10 well screen	271.37' - 306.43'	"	0.020"	Granular Bentonite (50#)	10.1' - 260.4'	100 bags	N/A
4" ID SS 304 sched 10 sump	306.43' - 308.83'	"	N/A	Bentonite Pellets (50#)	260.4' - 265.5'	2.5 buckets	1/4"
	____ - ____			Silica Sand (50#)	265.5' - 314.0'	29 bags	10-20
	____ - ____			Silica Sand (50#)	314.0' - 318.0'	2 bags	4-8

OTHER ACTIVITIES

Aquifer Test: well development	Date: 08/28/03	Well Decommission:	Yes:	No:	Date:
Description: SAP Franklin submersible pump. Developed 3 stages. Intake @ 306.7' (B) / 292.7' (M) / 285.6' (T). Flow rate: 23gpm, 23.5gpm, 21gpm. Final turb: (NTU) 1.24 (B) / 1.64 (M) / 1.83 (T)		Description:			

WELL SURVEY DATA (if applicable)

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

COMMENTS / REMARKS

Vol. calcs: P.C., 4 bags * 1.285 ft^3/bag = 5.14 ft^3; Granules, 100 bags * 0.71 ft^3/bag = 71.0 ft^3; Pellets, 2.5 buckets * 0.602 ft^3/bucket = 1.55 ft^3; 10-20 sand, 29 bags * 0.535 = 15.52 ft^3; 4-8 sand 2 bags * 0.666 ft^3/bag = 1.33 ft^3.

Reported By:	Title:	Signature:	Date:
Charlene Martinez	Geologist	Charlene Martinez	09/06/03

A-6003-658 (04/03)

WELL ATTRIBUTES REPORT

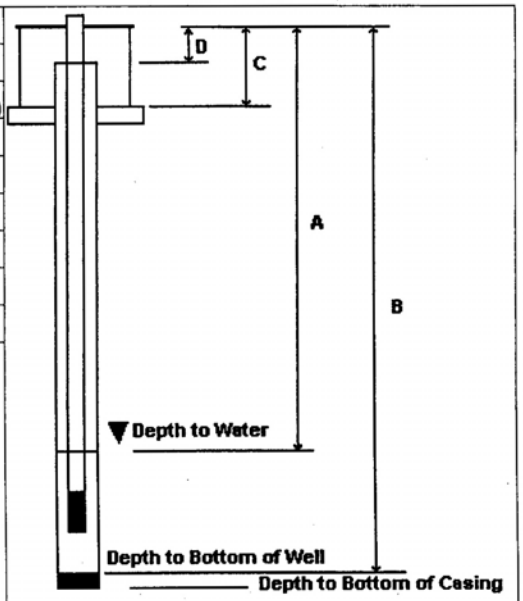
FIELD ORDER NO
WELL ID 54127
WELL NAME 299-E27-21
HOST WELL ID

DRILL DATE 07/21/03
CONST DATE 07/23/03
CONST DEPTH 308.83'

LAST INSPECTION
NORTHING
EASTING
ELEVATION

MEASUREMENT INFORMATION

		LAST	CURRENT
A	DEPTH TO WATER(ft)	274.46' TOC	274.47'(TOC)
	DEPTH TO WATER DATE	09/18/03	09/29/03
B	DEPTH TO BOTTOM(ft)	311.95' TOC	N/A
	DEPTH TO BOTTOM DATE	09/18/03	N/A
C	STICK UP(ft)	2.35'	2.35'
D	REFERENCE MARK(ft)		
	REFERENCE MARK IS TOC	☒ YES ☐ NO ☐ ND*	☒ YES ☐ NO



A DEPTH TO WATER FROM TOP OF CASING
B DEPTH TO BOTTOM OF WELL FROM TOP OF CASING
C TOP OF CASING TO GROUND SURFACE/PAD
D TOP OF CASING TO SURVEY REFERENCE MARKER

PERFORATION INFORMATION

CASING SIZE	TOP	BOTTOM	CUTS/FT/ROUND

CHANGES g.w. => 274.49' - 0.02' (landing plate) = 274.47' TOC.

CASING INFORMATION

SIZE	TOP	BOTTOM	MATERIAL	TYPE	CONNECTION	THICKNESS
4" ID	+2.0'	271.37'	stainless steel	304; sch. 10		

CHANGES

SCREEN INFORMATION

SIZE	TOP	BOTTOM	MATERIAL	TYPE	SLOT SIZE
4" ID	271.37'	306.43'	stainless steel	304; schedule 10	0.020-inch

CHANGES

ND* - Not Documented
BHI-EE-231 (02/20/02)

1/10/2003

BOREHOLE LOG

Page 1 of 8

Date: 07/21/03

Well ID: C4627 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: C4103 RCRA drilling | 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	BH 9"	N/A		0'-1' Backfill. Gravel, basalt.	Becker Hammer using 9" OD dual-wall casing
				1'-20' Sand (s), 100% vfn-fn grained, R, v. well sorted, non-basaltic, 10YR 4/4, dark yellowish brown (moist) weak-no rxn HCl.	2'-5' Aeolian Sand
5	Grab BH 9"			@5' 90% Sand, 5% silt, 5% gravel, Gravel, pea-size-sm. pebbles, R, well sorted basaltic. Sand, vfn-cse, mod-sorted, 45% basalt, 55% qtz/other, SR-R 2.5Y 4/3 olive brown (moist) strong rxn HCl. Loose matrix.	Collect 5' archive. 5' Hanford fmtn.
10	Grab BH 9"				collect 10' archive
15	Grab BH 9"			20'-25' gravelly SAND(gS) 15% gravel, 78% sand, 7% silt. Gravel mod-sorted, SR-R, mps ~2", basaltic. Sand, poorly-sorted, SR-SA, vfn-vcse grained, 80% basalt, 20% qtz/other,	collect 15' archive
20	Grab BH 9"			10YR 3/2, v. dark grayish brown (moist) mod rxn HCl. Loose matrix	collect 20' archive
25	Grab BH 9"			25'-40' SAND(s) 93% sand, 7% silt Sand, poorly sorted, vfn-vcse grained, SR-SA, 80% basalt, 20% qtz/other, 10YR 3/2, v. dark grayish brown (moist) mod rxn HCl. Loose matrix	collect 25' archive
30	Grab BH 9"			@30' Sand grading to mod-sorted, fn-cse grained, non-basaltic, SR-R, trace mica. 2.5Y 5/3 light olive brown (moist), no rxn HCl. Unconsolidated.	collect 30' archive
35	Grab BH 9"			@35' sand grading to v. poorly sorted vfn-vcse grained, SR-SA, 80% basalt, 20% qtz/other, silt ~5%, trace of pea-size, basaltic gravel (<5%) 10YR 3/2 v. dark grayish brown, Unconsolidated.	collect 35' archive

Reported By: Charlene Martinez | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/21/03 | Signature: L D Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 07/21/03

Well ID: C4127 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: C403 RCRA drilling | 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	BH 9" Grab	N/A		40'-65' gravelly SAND(gS) 10% gravel, 85% sand, 5% silt. Gravel, well sorted, SR-R, basaltic, red. pea-size. Sand, SR-SA, v. poorly-sorted, vfn-vcse grained, 80% basalt, 20% qtz/other. 10YR3/2, v. dark grayish brown (moist). No rxn HCl.	Becker Hammer using 9" OD dual-wall casing. collect 40' archive
45	Grab BH 9"				collect 45' archive
50	Grab BH 9"			65'-160' SAND(S) 95% sand, 5% silt Sand, mod-sorted, SR-SA, med-cse grained, 15% basalt, 85% qtz/other 2.5Y 5/3 light olive brown (moist). micaceous. no rxn HCl.	collect 50' archive
55	Grab BH 9"				collect 55' archive
60	Grab BH 9"				Collect 60' archive
65	Grab BH 9"				collect 65' archive
70	Grab BH 9"				collect 70' archive
75	Grab BH 9"			@75' sand grading to v. poorly sorted, SR-SA, v. cse-vfn grained, 70% basalt, 30% qtz/other. 2.5Y 4/3, dark grayish brown. no rxn HCl.	collect 75' archive.

Reported By: Charlene Martinez | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/21/03 | Signature: L D Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 3 of 8

Date: 07/21/03

Well ID: C4127 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: C403 RCRA drilling | 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	BH9" GRAB BH9"	N/A		@80' basalt content decreasing to 60%, qtz/other 40%. Sand continues to be v. poorly sorted, SR-SA, vfn-vcse grained.	Becker Hammer using 9" OD dual-wall casing. collect 80' archive
85	Grab BH9"			@85' trace of pea-size, basaltic gravel (<5%) sand. same as previous	collect 85' archive
90	Grab BH9"				collect 90' archive
95	Grab BH9"			@95' trace pea-size gravel, mps~0.5" basaltic	collect 95' archive
100	Grab BH9"			@100' trace of gravel (≤0.4") basaltic	collect 100' archive
105	Grab BH9"				collect 105' archive
110	Grab BH9"				collect 110' archive
115	Grab BH9"			@115' gravel increasing to ~8%. Pea-size to 5m pebbles, mod-sorted, SR-R, basaltic	collect 115' archive

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 07/21/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 07/24/03

Well ID: C4127 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: C403 RCRA drilling | 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	BH9 Grab BH9	n/A			Becker Hammer using 9" OD dual wall casing. Collect 120' archive
125	Grab BH9			@125' trace gravel, mps ~ 1.5", basaltic. no rxn HCl.	collect 125' archive
130	Grab BH9				Collect 130' archive
135	Grab BH9			@135' basaltic gravel (~ 5%) mod-sorted basaltic, mps ~ 2", pred. med-pebbles. Sand grading to mod-well sorted, fn-cse grained, SR-SA, 55% qtz/other, 45% basalt. no rxn HCl.	Collect 135' archive
140	Grab BH9			@140' sand grading to vfn-vcse, poorly-sorted, SR-SA, silt increasing to ~ 7%. no rxn HCl.	collect 140' archive
145	Grab BH9				Collect 145' archive
150	Grab BH9				collect 150' archive
155	Grab BH9			@155' increase in vcse-cse grained sand. Traces of pea-sized gravel.	collect 155' archive

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 07/21/03

Reviewed By: L. D. Walker | Title: Geologist | Signature: L D Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 5 of 8

Date: 07/21/03

Well ID: C4127 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: C403 RCRA drilling | 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	BH 9" Grab BH 4"	n/a		160'–170' gravelly SAND (gS) 15% gravel, 75% sand, 10% silt. Gravel, well-sorted, sm-med pebbles, mps~1", basaltic, SR-SA. Sand, poorly sorted, SR-SA, vfn-vcse grained, 50% basalt, 50% qtz/other. 2.5Y5/1 gray (dry). no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 160' archive
165	Grab BH 9"				Collect 165' archive
170	Grab BH 9"			170'–185' SAND (S) 90% sand, 10% silt, trace gravel. Gravel, pea-size, basaltic. Sand, poorly sorted, SR-SA, vfn-vcse grained, 50% basalt, 50% qtz/other. 10YR5/2, grayish brown (dry) no rxn HCl.	Collect 170' archive
175	Grab BH 9"				Collect 175' archive
180	Grab BH 9"			185'–200' Silty Sandy GRAVEL (msG) 40% gravel, 50% sand, 10% silt. Gravel, well-sorted, SR-SA, basaltic, Sand, poorly-sorted, SR-SA, 45% basalt, 55% qtz/other. 10YR5/2 grayish brown (dry) no rxn HCl.	Collect 180' archive
185	Grab BH 9"				Collect 185' archive
190	Grab BH 9"				Collect 190' archive
195	Grab BH 9"				Collect 195' archive

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/21/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 8

Date: 07/21/03

Well ID: C4127 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: CY03 RCRA drilling | 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	BH9" Grab BH 9"	N/A		200'– 225' Silty SAND (mS) 88% sand, 12% silt, trace gravel. Sand, mod-sorted, med-ucse grained, SR-SA, 55% qtz/other, 45% basalt. 2.5Y5/1 gray (dry) no rxn HCl.	Becker Hammer using 9" OD dual-wall casing. Collect 200' archive
205	Grab BH 9"			@ 205' sand grading to poorly sorted, fn-ucse grained, trace of pea-sized, basaltic gravel.	Collect 205' archive
210	Grab BH 9"				Collect 210' archive
215	Grab BH 9"			@ 215' trace of mica.	Collect 215' archive.
220	Grab BH 9"			@ 220' trace gravel, sm-pebbles < 0.5".	Collect 220' archive
225	Grab BH 9"			225'– 235' Silty sandy GRAVEL (msG) 35% gravel, 55% sand, 10% silt gravel, well-sorted, basaltic, pea-sized. Sand, poorly sorted, ufn-ucse, 55% qtz/other, 45% basalt. Consolidated silt nodules w/ Fe oxide staining. 2.5Y5/1 gray (dry). no rxn HCl. micaceous	Collect 225' archive
230	Grab BH 9"				Collect 230' archive
235	Grab BH 9"			235'-240' Silty SAND (mS) 88% sand, 12% silt. Sand, poorly sorted, ufn-ucse, SR-SA, 55% Qtz/other, 45% basalt. 2.5Y5/1 gray (dry). no rxn HCl. micaceous	Collect 235' archive.

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/21/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 7 of 8

Date: 07/21/03

Well ID: C4127 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: CY03 RCRA drilling | 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	BH 9"	n/a		240' – 275' silty, sandy GRAVEL (msG) 30% gravel, 60% sand, 10% silt. Gravel, basaltic, well-sorted, pea-size. Sand, poorly sorted, vfn-vcse, SR-SA 45% basalt, 55% qtz/other. 2.5Y5/1 gray (drg). no rxn HCl. micaceous	Becker Hammer using 9" OD dual-wall casing. Collect 240' archive
245	Grab BH 9"				collect 245' archive
250	Grab BH 9"				Collect 250' archive. A.m IHEK. organics < detect.
255	Grab BH 9"			@ 255' gravel increasing to 55%, sand 35%, silt 10%. Gravel, well-sorted, SR-SA, sm-med pebbles, 45% basalt, 55% qtz/other. micaceous	collect 255' archive. A.m RCT ck. Sodium IODIDE meter used. γ @ background
260	Grab BH 9"				Collect 260' archive
265	GRAB BH 9"				Collect 265' archive
270	Grab BH 9"			275 – 285' gravelly SAND (gS) 20% gravel, 75% sand, 5% silt. Gravel, poorly sorted, pea-size - 1g pebbles, mpsr3", basaltic, SR-A, Sand, poorly sorted, vfn-vcse grained, SR-SA, 55% basalt, 45% qtz/other	Collect 270' archive
275	Grab BH 9"	sieve analysis			collect 275' archive. collect sample from cyclone (277'-280') for sieve analysis

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 07/21/03 | Signature: L.D. Walker | Date: 9/30/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 8 of 8

Date: 07/21/03

Well ID: C 4127 | Well Name: 299-E27-21 | Location: S. of CR-Vault

Project: C403 RCRA drilling | 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
280	BH 9"	n/a		285' – 318' Sandy GRAVEL(sG) 65% gravel, 30% sand, 5% silt. Gravel, Gravel, mod-sorted. 80% basalt, 20% qtz/other, SR-R, pea-size - med pebbles. Sand, poorly sorted, SR-SA, 60% basalt, 40% qtz/other. Unconsolidated	Becker Hammer using 9" OD dual-wall casing. Collect 280' archive
285	Grab BH 9"				Collect 285' archive
290	Grab BH 9"				Collect 290' archive
295	Grab BH 9"				Collect 295' archive
300	Grab BH 9"				Collect 300' archive
					v. hard drilling @ 303' bgs.
305	Grab BH 9"			@ 305' gravel v poorly sorted, sm pebbles-lg cobbles mps ~ 5-6", no visible cementation. Basalt content down to 40%, 60% qtz/other.	Collect 305' archive.
310	Grab BH 9"				Collect 310' archive.
		Sieve Analysis		p.m. IH tech reported oxygen in casing is decreasing. Unknown substance is eating oxygen (~ 310' bgs)	Collect sample from cyclone (312-315') for sieve analysis
315	Grab BH 9"				Collect 315' archive.
					lg. cobble @ 318' bgs
	Grab			TD => 318' bgs (07/21/03)	Collect TD @ 318' bgs

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 07/21/03

Reviewed By: L. D. Walker | Title: Geologist | Signature: L D Walker | Date: 9/30/03

A-6003-642 (03/03

WELL DEVELOPMENT AND TESTING DATA

Well Name:	Well ID:	Well Location:	Date:
299-E27-21	C4127	South of CR- Vault	08/28/03

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

Has the well been surveyed? ☐ Yes ☒ No | Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:

Start of Job 274.56' TOC

End of Job 274.47' TOC

DEPTH TO BOTTOM:

Start of Job 312.0' TOC

End of Job 311.9' TOC.

PART 2

WELL DEVELOPMENT DATA

Pump Model Franklin 5 HP submersible electric

Intake Depth B 306.7 / M 297.7' / T 285.6'

Starting Turbidity B 11.8 / M 7.98 / T 17.6

Pump Start	Stop	Flow Rate
0940 (63 mins => 1449 gallons)	1043	23 gpm
1055 (48 mins => 1128 gals)	1143	23.5 gpm
1243 (62 mins => 1302 gals)	1345	21.0 gpm
1449 + 1128 + 1302 =		3879 gals

Total Pumped 3879 gallons

Final Turbidity B 1.24 / M 1.64 / T 1.93

XD SN/Range (PSI) 20.0 psi

PART 3

INSTANTANEOUS SLUG TEST

Static Water Level (TOC)

Transducer Depth

Baseline Start

Injection Start

Baseline Start

Withdrawal Start

Slug Volume

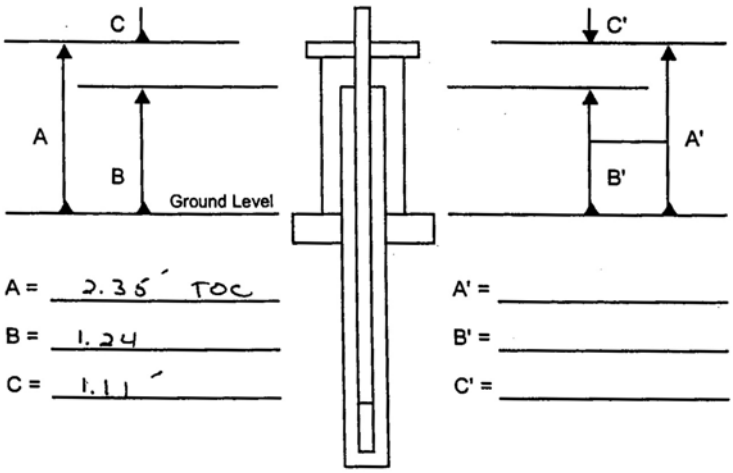
XD SN/Range (PSI)

Not used (Unable to locate manual 08/28/03)

PART 4

Last Recorded Measurements Date: 08/28/03

Current Measurements Date:



A = 2.35' TOC

B = 1.24

C = 1.11'

A' =

B' =

C' =

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

COMMENTS:

0600 P.O.D. / Safety meeting.
0615 Back to office
0705 At site.
0730 Tagged g.w. => 274.56' TOC
0730 Setting up rig.
0735 Tagged TD => 312' TOC. No fill in well.
0753 Tripping in Franklin 5 HP submersible pump.
0755 Calibrating instruments.
0900 Running 20.0 psi to depth. Initial XD => 47.781'
Begin test* 1 on Hermit 3000. (No Test)
TURB COND TEMP XD
Initial Readings:
0915 Transducer not working. Will develop old-fashioned way.

Prepared by (print name):	Signature:	Date:
Charlene Martinez	Charlene Martinez	08/28/03
Reviewed by (print name):	**Signature:**	**Date:**
L.D. Walker	L.D. Walker	9/30/03

A-6003-644 (03/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Date: 08/28/03

Well ID: C4127 | Well Name: 299-E27-21

Location: South of CR-vault | Report No.: 1 (well development)

Start	Finish	Total
Time 0600	Time	Time
Hole Depth/Csg — / —	Hole Depth/Csg — / —	Hole Depth/Csg — / —

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: N/A

See Report No. 1 well development

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0935		Running E-tape into well
0935		Driller hooking up pump & flow meter.
0940		Initial xD = 274.62' (TOC) Test #1
0940:00		Begin test: xD = 274.65' (23 gpm. Flow open all the way).

Time | xD

0940:15 274.64 ← Readings: Test #1

Column 2		Column 3	
0940:30	274.64	0945:00 274.64	1013:15 274.64
0940:45	274.64	0945:30 274.64	1016:01 274.64
0941:00	274.64	0946:00 274.64	1018:45 274.65
0941:20	274.64	0946:25 274.64	1020:15 274.65
0941:30	274.64	0947:00 274.64	1025:30 274.65
0941:50	274.64	0948:06 274.64	1027:12 274.65
0942:00	274.64	0950:30 274.65	1029:32 274.64
0942:30	274.64	0953:00 274.65	1031:40 274.64
0942:45	274.64	0957:30 274.65	1032:15 274.65
0943:00	274.64	1000:02 274.64	1035:01 274.64
0943:20	274.64	1003:09 274.64	1037:19 274.65
0943:43	274.64	1007:11 274.64	1039:28 274.65
0944:02	274.64	1010:30 274.64	1041:01 274.65

Time	xD(ft)	Turb (NTU)	Cond (µS/cm)	T °C
0948	274.64	11.8	376 (corr 374)	20.2
1000	274.64	6.81	373	20.2
1020	274.65	1.34	375	20.1
1032	274.65	1.13	373	20.4
1041	274.65	1.24	376	20.0
1050	Test #1 complete. Final xD 274.62'. 100% recovery.			
1050. Remove 9' tremmie pipe.				
Intake set @ 297.7' TOC. Test #2				
Initial xD => 274.62' TOC				
1055 Test #2 start. Readings test #2				

Time	xD(ft)	Turb	Cond	T°C
1043	shut pump off. Recovery test #1			
1100	274.68	7.98	361	20.4
1110	274.67	1.82	365	19.8
1120	274.666	1.28	363	20.0
1128	274.666	1.35	362	20.0
1142	274.66	1.64	363	20.2

1043:15	274.60	1044:30 274.61	1046:00 274.62
1043:30	274.60	1044:47 274.62	1046:30 274.63
1043:45	274.60	1045:00 274.62	1046:45 274.62
1043:55	274.61	1045:15 274.62	1047:00 274.62
1044:10	274.61	1045:45 274.62	1048:00 274.62

Reported By: Charlene Martinez | Title: Geologist | Date: 08/28/03

Signature: Charlene Martinez

Reviewed By: L.D. Walker | Title: Geologist | Date: 9/30/03

Signature: L.D. Walker

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING
Continuation Page

Date: 08/28/03

Well Name: 299-E27-21 | Well ID: C4127

Location: South of CR-vault | Continuation of Report No.: 1 (well development)

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth
		well development
Time	XD	Test # 2 Start 1055:00 (valve) Flow meter open all the way 23.5 gpm.
1055:15	274.64	1058:20 274.68 / 1109:00 274.67 / 1128:15 274.66
1055:30	274.65	1058:40 274.68 / 1110:00 274.67 / 1130:03 274.67
1055:45	274.67	1059:00 274.68 / 1112:05 274.67 / 1131:00 274.67
1056:00	274.67	1059:15 274.68 / 1114:15 274.68 / 1132:15 274.66
1056:10	274.67	1059:30 274.68 / 1116:00 274.66 / 1133:30 274.68
1056:25	274.67	1059:45 274.68 / 1117:00 274.66 / 1134:00 274.67
1056:45	274.67	1100:00 274.68 / 1120:00 274.66 / 1135:17 274.67
1057:00	274.67	1102:25 274.68 / 1122:00 274.66 / 1136:20 274.68
1057:15	274.67	1104:15 274.68 / 1123:00 274.66 / 1138:15 274.68
1057:30	274.68	1106:00 274.68 / 1125:01 274.67 / 1140:00 274.68
1057:45	274.68	1107:12 274.68 / 1126:00 274.66 / 1142:00 274.68
1058:00	274.68	1108:00 274.67 / 1127:04 274.66 / 1143:00 274.68
1143		STOP test # 2. Recovery 100%. Final XD = 274.62'
1145	1230	Purge water truck full. off site.
1143	1159	B. Edrington on site to ck transducer & Hermit. Something wrong. Off-site w/ transducer.
1148	1157	move pump up to next interval. (285.6' TOC)
		Test # 3 Readings:
Time	XD	Test # 3 Start: 1243 (1243) 274.59': 21 gpm / 1306:01 (cm) 274.62 / Time XD (Ft) nru turb ms/cm cond T°C: 1245 27462 17.6 358 20.6; 1255 274.63 3.59 355 20.6; 1324 274.62 2.15 353 20.8; 1343 274.62 1.83 353 20.7
1243:17	274.62	1245:17 274.62 / 1310:00 274.62
1243:45	274.62	1246:00 274.63 / 1312:31 274.62
1244:02	274.62	1250:05 274.63 / 1318:07 274.62
1244:20	274.63	1253:01 274.63 / 1324:00 274.62
1244:31	274.62	1255:15 274.63 / 1333:08 274.62
1244:45	274.62	1300:01 274.62 / 1343:00 274.62
1244:58	274.62	1303:00 274.62
1348	1421	Tripping out tremmie pipe & development pump
1425		Tagged g.w. 274.47' TOC. Tagged bottom => 311.9' TOC.
1433		Pumping off site. Site secure. End of shift.

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Date: 08/28/03 | Title: Geologist | Date: 9/30/03

Signature: Charlene Martinez | Signature: L.D. Walker

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - WELL SERVICES

Page 1 of 1

Date	Well No.	Rig Type/Model	Rig No.	Contract/Work Order No.	Report No.
09/18/03	299-E27-21 C4127	Pump setting rig			1

Purpose: Install pumps in CY03 RCRA wells.

Reference:

Location: South of the CR-Vault

HISTORICAL DATA

Construction Depth	308.83' bgs
Casing Size / Type / Set At	4" ID SS 304, sch. 10 / +2.0' – 271.37' bgs
Casing Perforations Schedule / Interval	
Well Screen(s) Type / Interval	4" ID 0.020" slot SS 304 sch 10 / 271.37' – 306.43' bgs
Last Recorded Depth-to-Water	274.56' TOC
Last Recorded Depth-to-Bottom	312.0' TOC
Current Depth-to-Water	274.46' TOC
Current Depth-to-Bottom	311.95' TOC

PUMP SYSTEM CONFIGURATION

	Pre-Maintenance	Post-Maintenance
Pump Type 0.7 HP	Grundfos Redi-flo3	
Pump Model	Prod # 139 model A. 960309	
Tubing Size/Type	0.75" OD SS304	
Length-Bottom of Tubing to Pump Intake	1.10'	
Tubing Length	280.0'	
Length-Top of Tubing to Reference Point		
Pump Intake Set at (Depth)	281.10'	

Reference/Measuring Point: TOC (TOP OF CASING)

Start Time: 1215
End Time: 1400
Time:
Contract Time:
Total Time: 1.75 hrs

Personnel:
- Layne Christensen
  - Dave DeWitt
  - Ken ~~Johnson~~ Jones
- Fluor Hanford
  - Ed Rafuse (BTR)
- CH2M Hill (CHG)
  - Charlene Martinez (geologist)

Materials Used: 28 X 10' sections SS 304 schedule 40, 0.75" OD tremmie pipe, w couplers
Grundfos Redi-flo3 (0.7HP) electric submersible pump.

Description of Operations/Remarks

1215 P.O.D. / Safety meeting.
1235 On site. Pump setting rig set up.
1245 Tagged g.w. @ 274.56' TOC.
Tagged TD @ 311.95' TOC.
1250 Preparing to install Grundfos Redi-flo3 (0.7 HP) pump using SS 304, schedule 40, 0.75" OD tremmie pipe.
1255 Begin installing pump.
By the way ⇒ happy birthday to me. Happy birthday to me.
1400 Done. Mast on rig down.
1405 Pump setting rig off-site to C4190

09/19/03 Tested pump ⇒ works.
09/19/03

Not used
Charlene Martinez
09/18/03

Report By: Charlene Martinez
Title: Geologist
Signature: Charlene Martinez

Reviewed By: L. D. Walker
Title: Geologist
Date: 9/30/03
Signature: L D Walker

DISTRIBUTION: White-Field File Custodian Yellow-Group Files Pink-Project Coordinator Goldenrod-Team Leader BC-6000-278 (04/91)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend **Company:** Fluor Federal Services
Date Requested: 9/29/03	**Requestor:** Chris S. Wright (FH)
Date of Survey: 10/31/03	**Surveyor:** Fluor Federal Services Survey Dept.
ERC Point of Contact:	**Survey Co. Point of Contact:** Grant F. Brazil, P.L.S.
Description of Work: Civil Survey of Groundwater Monitoring Well C4127 (299-E27-21).	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 200E

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
2E-127 (FFS) and 2E-134 (FFS)

Vertical Control Monuments:
2E-33 (FFS) and 2E-38 (FFS)

Well ID	Well Name	Easting	Northing	Elevation	
C4127	299-E27-21	575145.03	136407.21		Center of Casing
				205.728	Top Casing, N. Edge
				204.995	Brass Survey Marker
				205.734	Top Pump Base-plate, N. Edge

Notes:

Surveyor Statement:
I, Grant F. Brazil, a Professional Land Surveyor registered in the State of Washington (Registration No. 22326), hereby certify that this report is based on a field survey performed in October, 2003 under my direct supervision, and that the data contained here is true and correct.

Original to:
Distribution by DIS:

Well 299-E27-23

WELL SUMMARY SHEET

Start Date: 08/05/03
Finish Date: 08/12/03
Page 1 of 2

Well ID: C4190
Well Name: 299-E27-23
Location: West of C-Tank Farm
Project: C403 RCRA drilling
Prepared By: Charlene Martinez
Date: 08/19/03
Reviewed By: L. D. Walker
Date: 9/5/03
Signature: Charlene Martinez
Signature: LD Walker

CONSTRUCTION DATA

Description	Diagram
9" OD dual-wall temporary casing used.	
6" ID Protective casing set 1.0' above ss	
4" ID ss304 schedule 10 casing: +1.8' → 273.51'	
Portland Cement Grout: 0' → 9.9'	
Granular Bentonite: 9.9' → 263.0'	
1/4" Bentonite Pellets: 263.0' → 267.8'	
All temporary (ew) casing removed from ground:	
All depths in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0'-1.5' Backfill (Crushed GRAVEL)
		1.5'-10' SAND(S)
		10'-12' gravelly SAND(gS)
		12'-15' sandy GRAVEL(sG)
		15'-20' gravelly SAND(gS)
40		20'-103' SAND(S)
80		
		103'-107' gravelly SAND(gS)
		107'-160' SAND(S)
120		
160		160'-200' silty SAND(mS)
200		200'-210' silty sandy GRAVEL(msG)
		210'-226' SAND(S)
		226'-230' gravelly SAND(gS)
		230'-245' SAND(S)

A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 08/05/03
Finish Date: 08/12/03
Page 2 of 2

Well ID: C4190
Well Name: 299-E27-23
Location: West of C-Tank Farm
Project: CY03 RCRA drilling
Prepared By: Charlene Martinez
Date: 08/19/03
Reviewed By: L.D. Walker
Date: 9/5/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
10-20 mesh silica sand: 267.8' → 318.0'	
4" ID ss 304 schedule 10, 0.020" cont. wire-wrap screen: 273.51' → 308.54'	
4" ID ss 304 schedule 10 sumplendcap: 308.64' → 310.97'	
All temporary casing removed from ground:	
All depths are in feet below ground surface:	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
240		245'–255' silty sandy GRAVEL (msG)
		255'–260' GRAVEL (G)
		260'–318' sandy GRAVEL (sG)
280		TD => 318' bgs
		static water => 273.1' bgs (08/12/03)
320		
360		

A-6003-643 (03/03)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 08/05/03
Finish Date: 09/02/03
Page 1 of 1

Well ID: C 4190 | Well Name: 299-E27-23 | Approximate Location: West of C-Tank Farm
Project: C-403 RCRA drilling | Other Companies: CHG, FH
Drilling Company: Layne Christensen | Geologist(s): C. Martinez, M.J. Hocking
Driller: Paul ("Derry") Lodder License #: 1628

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 ____
Carbon steel dual-wall	0' - 318'	9"	Cable Tool:	Diameter ____ From ____ to ____
casing, FJ. 9" OD (outer)	____ - ____		Air Rotary:	Diameter ____ From ____ to ____
7" 16" (inner	____ - ____		A.R. w/Sonic:	Diameter ____ From ____ to ____
	____ - ____		Reverse Air (Becker Hammer)	Diameter 9" From 0' to 318'
	____ - ____			Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter ____ From ____ to ____

Drilling Fluid: N/A

Total Drilled Depth: 318' | Hole Dia @ TD: 9" | Total Amt. Of Water Added During Drilling: none
Well Straightness Test Results: Passed using 4" ID, 20.4' long tool on 08/14/03 | Static Water Level: 273.1' | Date: 08/12/03

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Spectral Gamma	0' - 318'	08/07/03 & 08/08/03		____ - ____	
	____ - ____			____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	Volume	Mesh Size
4" ID SS304 Sch. 10 casing	+1.8 - 273.51'	F480	N/A	Portland Cement (94#)	0' - 9.9'	5 bags	N/A
4" ID SS304 Sch. 10 wellscreen	273.51' - 308.54'	"	0.030"	Granular Bentonite (50#)	9.9' - 263.0'	107.5 bags	N/A
4" ID SS304 Sch. 10 sump	308.54' - 310.97'	"	N/A	Bentonite Pellets (50#)	263.0' - 267.8'	2 buckets	1/4"
	____ - ____			Colorado Silica Sand (50#)	267.8' - 318.0'	29.5 bgs	10-20
	____ - ____				____ - ____		

OTHER ACTIVITIES

Aquifer Test: well development	Date: 09/02/03	Well Decommission:	Yes:	No:	Date:
Description: 5 HP Franklin Submersible pump. Developed 3 Stages Intake 311.3' (B) / 301.3' (M) / 291.3' (T). Pump rate 24.5 gpm, 26 gpm, 6 gpm. Final turb (NTU) 3.93 (B) / 0.72 (M) / 3.0 (TOP)		Description:			

WELL SURVEY DATA (if applicable)

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

COMMENTS / REMARKS

Vol. calcs: P.C., 5 bags * 1.285 ft³/bag = 6.43 ft³; Granules, 107.5 bags * 0.71 ft³/bag = 76.33 ft³; pellets, 2 buckets * 0.62 ft³/bucket = 1.24 ft³; 10-20 sand, 29.5 bags * 0.535 = 15.78 ft³

Reported By:	Title:	Signature:	Date:
Charlene Martinez	Geologist	Charlene Martinez	09/06/03

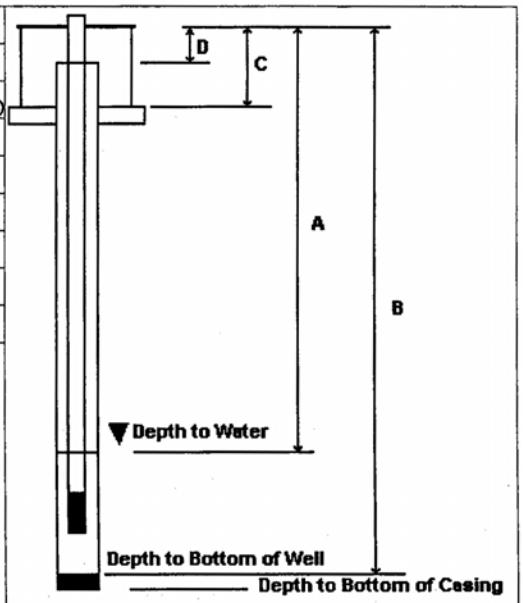
A-6003-658 (04/03)

WELL ATTRIBUTES REPORT

FIELD ORDER NO				LAST INSPECTION	
WELL ID	C 4190	DRILL DATE	08/05/03	NORTHING	
WELL NAME	299-E27-23	CONST DATE	08/11/03	EASTING	
HOST WELL ID		CONST DEPTH	310.97'	ELEVATION	

MEASUREMENT INFORMATION

		LAST	CURRENT
A	DEPTH TO WATER(ft)	276.46' TOC	276.52' (TOC)
	DEPTH TO WATER DATE	09/18/03	09/29/03
B	DEPTH TO BOTTOM(ft)	314.45' TOC	N/A
	DEPTH TO BOTTOM DATE	09/18/03	N/A
C	STICK UP(ft)	3.42'	2.93'
D	REFERENCE MARK(ft)		
	REFERENCE MARK IS TOC	☒ YES ☐ NO ☒ ND*	☒ YES ☐ NO



A DEPTH TO WATER FROM TOP OF CASING
B DEPTH TO BOTTOM OF WELL FROM TOP OF CASING
C TOP OF CASING TO GROUND SURFACE/PAD
D TOP OF CASING TO SURVEY REFERENCE MARKER

PERFORATION INFORMATION

CASING SIZE	TOP	BOTTOM	CUTS/FT/ROUND

CHANGES 3.42' measured from ground surface + not from top of cement pad.

g.w. => 276.54' - 0.02' (landing plate) = 276.52' TOC

CASING INFORMATION

SIZE	TOP	BOTTOM	MATERIAL	TYPE	CONNECTION	THICKNESS
4" ID	+1.8'	273.51'	Stainless steel	304, sch. 10		

CHANGES

SCREEN INFORMATION

SIZE	TOP	BOTTOM	MATERIAL	TYPE	SLOT SIZE
4" ID	273.51'	308.54'	stainless steel	304, schedule 10	0.020 inch

CHANGES

ND* - Not Documented
BHI-EE-231 (02/20/02)

1/10/2003

BOREHOLE LOG

Page 1 of 8

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH 9"	N/A		0'-1.5' Backfill material. Crushed gravel.	Becker Hammer using 9" OD dual wall casing
				1.5'-10' SAND (S) 100%. v. well sorted, vfn-med grained, R. 10YR 4/3 brown (moist). Strong rxn HCl.	Redrill of C4126. no archive samples collected until 280' bgs.
5					
				10'-12' gravelly sand (gS) 20% gravel, 80% sand. Gravel, poorly sorted sm pebbles-med cobbles. mps ~3.5"; SR-SA. sand, vfn-med, v. well sorted. 10YR 4/3 brown (moist) strong rxn HCl.	Continuous IH support from 0'-170' bgs due to NH3 detected @ C4126. NH3 ranged from 0 ppm - 5 ppm (~110' bgs) in borehole.
10					
				12'-15' sandy GRAVEL (sG) 40% gravel, 55% sand, 5% silt. Gravel, v poorly sorted, SR-SA, sm pebbles-med cobbles, mps ~4". Sand, SR-SA, poorly sorted, vfn-vcse, 75% basalt, 25% qtz/other. 10YR 3/2 v. dark grayish brown (moist) no rxn HCl.	
15					
				15'-20' gravelly SAND (gS) 15% gravel, mod-sorted, lg. pebbles-sm cobbles. Sand, fn-vcse, poorly sorted, SR-SA 2.5Y 4/2 dark grayish brown (moist) 60% basalt, 40% qtz/other. no rxn HCl.	
20					
				20'-103' SAND (S) 92% sand, 8% gravel. Gravel, basaltic, well-sorted, pea-sized. Sand, SR-SA, poorly sorted vfn-vcse. 60% basalt, 40% qtz/other 2.5Y 4/2 dark grayish brown (moist) no rxn HCl.	
25					
30					
35					

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/05/03 | Signature: L.D. Walker | Date: 9/23/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: West of C-Tank Farm

Project: CY03 RCRA drilling | 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	3H9"	n/A		@ 40' no trace of gravel. 95% sand, 5% silt. Sand, vfn-vcse.	Becker Hammer using 9" OD dual-wall casing
45					
50					
55				@ 55' trace gravel, basaltic, mps ~ 3" sand, v. poorly sorted.	
60					
65				@ 65' trace gravel, basaltic, mps ~ 1.5" sand, v. poorly sorted	
70					
75				@ 75' increase in pea-size basaltic gravel (~ 9%), sand, v. poorly sorted.	

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 08/05/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 9/24/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 3 of 8

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH9"	n/a		@80', 5-8% basaltic, pea-size gravel. Sand, v. poorly sorted.	Becker Hammer using 9" OD dual-wall casing
85				@85' gravel grading to well-sorted basaltic, sm pebbles, mps ~ 0.5". SR-SA. Sand, v. poorly sorted.	
90				@90'. silt coating on gravel. mps ~ 1.5". gravel, basaltic. SR-SA. < 5%.	
95				@95' gravel, pea-size-sm pebbles. ~9% basaltic	
100				@100' pea-size to med. pebbles, basaltic	
105				103'-107' gravelly SAND(gS) 12% gravel, 88% sand. Gravel, basaltic, mod-sorted, SR-SA, pea-size - sm pebbles. Sand, v. poorly sorted, SR-SA, vfn-vcse, 65% basalt, 35% qtz/other. 2.5Y4/2 dk. grayish brown (moist) no rxn HCl.	
110				107'-160' Sand (s) trace gravel. Sand, poorly sorted, SR-SA, vfn-vcse grained. 2.5Y4/2 dk. grayish brown (moist). no rxn HCl. 60% basalt. 40% qtz/other.	
115					

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/05/03 | Signature: L.D. Walker | Date: 9/24/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: west of C-Tank Farm

Project: C403 RCRA drilling | 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	B49"	N/A		@120' sand grading to mod-sorted, SR-R, fn-cse grained. 45% basalt, 55% qtz/other, 2.5Y 4/3 olive brown (moist) no rxn HCl.	Becker Hammer using 9" OD dual-wall casing
125				@125' trace silt.	
130				@130' 8% basaltic, pea-size gravel. Sand grading to 60% basalt, 40% qtz/ other, poorly sorted, vfn-vcse grain, SR-SR, 2.5Y 4/3 dk grayish brown (moist), no rxn HCl.	
135					
140				@140' trace gravel, mps ~ 1".	
145				@145' trace mica. Increase in silt (<5%) trace gravel, mps ~ 1". Sand, poorly sorted, vfn-vcse, 60% basalt, 40% qtz/other	
150					
155					

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/05/03 | Signature: L.D. Walker | Date: 9/24/03

A-6003-642 (03/03

BOREHOLE LOG

Page 5 of 8

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	BH9"	n/a		160'– 200' silty SAND(mS) 5% gravel, 82% sand, 13% silt. Gravel, well-sorted, basaltic, pea-size, SR-R. Sand, poorly-sorted, fn-vcse, SR-SA, 50% basalt, 50% qtz/other. 2.5Y5/1 gray (dry) & 2.5Y5/3 grayish brown (dry) no rxn HCl.	Becker Hammer using 9" OD dual-wall casing
165					
170					
175					
180				@180' basalt content down to 40%. qtz/other 60% sand, ufn-vcse, poorly sorted.	
185				@183' sand grading to well-sorted, fn-med grained, trace mica. 2.5Y4/4 olive brown (dry)	
190					
195				@195' sand grading to v. poorly sorted, SR-SA, vfn-vcse grained. Basalt 60%, qtz/other 40%. 10YR4/2 dk. grayish brown (moist) no rxn HCl	

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 08/11/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: LD Walker | Date: 9/23/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 6 of 8

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: West of C-Tank Farm

Project: CY03 RCRA drilling | 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	8Hq"	n/A		200'–210.0' silty sandy GRAVEL (msG) 30% gravel, 60% sand, 10% silt. Gravel, well-sorted, SR-R, pea-size to sm. pebbles, mps ~0.5", basaltic. Sand, poorly sorted, SR-SA, vfn-vcse, micaceous, 50% qtz/other, 50% basalt. 2.5Y4/2 dk. grayish brown (moist), no rxn HCl.	Becker Hammer using 9" OD dual-wall casing
205					
210				210'–226' SAND(S) 95% sand, 5% silt. Sand, well sorted, med-cse grained SR-SA, micaceous. 10YR5/2 grayish brown (dry) 40% basalt, 60% qtz/other no rxn HCl.	
215					
220				226'–230' gravelly SAND(gS) 20% gravel, 75% sand, 5% silt. Gravel, well-sorted, SR-SA, basaltic, pea-size ~3m. pebbles. Sand, poorly sorted, SR-SA vfn-vcse, 60% basalt, 40% qtz/other 10YR4/2, dk. grayish brown (moist) no rxn HCl.	A.M. RCT on site. CK'd spoils pile from 0'–230' bgs. α, β, γ @ background.
225				230'–245' SAND(S) 95% sand, 5% silt, trace gravel. Sand, mod-sorted SR-SA, fn-vcse, 50% basalt, 50% qtz/other	
230					
235				@235' trace basaltic gravel, mps ~3", sand, v. well sorted, vfn-med, SR-R micaceous, 35% basalt, 65% qtz/other. 2.5Y5/2 grayish brown (dry) no rxn HCl.	

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/05/03 | Signature: L.D. Walker | Date: 9/24/03

A-6003-642 (03/03)

BOREHOLE LOG

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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	B#9"	n/A		245'–255' Silty sandy GRAVEL (msG) 40% gravel, 50% sand, 10% silt. Gravel, well sorted, SR-SA, pea-size -sm pebbles, 70% basalt, 30% qtz/other. Sand, poorly sorted, SR-SA, vfn-vcgr, 40% basalt, 60% qtz/other, micaceous, silt nodules, 10YR 5/3 brown (moist) no rxn HCl.	Dual-wall casing 9" OD Becker Hammer
245					
250				@ 250' gravel increase to 70%, sand, 20%, silt 10%. Gravel, v. poorly sorted, pea-size - med. cobbles. mps ~ 5".	
255				255'–260' GRAVEL (g) 80% gravel, 15% sand, 5% silt. Gravel, poorly sorted, sm. pebbles - med cobbles, 65% basalt, 35% qtz/other, SR-SA. Sand, poorly sorted, SR-SA, 50% basalt, 50% qtz/other, no rxn HCl, vfn-vcgr. grained.	
260				260'–318' sandy GRAVEL (sG) 55% gravel, 38% sand, 7% silt. Gravel, poorly sorted, SR-SA, mps ~ 3.5", sm-pebble to med. cobbles, 65% basalt, 35% qtz/other. 10YR 4/2 dk. grayish brown (moist) no rxn HCl.	
265					
270					
275				@ 275' bgs => increase in basalt content 70% basalt, 30% qtz/other	

Reported By: Charlene Martiner | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martiner | Date: 08/05/03 | Signature: L.D. Walker | Date: 9/24/03

A-6003-642 (03/03)

BOREHOLE LOG

Page 8 of 8

Date: 08/05/03

Well ID: C4190 | Well Name: 299-E27-23 | Location: West of C-Tank Farm

Project: C403 RCRA drilling | 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
280	BH 9"	n/a		@280' gravel v. poorly sorted, pred. lg pebbles–lg cobbles. SR-A, very fragmented, basaltic. Sand, v. poorly sorted, vfn-vcse, 80-85% basalt, 15-20% qtz/other	Becker Hammer using 9" OD dual-wall casing
	Grab BH 9"				collect 280' archive
285	Grab BH 9"				collect 285' archive
290	Grab BH 9"			@290' increase in gravel content ~70% gravel, 25% sand, <5% silt.	collect 290' archive
295	Grab BH 9"				collect 295' archive
300	Grab BH 9"				collect 300' archive
305	Grab BH 9"				collect 305' archive
310	Grab analysis sample	sieve			collect 310' archive collect sieve analysis sample (310'-312' bgs) large basalt boulder @311' bgs.
	BH 9"	n/a			
315	Grab BH 9"				collect 315' archive
	GrnB	TD=> 318' bgs			collect 318' archive TD @ 319' bgs

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 08/05/03 | Signature: L.D. Walker | Date: 9/24/03

A-6003-642 (03/03)

WELL DEVELOPMENT AND TESTING DATA

Well Name:	Well ID:	Well Location:	Date:
299-E27-23	C4190	West of 241-C Tank Farm	9-2-03

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

Has the well been surveyed? ☐ Yes ☒ No

Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:

Start of Job	276.52' TOC
End of Job	276.40' TOC

DEPTH TO BOTTOM:

Start of Job	314.4' TOC
End of Job	314.4' TOC

PART 2

WELL DEVELOPMENT DATA

Pump Model 5HP Franklin Electric

	BTM	MED	TOP
Intake Depth	311.3 TOC	301.3 TOC	291.3 TOC
Starting Turbidity	35 NTU	1.8 NTU	26 NTU

Pump Start	Stop	Flow Rate
0940	1037	24.5 GPM
1105	1135	26 GPM
1347	1505	6 GPM

Total Pumped 3,624.5 Gal.

	BTM	MED	TOP
Final Turbidity	3.93 NTU	0.74 NTU	3.00 NTU

XD SN/Range (PSI) 20.0 Psi

PART 3

INSTANTANEOUS SLUG TEST

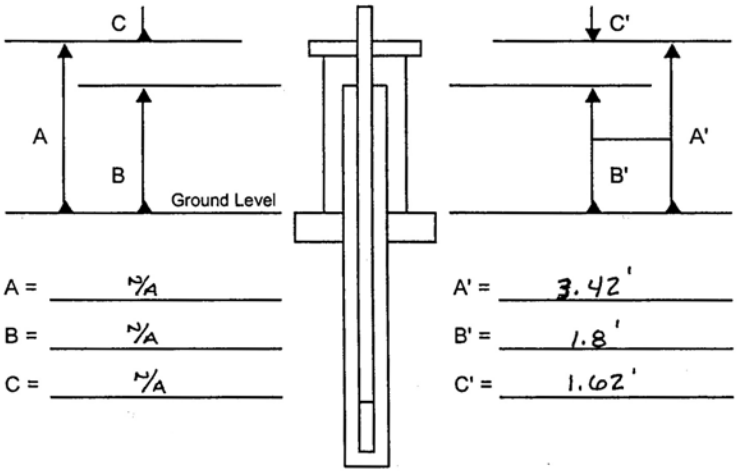
NOT USED

Static Water Level (TOC)	
Transducer Depth	
Baseline Start	
Injection Start	
Baseline Start	
Withdrawal Start	
Slug Volume	
XD SN/Range (PSI)	

PART 4

Last Recorded Measurements Date: N/A

Current Measurements Date: 9-2-03



A = N/A

B = N/A

C = N/A

A' = 3.42'

B' = 1.8'

C' = 1.62'

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

COMMENTS:

0600 - POD / Safety Mtg.
0610 - Geologist on site.
0615 - Geologist waits on Layne to set up pump rig.
0700 - Layne to go get generator & forklift; Geologist takes measurements.
0715 - DTW = 276.52' TOC (273.10' bgs); DTB = 314.4' TOC (310.98' bgs); Stkup = 3.42'; fill = 311.0' bgs - 310.98' bgs = 0.02'
0730 - Layne set up and ready to start.
0745 - Layne wants to pull bailer loads (even though there is only 0.02'); waiting for barrel from FWS Tim Hottell.
0750 - Begin bailing.
0817 - End bailing; begin dropping pump.

epared by (print name): Jess Hocking	Signature: Jess Hocking	Date: 9/2/03
Reviewed by (print name): L.D. Walker	Signature: L.D. Walker	Date: 9/24/03

A-6003-644 (03/03)

FIELD ACTIVITY REPORT - DAILY DRILLING Continuation Page		Page 2 of 5 Date: 9-2-03
Well Name: 299-E27-23	Well ID: C4190	
Location: West of 241-C Tank Farm	Continuation of Report No.: Well Development	

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth
	0830	Geologist calibrates field equipment: 2100P HACH TURBIDIMETER, YSI 55 D.O. METER, Orion model 124 conductivity & Orion model 290 A pH METER are all running within standard specs; details on last page of Development ~~page~~ report. MJH
	0930	Pump at depth; Layne hooks up flow meters; Geologist drops transducer
	0936	Initial XD = 27.390' H_2O
	0940	Start test; Development begins.
	0942	XD = 27.260' H_2O (0.13' draw) @ ~26 GPM [MAX]
	0945	Initial attributes sample taken; Turb. = 35 NTU; Details on back page.
	0951	XD = 27.232' H_2O (0.158' draw) @ ~26 GPM
	1001	XD = 27.235' H_2O (0.155' draw) @ ~26 GPM.
	1014	XD = 27.225' H_2O (0.165' draw) @ ~26 GPM.
	1021	XD = 27.255' H_2O (0.135' draw) @ ~26 GPM.
	1028	XD = 27.225' H_2O (0.165' draw) @ ~26 GPM
	1034	XD = 27.252' H_2O (0.138' draw) @ ~26 GPM.
	1037	Pump shut off; Recovery test started
	1038	XD = 27.248' H_2O (99.5% Rec.); possible mistake made by Layne w/pump shut-off.
	1041	XD = 27.278' H_2O (99.6% Rec.)
	1043	Layne does not shut off pump for first several minutes of recovery test - which will explain jump in hydrograph later.
	1052	XD = 27.277' H_2O (99.6% Rec.); Recovery test ended, ready to move pump up ~10'.
	1056	Layne begins to move pump up 10'.
	1104	Pump intake @ 301.3' TOC.; Initial XD = 18.287' H_2O.
	1105	Start pump and draw test.
	1106	XD = 18.308' H_2O (draw = -0.021') @ ~26 GPM.
	1114	XD = 18.268' H_2O (draw = 0.019') @ ~26 GPM.
	1121	XD = 18.274' H_2O (draw = 0.013') @ ~26 GPM.
	1127	XD = 18.277' H_2O (draw = 0.010') @ ~26 GPM.

Reported By: Jess Hocking		Reviewed By: L.D. Walker	
Title: Geologist / Hydrogeologist	Date: 9/2/03	Title: Geologist	Date: 9/24/03
Signature: Jess Hocking		Signature: L.D. Walker	

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING Continuation Page	Page 3 of 5 Date: 9-2-03
Well Name: 299-E27-23	Well ID: C4190
Location: West of 241-C Tank Farm.	Continuation of Report No.: Well Development

Time/Depth		Description of Activities/Operations with Depth
From	To	
	1131	XD = 18.259' H_2O (draw = 0.028')
	1134	XD = 18.256' H_2O (draw = 0.031')
	1135	Draw test ended; recovery test started.
	1137	XD = 18.298' H_2O (~100% Rec.)
	1140	XD = 18.298' H_2O (100% Rec.); Purge truck full - will be emptied before final pump test (top of three sections).
	1143	XD = 18.307' H_2O (100% Rec.); Recovery test shut off; Layne begins to move pump to third and final stage (10 ft. higher than last stage.
	1304	Purge truck back.
	1310	Problem w/ transducer; pull pipe to find source.
	1340	Problem found and solved
	1345	Initial XD = 0.066' H_2O
	1347	Begin third draw test.; Flow @ 3 GPM
	1350	Kicked flow up to ~~7 GPM~~ MAX 5 GPM
	1351	XD = 0.055' H_2O (draw = 0.011') @ ~~7 GPM~~ MAX 5 GPM
	1358	XD = 0.040' H_2O (draw = 0.026') @ 6 GPM
	1408	XD = 0.016' H_2O (draw = 0.05') @ 6 GPM
	1424	XD = -0.004' H_2O ("sucking air") @ 6 GPM
	1425	XD = 0.011' H_2O (draw = 0.055') @ 6 GPM; Geologist suspects Hermit or transducer of malfunction and non-sense readings to correlate.
	1428	XD = 0.015' H_2O (draw = 0.051') @ 6 GPM.
	1435	XD = 0.003' H_2O (draw = 0.063') @ 6 GPM.
	1500	XD = -0.020' H_2O ("sucking air") @ 6 GPM - transducer out of water, pump intake still in water.
	1505	Stop draw test and begin recovery test.
	1506	XD = -0.010' H_2O (transducer still out of water)
	1511	XD = 0.008' H_2O (12% Rec)
	1512	XD = 0.011' H_2O (16% Rec.)

Reported By: Jess Hocking		Reviewed By: L.D. Walker	
Title: Geologist / Hydrogeologist	Date: 9/2/03	Title: Geologist	Date: 9/24/03
Signature: Jess Hocking		Signature: L.D. Walker	

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING
Continuation Page

Date: 9-2-03

Well Name: 299-E27-23 | Well ID: C4190

Location: West of 241-C Tank Farm. | Continuation of Report No.: Well Development

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth
	1516	Recovery test stops premature as Layne begins to trip out pump and transducer - which may not be all bad since transducer began ~~the~~ MJH to fritz-out anyway.
	1527	Still tripping pump out of C4190.
	1617	Pump out of well and Pump Rig broke down off site - heading for decon. pad. Geologist takes final measurements and cleans equipment from site.
	1620	C4190 ready for sample pump installation.
	1630	Geologist no longer needed; heads for town.
		Calibration Results: 2100P HACH TURBIDITIMETER
		4.57 NTU 0-10 NTU } Within standard ranges.
		48.0 NTU 0-100 NTU }
		554 NTU 0-1000 NTU }
		YSI 55 Dissolved Oxygen METER:
		Operating within standard ranges.
		Orion model 124 Conductivity Meter:
		10^{+} µS/cm off standard = acceptable range.
		Orion model 290A pH Meter:
		7.001 = 7.00 buffer
		10.025 = 10.00 buffer
		slope = 99% = acceptable.

Reported By: Jess Hocking

Title: Geologist / Hydrogeologist | Date: 9/2/03

Signature: Jess Hocking

Reviewed By: L.D. Walker

Title: Geologist | Date: 9/24/03

Signature: L.D. Walker

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING
Continuation Page

Page 5 of 5

Date: 9-2-03

Well Name: 299-E27-23 | Well ID: C4190

Location: West of 241-C Tank Farm. | Continuation of Report No.: Well Development

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth

Sample Results:

	TIME	TURB	pH	DO	Cond.	Temp.
BTM.	0945	35 NTU	8.47	4.11 mg/L	405 mS/cm	21 °C
	1005	13.5 NTU	8.05	4.56 mg/L	411 mS/cm	20.3 °C
	1020	3.38 NTU	7.93	4.13 mg/L	407 mS/cm	21 °C
	1030	3.93 NTU	7.86	4.46 mg/L	409 mS/cm	20.2 °C
MED.	1111	1.80 NTU	7.98	4.46 mg/L	405 mS/cm	21.6 °C
	1124	0.77 NTU	7.87	4.65 mg/L	404 mS/cm	20.3 °C
	1133	0.74 NTU	-	-	-	-
TOP	1356	26.0 NTU	7.96	3.87 mg/L	372 mS/cm	23.7 °C
	1413	5.04 NTU	7.87	3.97 mg/L	376 mS/cm	21.8 °C
	1433	3.65 NTU	7.92	4.02 mg/L	384 mS/cm	21.5 °C
	1505	3.00 NTU	7.91	3.23 mg/L	381 mS/cm	22.1 °C

NOT USED
Jess Hocking 9/2/03

Reported By: Jess Hocking
Title: Geologist / HydrogeoTegist | Date: 9/2/03
Signature: Jess Hocking

Reviewed By: L.D. Walker
Title: Geologist | Date: 9/24/03
Signature: LD Walker

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - WELL SERVICES

Page 1 of 1

Date	Well No.	Rig Type/Model	Rig No.	Contract/Work Order No.	Report No.
09/18/03	C4190 299-E27-23	Pump setting rig			1

Purpose: Install pump in C403 RCRA wells.

Reference:

Location: west of C-Tank farm

HISTORICAL DATA

Construction Depth	310.97' bgs
Casing Size / Type / Set At	4" ID SS304 sch 10 +1.8' – 273.51'
Casing Perforations Schedule / Interval	
Well Screen(s) Type / Interval	4" ID SS304 sch 10, 0.020" slot, 273.51' – 308.54'
Last Recorded Depth-to-Water	276.52' TOC
Last Recorded Depth-to-Bottom	314.4' TOC
Current Depth-to-Water	276.46' TOC
Current Depth-to-Bottom	314.45' TOC

PUMP SYSTEM CONFIGURATION

	Pre-Maintenance	Post-Maintenance
Pump Type: 0.7 HP	Grundfos Redi-flo3	
Pump Model	Prod. # 96030-139 model A	
Tubing Size/Type	0.75" OD SS304, Sch. 40	
Length-Bottom of Tubing to Pump Intake	1.11'	
Tubing Length	280.0'	
Length-Top of Tubing to Reference Point		
Pump Intake Set at (Depth)	281.11'	

Reference/Measuring Point: TOC (TOP OF CASING)

Start Time: 1400
End Time: 1630
Time:
Contract Time:
Total Time: 2.5 hrs

Personnel:
Layne Christensen
- Dave DeWitt
- Ken Jones

Fluor Hanford
- Ed Rafuse

CH2M Hill (CHG)
- Charlene Martinez

Materials Used: 28 x 10' long SS 304, schedule 40, 0.75" OD tremmie pipe & couplers
0.7 HP Grundfos Redi-flo3 electric submersible pump.

Description of Operations/Remarks

1405 on site from C4127

1410 Drill crew off site to pick up tremmie pipe & pump for installation.

1415 Tagged g.w. => 276.46' TOC

Tagged T.D => 314.45' TOC

Still my birthday. Happy birthday to me. Happy birthday to me.

1440 Drill crew on site. Setting up rig to install Grundfos Redi-flo3 (0.7 Hp) pump.

1445 Installing pump + tremmie pipe.

1618 Done 09/19/03 Tested pump=>works (cm) 09/19/03

1618 Lowering mast on pump setting rig.

1630 Site secure. End of shift.

Charlene Martinez 09/18/03

not used

Report By: Charlene Martinez	Reviewed By: L.D. Walker
Title: Geologist	Title: Geologist Date: 9/30/03
Signature: Charlene Martinez	Signature: L.D. Walker

DISTRIBUTION: White-Field File Custodian Yellow-Group Files Pink-Project Coordinator Goldenrod-Team Leader BC-6000-278 (04/91)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend **Company:** Fluor Federal Services
Date Requested: 9/29/03	**Requestor:** Chris S. Wright (FH)
Date of Survey: 10/31/03	**Surveyor:** Fluor Federal Services Survey Dept.
ERC Point of Contact:	**Survey Co. Point of Contact:** Grant F. Brazil, P.L.S.
Description of Work: Civil Survey of Groundwater Monitoring Well C4190 (299-E27-23).	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 200E

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
2E-127 (FFS) and 2E-134 (FFS)

Vertical Control Monuments:
2E-33 (FFS) and 2E-38 (FFS)

Well ID	Well Name	Easting	Northing	Elevation	
C4190	299-E27-23	575069.46	136452.23		Center of Casing
				206.563	Top Casing, N. Edge
				205.661	Brass Survey Marker
				206.569	Top Pump Base-plate, N. Edge

Notes:

Surveyor Statement:
I, Grant F. Brazil, a Professional Land Surveyor registered in the State of Washington (Registration No. 22326), hereby certify that this report is based on a field survey performed in October, 2003 under my direct supervision, and that the data contained here is true and correct.

Original to:
Distribution by DIS:

Appendix B

Sediment Samples Physical Properties Data, Chain of Custody Forms, Core Photographs and Core Log

Appendix B

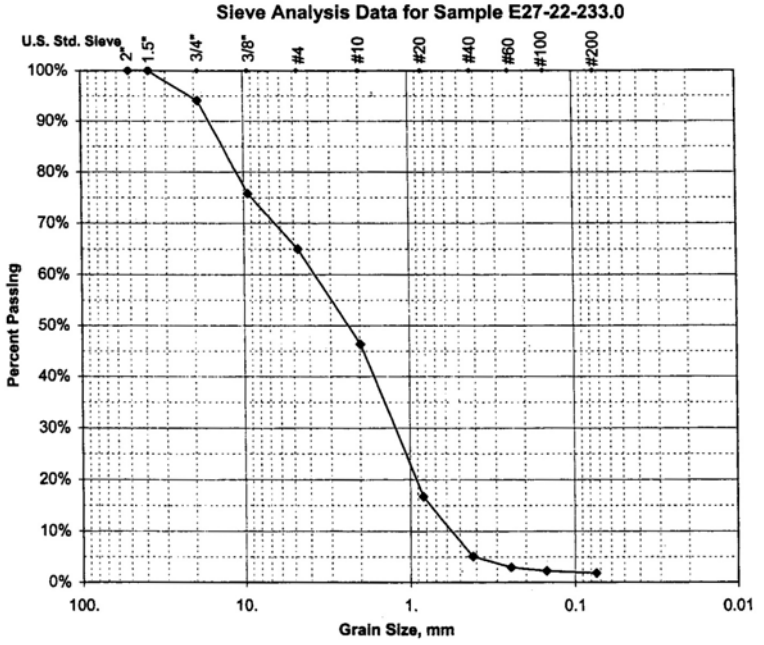
Sediment Samples Physical Properties Data, Chain of Custody Forms, Core Photographs and Core Log

CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-22	DEPTH	233	SAMPLE#	E27-22-233.0	WELL ID#	C4124
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	09/05/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1495.50	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	88.8	5.9	94.1	19.05	
	3/8"	362.9	24.3	75.7	9.42	
	#4	523.8	35.0	65.0	4.70	
	#10	802.3	53.6	46.4	1.98	
	#20	1245.5	83.3	16.7	0.83	
	#40	1419.8	94.9	5.1	0.42	
	#60	1451.8	97.1	2.9	0.25	
	#100	1462.3	97.8	2.2	0.150	
	#200	1468.9	98.2	1.8	0.074	



Comments: Sandy gravel. Sample collected from cyclone.
Sample representative of formation.
All data are accurately and completely recorded.
Checked By: L.D. Walker Date: 9/30/03

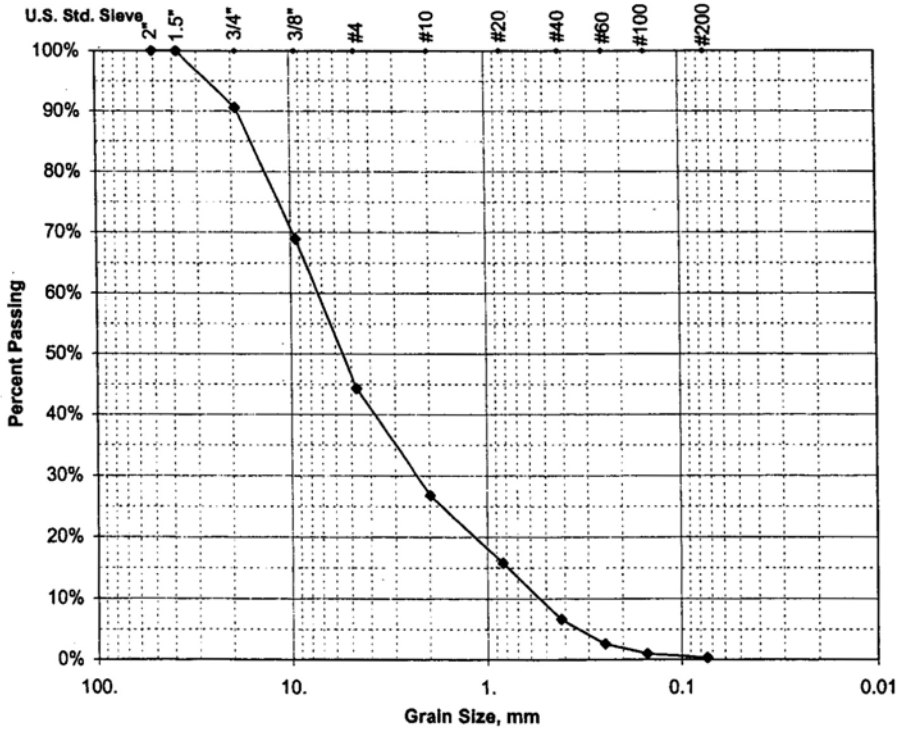
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-22	DEPTH	268	SAMPLE#	E27-22-268.0	WELL ID#	C4124
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	09/05/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1417.80	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	133.8	9.4	90.6	19.05	
	3/8"	441.1	31.1	68.9	9.42	
	#4	790.1	55.7	44.3	4.70	
	#10	1038.0	73.2	26.8	1.98	
	#20	1193.9	84.2	15.8	0.83	
	#40	1324.0	93.4	6.6	0.42	
	#60	1381.0	97.4	2.6	0.25	
	#100	1403.7	99.0	1.0	0.150	
	#200	1413.5	99.7	0.3	0.074	

Sieve Analysis Data for Sample E27-22-268.0



Comments: Sandy gravel. Sample collected from cyclone.
Sample representative of formation.
All data are accurately and completely recorded.
Checked By: L.D. Walker Date: 9/30/03

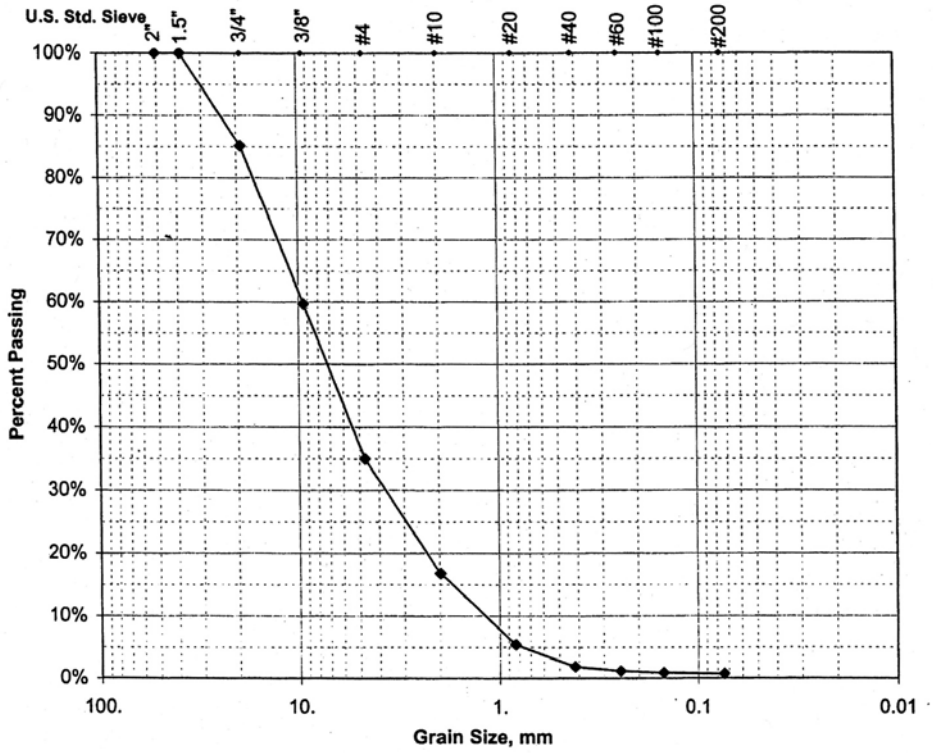
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-4	DEPTH	270-271	SAMPLE#	E27-4-270.0	WELL ID#	C4125
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	08/14/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1674.50	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	249.2	14.9	85.1	19.05	
	3/8"	675.2	40.3	59.7	9.42	
	#4	1089.0	65.0	35.0	4.70	
	#10	1393.3	83.2	16.8	1.98	
	#20	1583.7	94.6	5.4	0.83	
	#40	1643.4	98.1	1.9	0.42	
	#60	1655.3	98.9	1.1	0.25	
	#100	1659.5	99.1	0.9	0.150	
	#200	1662.3	99.3	0.7	0.074	

Sieve Analysis Data for Sample E27-4-270.0



Comments: Gravel. Sample collected from cyclone.
Sample representative of formation.
All data are accurately and completely recorded.
Checked By: L.D. Walker Date: 9/30/03

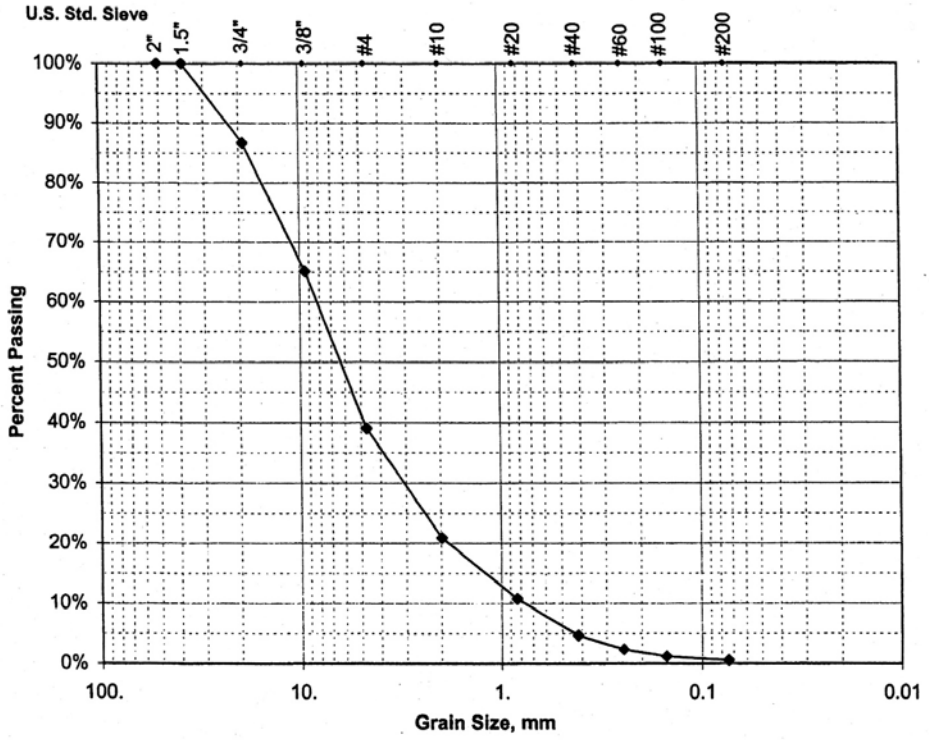
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-4	DEPTH	301-303	SAMPLE#	E27-4-301.0	WELL ID#	C4125
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	08/14/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1502.20	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	200.4	13.3	86.7	19.05	
	3/8"	524.6	34.9	65.1	9.42	
	#4	916.4	61.0	39.0	4.70	
	#10	1188.8	79.1	20.9	1.98	
	#20	1341.0	89.3	10.7	0.83	
	#40	1431.8	95.3	4.7	0.42	
	#60	1467.0	97.7	2.3	0.25	
	#100	1484.5	98.8	1.2	0.150	
	#200	1494.2	99.5	0.5	0.074	

Sieve Analysis Data for Sample E27-4-301.0



Comments: Sandy gravel. Sample collected from cyclone.

Sample representative of formation.

All data are accurately and completely recorded.

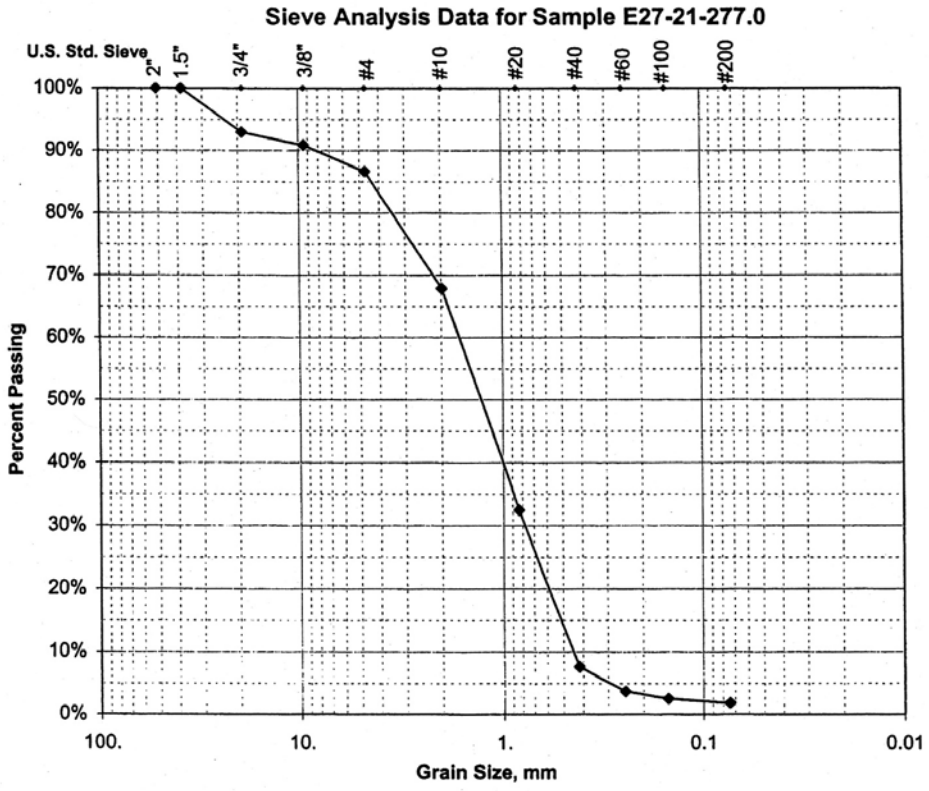
Checked By: L.D. Walker Date: 9/30/03

CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-21	DEPTH	277.0-280.0	SAMPLE#	E27-21-277.0	WELL ID#	C4127
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	07/22/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1625.60	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	114.8	7.1	92.9	19.05	
	3/8"	148.8	9.2	90.8	9.42	
	#4	217.2	13.4	86.6	4.70	
	#10	522.5	32.1	67.9	1.98	
	#20	1098.4	67.6	32.4	0.83	
	#40	1502.1	92.4	7.6	0.42	
	#60	1565.5	96.3	3.7	0.25	
	#100	1584.6	97.5	2.5	0.150	
	#200	1596.2	98.2	1.8	0.074	



Comments: Gravelly sand. Sample collected from cyclone.

Sample is representative of formation.

All data are accurately and completely recorded.

Checked By: L.D. Walker Date: 9/30/03

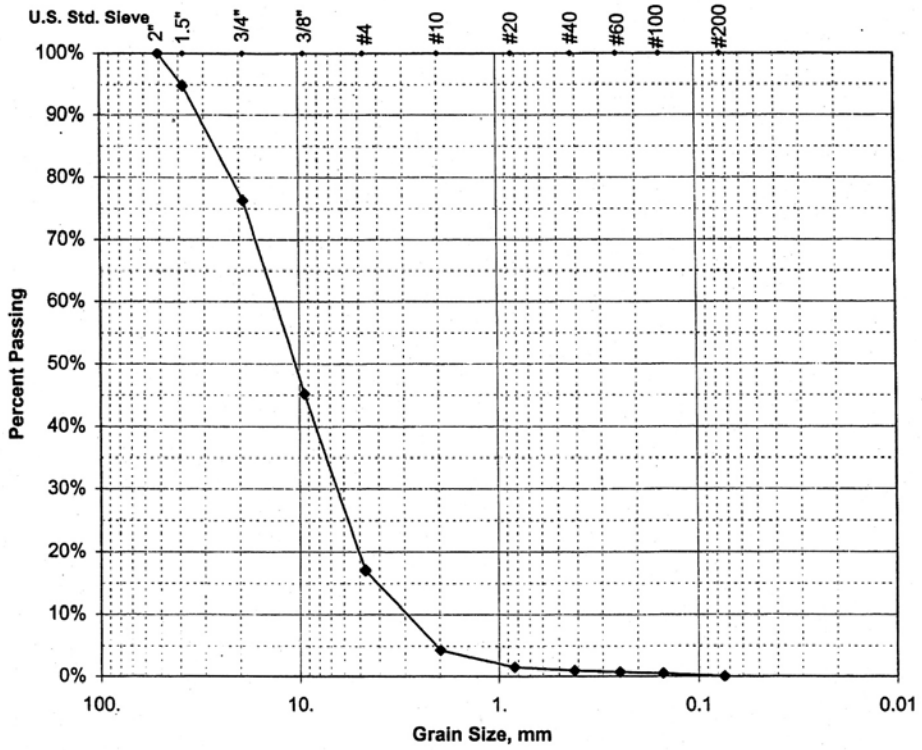
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-21	DEPTH	312-315	SAMPLE#	E27-21-312.0	WELL ID#	C4127
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	07/22/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1743.50	2"	0.0	0.0	100.0	50.80	
	1.5"	91.1	5.2	94.8	38.10	
	3/4"	413.1	23.7	76.3	19.05	
	3/8"	956.1	54.8	45.2	9.42	
	#4	1446.6	83.0	17.0	4.70	
	#10	1668.9	95.7	4.3	1.98	
	#20	1717.2	98.5	1.5	0.83	
	#40	1726.5	99.0	1.0	0.42	
	#60	1731.1	99.3	0.7	0.25	
	#100	1735.0	99.5	0.5	0.150	
	#200	1743.5	100.0	0.0	0.074	

Sieve Analysis Data for Sample E27-21-312.0



Comments: Gravel. Sample collected from cyclone. Fines washed away.
Sample not representative of formation.
All data are accurately and completely recorded.
Checked By: L.D. Walker Date: 9/30/03

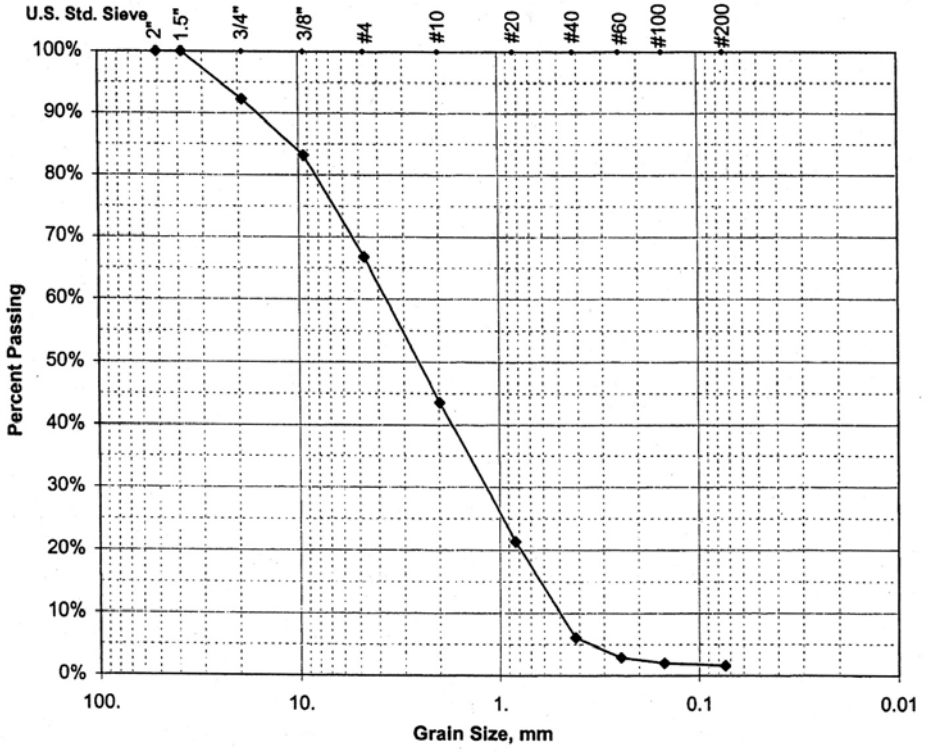
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-20	DEPTH	275.0-277.0	SAMPLE#	E27-20-275.0	WELL ID#	C4126
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	07/30/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1669.70	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	128.8	7.7	92.3	19.05	
	3/8"	281.1	16.8	83.2	9.42	
	#4	555.7	33.3	66.7	4.70	
	#10	943.2	56.5	43.5	1.98	
	#20	1313.1	78.6	21.4	0.83	
	#40	1568.2	93.9	6.1	0.42	
	#60	1620.7	97.1	2.9	0.25	
	#100	1635.7	98.0	2.0	0.150	
	#200	1642.7	98.4	1.6	0.074	

Sieve Analysis Data for Sample E27-20-275.0



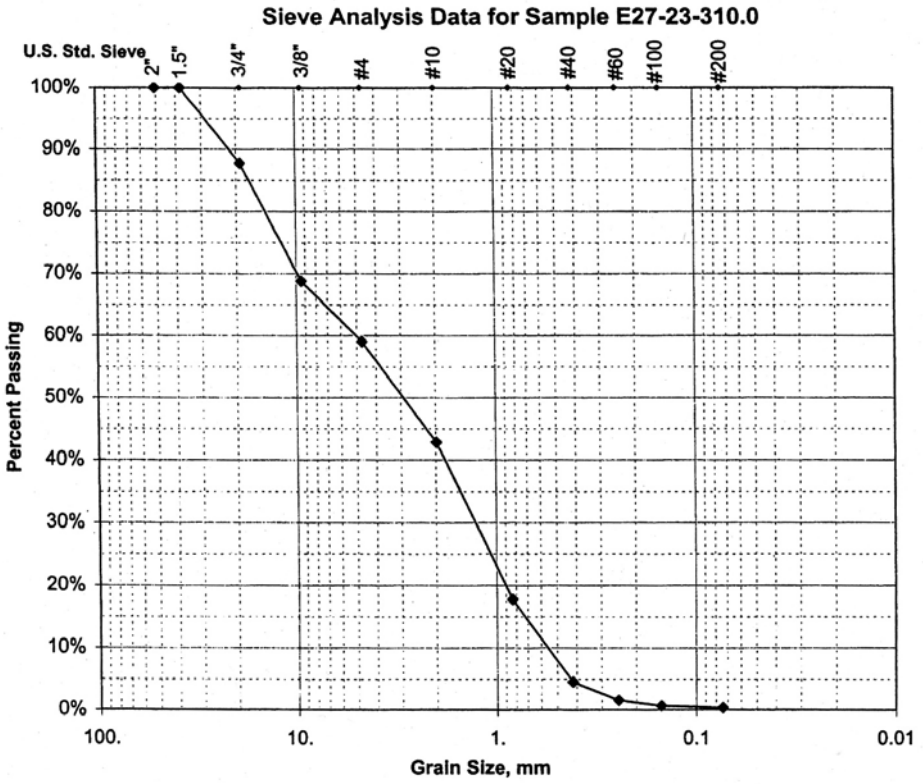
Comments: Sandy gravel. Sample collected from cyclone.
Sample is representative of formation.
All data are accurately and completely recorded.
Checked By: L.D. Walker Date: 9/30/03

CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	299-E27-23	DEPTH	310-312	SAMPLE#	E27-23-310.0	WELL ID#	C4190
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	08/06/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1575.60	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	193.2	12.3	87.7	19.05	
	3/8"	492.2	31.2	68.8	9.42	
	#4	645.9	41.0	59.0	4.70	
	#10	901.4	57.2	42.8	1.98	
	#20	1296.2	82.3	17.7	0.83	
	#40	1504.6	95.5	4.5	0.42	
	#60	1551.2	98.5	1.5	0.25	
	#100	1565.1	99.3	0.7	0.150	
	#200	1570.4	99.7	0.3	0.074	



Comments: Sandy Gravel. Sample collected from cyclone.
Sample representative of formation.
All data are accurately and completely recorded.
Checked By: L.D. Walker Date: 9/24/03

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 1 of 1

Collector: Fluor Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN: E4-35 FAX:
SAF No.	Sample Origin: 299-E27-22 (C4124)	Purchase Order/Charge Code
Project Title: C403 RCRA drilling.	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab)	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-19-21.5		CORE	08/21/03	1515	2 lexan liners		
C4124-21.5-24.0		"	08/21/03	1534	2 lexan liners		
C4124-24.0-26.5		"	08/21/03	1602	2 lexan liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Charlene Martinez Charlene Martinez 08/21/03

Relinquished By (Print / Sign)	Date/Time	Received By (Print / Sign)	Date/Time
"		BRUCE A. WILLIAMS	8/25/03 1050
BRUCE A WILLIAMS	8/25/03 10:00	Ginny LeGore Ginny LeGore	8/25/03 10:00

Matrix*

S = Soil		DS = Drum Solids	
SE = Sediment		DL = Drum Liquids	
SO = Solid		T = Tissue	
SL = Sludge		WI = Wipe	
W = Water		L = Liquid	
O = Oil		V = Vegetation	
A = Air		X = Other	

FINAL SAMPLE DISPOSITION: Disposal Method (e.g., Return to customer, per lab procedure, used in process) Disposed By Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

A-6003-432 (05/02)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 1 of 2

Collector: Fluor Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E 27-22 (C4124)	Purchase Order/Charge Code
Project Title: C403 RCRA Drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab)	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-26.5	-29.0	S	08/22/03	0655	2 Lexan Liners		
C4124-29.0	-31.5	S	08/22/03	0733	2 Lexan Liners		
C4124-31.5	-34.0	S	08/22/03	0747	2 Lexan Liners		
C4124-34.0	-36.5	S	08/22/03	0814	2 Lexan Liners		
C4124-36.5	-39.0	S	08/22/03	0845	2 Lexan Liners		
C4124-39.0	-41.5	S	08/22/03	0902	2 Lexan Liners		
C4124-41.5	-44.0	S	08/22/03	0926	2 Lexan Liners		
C4124-44.0	-46.5	S	08/22/03	0945	2 Lexan Liners		
C4124-46.5	-49.0	S	08/22/03	1014	2 Lexan Liners		
C4124-49.0	-51.5	S	08/22/03	1035	2 Lexan Liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By (Print / Sign)	Date/Time	Received By (Print / Sign)	Date/Time
Charlene Martinez / Charlene Martinez	08/22/03	BRUCE WILLIAMS /	8/25/03 0730
BRUCE WILLIAMS /	8/25/03 1000	Relinquished By Gina LeCuyer	8/25/03 11:00
Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time

Matrix*

S = Soil		DS = Drum Solids	
SE = Sediment		DL = Drum Liquids	
SO = Solid		T = Tissue	
SL = Sludge		WI = Wipe	
W = Water		L = Liquid	
O = Oil		V = Vegetation	
A = Air		X = Other	

FINAL SAMPLE DISPOSITION: Disposal Method (e.g., Return to customer, per lab procedure, used in process) Disposed By Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

A-6003-432 (05/02)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 2 of 2

Collector: Fluor Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E27-22 (C4124)	Purchase Order/Charge Code
Project Title: C403 RCRA drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab)	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-51.5	-54.0	S	08/22/03	1100	2 Lexan Liners		
C4124-54.0	-56.5	S	08/22/03	1121	2 Lexan Liners		
C4124-56.5	-59.0	S	08/22/03	1253	2 Lexan Liners		
C4124-61.5	-64.0	S	08/22/03	1341	2 Lexan Liners		
C4124-64.0	-66.5	S	08/22/03	1406	1 Lexan Liner	64 - 65 - EMPTY - NO RECOVERY	
C4124-66.5	~~-66~~ 69.0	S	08/22/03	1435	2 Lexan Liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By Print / Sign	Date/Time	Received By Print / Sign	Date/Time
Charlene Martinez / Charlene Martinez	08/22/03	Beke Williams /	8/25/03 0900
Beke A. Williams /	8/25/03 11:00	Ginny LeGore / Ginny LeGore	8/25/03 11:00

Matrix*

S	= Soil	DS	= Drum Solids
SE	= Sediment	DL	= Drum Liquids
SO	= Solid	T	= Tissue
SL	= Sludge	WI	= Wipe
W	= Water	L	= Liquid
O	= Oil	V	= Vegetation
A	= Air	X	= Other

FINAL SAMPLE DISPOSITION | Disposal Method (e.g., Return to customer, per lab procedure, used in process) | Disposed By | Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

A-6003-432 (05/02)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 1 of 1

Collector: Fluor Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E27-22 (C4124)	Purchase Order/Charge Code
Project Title: C403 RCRA drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab): V	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-71.5	-74.0	S	08/25/03	0735	2 Lexan Liners		
C4124-74.0	-76.5	S	08/25/03	0803	2 Lexan Liners		
C4124-76.5	-79.0	S	08/25/03	0842	2 Lexan Liners		
C4124-79.0	-81.5	S	08/25/03	0918	2 Lexan Liners		
C4124-81.5	-84.0	S	08/25/03	0950	2 Lexan Liners		
C4124-84.0	-86.5	S	08/25/03	1017	2 Lexan Liners		
C4124-86.5	-89.0	S	08/25/03	1100	2 Lexan Liners		
C4124-89.0	-91.5	S	08/25/03	1123	2 Lexan Liners		
C4124-91.5	-94.0	S	08/25/03	1236	2 Lexan Liners		
C4124-94.0	-96.5	S	08/25/03	1308	2 Lexan Liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By (Print / Sign)	Date/Time	Received By (Print / Sign)	Date/Time
Charlene Martinez / Charlene Martinez	08/25/03	BLAKE WILLIAMS /	8/27/03 1140
BLAKE WILLIAMS /	8/27/03 1100	Ray Clayton Ray Clayton	8/27/03 1140

Matrix*

S = Soil		DS = Drum Solids	
SE = Sediment		DL = Drum Liquids	
SO = Solid		T = Tissue	
SL = Sludge		WI = Wipe	
W = Water		L = Liquid	
O = Oil		V = Vegetation	
A = Air		X = Other	

FINAL SAMPLE DISPOSITION — Disposal Method (e.g., Return to customer, per lab procedure, used in process) — Disposed By — Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

A-6003-432 (05/02)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 1 of 2

Collector: Fluor Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E27-22 (C4124)	Purchase Order/Charge Code
Project Title: C103 RCRA drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab)	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-96.5-	99.0	S	08/26/03	0645	2 Lexan Liners		
C4124-99-	101.5	S	"	0714	"		
C4124-101.5-	104.0	S	"	0747	"		
C4124-104.0-	106.5	S	"	0817	"		
C4124-106.5-	109.0	S	08/26/03	0859	2 Lexan Liners		
C4124-109.0-	111.5	S	"	0928	"		
C4124-114.0-	116.5	S	"	1026	"		
C4124-119.0-	121.5	S	"	1104	"		
C4124-124.0-	126.5	S	"	1143	"		
C4124-129.0-	131.5	S	08/26/03	1310	2 Lexan Liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By (Print / Sign)	Date/Time	Received By (Print / Sign)	Date/Time
Charlene Martinez / Charlene Martinez	08/26/03	BRUCE WILLIAMS /	8/27/03 1100
BRUCE WILLIAMS /	8/27/03 1100	Ray Clayton Ray Clayton	8/27/03 1100

Matrix*

S	= Soil	DS	= Drum Solids
SE	= Sediment	DL	= Drum Liquids
SO	= Solid	T	= Tissue
SL	= Sludge	WI	= Wipe
W	= Water	L	= Liquid
O	= Oil	V	= Vegetation
A	= Air	X	= Other

FINAL SAMPLE DISPOSITION: Disposal Method (e.g., Return to customer, per lab procedure, used in process) Disposed By Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

A-6003-432 (05/02)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 2 of 2

Collector: Fluor Hanford	Contact/Requestor: CHRIS WRIGHT	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E27-22	Purchase Order/Charge Code
Project Title: C403 RCRA drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab)	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-134.0-136.5		S	08/26/03	1401	2 Lexan Liners		
C4124-139.0-141.5		S	"	1446	"		
C4124-144.0-146.5		S	08/26/03	1545	2 Lexan Liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By (Print / Sign)	Date/Time	Received By (Print / Sign)	Date/Time
Charlene Martinez / Charlene Martinez	08/26/03	Ray Clayton / BA WILLIAMS	8/27/03 1100
BA WILLIAMS / BA	8/27/03 1100	Ray Clayton Ray Clayton	8/27/03 11:00
Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time

Matrix*

S = Soil		DS = Drum Solids	
SE = Sediment		DL = Drum Liquids	
SO = Solid		T = Tissue	
SL = Sludge		WI = Wipe	
W = Water		L = Liquid	
O = Oil		V = Vegetation	
A = Air		X = Other	

FINAL SAMPLE DISPOSITION | Disposal Method (e.g., Return to customer, per lab procedure, used in process) | Disposed By | Date/Time

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 1 of 1

Collector: Fluor Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E27-22 (C4124)	Purchase Order/Charge Code
Project Title: C403 RCRA drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab)	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-149.0	-151.5	S	08/27/03	0707	2 Lexan Liners		
C4124-154.0	-156.5	S	"	0821	1 Lexan Liner		
C4124-159.0	-161.5	S	08/27/03	0915	2 Lexan Liners		
C4124-164.0	-166.5	S	"	1018	"		
C4124-169.0	-171.5	S	08/27/03	1115	2 Lexan Liners		
C4124-174.0	-176.5	S	"	1307	"		
C4124-179.0	-181.5	S	08/27/03	1354	2 Lexan Liners		
C4124-184.0	-186.5	S	"	1454	"		
C4124-189.0	-191.5	S	08/27/03	1549	2 Lexan Liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By (Print / Sign)	Date/Time	Received By (Print / Sign)	Date/Time
Charlene Martinez / Charlene Martinez	08/27/03	BRUCE A. WILLIAMS	9/3/03 0850
BRUCE WILLIAMS	9/3/03 1325	TANYA V. CREMAN	9/3/03 1340

Matrix*

S	= Soil	DS	= Drum Solids
SE	= Sediment	DL	= Drum Liquids
SO	= Solid	T	= Tissue
SL	= Sludge	WI	= Wipe
W	= Water	L	= Liquid
O	= Oil	V	= Vegetation
A	= Air	X	= Other

FINAL SAMPLE DISPOSITION: Disposal Method (e.g., Return to customer, per lab procedure, used in process) Disposed By Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

A-6003-432 (05/02)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 1 of 1

Collector: Fluor Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E27-22 (C4124)	Purchase Order/Charge Code
Project Title: C403 RCRA drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab): 9	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-194.0	-196.5	S	09/02/03	0749	2 Lexan Liners		
C4124-199.0	-201.5	S	09/02/03	0925	2 Lexan Liners		
C4124-204.0	-206.5	S	09/02/03	1029	2 Lexan Liners		
C4124-209.0	-211.5	S	09/02/03	1125	2 Lexan Liners		
C4124-214.0	-216.5	S	09/02/03	1324	2 Lexan Liners	MISS LABELED (2) 2 SETS OF 209-211.5	
C4124-219.0	-221.5	S	09/02/03	1448	1 Lexan Liner		
C4124-224.0	-226.5	S	09/02/03	1548	2 Lexan Liners		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By Print / Sign	Date/Time	Received By Print / Sign	Date/Time
Charlene Martinez / Charlene Martinez	09/02/03	BRENDA WILLIAMS	9/3/03 0855
Relinquished By	Date/Time	Received By	Date/Time
BRENDA WILLIAMS	9/03/03 13:24	Tanya Vickerman	9/3/03 1340
Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time

Matrix*

S = Soil		DS = Drum Solids	
SE = Sediment		DL = Drum Liquids	
SO = Solid		T = Tissue	
SL = Sludge		WI = Wipe	
W = Water		L = Liquid	
O = Oil		V = Vegetation	
A = Air		X = Other	

FINAL SAMPLE DISPOSITION | Disposal Method (e.g., Return to customer, per lab procedure, used in process) | Disposed By | Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

A-6003-432 (05/02)

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. No.

Page 1 of 1

Collector: Flyer Hanford	Contact/Requestor: Chris Wright	Telephone No.: 373-3994 MSIN FAX
SAF No.	Sample Origin: 299-E27-22 (C4124)	Purchase Order/Charge Code
Project Title: C403 RCRA drilling	Logbook No.	Ice Chest No. Temp.
Shipped To (Lab)	Method of Shipment	Bill of Lading/Air Bill No.
Protocol	Data Turnaround	Offsite Property No.

Sample No.	Lab ID	*	Date	Time	No./Type Container	Sample Analysis	Preservative
C4124-229.0 - 231.5		S	09/03/03	0718	1 Lexan Liner		

POSSIBLE SAMPLE HAZARDS/REMARKS (List all known wastes) MSDS ☐ Yes ☐ No

SPECIAL INSTRUCTIONS Hold Time

Relinquished By (Print / Sign)	Date/Time	Received By (Print / Sign)	Date/Time
Charlene Martinez / Charlene Martinez	09/03/03	Renea Willis / [signature]	9/3/03 0845
Bruce Williams / [signature]	09/03/03 1342	Tanya Vickerman / [signature]	1340 9/3/03

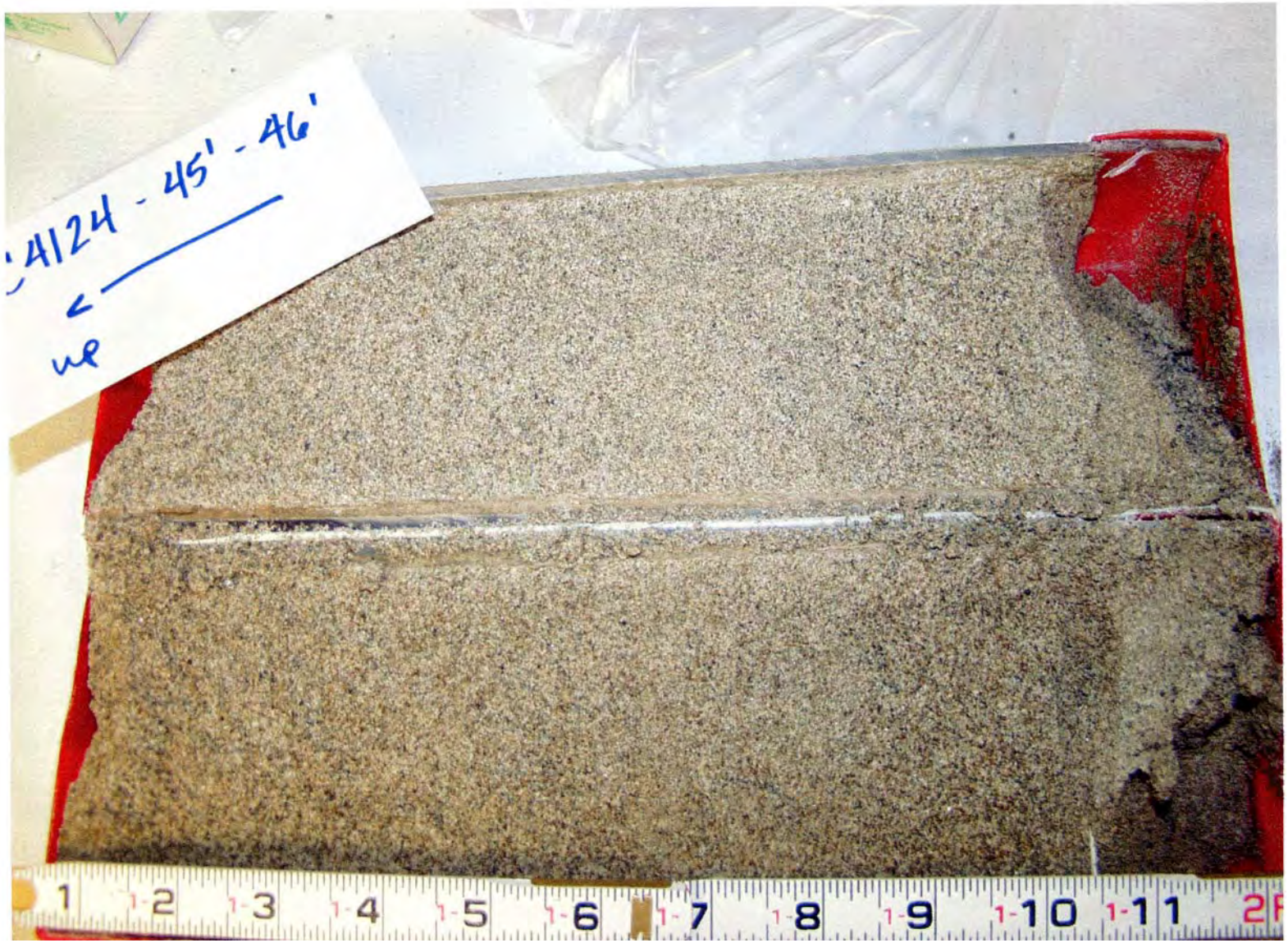
Matrix*

S	= Soil	DS	= Drum Solids
SE	= Sediment	DL	= Drum Liquids
SO	= Solid	T	= Tissue
SL	= Sludge	WI	= Wipe
W	= Water	L	= Liquid
O	= Oil	V	= Vegetation
A	= Air	X	= Other

FINAL SAMPLE DISPOSITION: Disposal Method (e.g., Return to customer, per lab procedure, used in process) Disposed By Date/Time

All samples containing hazardous materials shall be picked up by requestor and returned to parent container or site of origin.

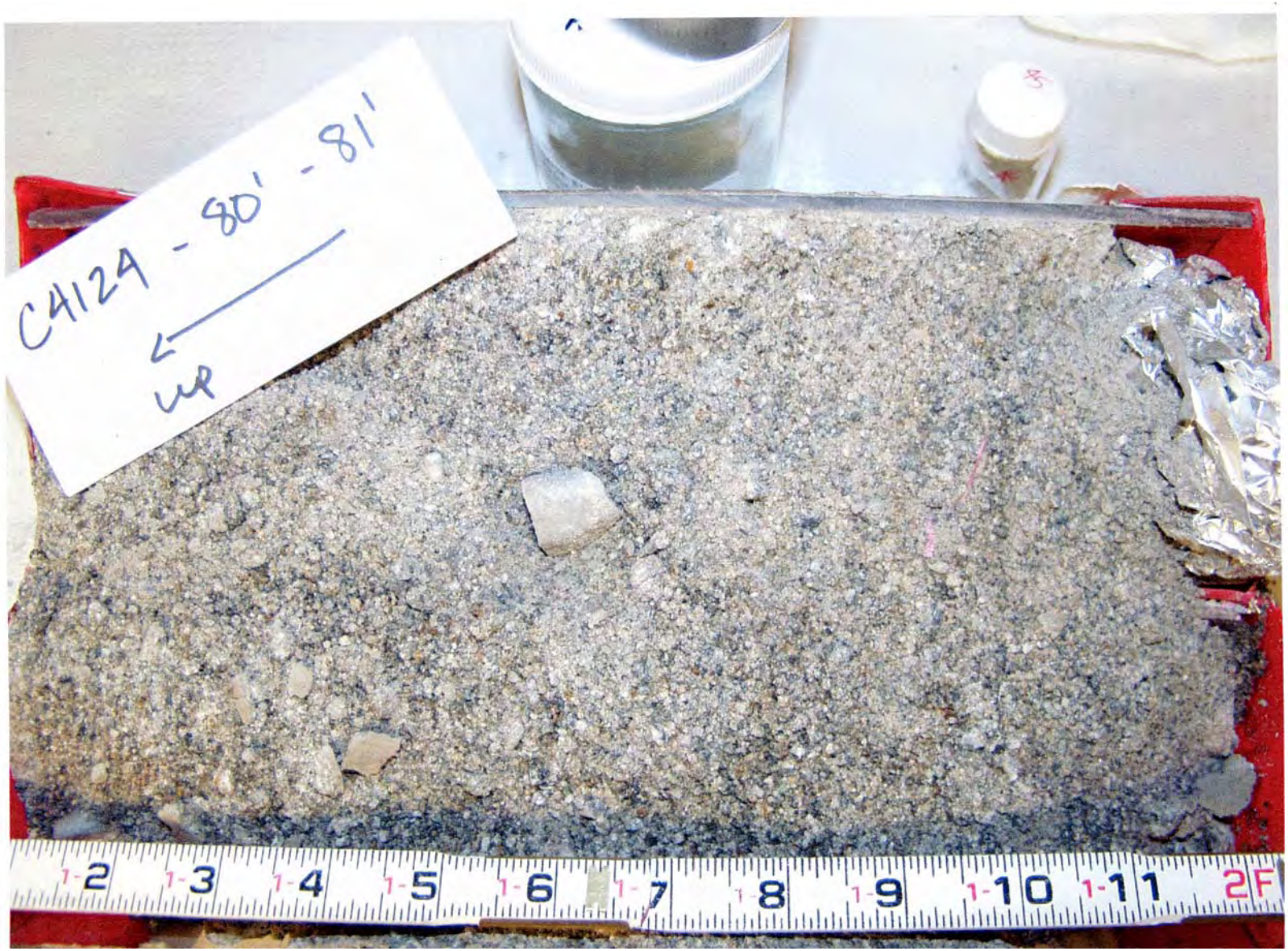
A-6003-432 (05/02)


4124 - 45' - 46'
1
1-2
1-3
1-4
1-5
1-6
1-7
1-8
1-9
1-10
1-11


C4124 - 46.5' - 47.5


C4124- 47.5-48.5
up


4124 - 49-50'
1
1-2
1-3
1-4
1-5
1-6
1-7
1-8
1-9
1-10
1-11


C4129 - 80' - 81'
UP


C4124 -815' -825
up
1-5
1-6
1-7
1-8
1-9
1-10
1-11


CH124 - 82.5' - 83.5'
UP

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 (299-E27-22) Depth 19-25' Date 10-28-03 Sheet 1 of 23

Location C Tank Farm Project Vadose Zone

Logged by BN Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
19		S.S				SM			S1		sand, loose, mod sorted,			Cores collected in late August -
											pebbly sand, loose, lgst clast = 10 mm,			stored at room temp. for about
											5Y4/2 (olive gry.) - dry, mostly			two months.
20		S.S							X		crs sand, massive, no rxn w/ HCl, poorly sorted, 50-60% basalt			
											sand, md-crs, 2.5Y4/2 - dry, mod			
											sorted, msv., loose			S1 = slough
									X		pebbly sand, loose, max. clast size = 1 cm			
21						↓					mostly crs sand, some oxidation, mostly crs sand to fn pebbly, 60-70% lmst			
21.5						SM			S1		sand, massive, loose			
											sand, md-crs, wkly stratified, oxidized blebs, 30-40% bas, lgst clast = 1 cm,			
											loose, wk rxn w/ HCl, 2.5Y 5/2, poorly sorted			
22.5														
											lgst clast = 2 cm			
23.5						↓								
24						D			S1		pebbly sand, v loose, 2.5Y 5/2 lgst clast = 2 cm			
											30-40% basalt, mtl, subangular			
											no rxn w/ HCl, massive			
25						↓								

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 25-31' Date 10-28-03 Sheet 2 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
25		S.S				D					pebbly sand, loose, msv, S = 30-40% bas.			
											max part size = 1.5 cm, poorly sorted,			
											2.5Y 5/2 (dry), no rxn w/ HCl			
26											20% fn pebble, 50% crs sand, 30 fn-md sand			
26.5		S.S.									empty			
						D								
											poorly sorted, loose, msv sand			
27.5		S.S.												
											pebbly sand, mod strng rxn w/ HCl,			
											20% pebble 80% sand, S = 40-50% bas.			
28.5										X	loose, msv. max part size = 1cm, poorly sorted			
											empty			
29		S.S.				D					pebbly sand, max part = 2cm, poorly sorted,			
											msv, wk rxn w/ HCl, S = 10-50% bas.			
											lrger clasts @ top, no rxn w/ HCl			
30											5% fn pebble, 60% crs sand,			
		S.S.				SM					30% fn-md sand			with sample
31										X				

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 31.5-37.5' Date 10/28/03 Sheet 3 of 23

Location C Tank Farm Project Vadose Zone

Logged by BN Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
31.5		S.S.				D		sl. pebbly, sand, mostly md-crs sand, ang-sbrv, mod. sorted, 2.5Y5/2, last clast = 2cm			
32.5								wk rxn w/ HCl, S = 40-50% basalt,			
		S.S.						loose, fe oxide blebs - small			
33.5								fn-md sand (like below)			pebbly crs sand, poorly sorted
											Contact
								sl?			fn-md sand, well sorted
34		S.S.				SM		sand, fn-md, well sorted, wkly lam., sl. compact, mod rxn w/ HCl, last clast = blk (at top), 2.5Y6/2,			
35		S.S.						S = 15-20% basalt			
							PM				PM @ 35.7' = paleomag sample
36											
36.5						SM		fn-md sand - same as above			
37.5											

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 37.5-43.5' Date 10-28-03 Sheet 4 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
37.5		S.S.				SM					same as above			
38.5														
39		S.S.				SM					sand, fn-md, well sorted, compact,			
											wkly lam., wk rxn w/ HCl,			
									PM		2.5Y 6/3, lgst clast = md sand			Paleomag smpl @ 39.3'
40		S.S									15-20% mafic			
											very uniform			
41														
41.5		S.S				SM			sl.		fn-md sand, as above except			
											massive			
42.5														
		S.S.									mostly md sand in lower 1/2			
											compact, well sorted			
									PM					Paleomag smpl 43.3'
43.5														

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 44-50' Date 10-28-03 Sheet 5 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N. Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
44		S.S.				SM	SI?	msv fn-md sand, loose			
								silty fn sand, mottled (paleosol?)			?paleosol-thin?
								sand, fn-md, well sorted, compact,			
								massive, 15-20% mafic,			
45		S.S.						2.5Y5/3, WK rxn w/ HCl, max			
								pat. size= md sand, mottled			
								toward base?			
46						↓					
46.5		S.S.				SM	SI	loose, fine sand, 2.5Y6/2			
								sand, fn-md, well sorted, wkly lam.			
								Compact, 2.5Y5/3, max pat. size = crs sand			
47.5		S.S.						15-20% mafic			
											sharp contact
						↓	PM	silty fn sand, well lam. 10YR5/3 (moist) [brown],			paleomag smpl @ 48.2'
48.5						M		v. well sorted, crsens downward, compact			, mod rxn w/ HCl
49		S.S.				SM	SI	pebbly sand, loose, poorly sorted			
						D		pebbly sand, mostly crs to v. crs sand, poorly sorted, loose, msv			
								max pat. size = 5mm, S=50-60% basalt,			5% fn pebbles, 70% crs-vcrs S,
50						↓		25% fn-md sand, mod rxn w/ HCl			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 50-56' Date 10/28/03 Sheet 6 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
50		S.S.				D					pebbly sand like 49-50'			
											Fe oxide blebs			
51														
51.5		S.S				M					pebbly silty sand, v. poorly sorted, more brown (10YR 4/3), max pebble size = 2cm, msv, compact, S = 60-70% bas			paleosol? ↓ sharp contact
52.5		S.S				D					pebbly sand, sl. compact, wk. lam, lens clast = 1cm, poorly sorted, 2.5Y5/3			
53.5											sand, md-crs, loose, 2.5Y6/3 ~~mod. sorted~~			gradation
54		S.S				D					pebbly sand, loose, msv, poorly sorted			SI = slough
											slightly pebbly sand, poorly sorted,			
55		S.S.									pebbly sand, 2.5Y5/2, msv, max pebble size = 1cm, 5% fn pebbles, 60% crs-vcrs sand 30% fn-md sand, poorly sorted, Fe oxide blebs, S = 60-70% basalt, WK reaction w/ HCl			
56														

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 56.5-66.0' Date 10/28/03 Sheet 7 of 23

Location C Tank Farm Project Vadose Zone

Logged by BN Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
56.5		S.S.				D				SI	pebbly sand, loose, poorly sorted			
											Sand, 80% crs-vcrs, 20% fa-med, mod. sorted, 2.5Y 5/2,			
											max pcl size - 3cm			
57.5		S.S.									clasts up to 3cm			
											S= 70-80% basalt, salt and pepper			
58.5														Break in continuous cores
61.5		S.S.				D					Sandy gravel, lgst clast = 5cm, loose, mSV			
											Pebbly sand, poorly sorted, loose, mSV,			
											2.5Y 5/3. Fe oxide blebs and coatings,			
62.5											lgst clast = 5mm S = 60-70% basalt,			
		S.S.									salt and pepper, wk rxn w/ HCl			
63.5														
65.0		S.S.				D					All slough? Angular gravel w/ silty matrix			
											loose, v. poorly sorted silty fine-crs			
66.0										SI	sand, 2.5Y 6/2			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 66.5 - 75.0' Date 10/29/03 Sheet 8 of 23

Location C Tank Farm Project Vadose Zone

Logged by BN Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
66.5		S.S.				D					Pebbly sand, 20% pebbles, 50% crs-v.crs sand, 25% fn-md sand, 5% silt, 2.5Y 6/2 (dry) loose, msv, poorly sorted, S = 40-50% bmsclt, wk rxn w/ HCl, matrix supported pebbles			
67.5		S.S.												
68.5														
71.5		S.S.				D					Pebbly sand, loose, v. poorly sorted, + broken cobble			
72.5														
		S.S.									slightly pebbly sand, few % sm. pebbles, 60% crs-v crs sand, 30% fn-md sand, mod sorted, msv, 2.5Y 5/2, 40-50% bms, wk rxn w/ HCl			
73.5														
74		S.S.				D					Pebbly silty sand, v. poorly sorted, loose, msv			
75											slightly pebbly sand, like 72.5-73.5			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 75-81' Date 10-29-03 Sheet 9 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
75		S.S.				D					slightly pebbly sand, 5% sm. pebbles, 50% crs-v. crs sand, 40% fn-md. sand, mod. sorted, msv, loose, S = 40-50% basalt, wk rxn w/ HCl		2.5 Y5/2	
76														
76.5		S.S.				SM					slightly pebbly sand, ≤5% sm. pebbles 50-60% crs-vcrs sand, 30-40% fn-md sand, msv, loose, lgst clast = 1cm, S = 50-60% basalt mod. sorted, wk rxn w/ HCl			
77.5		S.S.												
78.5														
79		S.S.				D				SI	silty pebbly sand, loose, v. poorly sorted msv., lgst clast = 2cm, 2.5Y6/2			
						SM					slightly pebbly sand, ≤5% sm. pebbles, 40-50% crs-v crs sand. 50-60% fn-md sand, msv, loose, mod sorted, S = 50-60% basalt wk rxn w/ HCl, lgst clast = 2cm			
80		S.S.												
81														

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 81.5-87.5' Date 10-29-03 Sheet 10 of 23

Location C Tank Farm Project Vadose Zone

Logged by B.N. Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
81.5		S.S.						Empty			
						M		Sand, fn-crs, well sorted, sl. compact			
								wk. laminated, lgst particles = crs sand			
82.5		S.S					PM	2.5Y 4/4 (olive brn - moist),			Paleomag smpl @ 82.6
								micaceous, S = 15-20% mafic			
								mod rxn w/ HCl, crseus toward bottom			
83.5						↓	x	well laminated, drag folding, Fe oxide blebs			
84		S.S				SM		Sand, few sm pebbles, 50%			
								crs-v crs. sand, 50% fn-md sand,			
								mod. sorted, MSV, loose			
85		S.S.						40-50% mafic, lgst clast = 1cm,			
								wk rxn w/ HCl			
86						↓					
86.5		S.S				SM	<1"	Sand, mostly crs at top, md-crs			
								and bottom; wk lam, mod			
								sorted 2.5Y 5/2, wk rxn w/ HCl			
87.5						↓		lgst particle = v. crs sand, loose to			
								sl. compact			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 | Depth 87.5-93.5' | Date 10-29-03 | Sheet 11 of 23

Location C Tank Farm | Project Vadose Zone

Logged by B.N. Bjornstad (Print / Sign) | Drilling Contractor

Reviewed by (Print / Sign) Date | Driller

Lithologic Class. Scheme | Procedure | Rev | Rig/Method

Steel Tape/E-Tape / | Field Indicator Equip. 1) 2) | Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
87.5		S.S.				SM		Sand, md-crs, well lam in upper half, mod-well sorted max part. size = crs sand, compact, 2.5Y5/3, wk rxn w/ HCl			PM @ 88.2
88.5							PM				
89		S.S.				SM		Sand, 60% crs-vcrs, 40% fn-md, wk lam., mod. sorted, sl. compact, max part. size = v. crs. sand 2.5Y 6/2, 40-50% mafic, wk rxn. w/ HCl			
90		S.S.									
91											
91.5		S.S.				D		loose, v. poorly sorted dry silty sand			
92.5		S.S.				SM	SI	Sand, 60% crs-vcrs, 35% fn-md, wk lamination, max. part = v. crs sand, 2.5Y5/2, no rxn w/ HCl, sl. compact, mod. sorted, S = 40-50% basalt; salt and pepper			
93.5											

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 94-100' Date 10-29-03 Sheet 12 of 23

Location C Tank Farm Project Vadose Project

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
94		S.S.				D	sl	silty sand, loose, dry, msv.			
						↓		Sand, md-crs, wk lam., sl. compact			
						SM		2.5Y5/2, lgst particle = v.crs sand,			
95		S.S.						mod. sorted, wk rxn w/ HCl,			
								40-50% mafic,			
96						↓					
96.5		S.S				SM	sl?	loose, msv, crs-v.crs. sand, well sorted			
								Sand, md-crs, wk lam., 2.5Y5/2			
97.5						↓		sl. compact, lgst part = v.crs. sand			except endcaps
		S.S.	Mayes core #1			SM		wk rxn. w/ HCl, fines downward			Core unopened, crs sand at top
			↓				?	to md sand 30-40% mafic			fn sand at bottom
								↑ contact somewhere in here			
98.5						SM		fn sand, 2.5Y5/2, well sorted, mod			filter paper compressed and ~200 g for
								rxn w/ HCl			chem from bottom of core
99		S.S				SM	sl?	2 fn-crs sand, sl. compact, msv,			Slough or paleosol?
						↓		v. poorly sorted, sl. mottled			
						D		2. Sand, 40% crs-v.crs., 50% fn-md,	10%	silt	
100						↓		poorly sorted, sl. compact, max. s	+ =	v.crs. sand	
								2.5Y6/2, S = 30-40% basalt			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 100 - 106' Date 10-29-03 Sheet 13 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
100		S.S.				D		Sand, 70% crs-v.crs. 30% fn-md,			
								one v.sm-pebble, sl. compact,			
								msv, 2.5Y5/2, lgst clast = 1cm			
101								poorly sorted, wk rxn w/ HCl			
101.5		S.S				D	sl	msv, loose, v. poorly sorted, matrix-supported pebbles			
								sand, 40% crs-v.crs, 50% fn-md,			
102.5								mod. sorted, msv., sl. compact			
		S.S.						2.5Y5/2, wk rxn w/ HCl, lgst			
								clast = v. sm. pebble			
103.5						V					
104						D	sl	silty sand w/ angular pebble, v. poorly sorted, loose, msv			
								sand, 40% crs-v.crs, 50% fn-md,			
								wk lam., 2.5Y5/2, wk rxn w/ HCl			
105								2" silty sand @ 105.4', 2.5Y5/3, lam.			
						V		lgst clast = sm. pebble			
						SM					
						D					
106						V					

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 | Depth 106.5 - 115' | Date 10-29-03 | Sheet 14 of 23

Location C Tank Farm | Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION !NSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
106.5		S.S.				D			sl					
											Z fn-md sand, 2.5Y 5/3			
107.5											Sand, 50% crs-v.crs sand,			
		S.S.									50% fn-md sand, wk lam.,			
											2.5Y 5/2, Fe oxide blebs and			
											coatings, lgst part = 1cm,			
108.5											mod. sorted, S = 40-50% basalt			
109		S.S.				D			sl		pebbly sand, loose, MSV			sl = slough
											pebbly sand, 10% sm pebbles, 70% crs-v.crs sand, poorly sorted, loose			
110		S.S.									sl. pebbly sand, loose, S = 50-60% bas, ≤5% pebbles			
											2.5Y 5/2, no rxn w/ HCl, lgst clast = sm. pebble, Fe oxide blebs and			
											coatings			
111														
114		S.S.				SM			sl		loose crs sand, MSV			
											Sand, 50% crs, 30% md 10% f.,			
											mod sorted, 2.5Y 5/3, lgst part = v.crs sand			
115											wk lam., S = 30-40% basalt			
											wk rxn. w/ HCl			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 115-126 Date 10-29-03 Sheet 15 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
115		S.C.				D					Sand, 30% crs, 50% md, 20% fn, mod. sorted, wk lam., 2.5Y6/2, S = 30% mafic, lgst part = crs sand			
119		S.S.				D					Sand, 30% crs 50% md 20% fn, loose, msv, 2.5Y5/2, wk rxn w/ HCl S = 30-40% mafic, wk rxn w/ HCl			
120		S.S.												
121														
124		S.S.				D					loose crs - v.crs sand			
125		S.S.				SM					Sand, crs 40%, 40% md 10% f.. mod sorted, 30-40% basalt, lgst part = v crs sand. wk rxn w/ HCl, loose, wk lam.			
126														

W = Wet, M = Moist, D = Dry

1998/DCU/PROC/DBL/001

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No C4124	Depth 129 - 140	Date 10-29-03	Sheet 16 of 23
		Location C Tank Farm	Project Vadose Zone		

Logged by B N Bjornstad (Print / Sign) | (Print / Sign) | Drilling Contractor

Reviewed by (Print / Sign) Date | Driller

Lithologic Class. Scheme | Procedure | Rev | Rig/Method

Steel Tape/E-Tape / Field Indicator Equip. 1) 2) | Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
129		S.S.				D	sl?	Sand, fn-crs, poorly sorted, wk rxn w/ HCl, v. loose, msv			
130		S.S.				SM	x	fn sand, well sorted, 2.5Y5/3, mod rxn w/ HCl sl. compact			chem sample from fn sand lens
								Sand, 40% crs-vcrs, 30% md 20% fn sl. compact, mod sorted, 2.5Y5/2, 30-40% basalt, wk rxn w/ HCl			
131											
134		S.S.				D		Sand, 30% crs, 50% md, 20% fn, mod. sorted, loose to sl. compact, 2.5Y6/2, 30-40% basalt, msv, lgst part = v. crs. sand wk rxn w/ HCl			
135		S.S.									
136		S.S.									
139		S.S.				SM		Sand, 40-50% crs-vcrs, 40-50% fn-md sand, loose, msv, mod sorted, wk rxn w/ HCl mx pa = v crs. sand, 2.5Y 5/3			
140											

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 140-151 Date 10-29-03 Sheet 17 of 23

Location C Tank Farm Project Vadose Zone

Logged by BN Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
140		S.S.				D					Same as 139-140'			
						↓					fines to md sand at bottom			
141						↓					2.5Y6/3, mod. rxn w/ HCl			
144						D				5'	v. loose pebbly sand			
						↓								
											pebbly sand, 10-15% pebbles,			
145											60% crs-vcrs. sand, 30% fn-md sand,			
											loose, msv, poorly sorted,			
											max part size = 15mm, wk rxn			
											w/ HCl, S = 70-80% basalt, loose			
146						↓								
149						D				5'	pebbly sand, v. loose, msv, 2.5Y5/2			
						↓					max part = 1cm, msv			
150											Sandy pebble gravel, loose, 80-90% basalt, mod. sorted			
											Pebbly sand, 10% silt pebbles, 50% crs-vcrs sand			
											40% fn-md sand, poorly sorted, msv,			
											2.5Y5/2, wk rxn w/ HCl, S = 50-60% basalt			
151						↓					max part size = 2cm, loose			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 154-166 Date 10-30-03 Sheet 18 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
154											No recovery from 153-154
155						D		pebble gravel, v. loose, mod sorted 2.5Y5/2, max part = 4cm			All slough? - looks like it
156								silty pebbly sand, v. poorly sorted loose, 2.5Y5/2, msv, wk rxn w/ HCl, max part = 2cm			
160						D		Pebbly sand, 10% pebbles, 50% crs-vcrs. sand, 40% fn-md sand, poorly sorted. 2.5Y5/2, wk rxn w/ HCl, msv loose			
161											
164						SM		Sand, 50% crs, 30% md 20% fn mod sorted, msv, S = 30-40% bags, 2.5Y5/3, wk rxn w/ HCl, sl. compact max part = V. crs. sand			
165			Mayos Core #2				?				Core unopened (except end caps)
166						D		crs sand, 2.5Y5/2, mod sorted, wk rxn			Filter pack + 200g removed from bot

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 169-180 Date 10-30-03 Sheet 19 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad

Reviewed by _____ Date _____

Lithologic Class. Scheme _____ Procedure _____ Rev ____

Steel Tape/E-Tape _____ / _____ Field Indicator Equip. 1) _____ 2) _____

Drilling Contractor _____

Driller _____

Rig/Method _____

Depth Control Point _____

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
169		S.S.				D	sl	Sand, 60% crs - v.crs 40% fn-md			fine-grained clasts fell in
							↓ ?	40-50% basalt, msv, loose,			from above
								wk rxn w/ HCl, max part = v crs sand			
								sl. coarser above, S = 40-50% basalt			
170		S.S						2.5Y5/2			
								fine-grained mud clasts, moist,			
								angular, compact, mod-strng			
171						↓		calcareous at top, 2.5Y5/3			
174		S.S.				SM					
											Fine-grained mud clasts like @ 169'
							sl	Sand, md-crs., v.loose, with mud			
							↓	clast,			
175		S.S.						Sand, 60% crs 30% md, 10% fn			
								30-40% basalt, msv, mod sorted,			
								2.5Y5/3, max part = v.crs. sand			
176						↓		wk rxn w/ HCl			
179						SM	sl				
								Sand, 50% crs-v crs sand, 50% fn-md			
								50-60% basalt, msv, max part = v. crs sand			
180								mod sorted, wk rxn w/ HCl,			
								loose, 2.5Y5/2			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No C4124	Depth 180 - 191	Date 10-30-03	Sheet 20 of 23
		Location C Tank Farm	Project Vadose Zone		

Logged by BN Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C	Z	S	G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
180						SM					Sand, same as 179-180'			
181														
184														
						SM					fine pebbly gravel, v. loose, mod sorted 80-90% basalt			
185											Sand, 60% crs-v.crs. 20% md, 20% fn, poorly sorted, msv, max part = fn. pebble, 2.5Y5/2, sl. compact, mod rxn w/ HCl, 50-60% basalt			
186														
189						SM					v. loose crs-v. crs. sand			
											Sand, 50% crs-vcrs., 50%; fn-md 40-50% basalt, few pebbles toward top, mod sorted, msv, max part = 1.5cm wk rxn w/ HCl, sl. compact			
190														
191														

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 194-205 Date 10-30-03 Sheet 21 of 23

Location C Tank Farm Project Vadose Zone

Logged by BN Bjornstad (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
194		S.S.				D	W	Gravel, no matrix, broken clasts, max clast = 60cm			SI = slough
								pebbly sand, 10% pebbles, 50% crs-vcrs sand,			
								20% md 20% fn, poorly sorted,			
195		S.S.						msv, 2.5Y5/3, sl. compact, S = 40-50% bas.			
								fewer pebbles below			
196											
199						D	SI	sandy pebble gravel, v. loose, mod sorted, 80-90% basalt			
								Silty pebbly sand, 10% silt, 10% pebble			
								40% crs-vcrs sand, 40% fn-md sand,			
200								msv, poorly sorted, max part = 3cm			
								S = 25-35% basalt, WK rxn w/ HCl			
201								2.5Y6/2, sl. compact			
204						D	SI	sandy pebble gravel, v. loose, 80-90% bas			
								Pebbly sand, 5-10% pebble, 40% crs-v crs sand			
205								40% fn-md sand, 10% silt, poorly sorted,			
								msv, sl. compact, Max Int = 3cm			
								2.5Y6/2, WK rxn w/ HCl			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 Depth 205-211 Date 10-30-03 Sheet 22 of 23

Location C Tank Farm Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) Date

Lithologic Class. Scheme Procedure Rev

Steel Tape/E-Tape / Field Indicator Equip. 1) 2)

Drilling Contractor

Driller

Rig/Method

Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
205						D		Same as above (204-205)			
206						D					
209		A				D		Angular gravel (looks like broken cobble) not basalt			
210						D		Sand, 30% crs-vcrs sand, 30% med sand, 30% fn, 10% silt, v. poorly sorted, 2.5Y 6/2 sl. compact, max part = 3cm pebble, mod rxn w/ HCl / msv, 5=30-40% basalt			Repeated core intervals
209		B				D		1 large bottom-up cobble			
210						D		stough or paleosol?			
210		A				D		Pebbly silty sand, v. poorly sorted, msv to mottled, dv. compact, mod rxn w/ HCl max part = 0.5cm, 2.5Y 7/2			
211						D		like immed. above but more sand and better sorted			Repeated core intervals
210		B				D	sl	pebbly silty sand, v loose, v. poorly sorted			
211						D		silty pebbly sand, 10% pebbles, 50% crs-vcrs sand, 40% fn-md sand, v. poorly sorted, sl. compact, msv, 2.5Y 6/2, max part = 1.5cm			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No C4124 | Depth 219-230 | Date 10-30-03 | Sheet 23 of 23

Location C Tank Farm | Project Vadose Zone

Logged by B N Bjornstad (Print / Sign) | (Print / Sign)

Reviewed by (Print / Sign) | Date

Lithologic Class. Scheme | Procedure | Rev

Steel Tape/E-Tape / | Field Indicator Equip. 1) | 2)

Drilling Contractor | Driller | Rig/Method | Depth Control Point

DEPTH ( )	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG C Z S G	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	H_2O ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
219		SS-									
220								Gravel, rounded to angular (broken), fn-crs pebble size, no matrix, 25% basalt, others include gtzite and volcanic porphyry			
224						SM		1 lg gtzite clast, rounded except where broken, 80 mm dia			
225								silty pebbly sand, 5-10% pebbles, 30% crs-vcrs sand, 30% md sand, 20% fn sand 10% silt, poorly sorted, msv, lgst clast = 1cm 2.5Y4/2, wk rxn w/ HCl, sl. compact, S = 50-60% basalt			
226						↓					
229											
230						D		Gravel, rounded to angular, unbroken clasts mostly subrounded, ~25% basalt, lgst clast = 5cm (broken), no matrix other l. lhs = gtzite, volcanic porphyry totally loose			

W = Wet, M = Moist, D = Dry

1998/DCL/PROC/DBL/001

Appendix C

Spectral Gamma Ray Logs and Gyroscope Survey Data Results

Appendix C

Spectral Gamma Ray Logs and Gyroscope Survey Data Results

Stoller
Grand Junction Office established 1959

C-4124
Log Data Report

Borehole Information:

Borehole: C-4124			Site: North of C Tank Farm		
Coordinates (WA St Plane)		GWL[1] (ft): 230		GWL Date: 09/08/03	
North (Estimated)	East (Estimated)	Drill Date	Ground Level Elevation	Total Depth (ft)	Type
136650 m	575200 m	09/03	Not available	268.0	Becker

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	3.55	9.0	8.0	0.50	+3.55	268.0
Steel Tubing	3.1	6.24	6.0	0.120	+3.1	268.0

Borehole Notes:

The casing dimensions are derived from published values for Becker drill casing. Casing thicknesses at the joints are 0.875- and 0.240-in. for the 8- and 6-in. casings, respectively. The total depth of the borehole was provided by the driller. The well site geologist provided the depth to water. Borehole coordinates were provided by Fluor Hanford's person in charge and are estimates. Ground level elevation was not available. Logging data acquisition is referenced to the ground surface.

Logging Equipment Information:

Logging System: Gamma 1E		Type: SGLS (70%) SN: 34TP11019B
Calibration Date: 07/03	Calibration Reference:	GJO-2003-468-TAC
	Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2 Repeat			
Date	09/08/03	09/08/03			
Logging Engineer	Kos	Kos			
Start Depth (ft)	266.45	31.45			
Finish Depth (ft)	0.45	4.45			
Count Time (sec)	100	100			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	1.0	1.0			
ft/min	N/A[2]	N/A			
Pre-Verification	AE031CAB	AE031CAB			
Start File	AE031000	AE031267			
Finish File	AE031266	AE031294			

Log Run	1	2 Repeat			
Post-Verification	AE031CAA	AE031CAA			
Depth Return Error (in.)	-1.25	0			
Comments	No fine-gain adjustment.	No fine-gain adjustment.			

Logging Operation Notes:

Spectral gamma logging was performed in this borehole on September 8, 2003. Logging was conducted with a centralizer on the sonde. Logging was inadvertently initialized at the top of casing. Because the casing was not permanent, during analysis all measurements were corrected by the amount of stickup (3.55 ft) so that the ground surface is the reference point. A repeat section was collected in this borehole to evaluate system performance.

Analysis Notes:

Analyst:	Henwood	Date:	09/10/03	Reference:	GJO-HGLP 1.6.3, Rev. 0

Pre-run and post-run verifications for the logging system were performed before and after data acquisition. Acceptance criteria were met.

A combined casing correction for 0.620-in.-thick casing was applied throughout the borehole for both casings. The combined thickness at casing joints is 1.115 in. This thickness results in a significant reduction in gamma activity detection as the detector passes by a casing joint. However, it is not practical to correct individual data points for the effect of casing joints. The influence of the thick joints is apparent on the total gamma and ^{40}K logs where reduced count rates and concentrations are exhibited at approximately 10-ft depth intervals.

SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated with an EXCEL worksheet template identified as G1EJul03.xls using efficiency functions and corrections for casing, water, and dead time as determined from annual calibrations. Dead time corrections are applied where dead times exceed 10.5 percent; no dead times in excess of 10.5 percent were encountered. Correction for water was applied to the data below 230 ft.

Log Plot Notes:

Separate log plots are provided for the man-made radionuclide (^{137}Cs) detected in the borehole, naturally occurring radionuclides (^{40}K, ^{238}U, ^{232}Th [KUT]), a combination of man-made, KUT, and dead time, and total gamma plotted with dead time. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, casing corrections, or water corrections. A repeat log section is also included.

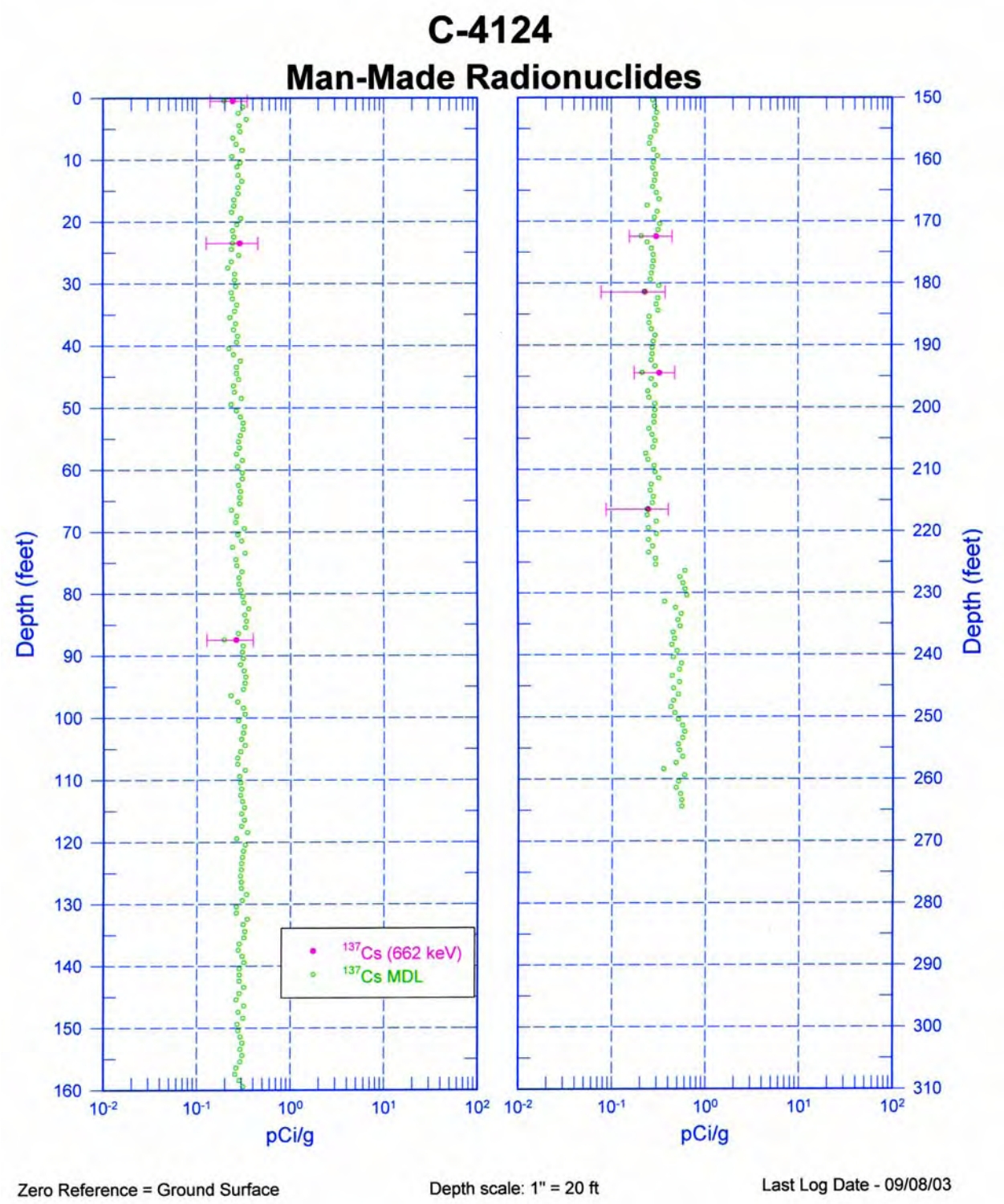
Results and Interpretations:

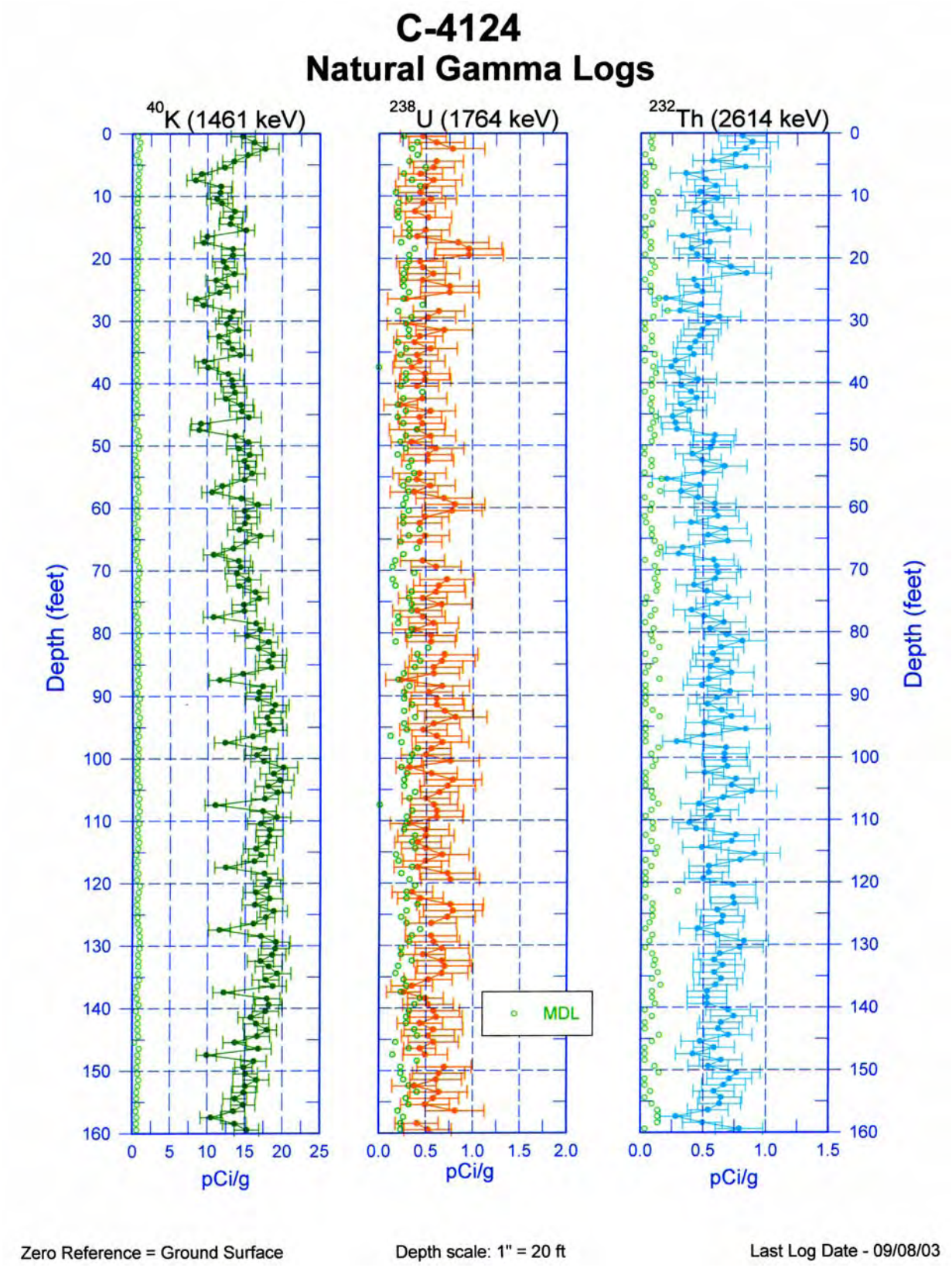
^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected at a few sporadic locations throughout the borehole near its MDL of approximately 0.2 pCi/g.

The repeat section indicated good agreement of the naturally occurring KUT.

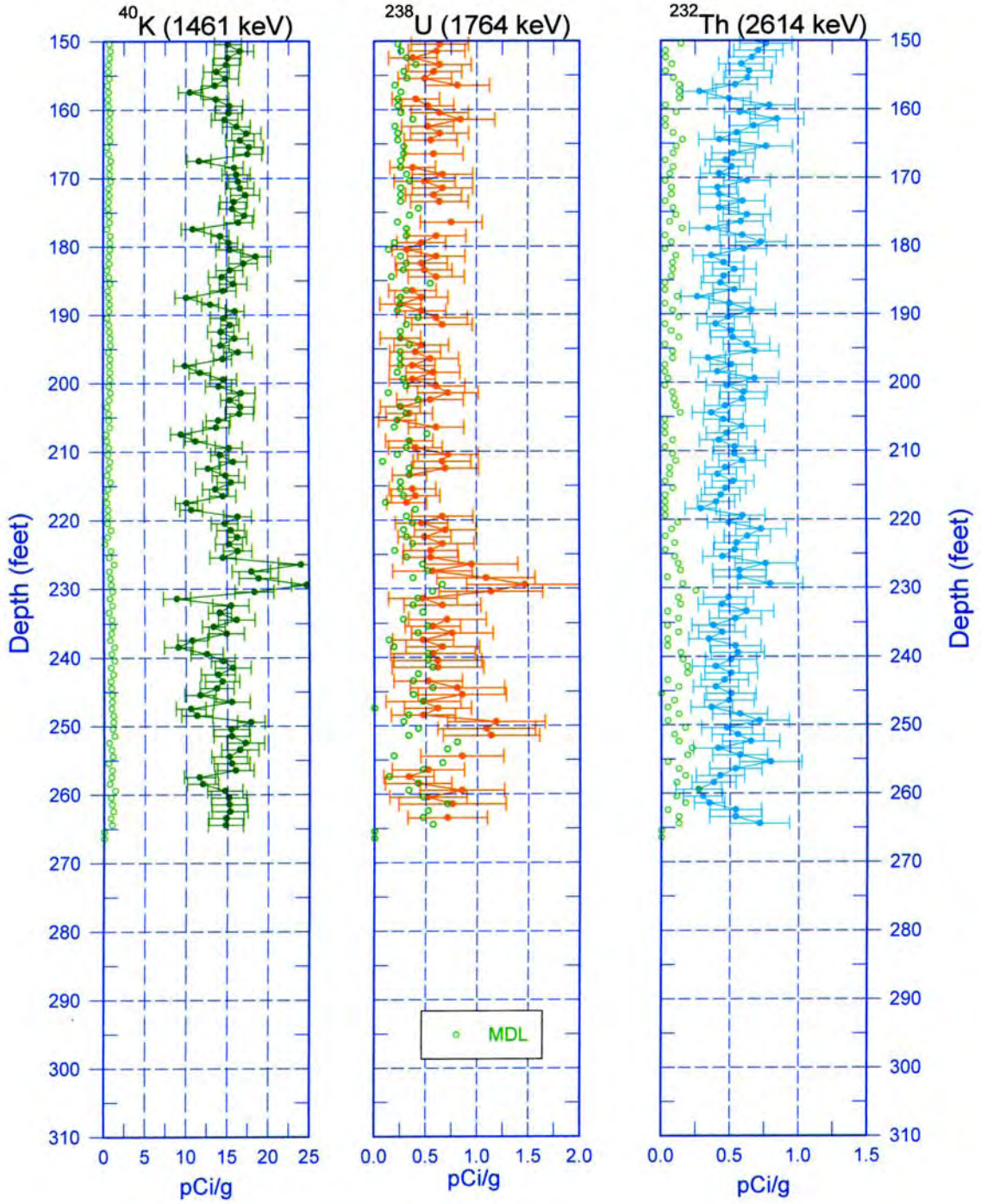
---

[1] GWL – groundwater level
[2] N/A – not applicable


C-4124
Man-Made Radionuclides
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
pCi/g
^{137}Cs (662 keV)
^{137}Cs MDL
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
Depth (feet)
Zero Reference = Ground Surface
Depth scale: 1" = 20 ft
Last Log Date - 09/08/03


C-4124
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
0 5 10 15 20 25
pCi/g
0.0 0.5 1.0 1.5 2.0
pCi/g
MDL
0.0 0.5 1.0 1.5
pCi/g
Zero Reference = Ground Surface
Depth scale: 1" = 20 ft
Last Log Date - 09/08/03

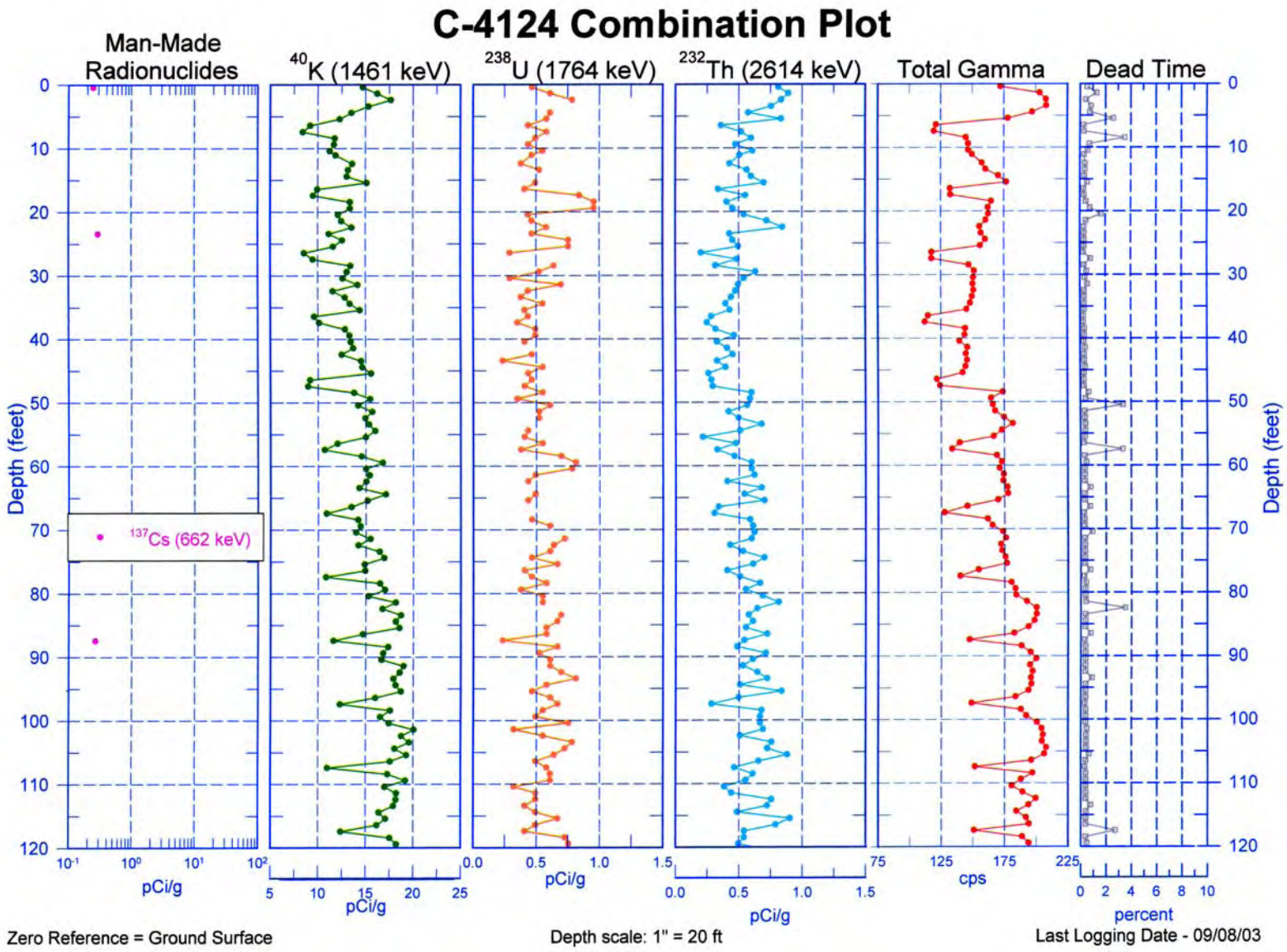
C-4124
Natural Gamma Logs

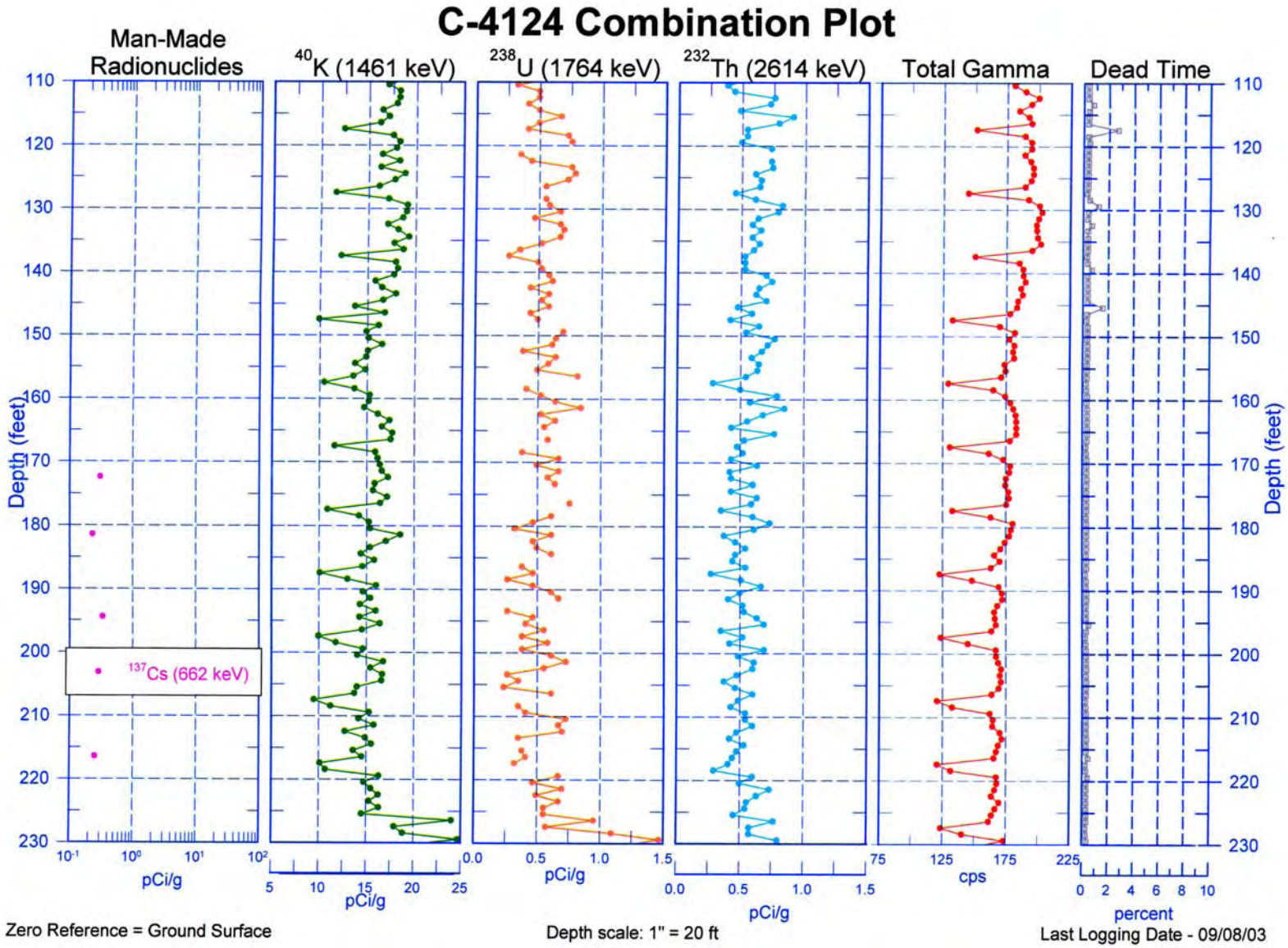


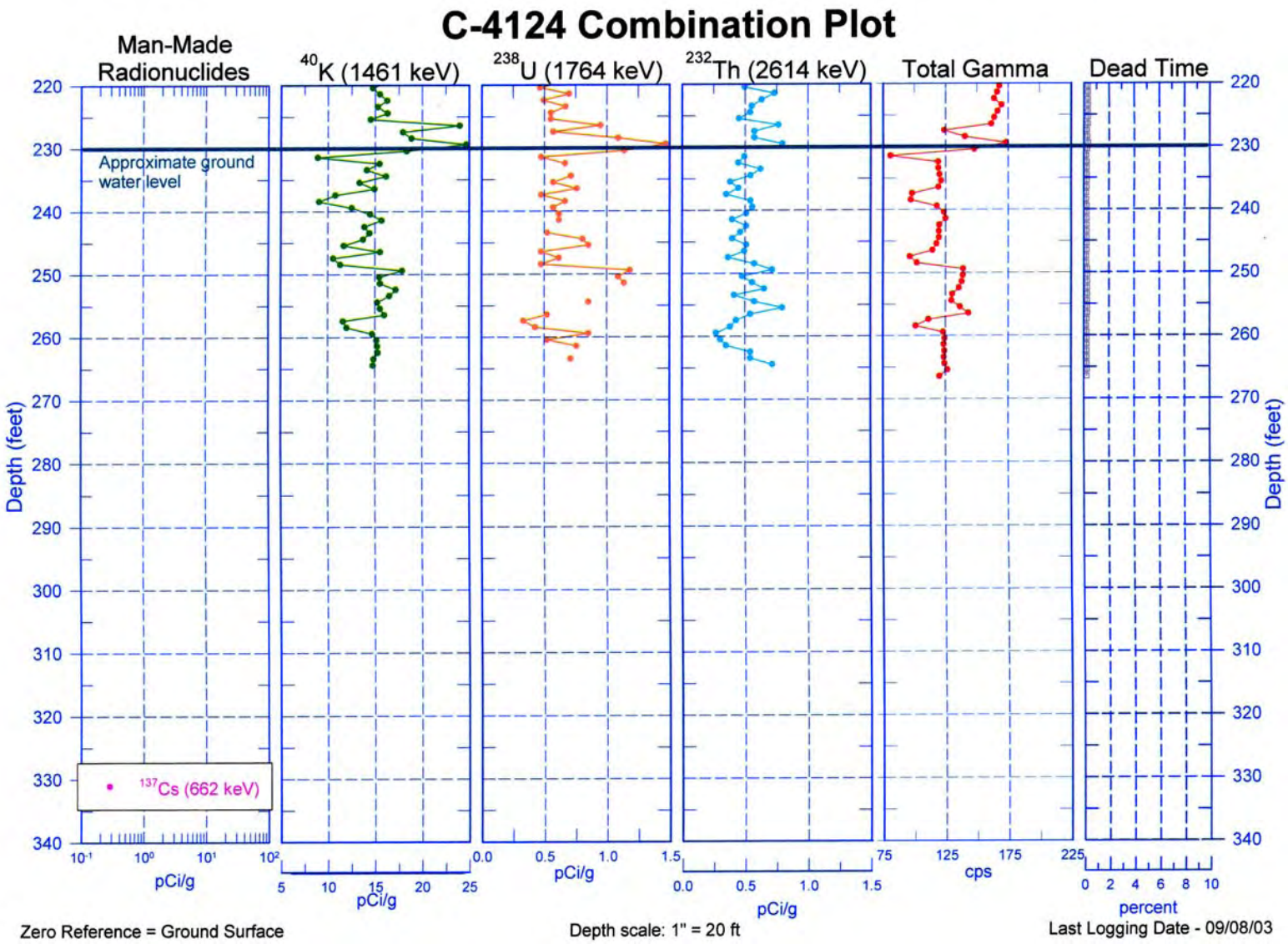
Zero Reference = Ground Surface

Depth scale: 1" = 20 ft

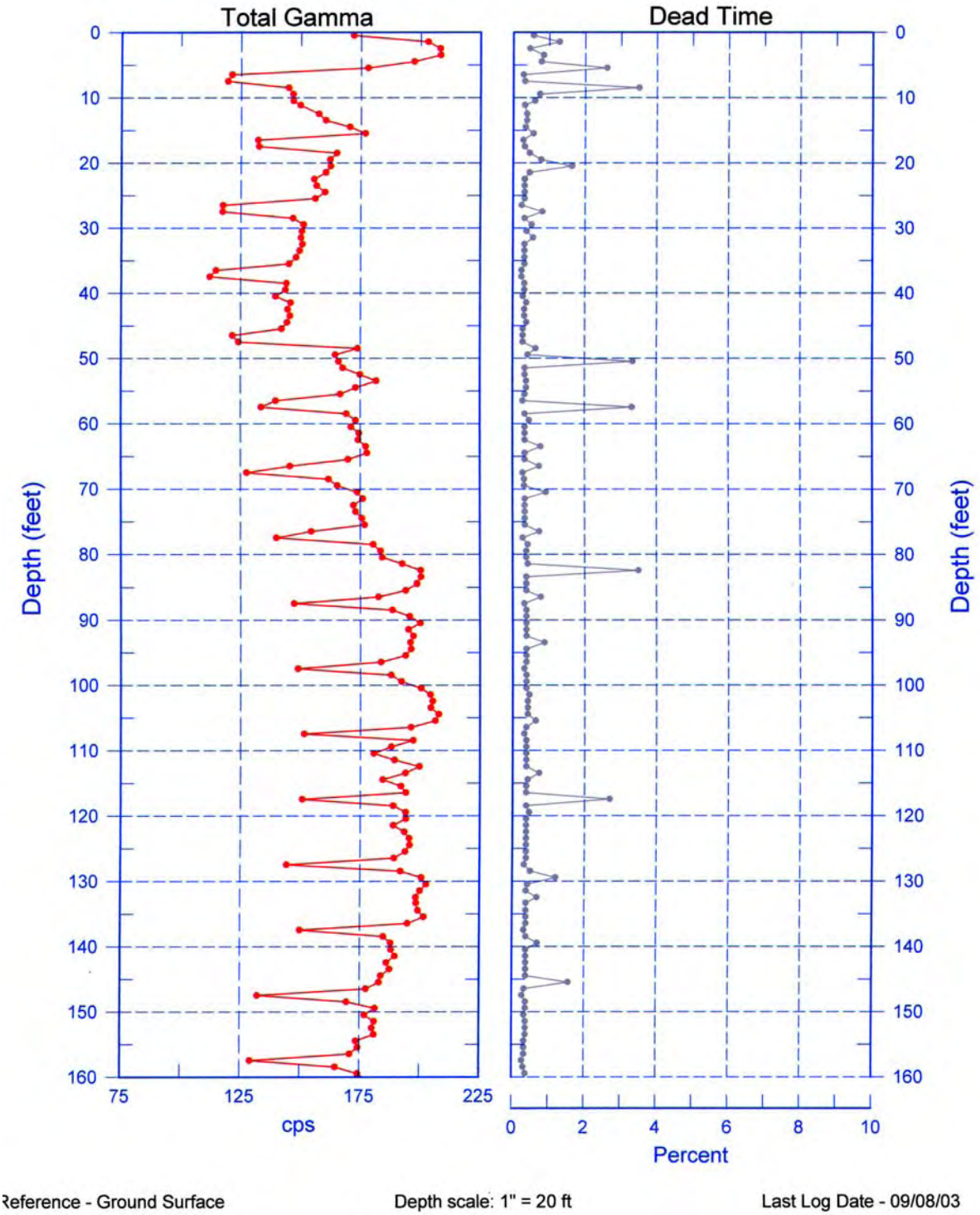
Last Log Date - 09/08/03


C-4124 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Depth scale: 1" = 20 ft
Last Logging Date - 09/08/03


C-4124 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Depth scale: 1" = 20 ft
Last Logging Date - 09/08/03


C-4124 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Approximate ground water level
137Cs (662 keV)
Depth (feet)
pCi/g
cps
percent
Zero Reference = Ground Surface
Depth scale: 1" = 20 ft
Last Logging Date - 09/08/03

C-4124
Total Gamma & Dead Time

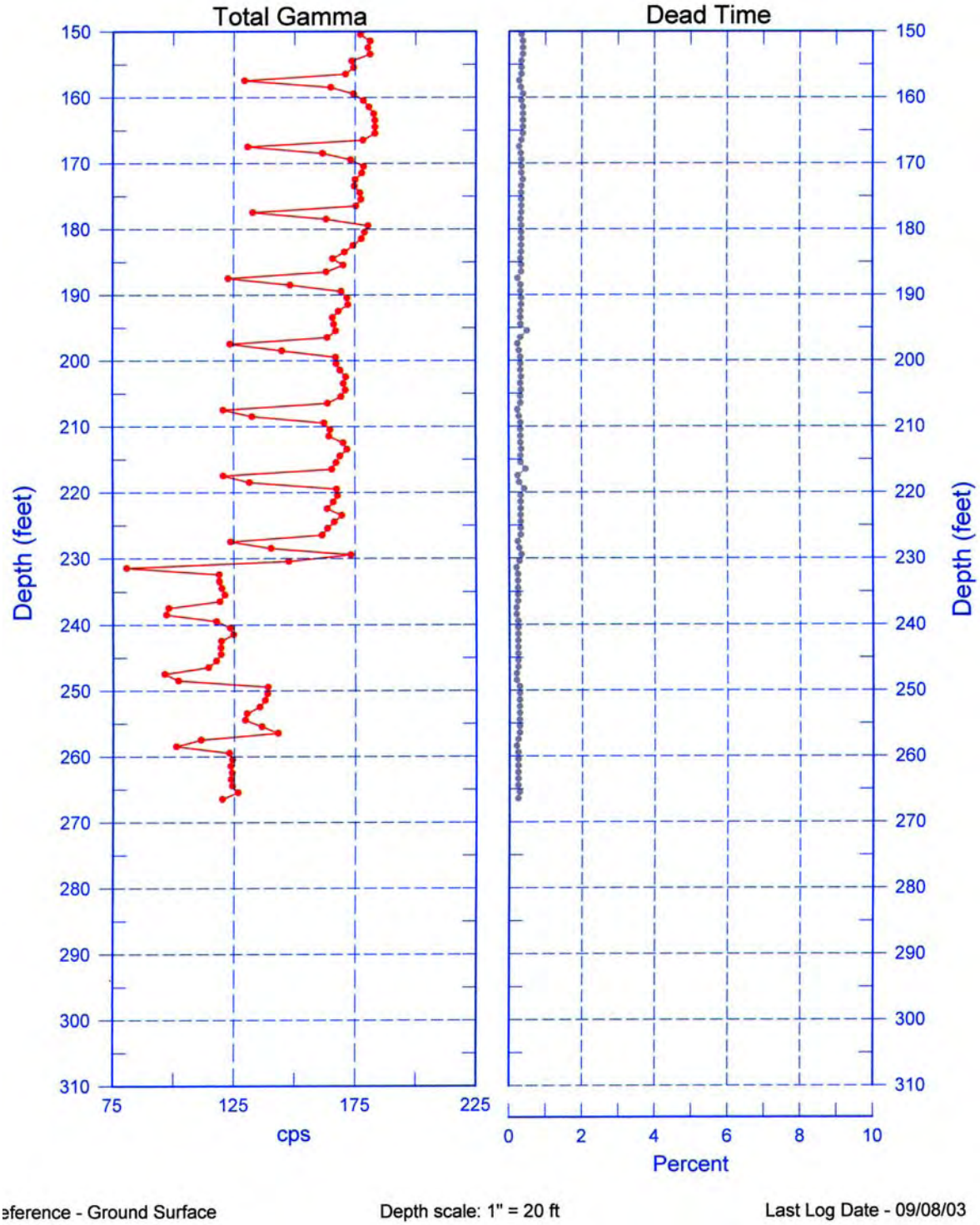


Reference - Ground Surface

Depth scale: 1" = 20 ft

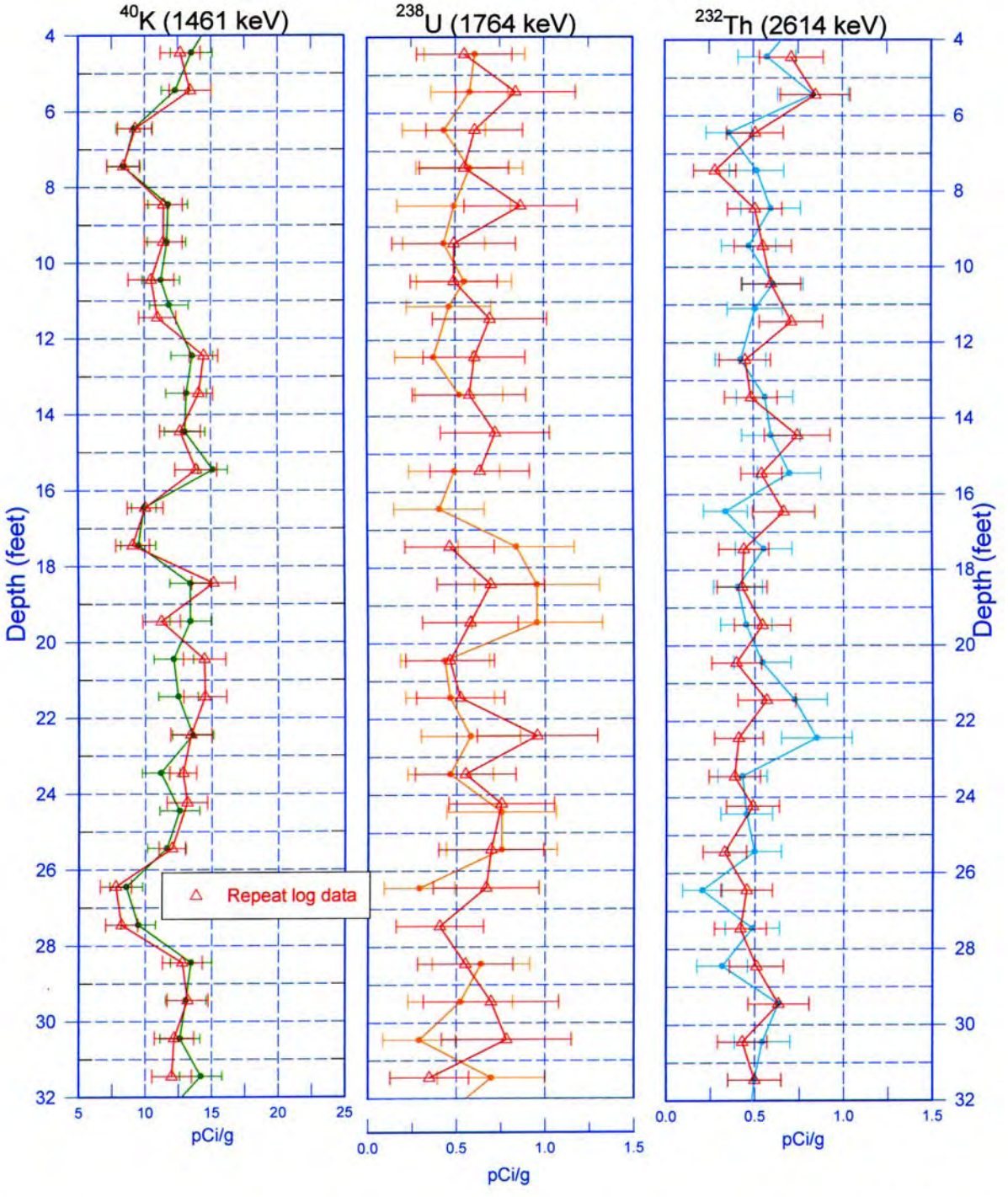
Last Log Date - 09/08/03

C-4124
Total Gamma & Dead Time



C-4124

Repeat Section of Natural Gamma Logs



Zero Reference = Ground Surface

Last Log Date - 09/08/03

Stoller
Grand Junction Office established 1959

C-4125
Log Data Report

Borehole Information:

Borehole: C-4125			Site: West of C Tank Farm		
Coordinates (WA St Plane)		GWL[1] (ft): 268		GWL Date: 08/15/03	
North (Estimated)	East (Estimated)	Drill Date	Ground Level Elevation	Total Depth (ft)	Type
136500	575025	08/03	Not available	309.0	Becker

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded steel	1.7	11.0	10.0	0.50	+1.7	30
Becker	3.1	6.24	6.0	0.12	+3.1	309.0
Becker	2.7	9.0	8.0	0.5	+2.7	309.0

Borehole Notes:

The casing dimensions are derived from published values for Becker drill casing. Casing thicknesses at the joints are 0.875- and 0.240-in. for the 8- and 6-in. casings, respectively. The Fluor Hanford drilling supervisor provided the total drilling depth, depth to water, and borehole coordinates. Ground level elevation was not available. Logging data acquisition is referenced to the ground surface.

Logging Equipment Information:

Logging System:	Gamma 1E		Type:	SGLS (70%) SN: 34TP40587A
Calibration Date:	07/03	Calibration Reference:	GJO-2003-468-TAC	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2 Repeat	3		
Date	08/15/03	08/16/03	08/16/03		
Logging Engineer	Spatz	Spatz	Spatz		
Start Depth (ft)	301.0	121.0	89.0		
Finish Depth (ft)	90.0	90.0	25.0		
Count Time (sec)	100	100	100		
Live/Real	R	R	R		
Shield (Y/N)	N	N	N		
MSA Interval (ft)	1.0	1.0	1.0		
ft/min	N/A[2]	N/A	N/A		
Pre-Verification	AE018CAB	AE019CAB	AE019CAB		
Start File	AE018000	AE019000	AE019032		
Finish File	AE018211	AE019031	AE019096		

Log Run	1	2 Repeat	3		
Post-Verification	AE018CAA	AE019CAA	AE019CAA		
Depth Return Error (in.)	-1	N/A	N/A		
Comments	Fine-gain adjustment made after files -102, -144, -177, -182.	No fine-gain adjustment.	No fine-gain adjustment.		

Logging Operation Notes:

Spectral gamma logging was performed in this borehole on August 15 and 16, 2003. Logging was conducted with a centralizer on the sonde. Measurements are referenced to ground surface. A repeat section was collected in this borehole to evaluate system performance. No logging was performed between the ground surface and 25 ft because a 10-in. casing was present in addition to the 6- and 8-in. casings. Logging depth achieved was 301 ft, 8.0 ft less than the reported drilling depth.

Analysis Notes:

Analyst:	Henwood	Date:	08/28/03	Reference:	GJO-HGLP 1.6.3, Rev. 0

Pre-run and post-run verifications for the logging system were performed before and after data acquisition. Acceptance criteria were met.

A combined casing correction for 0.620-in.-thick casing (0.5 +.12 in.) was applied below 25 ft for the 8- and 6-in. casings. The combined thickness at casing joints is 1.115 in. This thickness results in a significant reduction in gamma activity detection as the detector passes by a casing joint. However, it is not practical to correct individual data points for the effect of casing joints. The influence of the thick joints is apparent in the total gamma and ^{40}K logs where reduced count rates and concentrations are exhibited at approximately 10-ft depth intervals. For the depth interval between 25 and 30 ft a correction for 1.12-in. casing was applied where 10, 6, and 8-in. casings were present.

SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated with an EXCEL worksheet template identified as G1EJul03.xls using efficiency functions and corrections for casing, water, and dead time as determined from annual calibrations. Dead time corrections are applied where dead times exceed 10.5 percent; no dead times in excess of 10.5 percent were encountered. Correction for water was applied to the data below 268 ft.

Log Plot Notes:

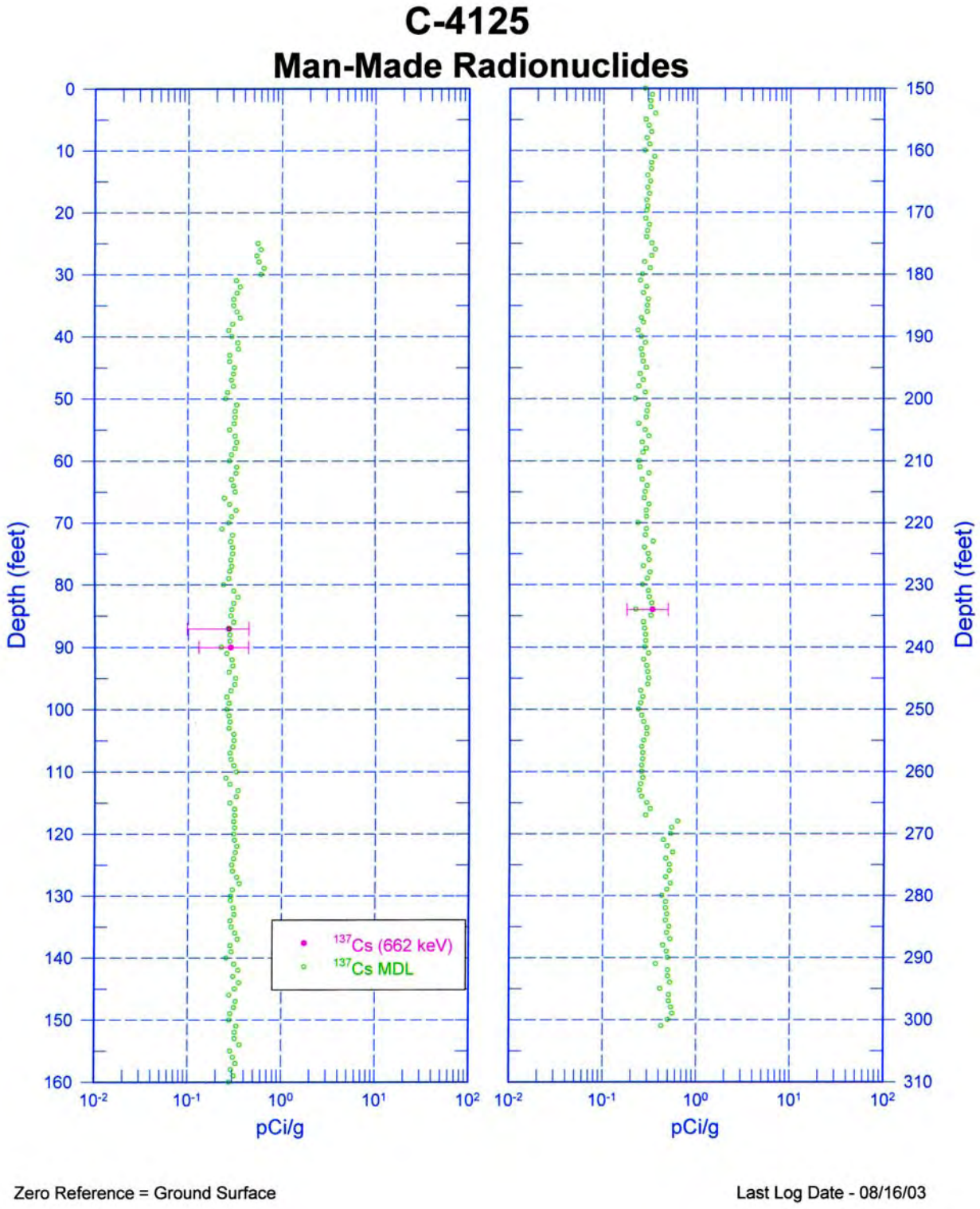
Separate log plots are provided for the man-made radionuclide (^{137}Cs) detected in the borehole, naturally occurring radionuclides (^{40}K, ^{238}U, ^{232}Th [KUT]), a combination of man-made, KUT, and dead time, and total gamma plotted with dead time. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, casing corrections, or water corrections. A repeat log section is also included.

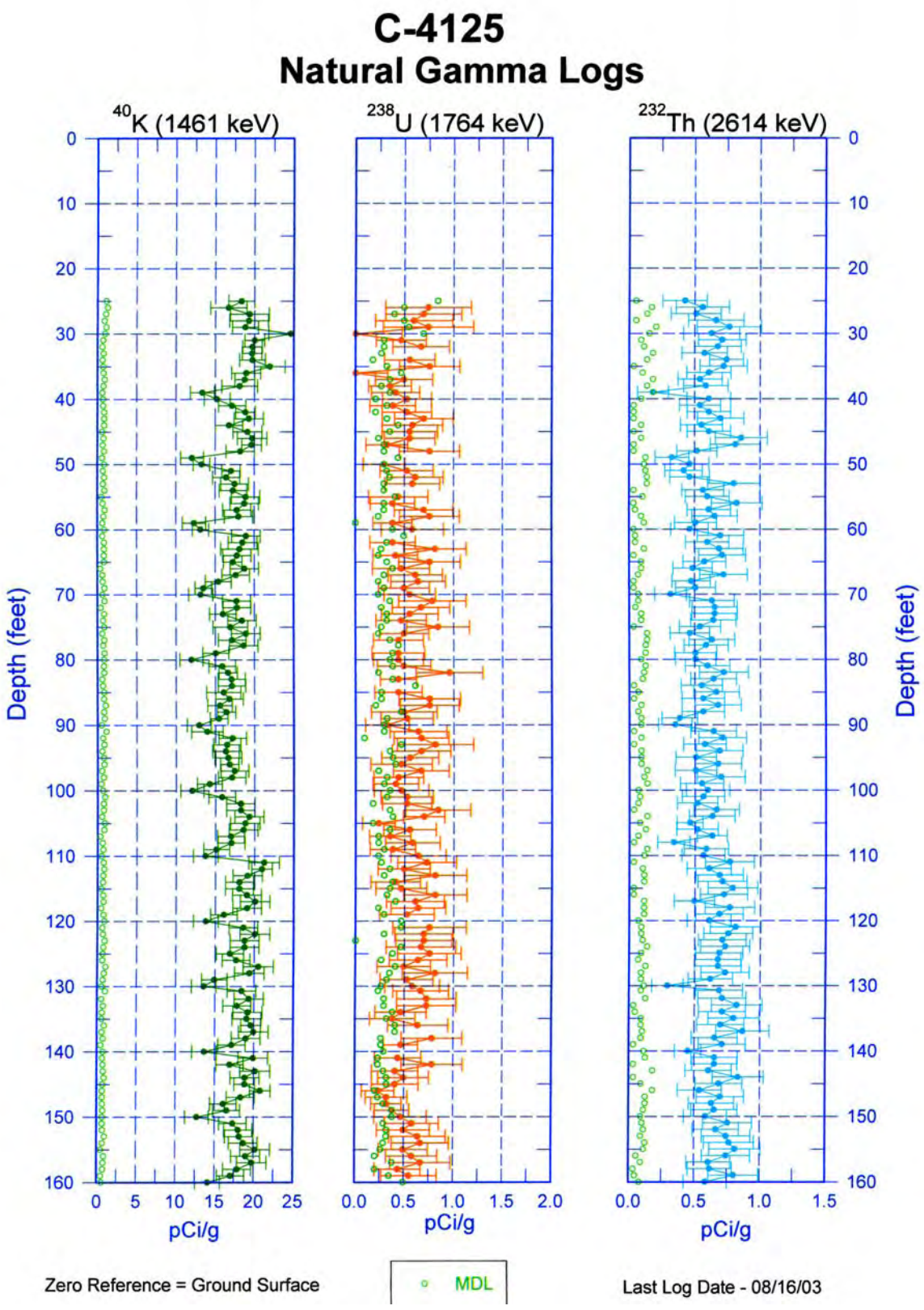
Results and Interpretations:

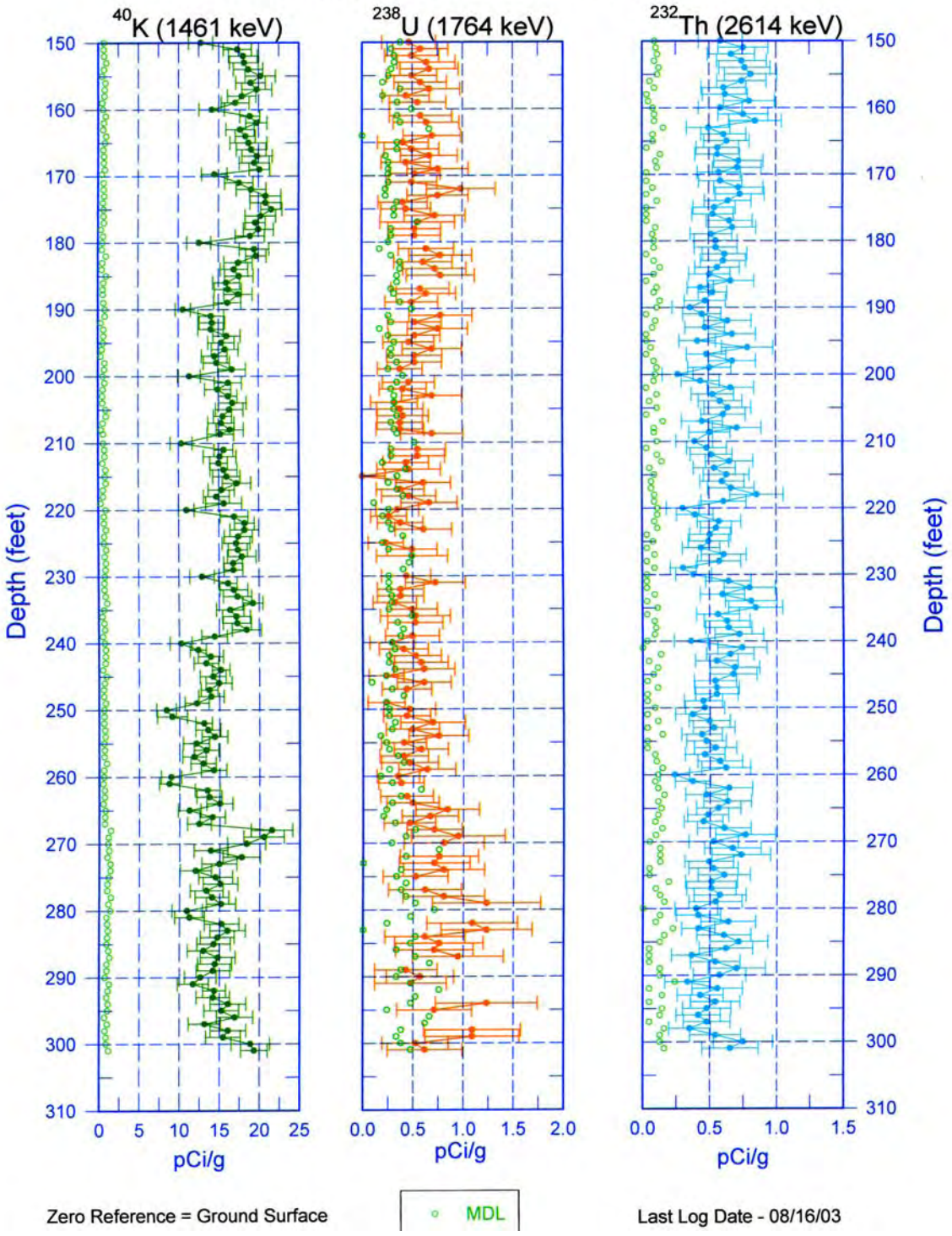
^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected at a few sporadic locations in the borehole near its MDL of approximately 0.2 pCi/g.

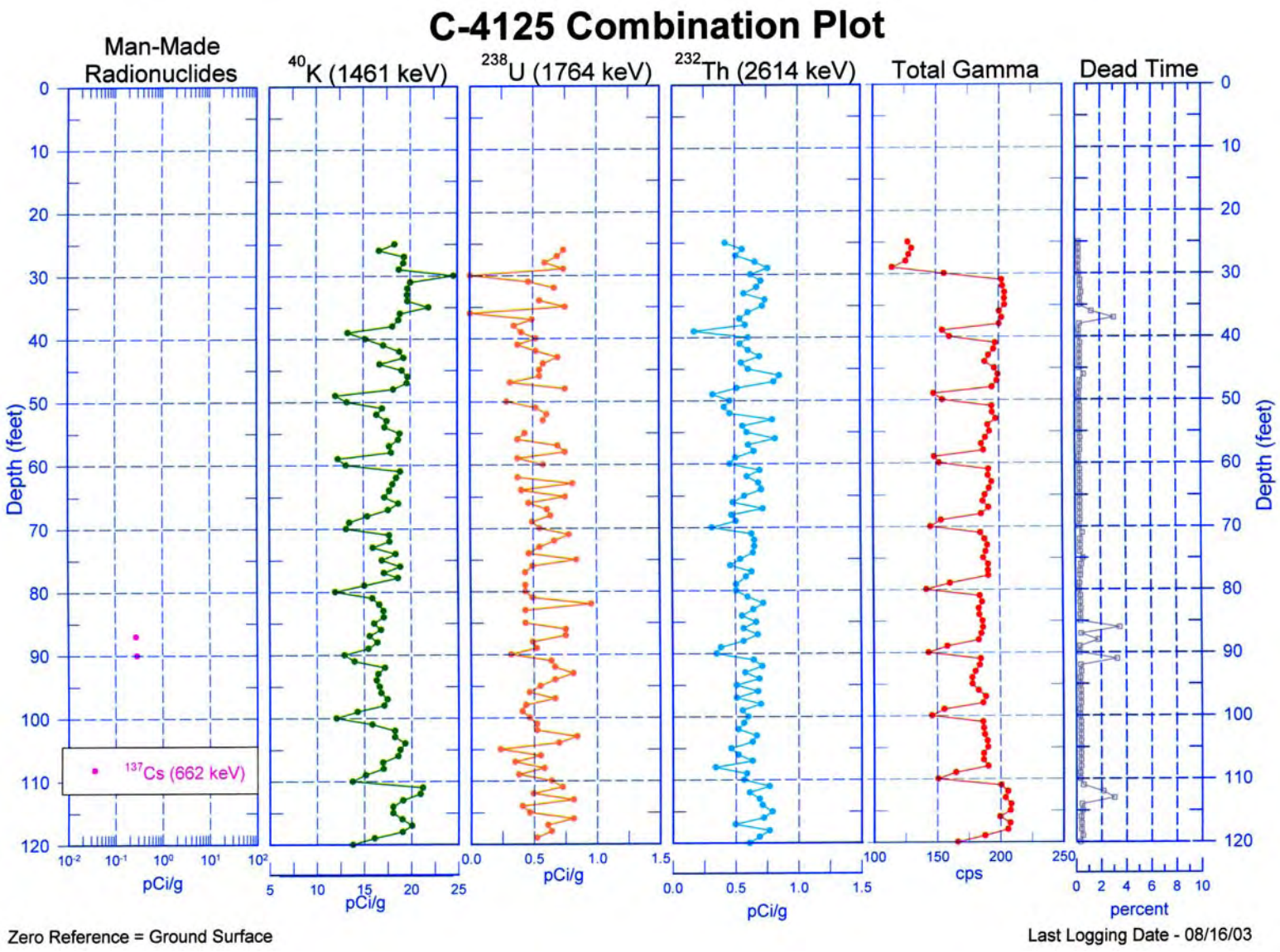
The repeat sections indicated good agreement of the naturally occurring KUT.

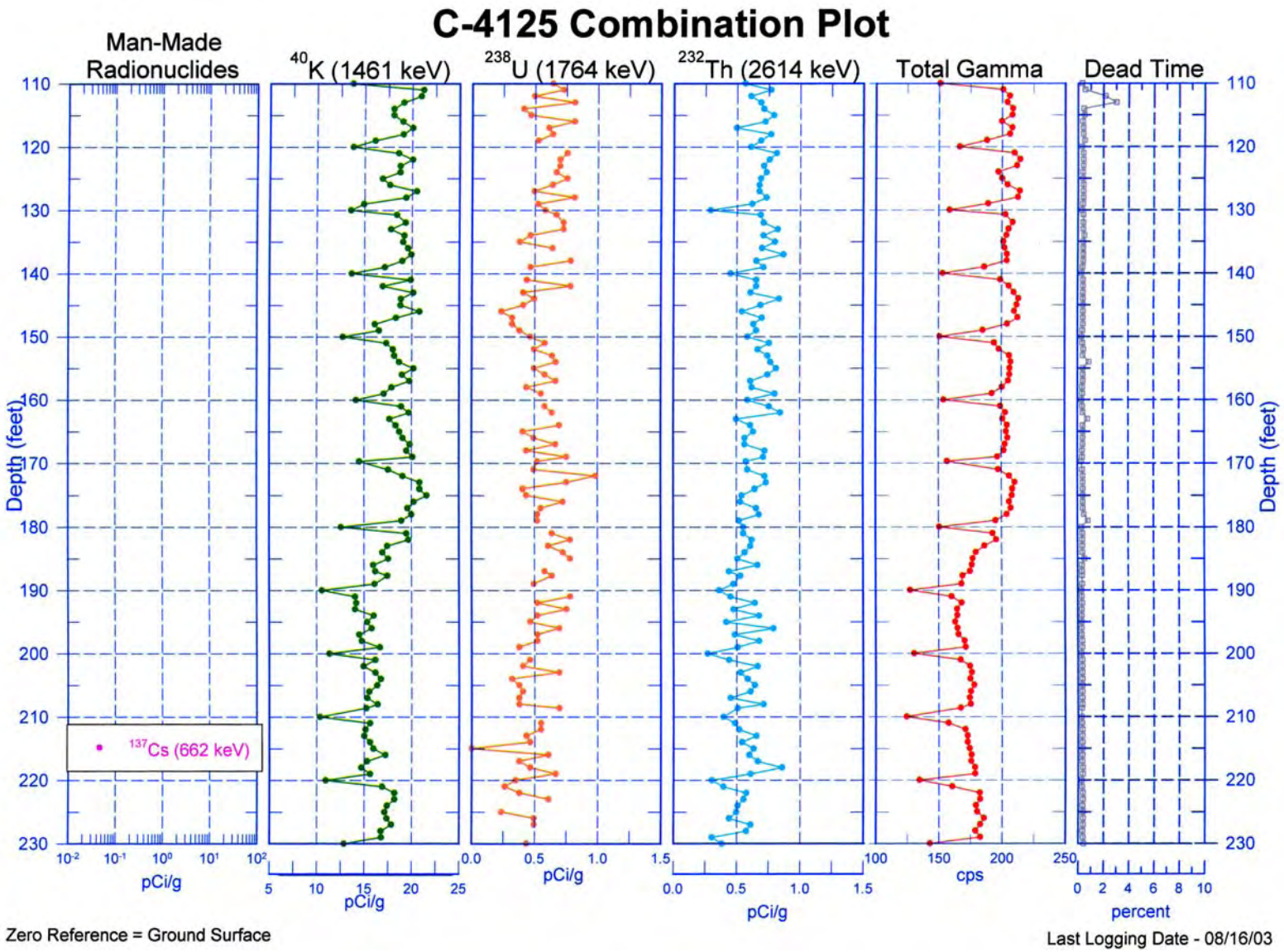
[1] GWL – groundwater level
[2] N/A – not applicable

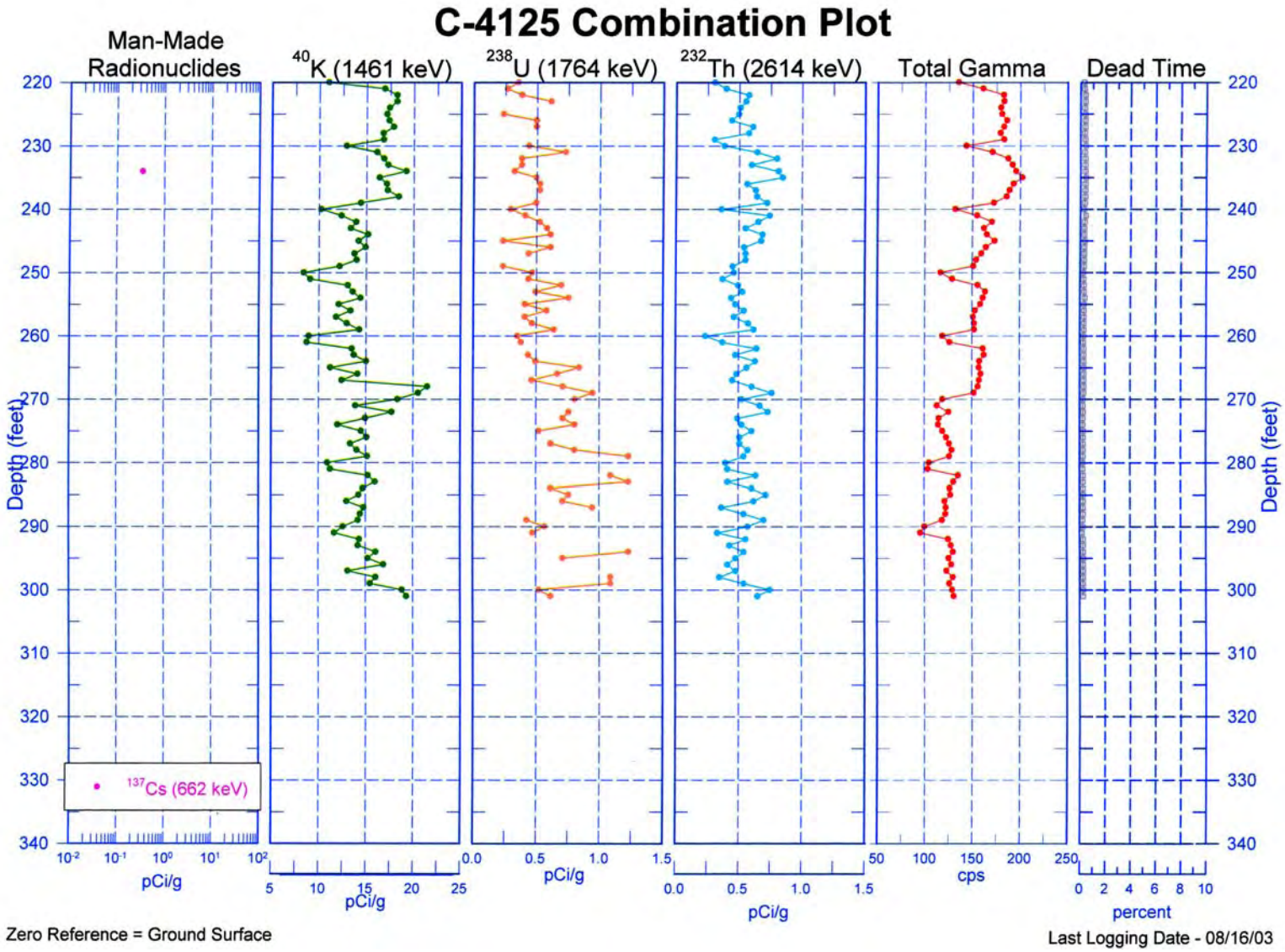

C-4125
Man-Made Radionuclides
Depth (feet)
pCi/g
137Cs (662 keV)
137Cs MDL
Zero Reference = Ground Surface
Last Log Date - 08/16/03

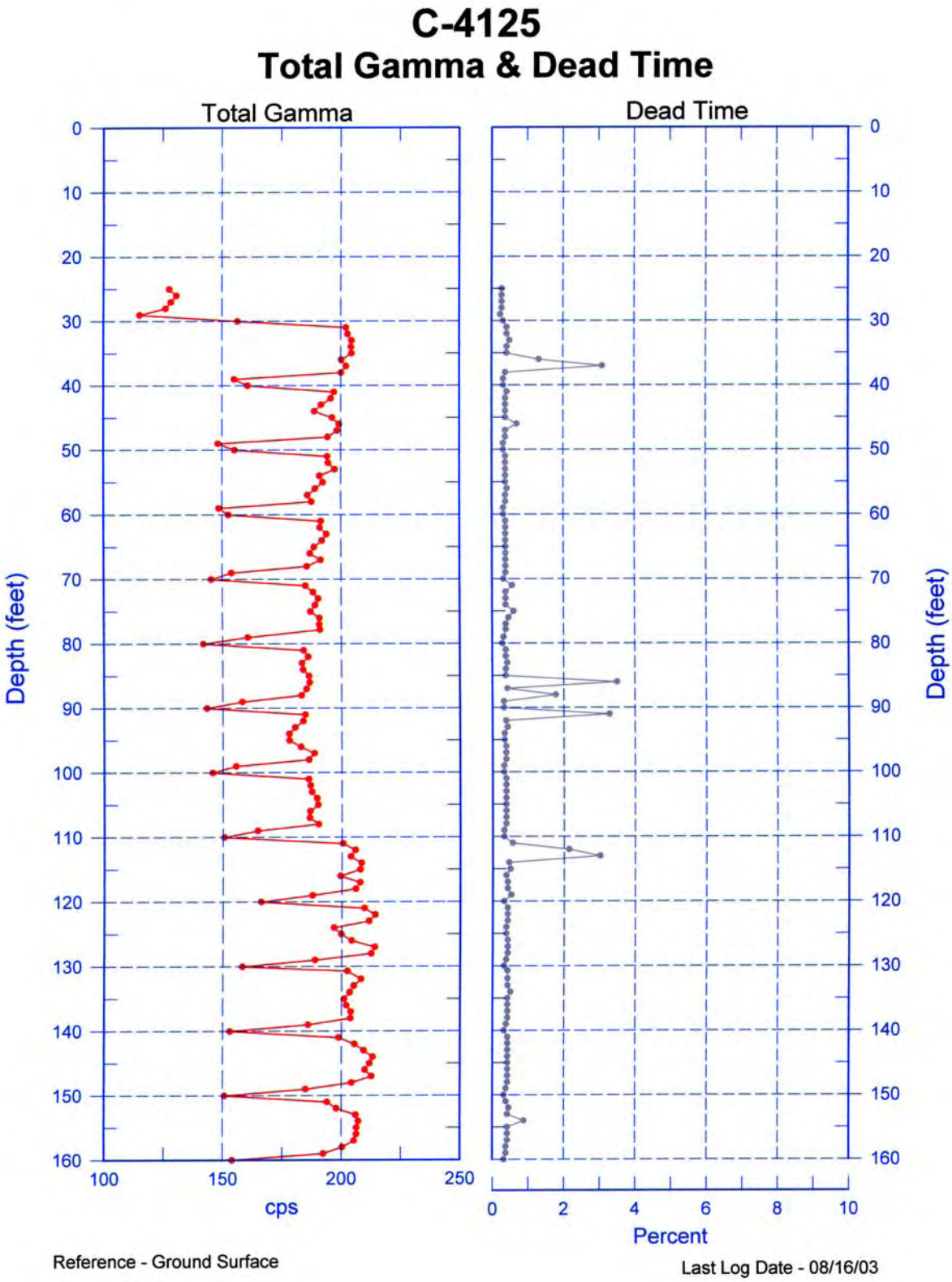

C-4125
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
0 5 10 15 20 25
pCi/g
0.0 0.5 1.0 1.5 2.0
pCi/g
0.0 0.5 1.0 1.5
pCi/g
Zero Reference = Ground Surface
MDL
Last Log Date - 08/16/03


C-4125
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
0 5 10 15 20 25
pCi/g
0.0 0.5 1.0 1.5 2.0
pCi/g
0.0 0.5 1.0 1.5
pCi/g
Zero Reference = Ground Surface
MDL
Last Log Date - 08/16/03

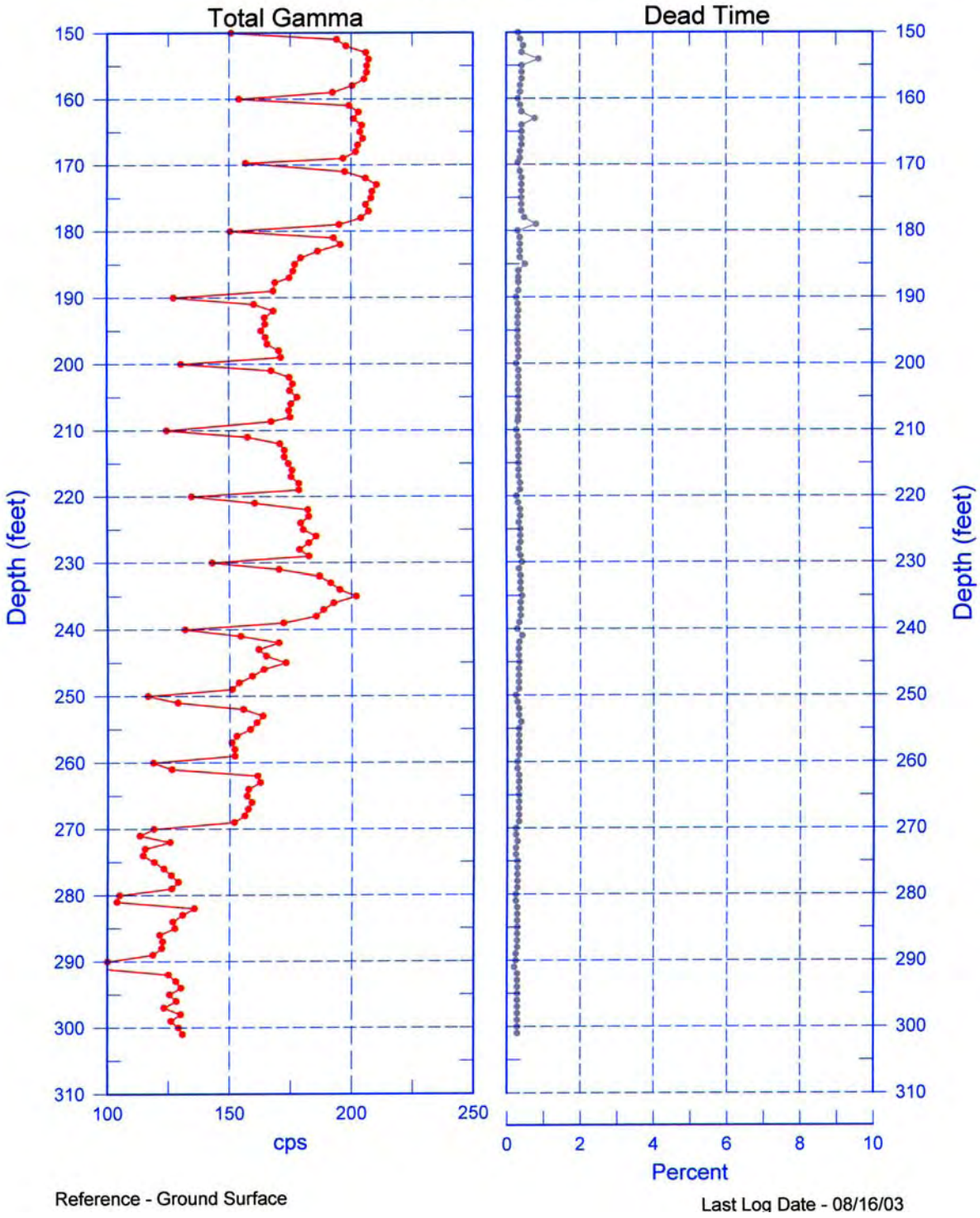

C-4125 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Last Logging Date - 08/16/03


C-4125 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Last Logging Date - 08/16/03


C-4125 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Last Logging Date - 08/16/03

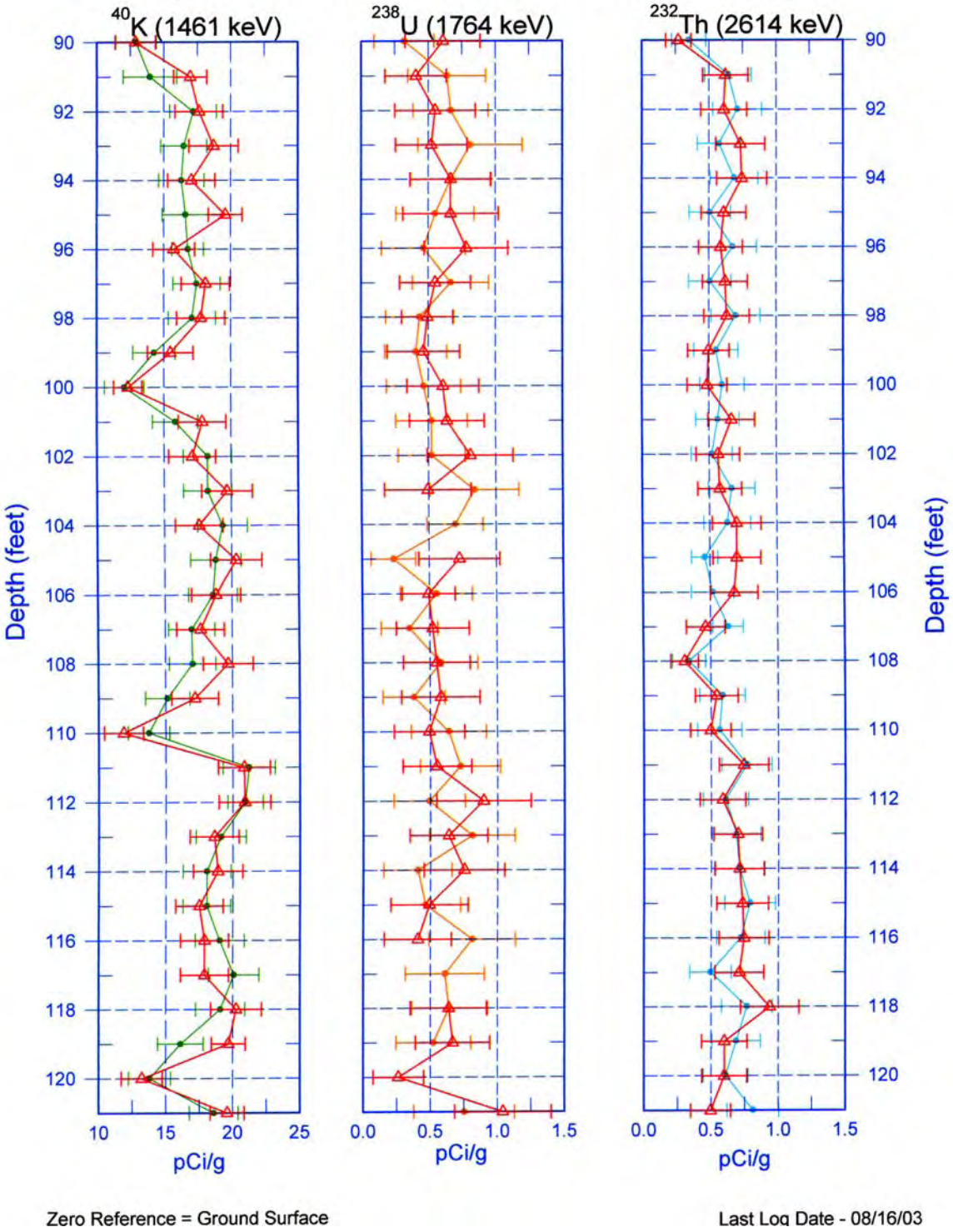

C-4125
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
100
150
200
250
cps
0
2
4
6
8
10
Percent
Reference - Ground Surface
Last Log Date - 08/16/03

C-4125
Total Gamma & Dead Time



C-4125

Repeat Section of Natural Gamma Logs



Stoller
Grand Junction Office established 1959

C-4127
Log Data Report

Borehole Information:

Borehole: C-4127			Site: South of C Tank Farm		
Coordinates (WA St Plane)		GWL[1] (ft): 272		GWL Date: 07/21/03	
North	East	Drill Date	Ground Level Elevation	Total Depth (ft)	Type
Not available	Not available	07/03	Not available	318.0	Becker

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Steel tubing	2.7	6.24	6.0	0.125	0	318.0
Threaded Steel	2.1	9.0	8.0	0.50	0	318.0

Borehole Notes:

The casing dimensions are derived from published values for Becker drill casing. Casing thicknesses at the joints are 0.875 in. and 0.240 in. for the 8-in. and 6-in. casings, respectively. The total depth of the borehole was provided by the driller. The well site geologist provided the depth to water. Logging data acquisition is referenced to the ground surface.

Logging Equipment Information:

Logging System: Gamma 1E		Type: SGLS (70%) SN: 34TP40587A
Calibration Date: 07/03	Calibration Reference:	GJO-2003-468-TAR
	Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3 Repeat	4	
Date	07/21/03	07/22/03	07/22/03	07/22/03	
Logging Engineer	Kos	Kos	Kos	Kos	
Start Depth (ft)	30.0	316.0	142.0	109.0	
Finish Depth (ft)	0.0	110.0	110.0	29.0	
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	
ft/min	N/A[2]	N/A	N/A	N/A	
Pre-Verification	AE002CAB	AE003CAB	AE003CAB	AE003CAB	
Start File	AE002000	AE003000	AE003207	AE003240	
Finish File	AE002030	AE003206	AE003239	AE003320	
Post-Verification	AE002CAA	AE003CAA	AE003CAA	AE003CAA	

Log Run	1	2	3 Repeat	4	
Depth Return Error (in.)	0	N/A	N/A	-1.75	
Comments	No fine-gain adjustment.	No fine-gain adjustment.	No fine-gain adjustment.	Gain adjustment files -3250, -3271, and -3297	

Logging Operation Notes:

Spectral gamma logging was performed in this borehole on July 21 and 22, 2003. Logging was conducted with a centralizer on the sonde and measurements are referenced to ground surface. A repeat section was collected in this borehole to evaluate system performance.

Analysis Notes:

Analyst:	Henwood	Date:	07/28/03	Reference:	GJO-HGLP 1.6.3, Rev. 0

Pre-run and post-run verifications for the logging system were performed before and after data acquisition. Acceptance criteria were met.

A combined casing correction for 0.675-in.-thick casing was applied throughout the borehole for both casings. The combined thickness at casing joints is 1.115 in. This thickness results in a significant reduction in gamma activity detection as the detector passes by a casing joint. However, it is not practical to correct individual data points for the effect of casing joints. The influence of the thick joints is apparent on the total gamma and ^{40}K logs where reduced count rates and concentrations are exhibited at approximately 10-ft depth intervals.

SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated with an EXCEL worksheet template identified as G1EJul03.xls using efficiency functions and corrections for casing, water, and dead time as determined from annual calibrations. Dead time corrections are applied where dead times exceed 10.5 percent; no dead times in excess of 10.5 percent were encountered. Correction for water was applied to the data below 272 ft.

Log Plot Notes:

Separate log plots are provided for the man-made radionuclide (^{137}Cs) detected in the borehole, naturally occurring radionuclides (^{40}K, ^{238}U, ^{232}Th [KUT]), a combination of man-made, KUT, and dead time, and total gamma plotted with dead time. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, casing corrections, or water corrections. A repeat log section is also included.

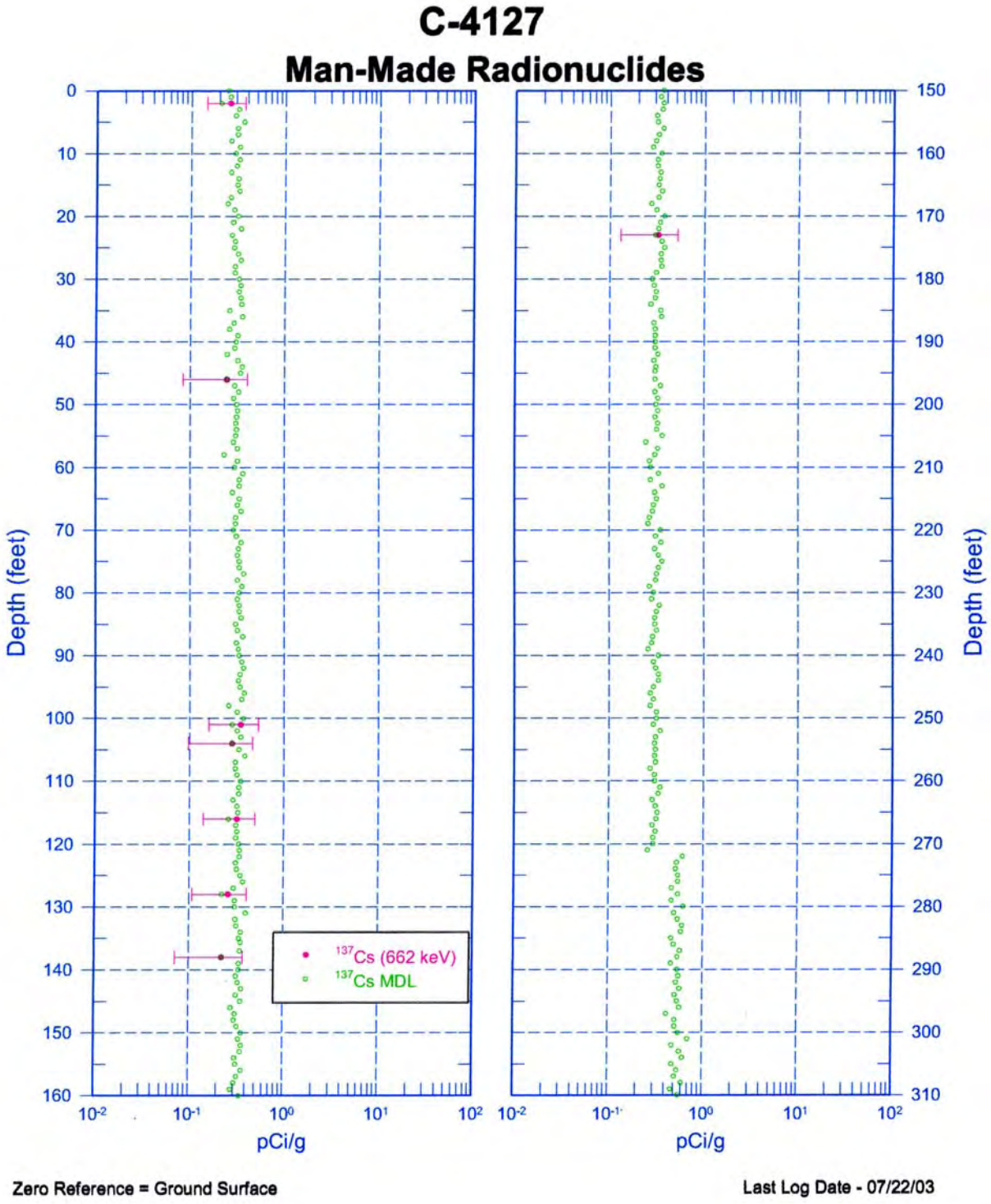
Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected at a few sporadic locations throughout the borehole near its MDL of approximately 0.2 pCi/g.

The repeat sections indicated good agreement of the naturally occurring KUT.

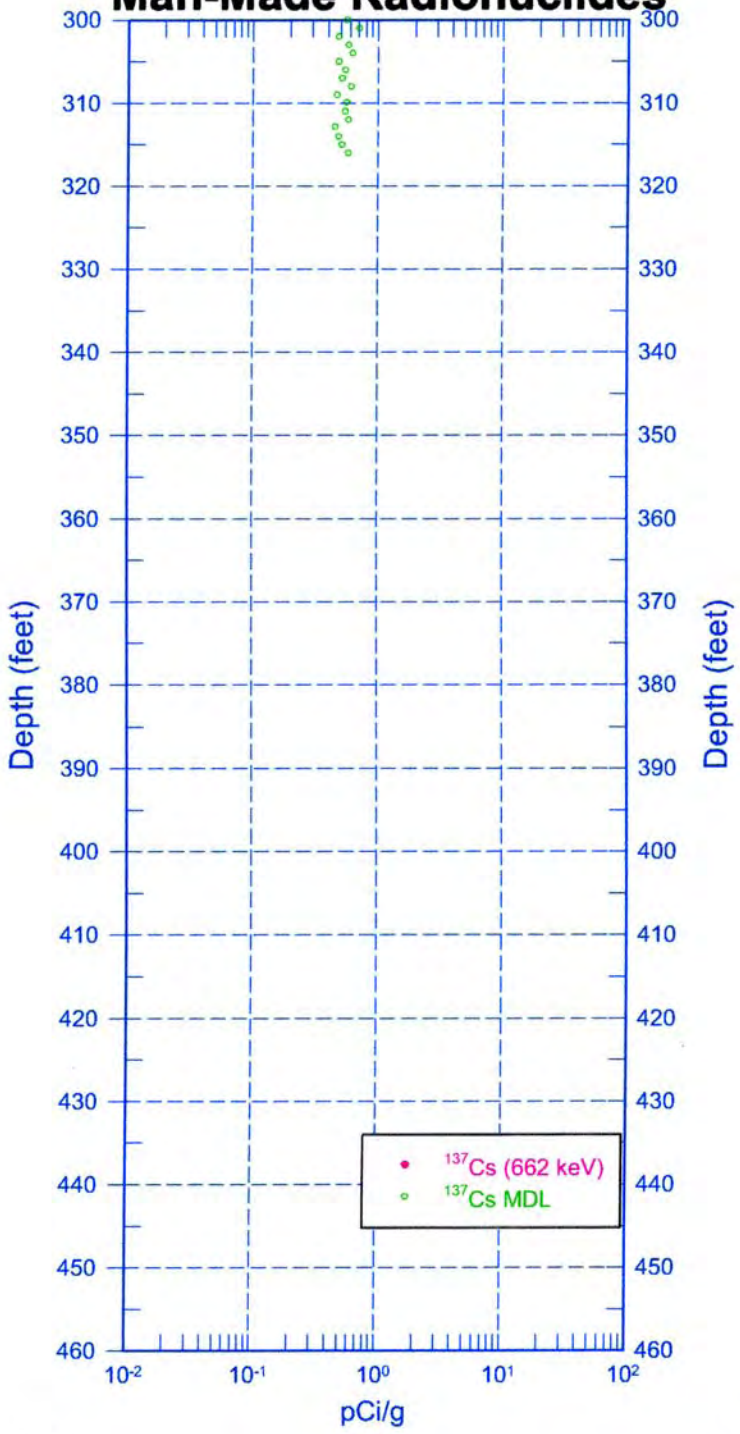
---

[1] GWL – groundwater level
[2] N/A – not applicable


C-4127
Man-Made Radionuclides
Depth (feet)
pCi/g
137Cs (662 keV)
137Cs MDL
Zero Reference = Ground Surface
Last Log Date - 07/22/03

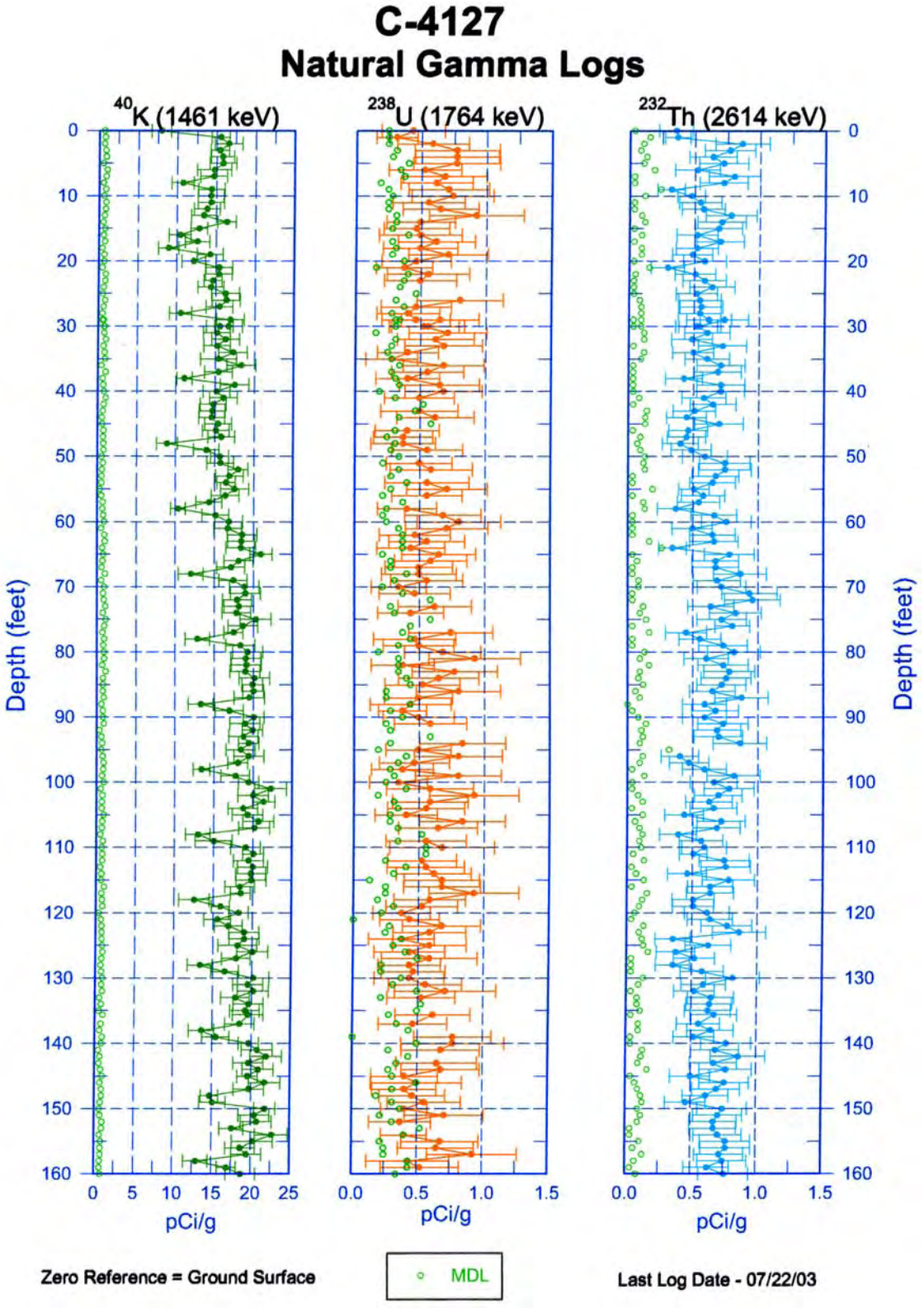
C-4127

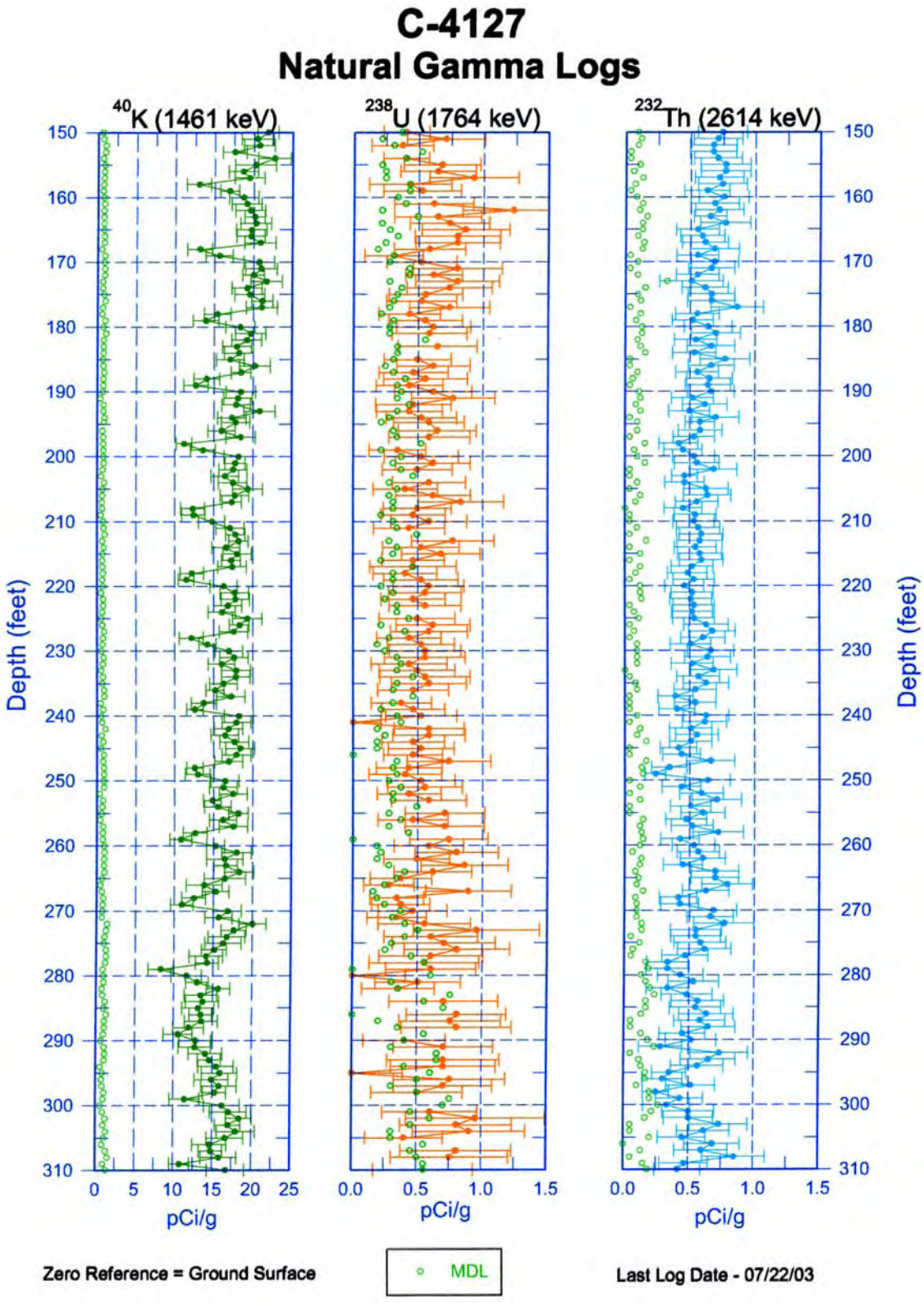
Man-Made Radionuclides

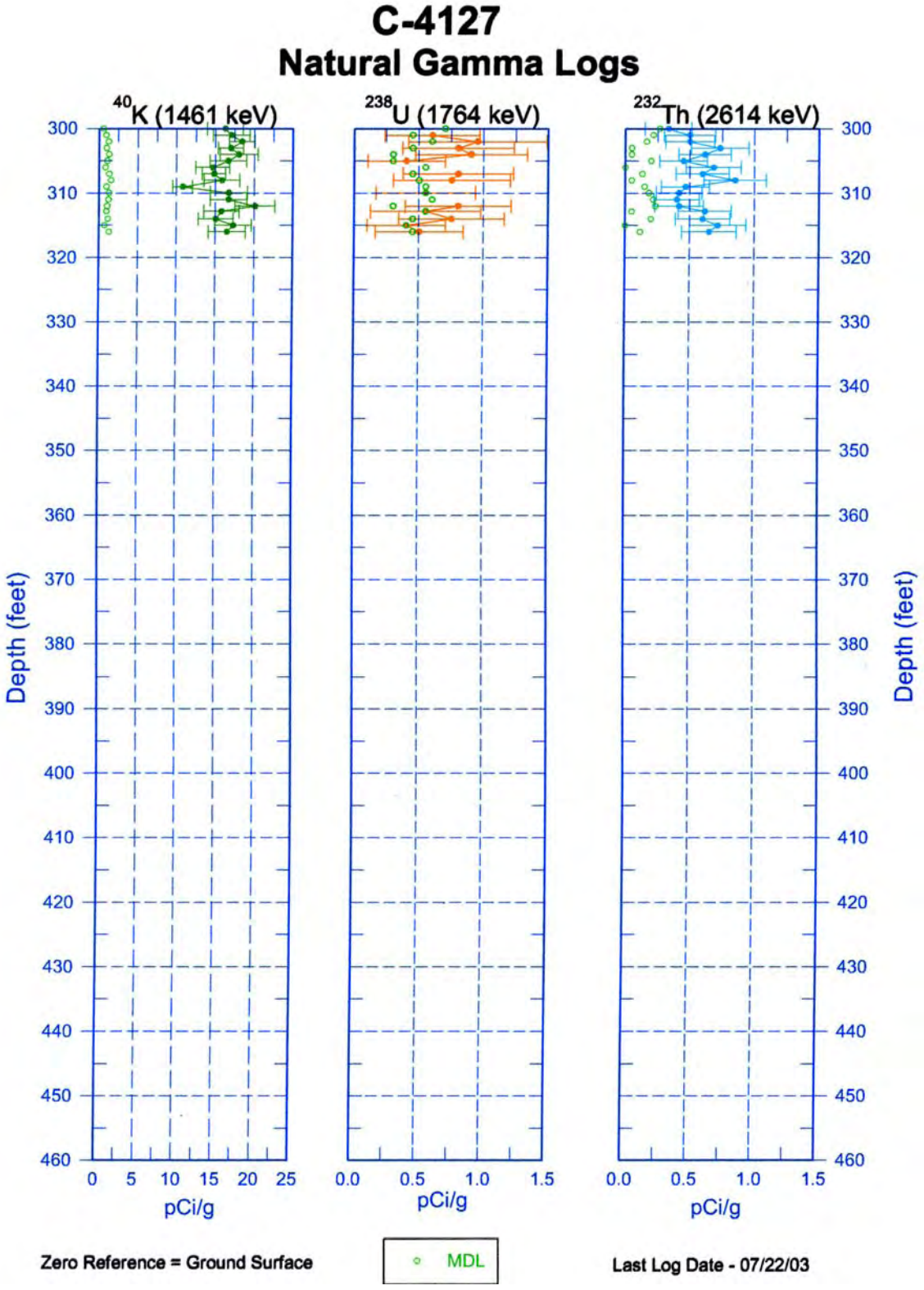


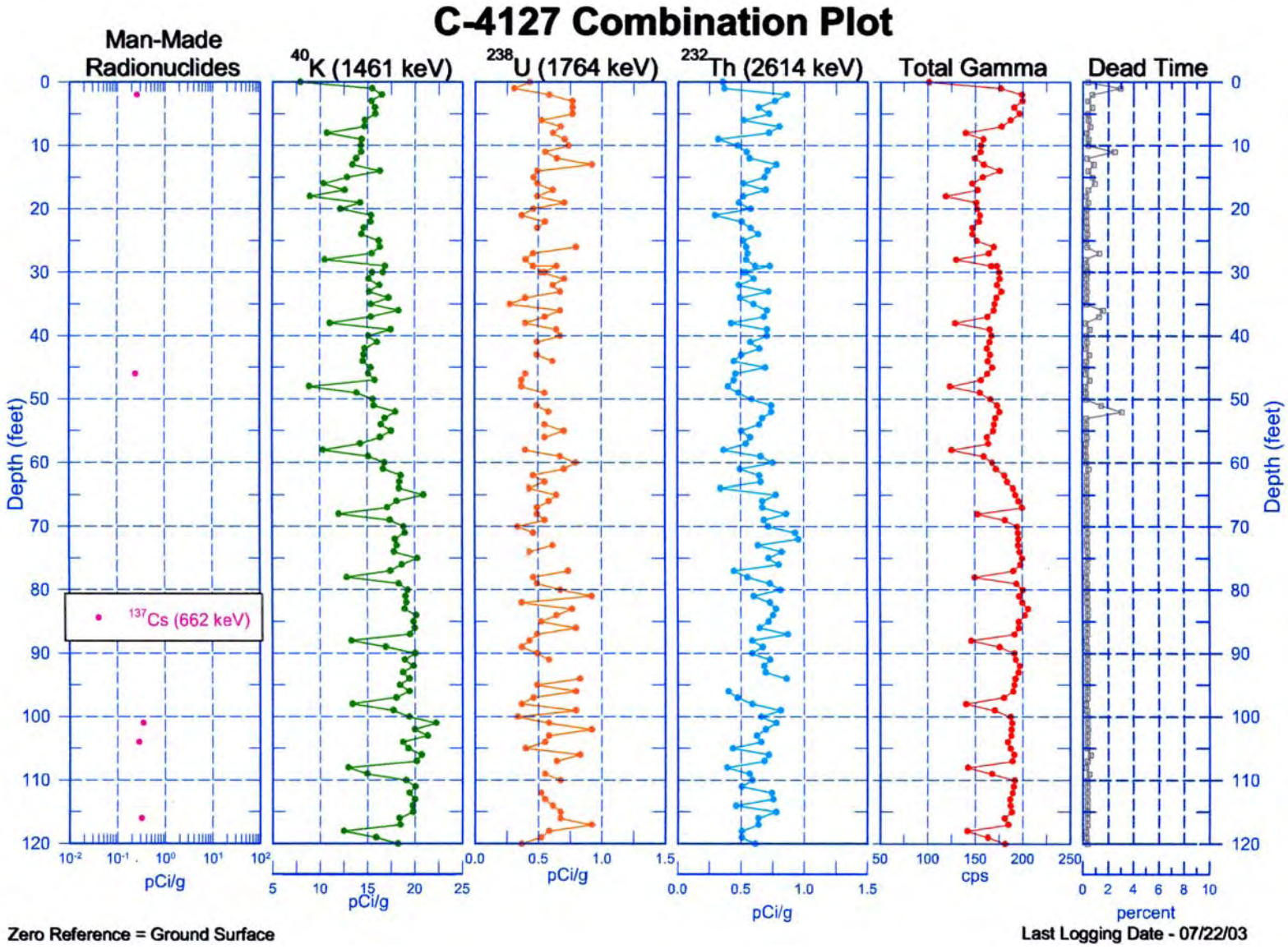
Zero Reference = Ground Surface

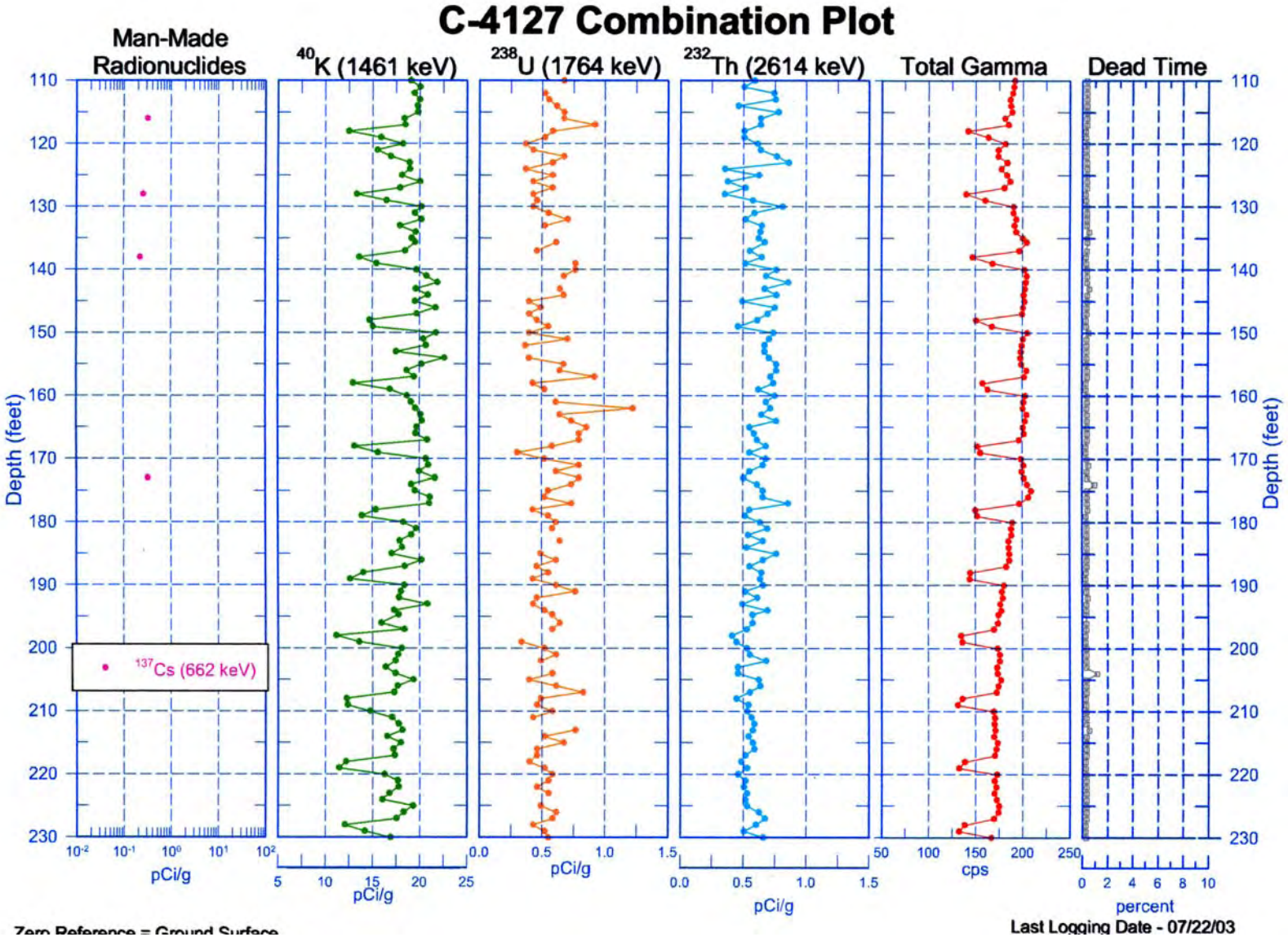
Last Log Date - 07/22/03

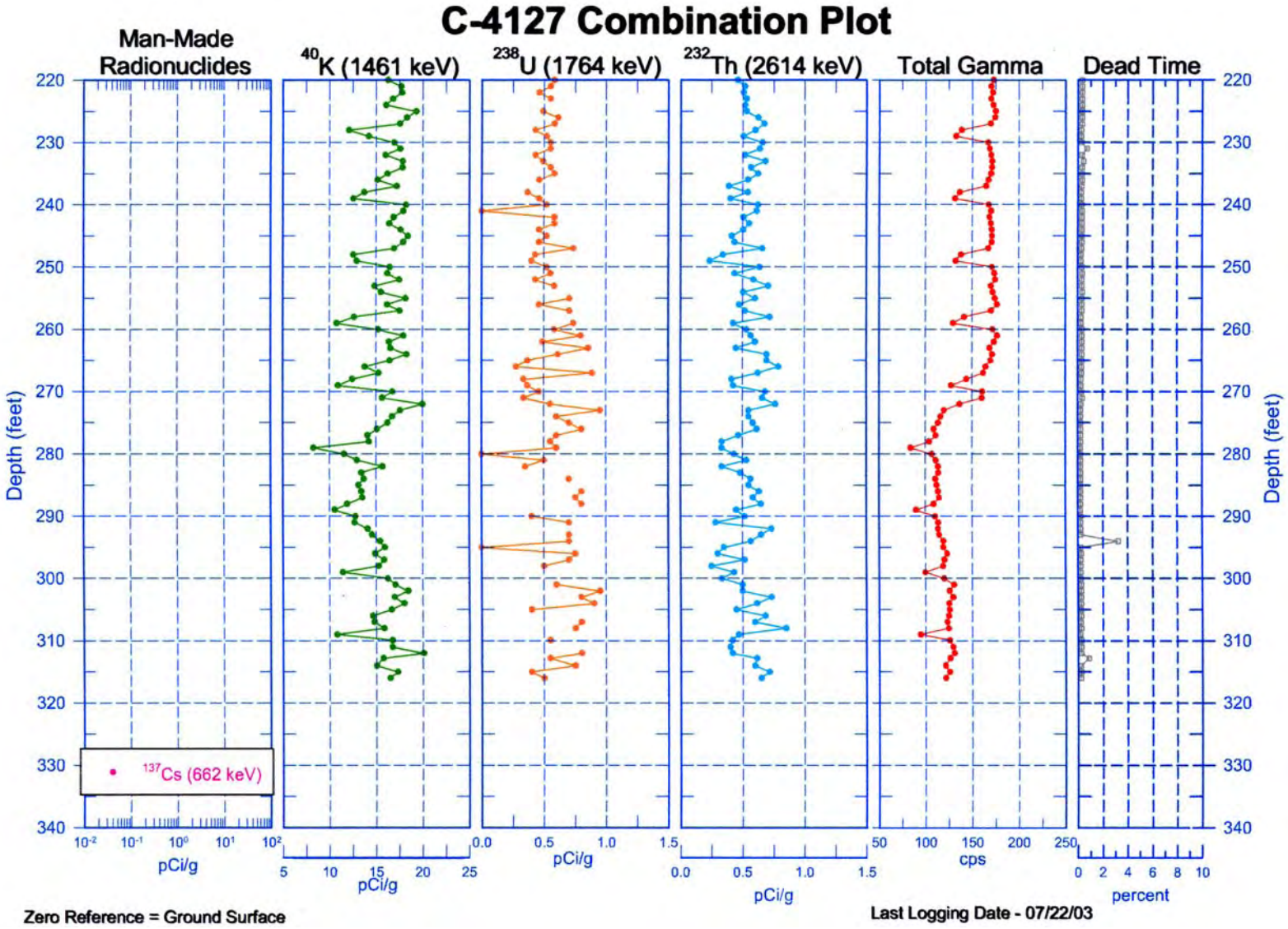

C-4127
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
0 5 10 15 20 25
0.0 0.5 1.0 1.5
pCi/g
MDL
Zero Reference = Ground Surface
Last Log Date - 07/22/03

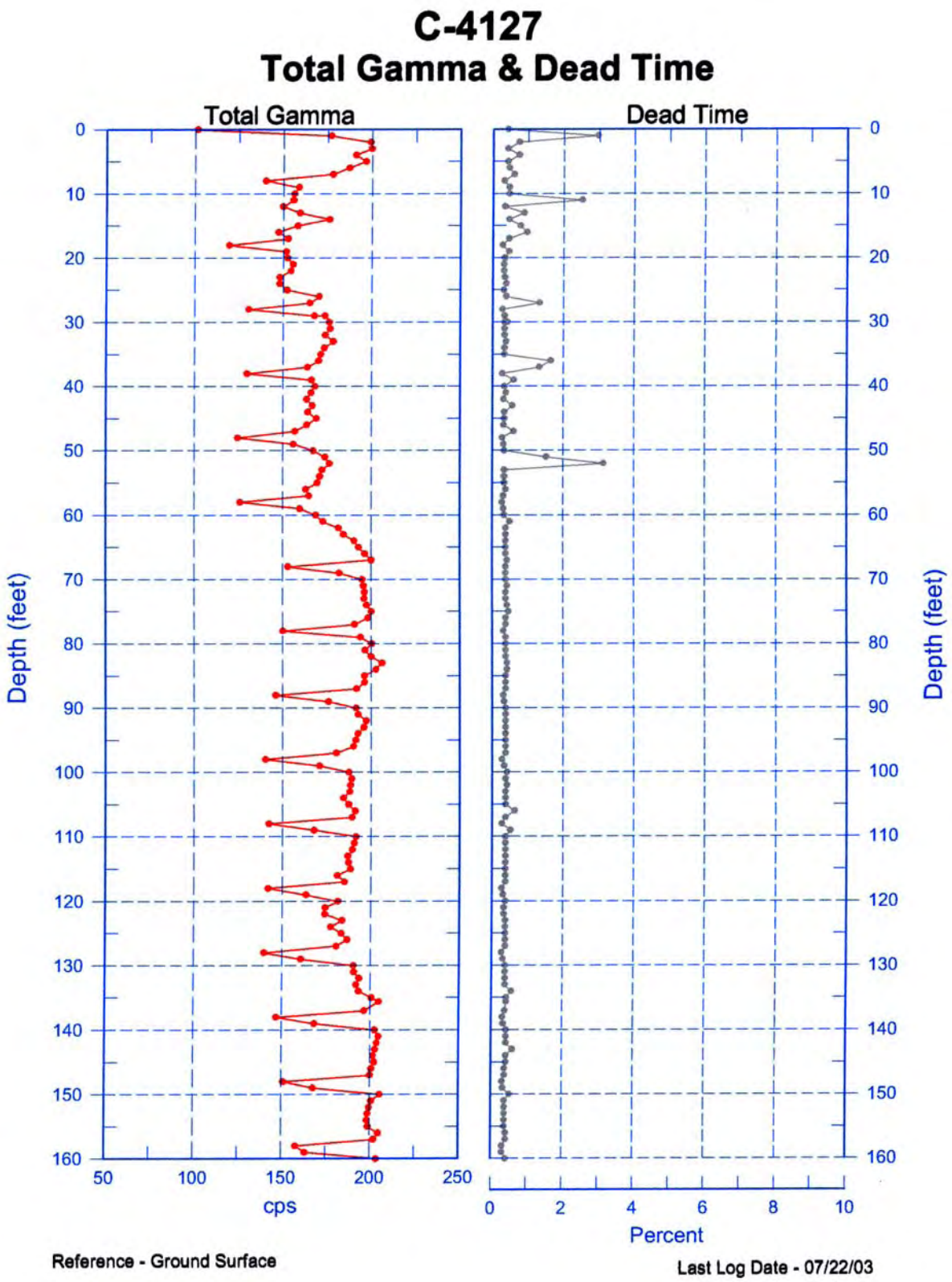

C-4127
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
0 5 10 15 20 25
0.0 0.5 1.0 1.5
0.0 0.5 1.0 1.5
pCi/g
pCi/g
pCi/g
Zero Reference = Ground Surface
MDL
Last Log Date - 07/22/03


C-4127
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
0 5 10 15 20 25
0.0 0.5 1.0 1.5
0.0 0.5 1.0 1.5
pCi/g
Zero Reference = Ground Surface
MDL
Last Log Date - 07/22/03

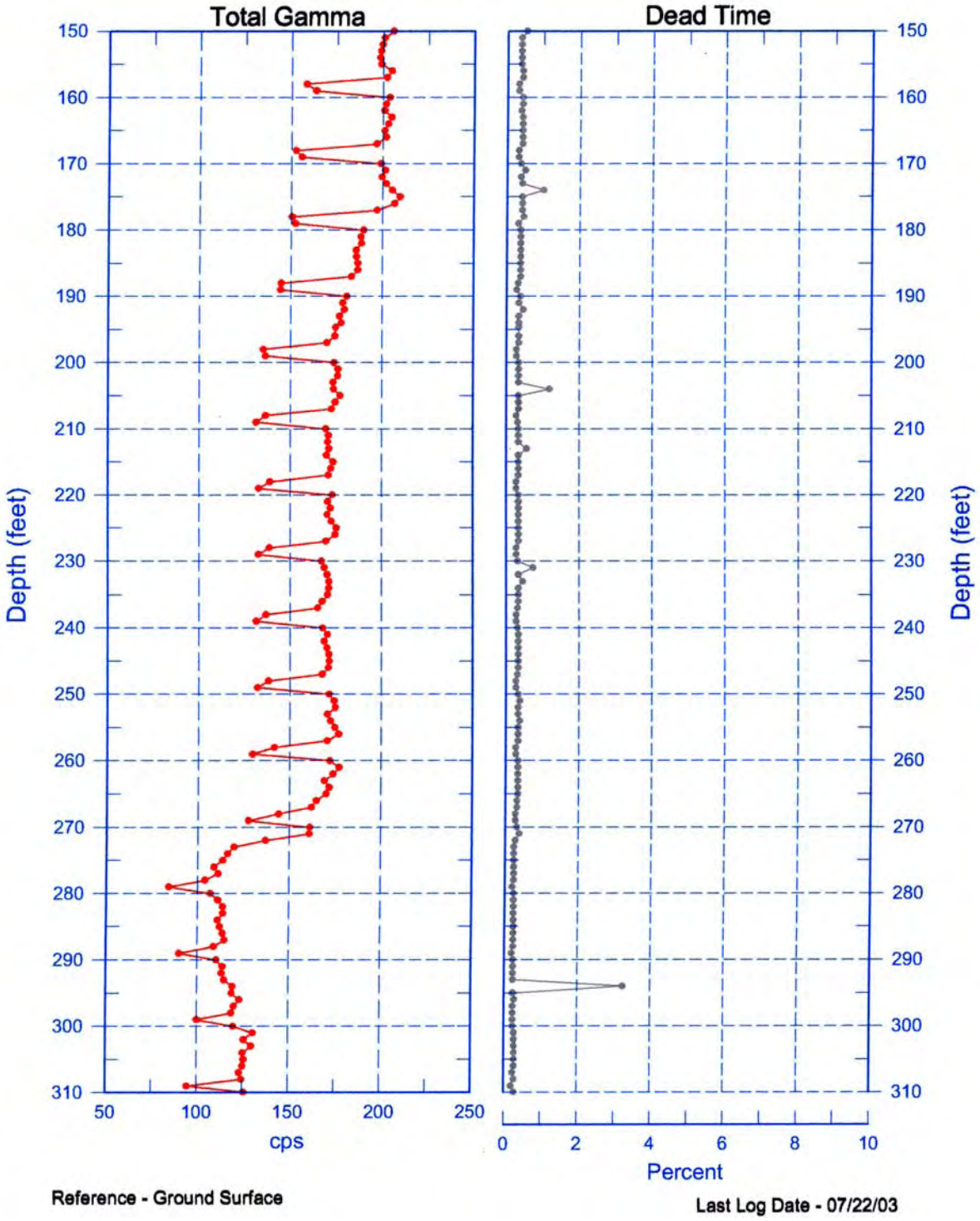

C-4127 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Last Logging Date - 07/22/03

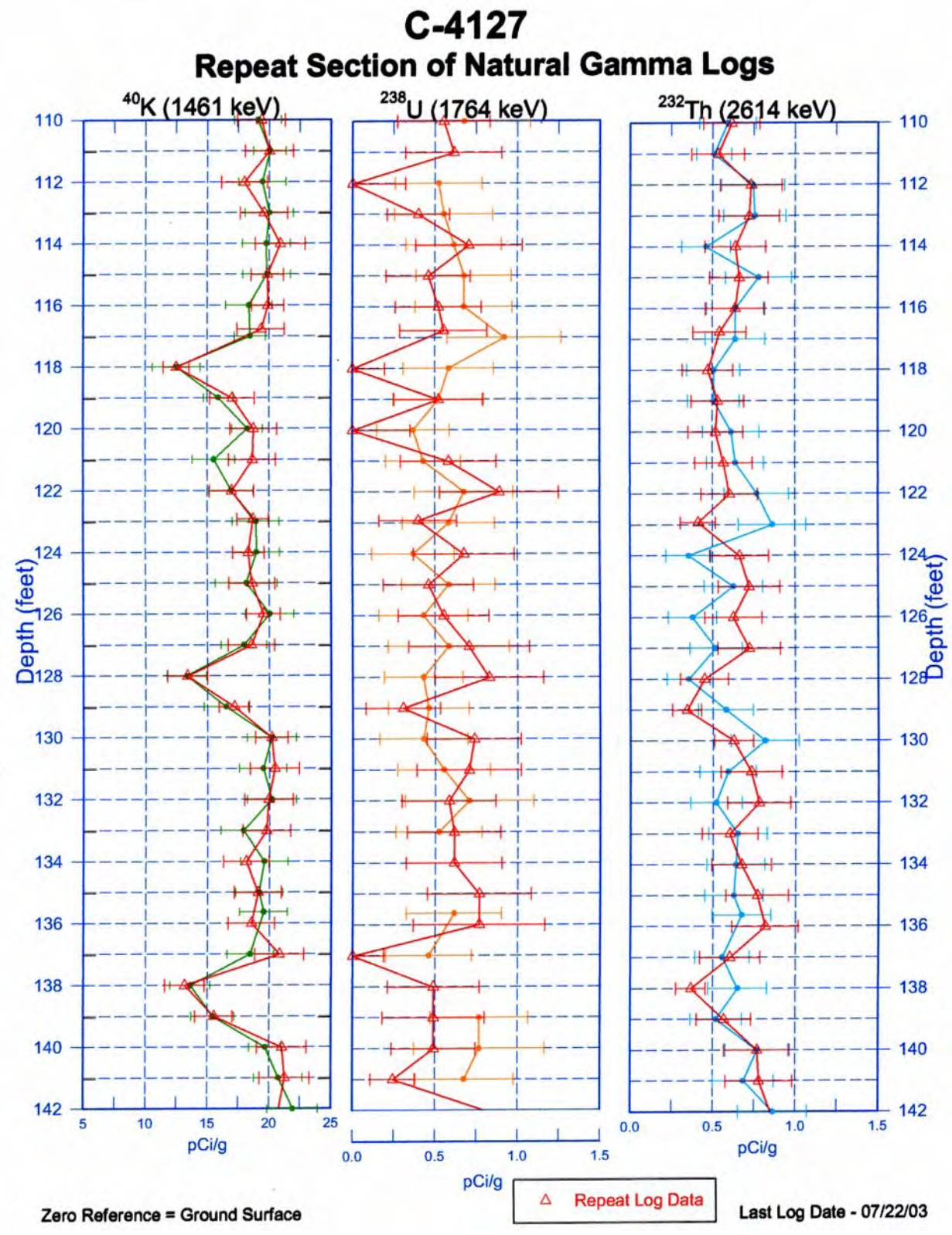

C-4127 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Last Logging Date - 07/22/03


C-4127 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference = Ground Surface
Last Logging Date - 07/22/03


C-4127
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
50
100
150
200
250
cps
0
2
4
6
8
10
Percent
Reference - Ground Surface
Last Log Date - 07/22/03

C-4127
Total Gamma & Dead Time




C-4127
Repeat Section of Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
110
112
114
116
118
120
122
124
126
128
130
132
134
136
138
140
142
5
10
15
20
25
0.0
0.5
1.0
1.5
pCi/g
Repeat Log Data
Zero Reference = Ground Surface
Last Log Date - 07/22/03

Stoller
Grand Junction Office established 1959

C4190
Log Data Report

Borehole Information:

Borehole:	C4190			Site:	Southwest of C Tank Farm
Coordinates (WA State Plane)		GWL (ft)[1]:	273	GWL Date:	8/6/2003
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
N/A[3]	N/A	August 2003	N/A	318	Becker

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded steel	2.85	6 1/4	6	1/8	+2.85	318
Threaded steel	2.25	9	8	1/2	2.25	318
Casing stickup was measured using a steel tape. The logging engineer measured the outside diameters for both the 6- and 8-in. casings using a caliper. The caliper and 6-in. inside casing diameter were measured using a steel tape; measurements were rounded to the nearest 1/16 in.						

Borehole Notes:

Zero reference is the ground surface. This borehole was logged through the drill pipe. The borehole is located approximately 30 ft east of UPR 200-E-86 and 20 ft north of the MO 822 change trailer. A 6-in. layer of crushed gravel is present on the ground surface surrounding the drill site.

The Becker drilling system utilizes a special dual-wall casing string. Air passes through the annular space between the inner and outer casing, and drill cuttings are brought up inside the inner casing. For this well, the casing consisted of a 6-in. ID inner casing with 0.125-in. wall thickness inside an 8-in. ID outer casing with 0.5-in. wall thickness. The inner casing is thicker at casing joints, where wall thickness is 0.406 in. Casing joints are approximately 1 ft long overall and occur at 10-ft intervals.

Logging Equipment Information:

Logging System:	Gamma 1E		Type: 70% HPGe (34-TP40587A)
Calibration Date:	07/2003	Calibration Reference:	GJO-2003-486-TAR
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2/Repeat	3		
Date	8/07/03	8/08/03	8/08/03		
Logging Engineer	Spatz	Spatz	Spatz		
Start Depth (ft)	319.0	147.0	114.0		
Finish Depth (ft)	115.0	115.0	0		
Count Time (sec)	100	100	100		

Log Run	1	2/Repeat	3		
Live/Real	R	R	R		
Shield (Y/N)	N	N	N		
MSA Interval (ft)	1.0	1.0	1.0		
ft/min	n/a[4]	n/a	n/a		
Pre-Verification	AE013CAB	AE014CAB	AE014CAB		
Start File	AE013000	AE014000	AE014033		
Finish File	AE013204	AE014032	AE014147		
Post-Verification	AE013CAA	AE014CAA	AE014CAA		
Depth Return Error (in.)	-2.5	n/a	-1		
Comments	No fine-gain adjustment.	No fine-gain adjustment.	Fine-gain adjustment after files -101 and -116.		

Logging Operation Notes:

Zero reference was the ground surface, and the borehole was logged through drill pipe.

SGLS data were collected using Gamma 1E. Pre- and post-survey verification measurements employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 118. Logging was performed with a centralizer installed on the sonde.

Analysis Notes:

Analyst:	Sobczyk	Date:	8/14/03	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of the day and compared to the control limits. All of the verification spectra were within the control limits, except for spectrum AE013CAB. This spectrum was slightly above the upper control limit for the 609-keV peak counts per second (cps) value. The peak counts per second at the 609-keV, 1461-keV, and 2615-keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for each day were between 0.5 percent higher and 7.0 percent lower at the end of the day. Examinations of spectra indicate that the detector functioned normally during all of the logging runs, and the spectra are accepted.

Log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. The pre-run verification spectrum was used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G1EJul03.xls). Zero reference was the ground surface. Based on measurements supplied by the logging engineer, the casing configuration was assumed to be a string of 6-in. and 8-in. casings to 319 ft. The casing correction factor was calculated using a combined casing thickness of 5/8 in. This casing thickness is based upon the field measurements. The combined thickness at casing joints is 1.115 in. This thickness results in a significant reduction in gamma activity detection as the detector passes by a casing joint. However, it is not practical to correct individual data points for the effect of casing joints every 10.0 ft. The influence of the thick joints is apparent on the total gamma and ^{40}K logs where reduced count rates and concentrations are exhibited at approximately 10-ft depth intervals. Water corrections were applied to the data below 273 ft. SGLS dead time corrections were not applied because dead time did not exceed 10 percent.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are

included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot rather than the ^{214}Bi peak at 609 keV because it exhibited higher net counts per second.

Results and Interpretations:

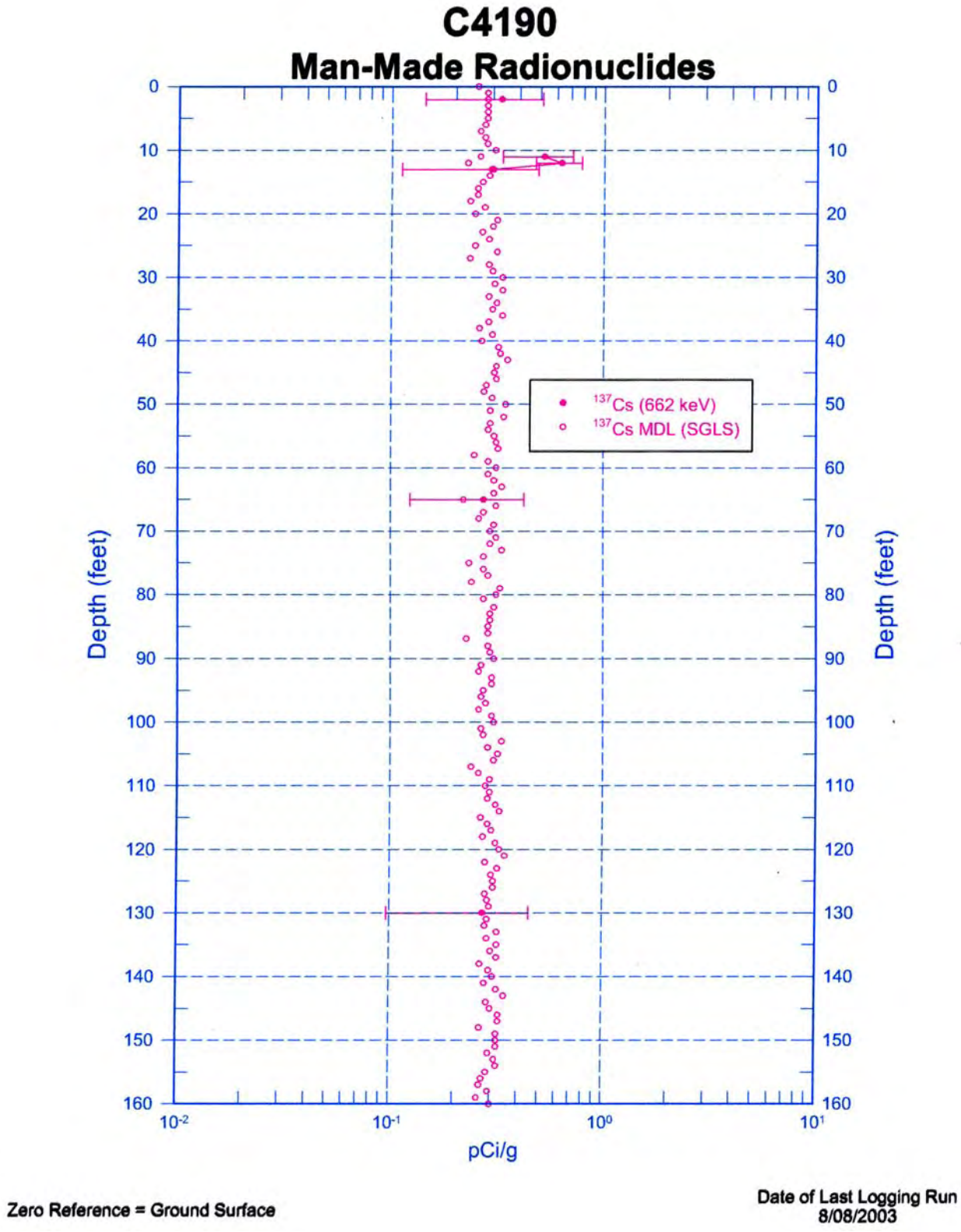
^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected near the ground surface at 2 ft and in the interval from 11 through 13 ft at concentrations ranging from the MDL (0.3 pCi/g) to 0.6 pCi/g. The maximum concentration of ^{137}Cs was measured at 12 ft. ^{137}Cs was also detected at log depths of 65, 130, and 218 ft with concentrations near the MDL.

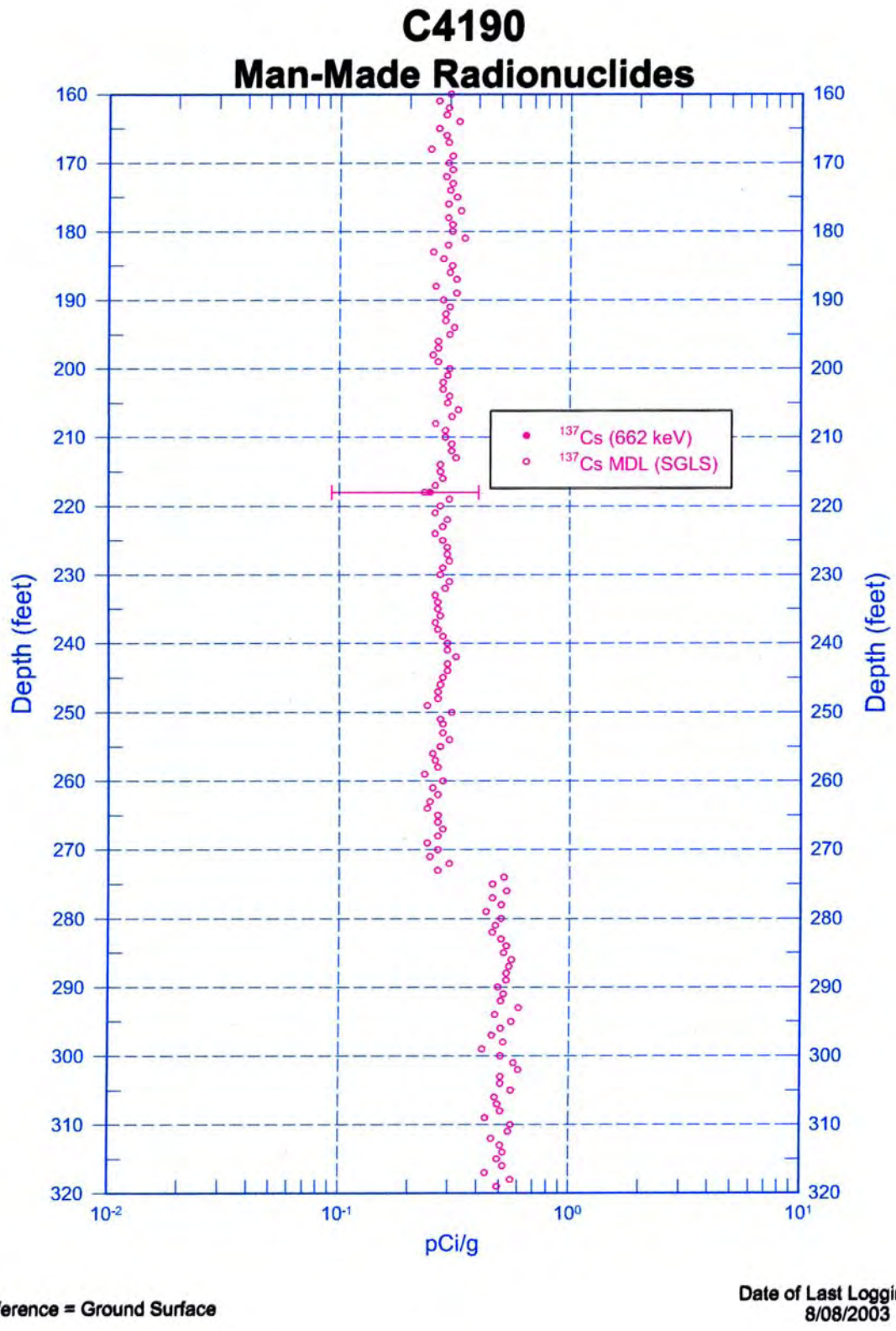
Logging through the drill pipe used in the construction of this borehole precludes the acquisition of SGLS spectra that consistently have statistically valid photopeaks. The relatively thick casing joints effectively shield the detector from the formation over a 3.0-ft zone at 10.0-ft intervals. Energy levels below 1461 keV are severely attenuated by the drill pipe.

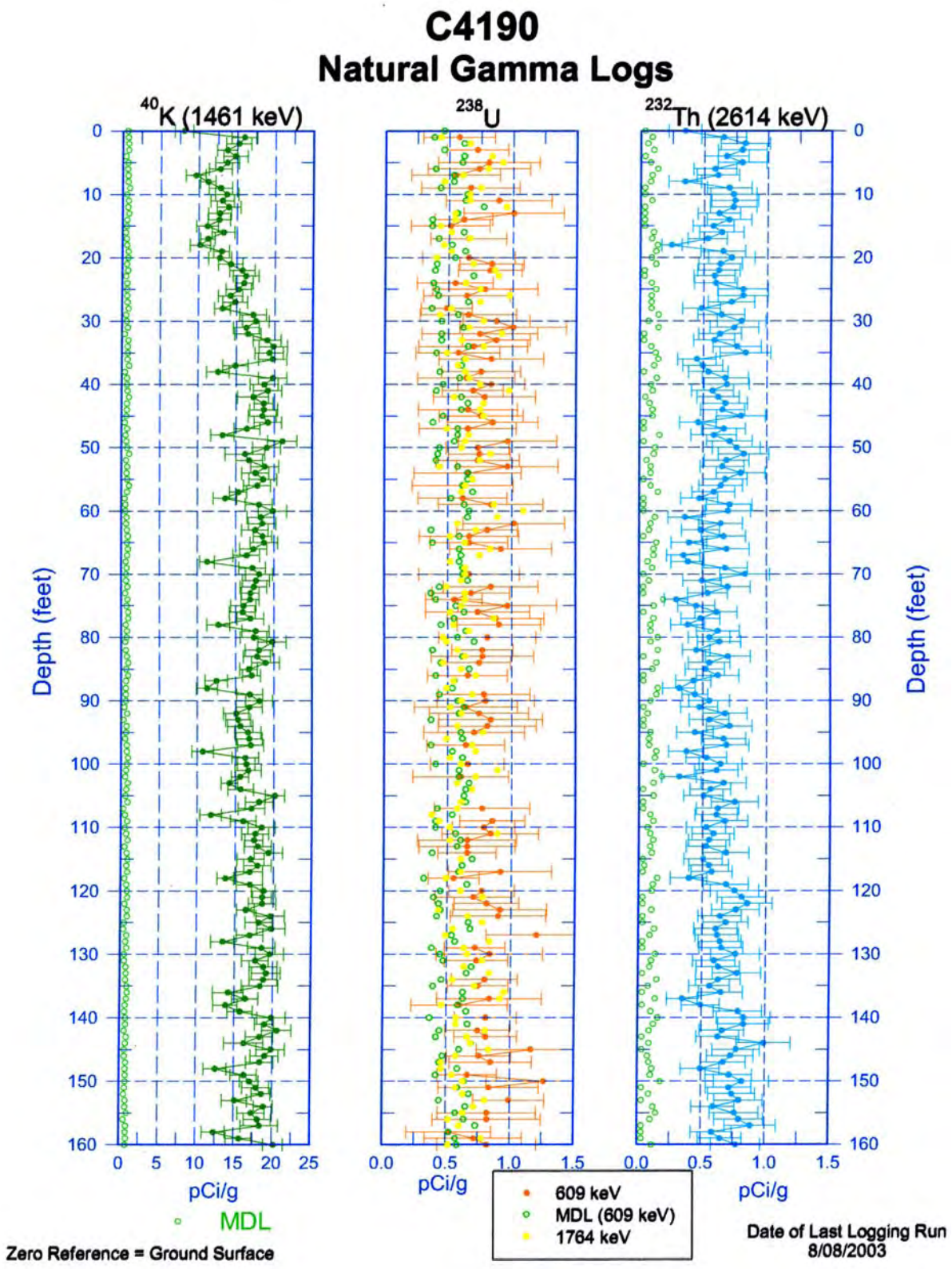
The plots of the repeat logs demonstrate reasonable repeatability of the SGLS. The natural radionuclides at energy levels of 609, 1461, 1764, and 2614 keV are comparable between the repeat and original SGLS log runs. ^{137}Cs encountered at 130 ft on the original log run did not repeat.

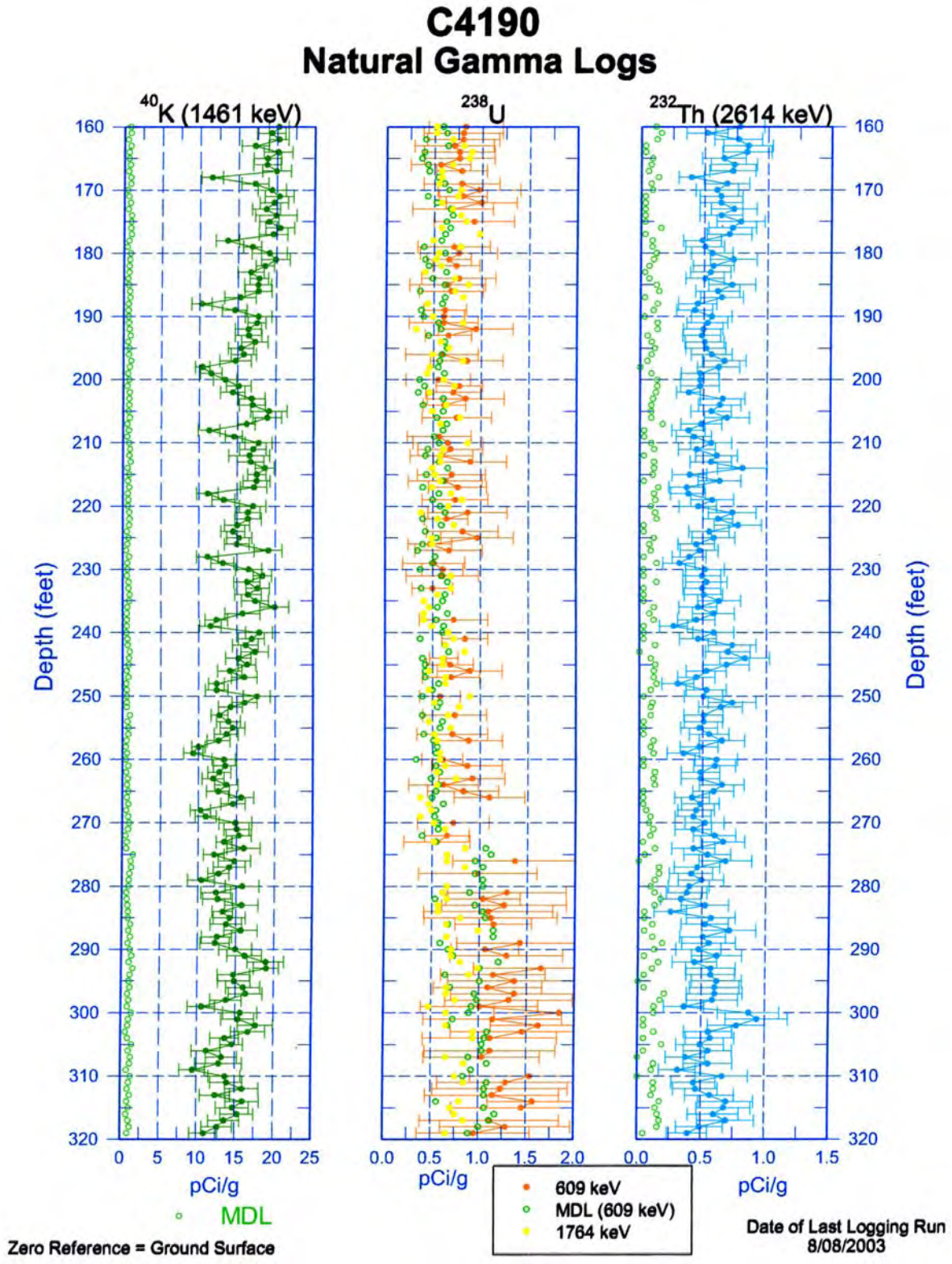
---

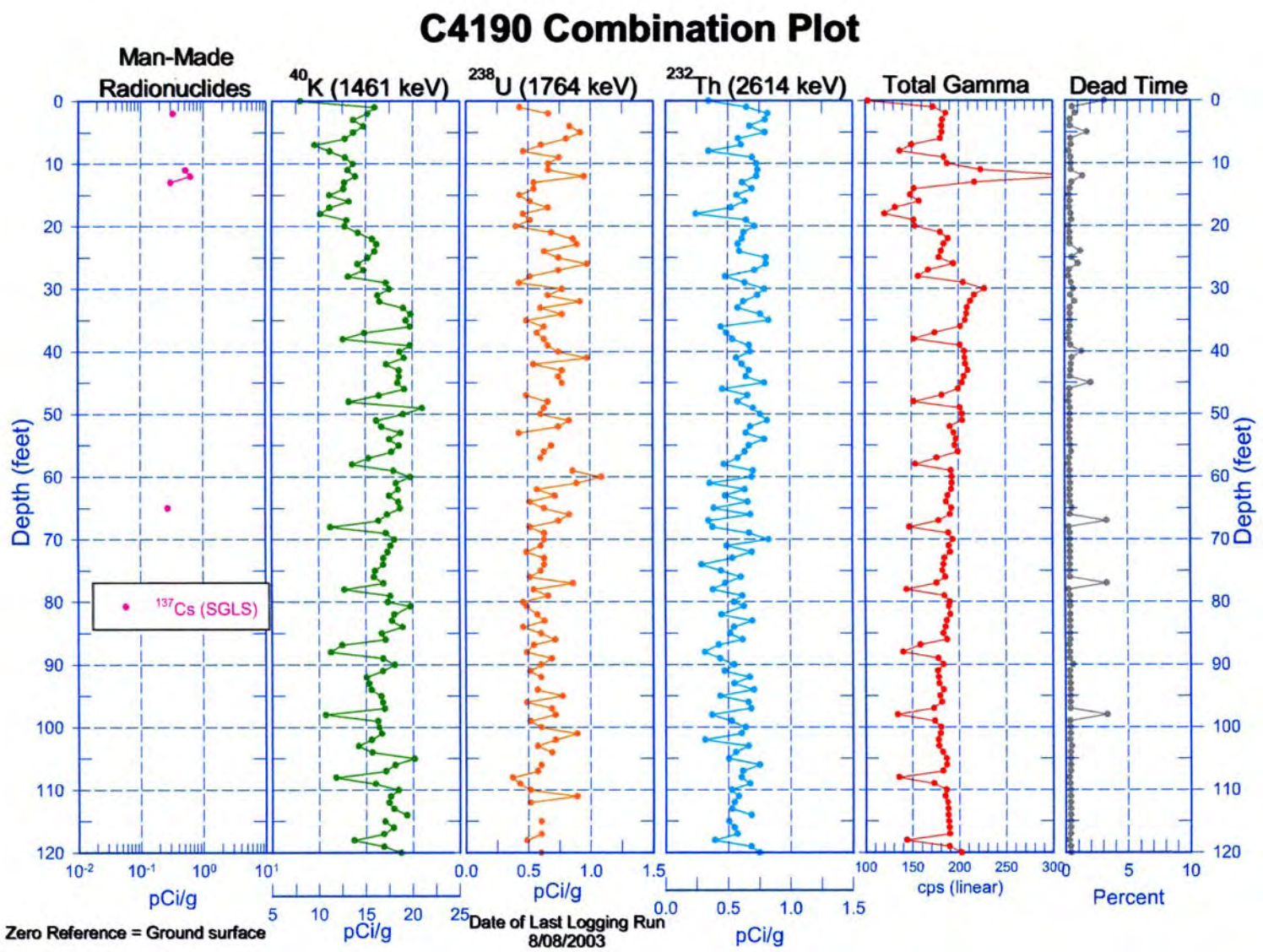
[1] GWL – groundwater level
[2] TOC – top of casing
[3] N/A – not available
[4] n/a – not applicable

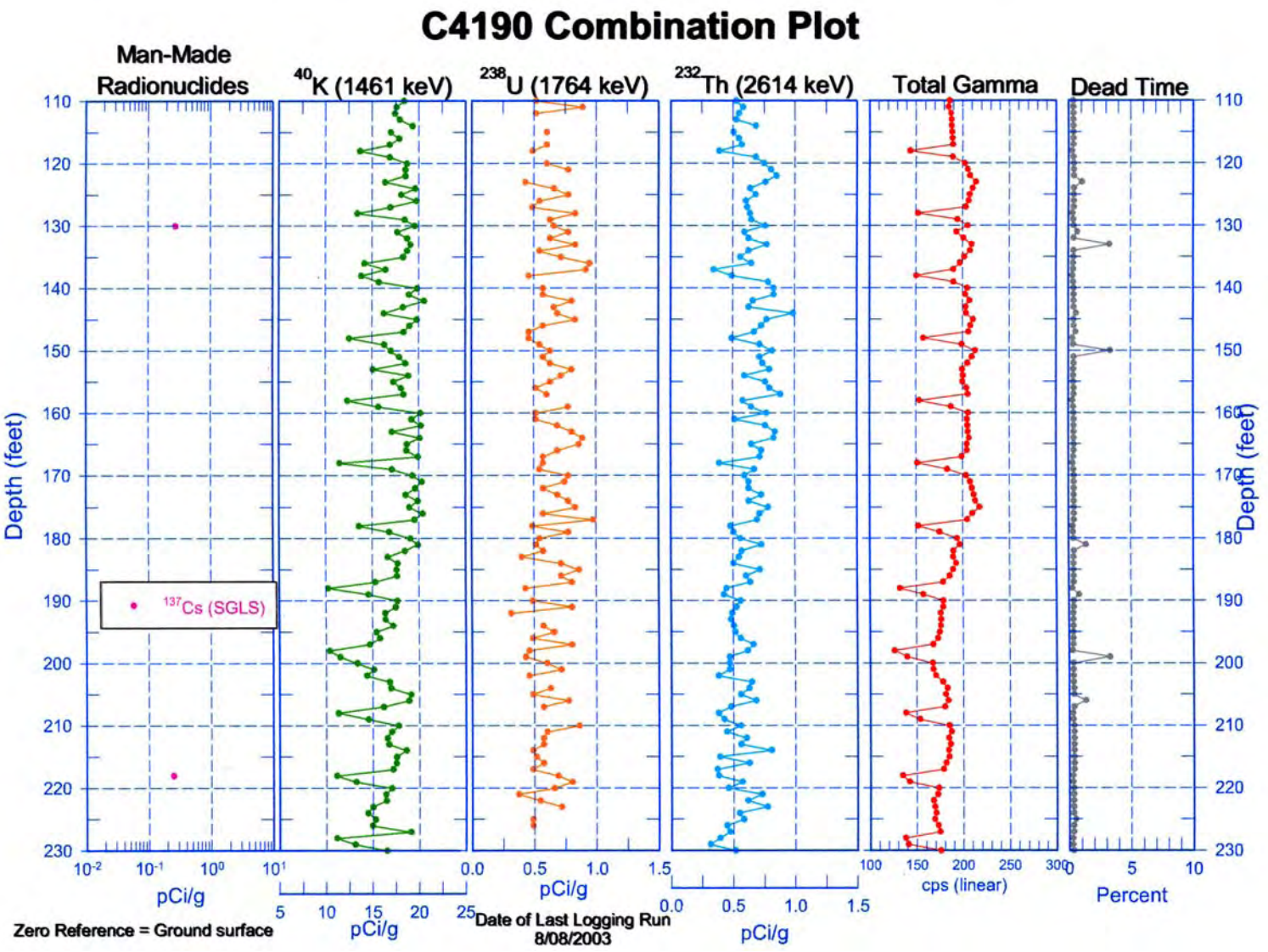

C4190
Man-Made Radionuclides
Depth (feet)
pCi/g
^{137}Cs (662 keV)
^{137}Cs MDL (SGLS)
Zero Reference = Ground Surface
Date of Last Logging Run
8/08/2003

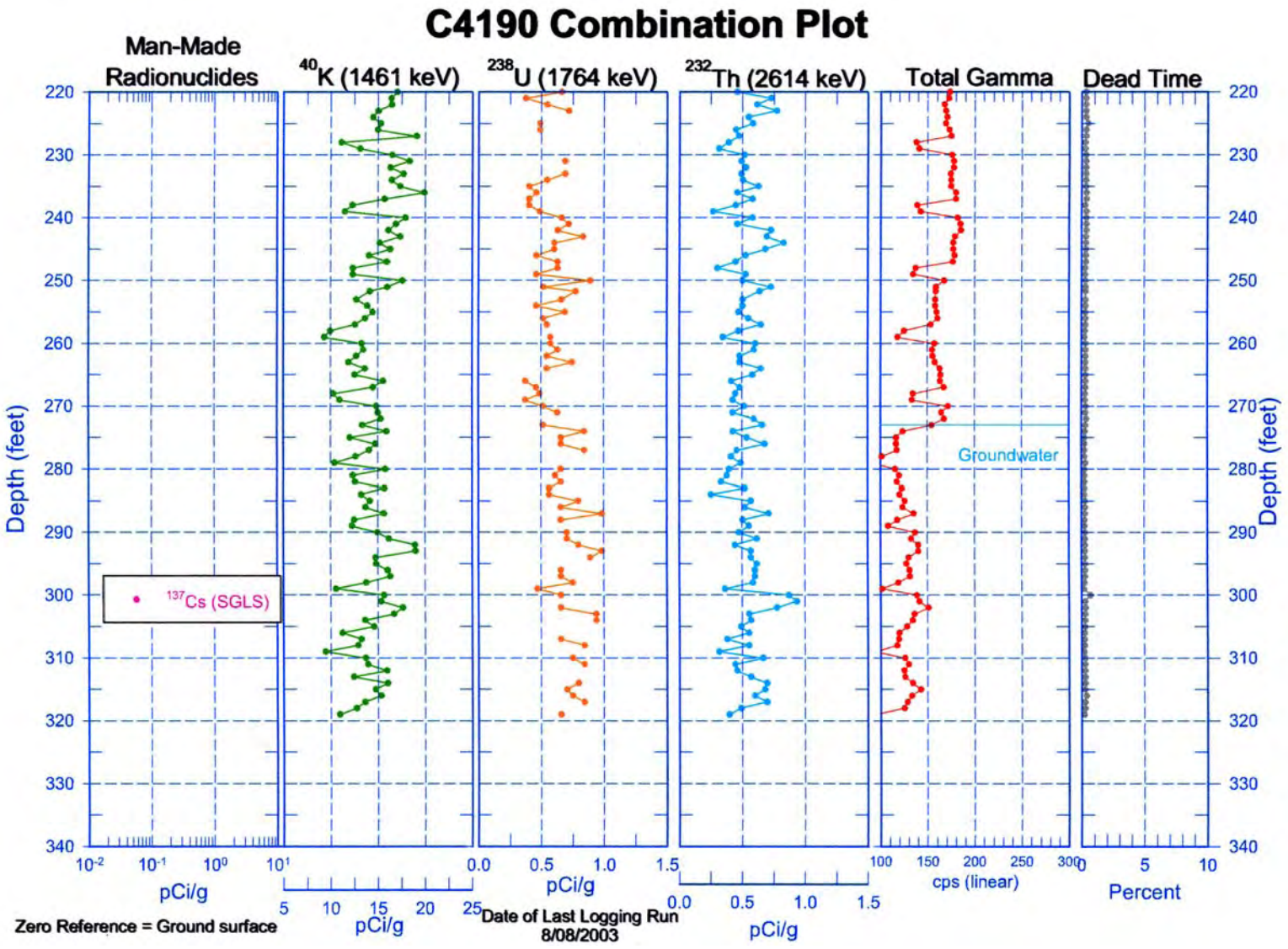

C4190
Man-Made Radionuclides
Depth (feet)
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
^{137}Cs (662 keV)
^{137}Cs MDL (SGLS)
10^{-2}
10^{-1}
10^{0}
10^{1}
pCi/g
Zero Reference = Ground Surface
Date of Last Logging Run
8/08/2003


C4190
Natural Gamma Logs
40K (1461 keV)
238U
232Th (2614 keV)
Depth (feet)
pCi/g
MDL
609 keV
MDL (609 keV)
1764 keV
Zero Reference = Ground Surface
Date of Last Logging Run
8/08/2003

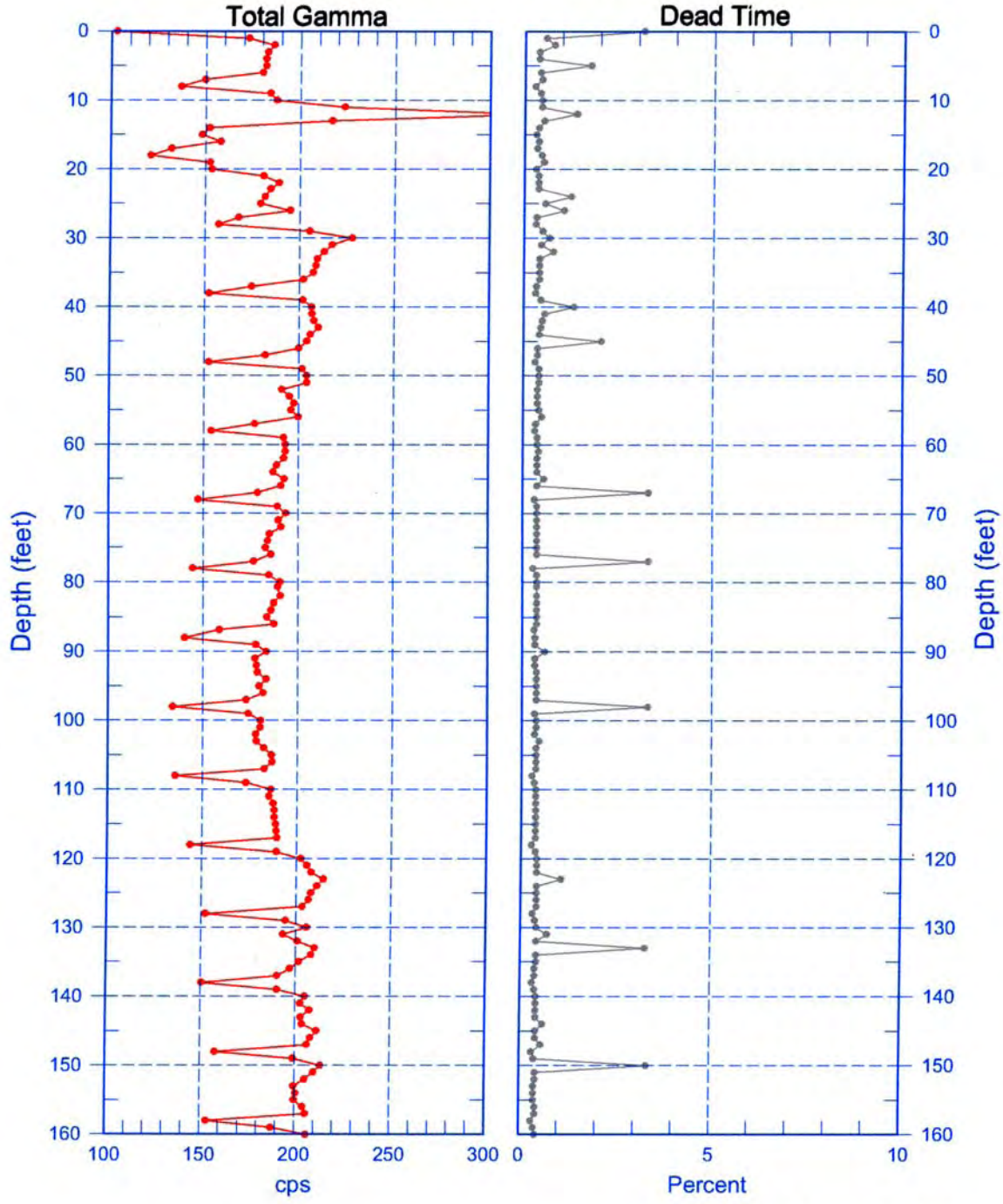

C4190
Natural Gamma Logs
40K (1461 keV)
238U
232Th (2614 keV)
Depth (feet)
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
0 5 10 15 20 25
pCi/g
MDL
0.0 0.5 1.0 1.5 2.0
pCi/g
609 keV
MDL (609 keV)
1764 keV
0.0 0.5 1.0 1.5
pCi/g
Zero Reference = Ground Surface
Date of Last Logging Run
8/08/2003


C4190 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (SGLS)
pCi/g
cps (linear)
Percent
Zero Reference = Ground surface
Date of Last Logging Run
8/08/2003


C4190 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (SGLS)
pCi/g
cps (linear)
Percent
Zero Reference = Ground surface
Date of Last Logging Run
8/08/2003


C4190 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (SGLS)
Groundwater
pCi/g
cps (linear)
Percent
Zero Reference = Ground surface
Date of Last Logging Run
8/08/2003

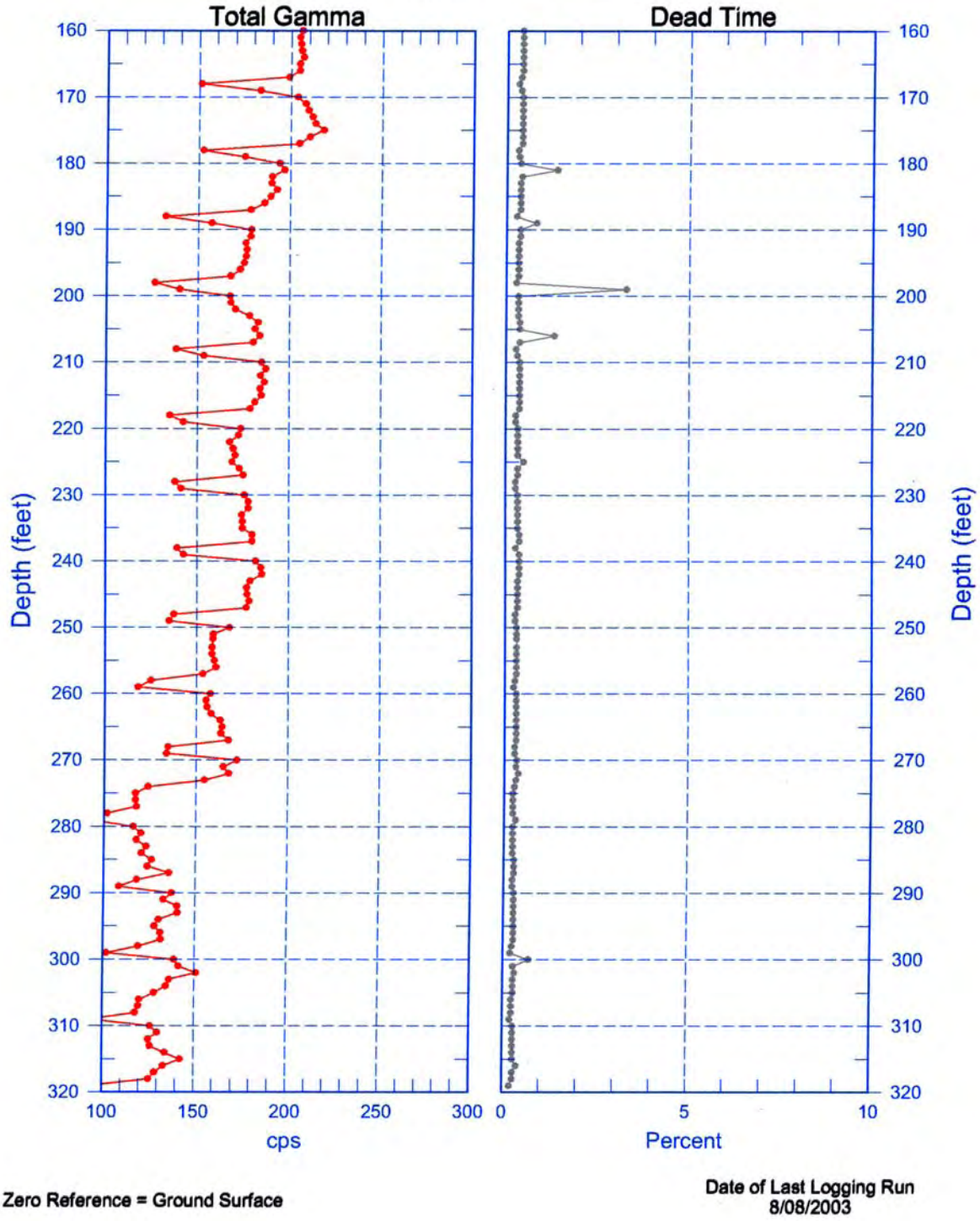
C4190
Total Gamma & Dead Time

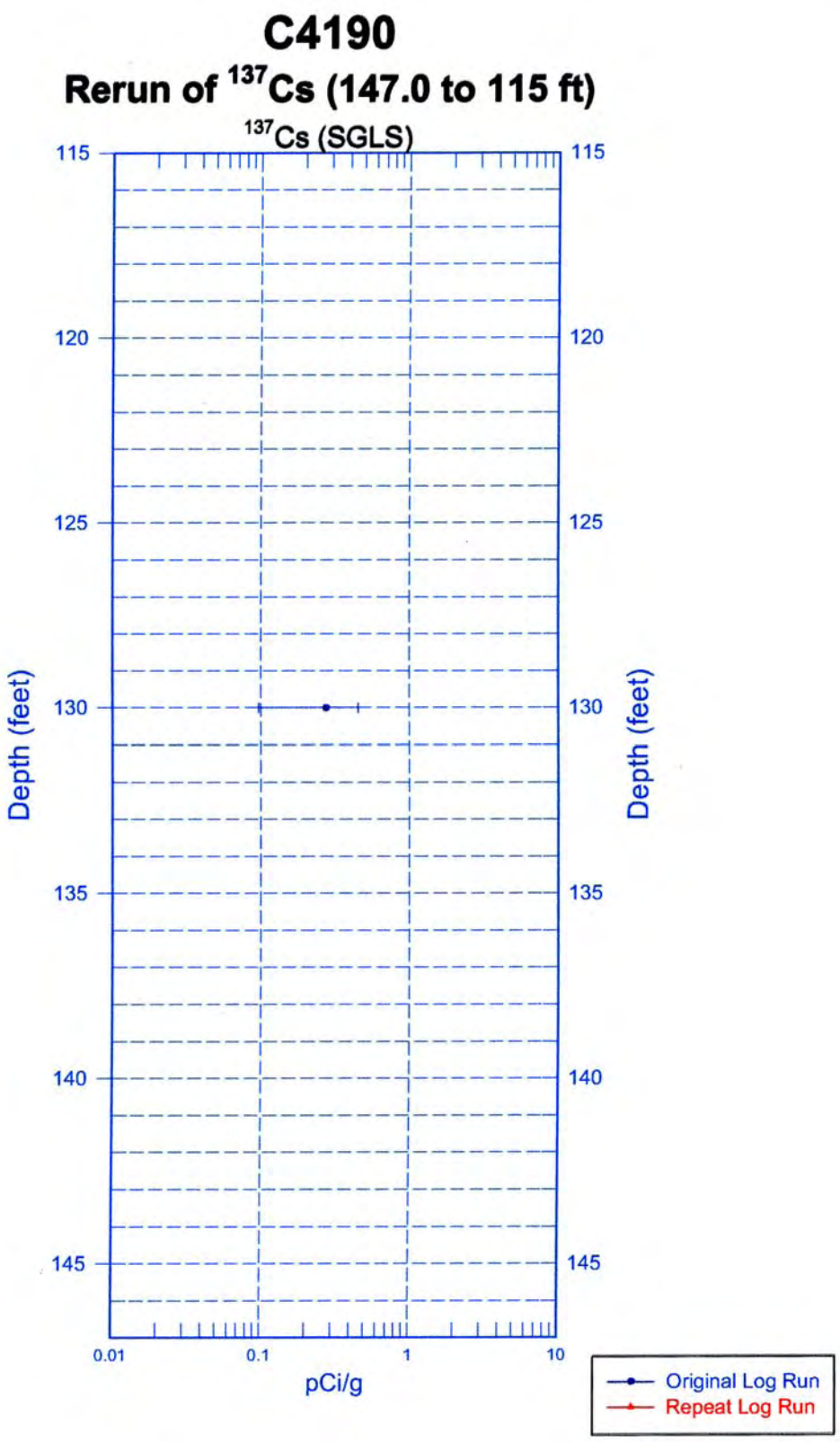


Zero Reference = Ground Surface

Date of Last Logging Run
8/08/2003

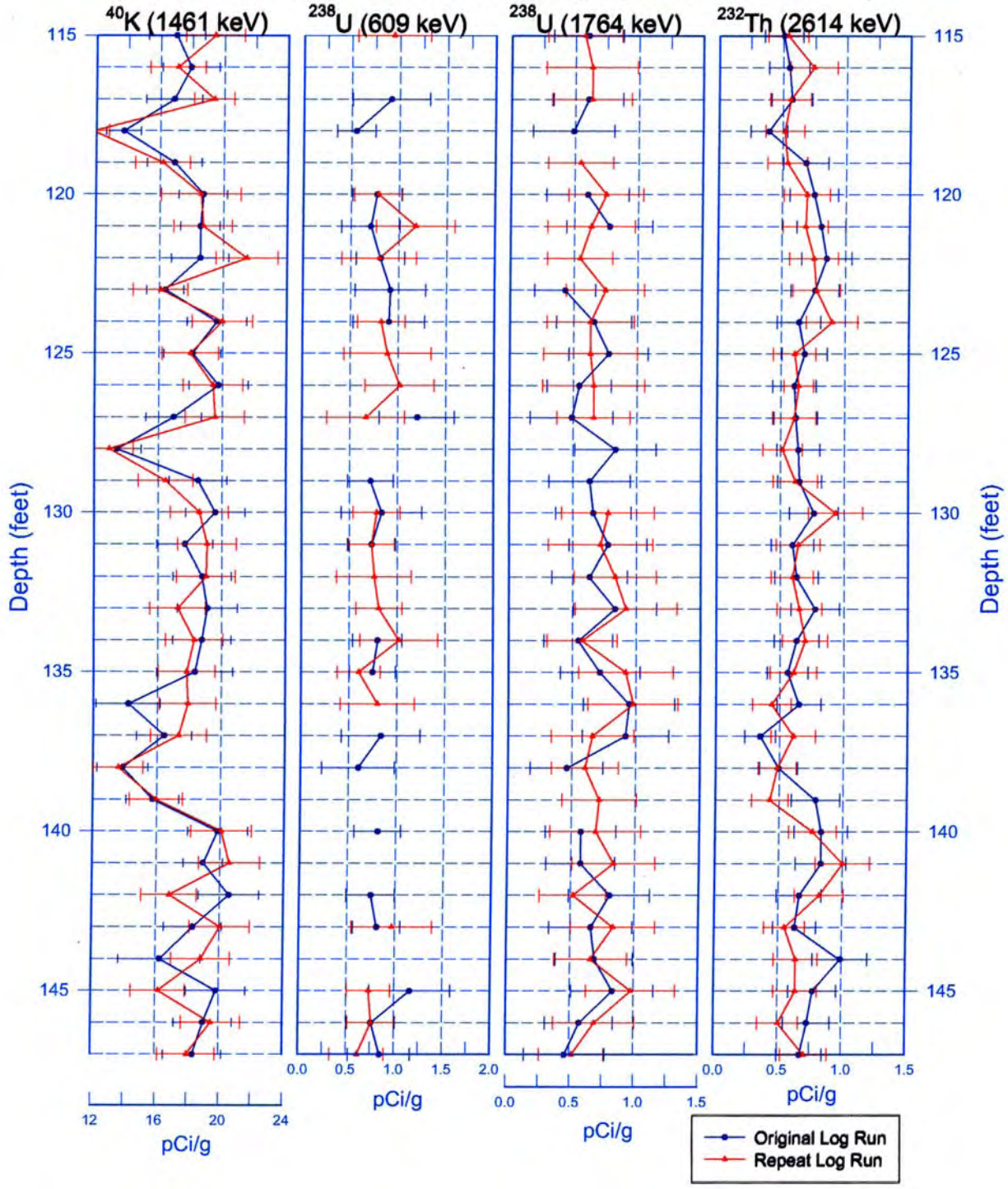
C4190
Total Gamma & Dead Time




C4190
Rerun of 137Cs (147.0 to 115 ft)
137Cs (SGLS)
115
120
125
130
135
140
145
Depth (feet)
0.01
0.1
1
10
pCi/g
Original Log Run
Repeat Log Run

C4190

Rerun of Natural Gamma Logs (147.0 to 115.0 ft)



Gyroscope Data Table for Well 299-E27-22

Hole: C4124	Time	CabLength (feet)	Inclination (fromVert.)	TF Gyro	TFHighSide	CourseDir (0°..360°)	Rec.ID (17)	ClosureDir (0°..360°)	ClosureDist (feet)	TVD (+feet)	+N/-S (feet)	+E/-W (feet)	Dogleg °/ 100f
2 S	2.85	0	0.15	157	293	306	2 S	0	0	0	0	0	0
3 S	3.42	20	0.06	310	90	302	3 S	305	0.04	20	0.02	-0.03	0.5
4 S	4.06	40	0.64	13.3	232	223	4 S	244	0.13	40	-0.1	-0.11	3.2
5 S	4.6	60	1.07	36.6	258	221	5 S	229	0.42	60	-0.3	-0.31	2.1
6 S	5.16	80	1.44	18.7	244	216	6 S	223	0.85	79.99	-0.6	-0.58	1.9
7 S	5.75	100	2.12	63	291	214	7 S	220	1.47	99.98	-1.1	-0.94	3.4
8 S	6.26	120	2.8	96.3	330	208	8 S	216	2.32	119.96	-1.9	-1.37	3.6
9 S	6.93	140	3.51	113	0.9	194	9 S	211	3.38	139.93	-2.9	-1.75	5.2
10 S	7.83	160	4.49	144	38.1	188	10 S	205	4.71	159.89	-4.3	-2	5.4
11 S	8.32	180	5.42	225	123	184	11 S	200	6.37	179.81	-6	-2.16	4.9
12 S	8.86	200	6.19	309	211	179	12 S	196	8.31	199.71	-8	-2.22	4.5
13 S	9.37	220	7.31	352	256	177	13 S	192	10.6	219.57	-10	-2.14	5.8
14 S	9.89	240	7.37	10.4	276	177	14 S	189	13.1	239.4	-13	-2	0.5
15 S	11.2	257	8.4	57.3	316	183	15 S	188	15.4	256.24	-15	-1.99	7.8

Gyroscope Data Table for Well 299-E27-4

Hole: C4125	Time	CabLength (feet)	Inclination (fromVert.)	TF Gyro	TFHighSide	CourseDir (0°..360°)	Rec.ID (17)	ClosureDir (0°..360°)	ClosureDist (feet)	TVD (+feet)	+N/-S (feet)	+E/-W (feet)	Dogleg °/100f
2 S	2.46	0	0.15	357	338	270	2 S	0	0	0	0	0	0
3 S	3.25	20	0.16	335	331	255	3 S	263	0.06	20	-0	-0.05	0.2
4 S	4.02	40	0.5	359	52	199	4 S	229	0.15	40	-0.1	-0.11	2.2
5 S	4.72	60	1	342	52	182	5 S	202	0.38	60	-0.4	-0.14	2.7
6 S	5.31	80	1.48	349	64	177	6 S	190	0.8	79.99	-0.8	-0.13	2.4
7 S	5.8	100	2.38	21.7	105	168	7 S	181	1.45	99.98	-1.5	-0.04	4.7
8 S	6.39	120	2.74	64	154	162	8 S	175	2.32	119.96	-2.3	0.19	2.3
9 S	6.98	140	4.47	127	215	165	9 S	171	3.56	139.92	-3.5	0.54	8.7
10 S	7.57	160	4.56	167	257	162	10 S	169	5.13	159.86	-5	0.99	1.3
11 S	8.11	180	6.37	219	310	161	11 S	167	7.02	179.77	-6.8	1.6	9.1
12 S	8.67	200	6.87	238	331	160	12 S	165	9.31	199.63	-9	2.38	2.7
13 S	9.13	220	7.8	247	345	154	13 S	163	11.8	219.47	-11	3.39	5.7
14 S	9.72	240	8.53	271	10	154	14 S	162	14.7	239.27	-14	4.64	3.7
15 S	10.3	260	9.17	284	26.9	150	15 S	160	17.7	259.03	-17	6.11	4.4
16 S	10.9	280	9.83	280	25.3	148	16 S	158	20.9	278.76	-19	7.82	3.6
17 S	12.7	297	10.1	274	18.3	149	17 S	157	23.9	295.5	-22	9.37	1.9

Gyroscope Data Table for Well 299-E27-21

Hole: C4127	Time	CabLength (feet)	Inclination (fromVert.)	TF Gyro	TFHighSide	CourseDir (0°.360°)	Rec.ID (17)	ClosureDir (0°.360°)	ClosureDist (feet)	TVD (+feet)	+N/-S (feet)	+E/-W (feet)	Dogleg °/ 100f
2 S	2.43	0	0.93	297	199	241	2 S	0	0	0	0	0	0
3 S	3.51	20	0.96	262	156	249	3 S	245	0.33	20	-0.1	-0.3	0.7
4 S	4.49	40	1.57	290	174	259	4 S	251	0.77	39.99	-0.3	-0.72	3.2
5 S	5.1	60	2.04	242	112	273	5 S	258	1.38	59.98	-0.3	-1.35	3.2
6 S	5.77	80	3.13	242	109	276	6 S	265	2.26	79.96	-0.2	-2.25	5.5
7 S	6.39	100	3.34	292	165	270	7 S	268	3.38	99.93	-0.2	-3.38	1.9
8 S	7.05	120	4.12	303	175	271	8 S	268	4.68	119.89	-0.1	-4.68	3.9
9 S	7.8	140	4.9	304	178	269	9 S	269	6.25	139.83	-0.1	-6.25	4
10 S	8.41	160	5.01	312	190	264	10 S	268	7.98	159.75	-0.3	-7.97	2.2
11 S	9.13	180	5.41	56.4	295	263	11 S	267	9.79	179.67	-0.5	-9.78	2
12 S	10.5	200	6.02	150	36	256	12 S	266	11.8	199.57	-0.8	-11.73	4.8
13 S	11.2	220	6.39	184	78.2	248	13 S	264	13.9	219.45	-1.5	-13.79	4.6
14 S	11.9	240	6.25	209	108	244	14 S	261	16	239.33	-2.4	-15.8	2.6
15 S	12.6	260	6.48	267	173	237	15 S	259	18.1	259.21	-3.5	-17.72	4.1
16 S	13.6	280	5.88	39.8	306	236	16 S	257	20.1	279.09	-4.7	-19.51	3
17 S	16.2	298	5.82	93.8	6.5	230	17 S	255	21.7	296.5	-5.8	-20.93	3.8

Gyroscope Data Table for Well 299-E27-23

Hole: C4190	Time	CabLength (feet)	Inclination (fromVert.)	TF Gyro	TFHighSide	CourseDir (0°..360°)	Rec.ID (17)	ClosureDir (0°..360°)	ClosureDist (feet)	TVD (+feet)	+N/-S (feet)	+E/-W (feet)	Dogleg °/ 100f
2 S	2.48	0	0.09	328	342	315	2 S	0	0	0	0	0	0
3 S	3.07	20	0.18	279	141	106	3 S	82.9	0.02	20	0	0.02	1.3
4 S	3.79	40	0.56	342	197	113	4 S	107	0.15	40	-0	0.14	1.9
5 S	4.49	60	1.85	18	248	97.5	5 S	103	0.57	59.99	-0.1	0.55	6.6
6 S	5.05	80	2.02	330	216	82.4	6 S	95.6	1.23	79.98	-0.1	1.22	2.7
7 S	5.69	100	2.36	25.1	285	68.4	7 S	87.7	1.96	99.97	0.08	1.96	3.2
8 S	6.21	120	2.28	62.8	338	52.6	8 S	79.9	2.7	119.95	0.47	2.66	3.2
9 S	6.69	140	1.11	115	52.4	30.8	9 S	74	3.19	139.94	0.88	3.07	6.6
10 S	7.23	160	0.06	190	90	68.2	10 S	71.7	3.35	159.94	1.05	3.18	5.3
11 S	7.77	180	0.68	251	90	129	11 S	73.4	3.42	179.94	0.98	3.28	3.3
12 S	8.34	200	1.75	338	171	135	12 S	79.1	3.65	199.94	0.69	3.59	5.4
13 S	8.82	220	2.64	136	345	120	13 S	86.7	4.21	219.92	0.24	4.2	5.3
14 S	9.36	240	2.87	189	62.4	94.8	14 S	90.3	5.1	239.9	-0	5.1	6.1
15 S	10.1	260	2.86	338	225	80.5	15 S	89.9	6.09	259.88	0.01	6.09	3.6
16 S	10.8	280	3.1	35.5	287	76.7	16 S	88.3	7.11	279.85	0.22	7.11	1.6
17 S	11.7	300	3.64	337	226	79.6	17 S	86.8	8.27	299.81	0.46	8.26	2.8
18 S	13.4	301	3.49	199	85.9	81.2	18 S	86.8	8.3	300.31	0.46	8.29	35.2

Appendix D

Slug Test Characterization Results for Well 299-E27-22 (C4124)

Appendix D

Slug Test Characterization Results for Well 299-E27-22 (C4124)

Battelle
. . . Putting Technology To Work

Project No. F43944

Internal Distribution
F.J. Anderson
M. Connelly
S.P. Luttrell
W.J. McMahon
D.A. Myers
L.C. Swanson
B.A. Williams
C.S. Wright

File/LB

Date September 30, 2003

To J.V. Borghese

From F.A. Spane

Subject Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of WMA-C Well 299-E27-22

The following letter report presents test descriptions and analysis results for multi-stress slug tests that were performed at four specific test/depth intervals within well 299-E27-22. The well is located within Waste Management Area SST C (WMA-C). The tests were performed at four, selected test/depth intervals, as the borehole was advanced to its final depth to the top of basalt at 81.7 m below ground surface (bgs). The primary objective of the hydrologic tests was to provide information pertaining to the variability and vertical distribution of hydraulic conductivity with depth within this region of the WMA-C facility. This type of characterization information is important for predicting/simulating contaminant migration (i.e., numerical flow/transport modeling) and designing proper monitor well strategies for WMA locations. A secondary objective of the program was to evaluate whether acceptable test results could be obtained via the "drill-and-test" method, using the Becker, dual-wall casing, air-percussion, hammer drilling method within anticipated highly permeable test formation conditions. With this respect, a number of slug testing methods and equipment deployments were evaluated for maximizing the quality of the test results obtained. Based on the results of this initial test evaluation, recommendations are also provided in this letter report for improving future, vertical characterization efforts employing the "drill-and-test" technique.

Discrete depth/interval groundwater samples were also obtained periodically during drilling (from cutting slurry returns) for the purpose of qualitatively determining the hydrochemical characteristics and vertical distribution of contaminants at this site. Results from the hydrochemical sampling are not presented in this letter report.

1. Executive Summary

Overall, the test results indicate that slug testing can be utilized rapidly and efficiently with a dual-wall, drill casing system to provide high-quality, vertically distributed hydraulic property characterization information. Slug test characterization of four test/depth intervals (Table 1) within the Hanford formation were attempted during the drilling of well 299-E27-22, to final depth to the top of basalt (81.7 m bgs). Three of the four test/depth intervals ranging in thickness from 0.3 to 1.1 m, were successfully characterized using the slug test method, providing hydraulic conductivity

estimates for these discrete Hanford formation test zones ranging from 0.04 to 6.9E3 m/day. The estimated hydraulic conductivity values obtained for the higher permeability test zones are well within the permeability range of 1.0E3 to 5.0E5 m/day assigned to the Hanford formation in this general area, based on site-wide groundwater flow, inverse calibration modeling (e.g., Wurstner et al. 1995)). Generally such highly permeable formations cannot be characterized using short-duration constant-rate pumping tests. The use of designed slug test characterization programs, where the test interval length (L) and well casing radius (r_c) can be manipulated offers significant promise for the characterization of highly permeable test formations. When combined with drill-and-test borehole programs, the opportunity of determining the vertical distribution of hydraulic conductivity can also be realized.

2. General Hydrologic Test Plan Description

The original hydrologic test plan, as presented in Spane (2003), identified six test/depth intervals that would be characterized at approximate depths below the water table of: 3, 4.5, 6, 12, 18, and 24 m. Testing would commence when the approximate target depth intervals were reached during drilling, and the drilling casing string was retracted exposing an approximate 1.5-m open borehole section. Minor test interval development was identified in the plan to be performed prior to testing for the purpose of removing drilling produced suspended materials from the borehole fluid-column to minimize the effects of borehole/test interval plugging during testing. The interval development was to be completed using either bailing, air-lifting or portable submersible pump methods.

After the borehole development activities were completed, the drilling casing string would be retracted ~1.5 m, and the borehole depth measured. The purpose of the borehole depth measurement was to assess the amount of borehole collapse and to determine the open borehole test interval. A series of multi-stress slug tests would then be performed on the open test interval section. The reason for utilizing a multi-stress slug test approach is to determine whether the slug test response exhibits either variable or stress-level dependence. As noted in Butler (1998) and Spane et al. (2003a), tests exhibiting either variable or stress-level dependence can provide valuable information pertaining to presence of dynamic well skin or non-linear (i.e., turbulence) test response conditions occurring within the test section. Anticipated slug test stress levels applied during testing were expected to be within the range of ~0.3 to 0.5 m for low-stress tests and ~1 m for high-stress tests. The slug tests were to be initiated pneumatically using compressed gas to depress the fluid-column levels to the designed test stress levels. Actual stress levels applied for each test were to be determined by comparing pressure transducer readings below and above the borehole fluid column surface. After the monitored fluid column had stabilized for several minutes at the prescribed stress level, the slug test (slug withdrawal test) would be initiated by suddenly releasing the compressed gas used to depress the borehole fluid-column level. The compressed gas would be released from the borehole column by opening valves (e.g., ball valves) mounted on the surface wellhead used to seal the casing system. As noted in Spane et al. (1996), the gas release valves should have a cross-sectional area that is greater (e.g. >1.5 times) than the cross-sectional area of the test system where fluid level surface is recovering during testing.

As a minimum, two low- and two high-stress tests were recommended to be conducted for each

test/depth interval. Individual slug tests should be fully recovered prior to depressing the fluid column for preparation of the next slug test within the characterization sequence. A wide-range in recovery times were expected based on anticipated range in permeability conditions. For example Spane (2003) predicted recovery times as rapid as <10 secs for high permeability test intervals to >5 min for lower permeability test sections. After slug testing activities were completed, the borehole depth would be re-measured for the purpose of determining any changes to the open borehole interval that may have occurred during testing.

A number of changes to the original test plan had to be made due to unforeseen test/site conditions. These included:

- a shallower depth to the top of basalt
- high instability of the open borehole test intervals
- changes to the general test system utilized

The top of basalt was encountered at a shallower depth than originally anticipated, which reduced the total number of intervals tested from the planned six to an actual four. The high instability of the test formation (i.e., Hanford formation) also caused several changes in the planned testing design. The exposed open borehole test interval produced by retracting the dual-wall casing system was reduced from 1.5 m to ~0.6 m and planned borehole development activities prior to testing were eliminated. The most significant departure from the planned testing design, however, pertains to changes in the downhole test system employed. These changes are discussed in the following report section.

3. Hydrologic Test System Description

Figure 1 shows the general test system configuration that was originally designed to be employed during slug testing. Salient features of the test system configuration are the: dual-wall drilling casing string, a central packer within the inner-casing string, and a surface-seal well-head installation.

The dual-wall, drilling casing string is the system used for borehole advancement during the drilling process. The dimensions of the casing string are reported as:

- Inner Casing: 0.1524-m I.D.; 0.1588-m. O.D.

- Outer Casing: 0.2032-m I.D.; 0.2286-m O.D.

As shown in the figure, an inflatable packer was to be used to isolate/seal the inner casing string from the annular zone between the two casings, where slug test response was originally planned to be initiated and to take place. A 1.5 m well-screen section (not shown in the figure) was also designed to be attached below the packer to maintain an open section for testing after retracting the dual-wall casing. A strain-gauge, 0 to 345 kPa (0 to 35 m) pressure transducer was to be mounted above the packer, with a pressure sensor by-pass tube that connected to the pressure transducer to the test zone below the packer.

These casing dimensions indicate a composite cross-sectional area for the annular space between the two casing strings (which is the location where the slug test responses was design originally to occur) of 0.013 m^2. This calculated cross-sectional area is equivalent to a 0.127-m representative test well casing diameter.

As noted in Section 2, the slug tests were originally designed to be conducted pneumatically, using compressed air to depress fluid levels within the borehole as part of initiating the test. The performance of pneumatic slug tests requires that a surface wellhead (not identified in Figure 1) be utilized to isolate/seal the annular cross-sectional area between the two casing strings. This wellhead isolation of the two casing strings allows containment of the administered compressed gas that will be used to pneumatically depress the annular fluid column to the designed slug test stress levels discussed in Section 2. Salient features of the well-head assembly include:

- an annular surface seal between the dual casing string
- a sealed through-pass connection allowing for passage of pressure transducer and cable to be used to measure pressure response below the inner-casing packer
- an outside pressure probe connection that allows direct measurement of the gas pressure within the annular area below the surface seal
- a gas line connection to allow compressed air to be introduced directly to the annular zone
- surface valves for the rapid/immediate release of the compressed air within the annular zone, which allows for the *immediate* initiation of slug test application.

The preceding discussion describes the test system as originally designed for use during drilling of the well. At a field-site meeting to examine assembled equipment to be utilized during testing approximately 1-week prior to the commencement of well drilling activities at the site, however, it was discovered that a significant flow restriction existed within the percussion bit assembly (i.e., ~1/10 the calculated cross-sectional annular zone area; 0.0013 m^2 vs. 0.013 m^2). It was decided that the test system as originally designed would be utilized on the first test/depth interval (Zone 1; Table 1), and if the system proved to be not completely successful, modifications to the test system would be made for subsequent test/depth intervals. In addition (as noted in Section 2), a number of unforeseen test/site conditions (e.g., borehole instability) were encountered during slug test characterization activities that were attempted for the first test/depth interval. Results obtained during the testing of Zone 1 and initial testing phases of Zone 2 indicated that the flow-restriction area within the bit was being clogged by infilling/collapsing borehole material, which significantly reduced the hydraulic communication between the casing annular zone and the underlying, effected test depth interval (produced by the retracted dual-wall drill casing). As a result, a number of test equipment and test performance modifications were examined during slug testing of the second

test/depth interval (Zone 2; Section 5.2). Based on these test results, the test equipment and test procedures for slug testing were modified for characterizing subsequent test/depth intervals. The modifications included:

- removal of the surface wellhead seal that isolated the inner casing area from the annular zone between the dual-wall casing string
- removal of the packer/screen assembly from the inner casing during testing
- slug tests were conducted both pneumatically and with slugging rods

The removal of the surface wellhead seal was needed to change the primary test response location from the dual-wall casing outer annular zone, to the area monitored by the inside casing string (i.e., I.D. = 0.1524 m). This modification required test stresses to be applied directly to the inner casing string. This change in test response area was necessitated due to results obtained during testing of Zones 1 and 2 that indicated that the annular zone (the zone of active testing) was not in communication with the underling test/depth interval that was created by retracting the dual-wall casing string. As previously discussed, the lack of communication between the casing outer annular zone and the underlying test/depth interval appears to have been the result of borehole instability and the clogging of the small entry port openings in the percussion bit assembly that provide fluid access at the base of the dual-wall casing, annular zone.

To produce analyzable slug test response data within the inner casing string area, the smaller I.D. working string used to deploy the packer/well screen assembly (Figure 1) could not be used. This allowed test responses to be monitored within the larger inner casing string, which is important for characterizing high-permeability test formations. Not using a packer/well-screen system, however, increases the uncertainty of the actual depth interval tested, due to borehole collapse/instability.

Slug testing for Zones 2 through 4 were conducted both pneumatically and using a slugging rod (0.0762 m O.D.), which theoretically produces a maximum initial displacement stress of 0.51 m within the 0.1524 m I.D. inner casing. Using both test methods provides a means of comparing results obtained for tests, where the initial test stress was applied solely within the inner casing (i.e., using the slugging rod) and when the inner casing and outer annular zone were stressed concurrently (i.e., during pneumatic tests).

4. Slug Test Response Predictions/Analysis

As shown in Figure 2 and discussed in Butler (1998) and Spane et al. (2003b), water levels within a stress well can respond in one of three ways to the instantaneously applied stress of a slug test. These response model patterns are: 1) an over-damped response, where the water levels recovers in an exponentially decreasing recovery pattern; 2) an underdamped response, where the slug test response oscillates above and below the initial static, with decreasing peak amplitudes with time; and 3) critically damped, where the slug test behavior exhibits characteristics that are transitional to the

over- and under-damped response patterns. Factors that control the type of slug test response model that will be expressed within a well include a number of aquifer properties (hydraulic conductivity) and well dimension characteristics (well-screen length, well-casing radius, well-radius, aquifer thickness, fluid-column length) and can be expressed by the response damping parameter, C_D, which Butler (1998) reports for unconfined aquifer tests as:

$$C_D = (g/L_e)^{½} r_c^2 \ln (R_e/r_w)/(2 K L) \quad (1)$$

where g = acceleration due to gravity

L_e = effective well water-column length

r_c = well casing radius; i.e., radius of well water-column that is active during testing

R_e = effective test radius parameter; as defined by Bouwer and Rice (1976)

r_w = well radius

K = hydraulic conductivity of test interval

L = well-screen length.

Given the multitude of possible combinations of aquifer properties, well casing dimensions, and test interval lengths, no universal C_D value ranges can be provided that describe slug test response conditions. However, for various combinations anticipated for testing at well 299-E27-22 during drilling the following general guidelines on slug test response prediction are provided:

- C_D >2 = over-damped response
- C_D 1 - 2 = critically-damped response
- C_D <1 = under-damped response

Over-damped test response generally occurs within stress wells monitoring test formations of low to moderately high hydraulic conductivity (e.g., Ringold Formation), and are indicative of test conditions where frictional forces (i.e., resistance of groundwater flow from the test interval to the well) are predominant over test system inertial forces.

Under-damped test response patterns are exhibited within stress wells where inertial forces are predominant over formation frictional forces. This commonly occurs in wells with extremely long well fluid columns (i.e., large water mass within the well column) and/or that penetrate highly permeable aquifers (e.g., Hanford formation). Tests exhibiting under-damped behavior should be conducted with very small stress level applications. If too high of a stress is applied, the slug test response will commonly exhibit oscillatory behavior superimposed on an over- or critically damped recovery response. Methods are currently not available for the analysis of slug tests exhibiting this type of composite slug test response. For test sites exhibiting composite oscillatory behavior, the

tests should be re-run at lower stress levels to allow analysis and quantitative hydraulic property determination using the appropriate, individual, analysis model method (under-, over-, or critically damped).

As mentioned previously, critically damped test responses are indicated by stress well water-level responses that are transitional to the over- and under-damped test conditions, as shown in Figure 2. They typically occur in wells that monitor test formations exhibiting high hydraulic conductivity. As noted in Butler (1998), distinguishing between over- and critically damped slug test response may be difficult in some cases (i.e., due to test signal noise) when examined on arithmetic plots. Proper model identification may be enhanced when semi-log plots are utilized, i.e., log head versus time. Critically damped slug tests exhibit a diagnostic concave-downward pattern when plotted in semi-log plot format. This is in contrast to over-damped response behavior, which displays either a linear or concave upward pattern.

High permeability test sites exhibiting over-damped or composite model response behavior are particularly limiting in the ability to define formations exhibiting higher hydraulic property values. Figure 3 shows predicted slug test responses for hydraulic conductivities ranging between 1 and 100 m/d, for a 1.5 m test interval. It should be noted that the test predictions shown in this section are based on responses occurring within the dual-wall annular zone (i.e., cross-sectional area = 0.013 m^2. These results would be similar, however, for test responses occurring within the inner casing (I.D. = 0.1524 m), due to its similar cross-sectional area of 0.018 m^2. As shown in Figure 3, test intervals having hydraulic conductivity values of approximately 100 m/d or less, should be readily resolved for tests exhibiting over-damped slug test behavior. Under ideal test conditions (i.e., for test not exhibiting complicating early-time transient effects), this permeability characterization limit may be extended up to ~150 m/d.

Because the annular zone cross-sectional area between the dual casing string (i.e., where the test response will occur) is relatively large (0.013 m^2), under-damped (oscillatory) test responses will not occur except under high hydraulic conductivity conditions. Since this type of test response is dependent on the fluid-column length (i.e., the inertial/mass effect), it is not possible to develop test prediction plots that are universally applicable for all test interval depths. Based on preliminary scoping calculations (not shown), however, under-damped slug test responses are likely to be exhibited during testing only when test interval permeabilities exceed 500 to 1,000 m/d (based on the test interval depth).

Methods that can be employed for analyzing unconfined aquifer tests exhibiting high permeability under-, over- or critically damped characteristics include techniques described in Springer and Gelhar (1991), Butler (1998), McElwee and Zenner (1998), Butler and Garnett (2000), Zurbuchen et al. (2002), and Butler et al. (2003). Because of the ease provided by a spreadsheet-based approach, the test analysis method presented in Butler and Garnett (2000) was used for the analysis of all tests, which exhibited high permeability/oscillatory response characteristics. For tests exhibiting intermediate to low permeability response characteristics, the unconfined aquifer analysis methods discussed in Butler (1998) can be employed. A summary and examples of their use under Hanford Site conditions is provided in Spane et al. (2003a).

5. Slug Test Results

The following discussion presents pertinent information describing slug testing activities and analysis results for the four test/depth intervals that were hydrologically characterized, as the borehole was advanced to its final depth to the top of basalt (i.e., 81.7 m bgs). Table 1 summarizes selected test information for the four test/depth intervals.

5.1 Zone 1

At ~0900 hours Pacific Daylight Time (PDT) on September 3, 2003, after reaching a depth of 73.9 m bgs, the dual-wall drill casing was pulled-back (retracted) 0.9 m, producing a theoretical test/depth interval for Zone 1 of 73.0 to 73.9 m bgs. The packer was set at a depth of 72.2 m bgs inside the inner casing string, with the bottom of the attached well-screen assembly set at a depth of 73.8 m bgs. Four pneumatic slug tests (Tests #1 - #4) were conducted between 1200 and 1255 hours, by pressurizing the dual-wall drill casing annular zone using applied stress pressures ranging between 0.50 and 1.0 m for individual tests. No downhole test responses were observed during the application or upon release of the applied compressed gas used to initiate the pneumatic slug tests. Infilling of sand within the packer/well screen assembly and clogging of the restricted entry ports within the percussion air-hammer bit (located at the base of the dual-wall drill casing annular zone) were suspected to have contributed to the unsuccessful hydraulic characterization of this test/depth interval. Although the test characterization results obtained for Zone 1 proved to be unsuccessful, it was decided that the same test system setup and procedure would be used initially for characterizing the next test/depth interval (Zone 2).

5.2 Zone 2

After reaching a depth of 76.2 m bgs at 0800 hours PDT on September 4, 2003, the dual-wall casing was retracted 0.6 m, producing a theoretical test/depth interval for Zone 2 of 75.6 to 76.2 m bgs. The packer was set at a depth of approximately 76.2 m bgs inside the inner casing string, with the bottom of the attached well-screen assembly set at a depth of 73.8 m bgs. Five pneumatic slug tests (Tests #5 - #9) were conducted between 0819 and 0942 hours, by pressurizing the dual-wall drill casing annular zone using applied stress pressures ranging between 0.27 and 1.7 m for individual tests. This was the same test procedure as utilized during testing Zone 1. As was exhibited during testing of Zone 1, no downhole test responses were observed during the application or upon release of the applied compressed gas used to initiate the pneumatic slug tests. This lack of annular zone test response was again attributed to infilling of sand within the packer/well screen assembly and clogging of the restricted entry ports within the percussion air-hammer bit (located at the base of the dual-wall drill casing annular zone). These combined factors were suspected to have contributed to the unsuccessful hydraulic characterization using this test system design.

Based on the unsuccessful test characterization results obtained previously for Zone 1 (tests #1 - #4) and the initial characterization results for Zone 2 (tests #5 - #9), the test equipment and testing procedure were modified for subsequent hydraulic characterization efforts (Note: these

modifications are discussed in Section 3). To initiate characterization of Zone 2 using the modified test system/procedures, the packer/well-screen assembly was removed from the inner casing at 0950 hours PDT, and the borehole re-advanced to a depth of 75.9 m bgs and the dual-wall casing retracted 0.8 m, producing a theoretical test/depth interval of 75.1 to 75.9 m bgs for subsequent characterization testing of Zone 2. Two standard slug withdrawal tests (Tests #10 - #11) were conducted between 1053 and 1059 hours, PDT by rapidly removing a previously submerged slugging rod (0.0762 m O.D.), which theoretically produced a maximum initial displacement stress of 0.51 m within the 0.1524 m I.D. inner casing. Well responses within the inner casing were monitored with a pressure transducer system, which was suspended (in the inner casing) approximately 3.3 m below the static water level. Both slug withdrawal tests produced identical oscillatory test responses, with oscillation periods of approximately 5 secs. Oscillatory test response recovered to static conditions after approximately 40 secs after slug withdrawal initiation.

Figure 4 shows the oscillatory response for test #10 and associated analysis solution match using the high permeability underdamped method as described in Butler and Garnett (2000) and Butler et al. (2003). As shown, a good solution match was obtained using a response dampening parameter, C_D, value of 0.2. Test analysis results for tests #10 and #11 produced nearly identical analysis parameter results, with hydraulic conductivity estimate values ranging between 1.9E3 and 2.1E3 m/day, for the two tests. It should be noted that the test interval length utilized in the analysis was based on a test interval of 1.1 m, which is reflective of the total depth *disturbed* by drilling and the open interval exposed by the retracted dual-wall casing.

After slug withdrawal test #11 was conducted using a slugging rod, modified pneumatic tests (tests #12 and #13) were attempted by resetting the packer/well-screen assembly (bottom set at 75.9 m bgs) back within the inner casing. The pneumatic slug tests were conducted for these tests by pressurizing the small-diameter (I.D. = 0.0254 m) working string used to set the packer, with pressure response monitored immediately below the packer within the test interval section. Tests #12 and #13 were conducted between 1223 and 1233 hours, using applied stress pressures ranging between 1.4 and 2.3 m for individual tests, and then rapidly releasing the introduced compressed air within the small-diameter working string. These pneumatic slug tests were not successful for several technical reasons. First, oscillatory test response characteristics are directly related to the square of the casing radius, r_c, where the oscillatory response takes place as noted in Butler and Garnett (2000). Reducing the casing diameter from 0.1524 m where oscillatory response characteristics were displayed during tests #10 and #11, to 0.0254 m during tests #12 and #13 causes the oscillatory behavior to be theoretically compressed (by a factor of 36!) producing turbulent, non-analyzable responses. Secondly, as noted in Butler et al., (2003) for high-permeability, under-damped tests, the test response should be monitored in proximity to the oscillating surface. For these tests, the pressure response should have been monitored within the 0.0254 tubing, which was not possible due to the O.D. size constraints of the pressure transducers available for this test borehole characterization.

Following completion of test #13, another slug test method was evaluated for possible further characterization use. For test #14, ~19 liters of water were added to the annular zone between the inner casing (0.1524 m) and the 0.0254 m packer working string. To initiate the test, the packer was deflated with the objective of rapidly producing a slug injection oscillatory test response within this inner annular zone, which would be produced by the column of added water above the packer. This

test proved to be unsuccessful, due to the slow and gradual deflation characteristics exhibited by the packer (i.e., > 30 seconds). Because of the response information observed for these tests, pneumatic slug tests using the small-diameter packer working string (e.g., tests #12 and #13) and slug injection tests using packer deflation were not utilized further in characterizing subsequent test/depth intervals.

5.3 Zone 3

After reaching a depth of 77.4 m bgs at 1440 hours PDT on September 4, 2003, the dual-wall casing was retracted 0.6 m, producing a theoretical test/depth interval for Zone 3 of 76.8 to 77.4 m bgs. No inner casing packer/well-screen assembly was utilized for test characterization of Zone 3. A series of four slug tests (Tests #15 - #18) were conducted between 1530 and 1620 hours, PDT by either rapidly removing a previously submerged slugging rod (i.e., slug withdrawal test), or rapidly submerging the slugging rod (i.e., slug injection test). The test responses within the inner casing were monitored with a pressure transducer system, which was suspended (in the inner casing) approximately 3.3 m below the static water level. In all cases, the slug tests exhibited slow over-damped recovery response behavior. Since the recovery times for these tests were extremely slow, consecutive slug injection/withdrawal tests were combined and analyzed compositely using a test history match approach. This approach is particularly useful when analysis of individual tests may be uncertain (i.e., due to only small recovery %), and relies on superimposing the predicted test responses of subsequent tests responses, which can be used to match the entire composite test sequence (test history match).

Figure 5 shows the observed well response for the two slug injection tests and two slug withdrawal tests using the 0.0762 m O.D. slugging rod. Also shown in the figure, is the predicted test history match for the four tests, which was produced by superimposing the four individual slug tests at their appropriate time of test initiation. An increasing water-level trend of +0.0008 m/min was observed over the test period and included in the test history match. As indicated, a hydraulic conductivity, K, of 0.04 m/day provides a good match to the observed test response sequence. To demonstrate the sensitivity of the analytical solution, Figure 6 shows the predicted history match using K values of 0.04, 0.4 and 4 m/day. As indicated, significant departures in the test history matches of the observed test responses are produced with higher K values. This suggests that the interval tested exhibits a K value of ≤0.04 m/day. It is not completely certain whether the relatively low hydraulic conductivity indicated for Zone 3 is actually representative of in-situ formation conditions or an artifact of the drilling process or borehole instability. Depth measurements made prior to and after completion of the slug testing sequence, however, indicated that the 0.6 m test/depth interval remained opened during characterization testing.

A series of three pneumatic slug withdrawal tests (tests #19 - #21) were also conducted between 0722 and 0750 hours, PDT on September 5, 2003. The pneumatic slug tests were conducted by pressurizing the inner-casing (I.D. = 0.1524 m) and the outside annular zone (at the same time) between the dual-wall casing. Both casing areas were pressurized to minimize any non-formational test system effects caused by the outer annular zone being hydraulically connected to the underlying test/depth interval. All pneumatic tests used applied stress (compressed gas) pressures ranging between 0.9 and 1.0 m for individual tests, which was then rapidly released using the wellhead

surface release valves. The pneumatic slug test responses were examined compositely like the slugging rod tests #15 - #18. These tests produced very similar results (i.e., in comparison to the composite slugging rod tests), but are not included in the final test analysis results for this test zone, due to pressure variability exhibited during the pressurization phase.

5.4 Zone 4

After reaching the top of basalt at a depth of 81.7 m bgs at 0915 hours PDT on September 5, 2003, the dual-wall casing was retracted 0.3 m, producing a theoretical test/depth interval for Zone 4 of 81.4 to 81.7 m bgs. As for the proceeding testing for Zone 3, no inner casing packer/well-screen assembly was utilized for test characterization of Zone 4. Two slug tests were conducted between 1007 and 1015 hours, PDT by rapidly submerging (slug injection test #22) and removing the previously submerged slugging rod (slug withdrawal test #23), which theoretically produces a maximum initial displacement stress of 0.51 m within the 0.1524 m I.D. inner casing. Well responses within the inner casing were monitored with a pressure transducer system, which was suspended (in the inner casing) approximately 3.3 m below the static water level. Both slug withdrawal tests produced identical oscillatory test responses, with oscillation periods of approximately 7 secs. Oscillatory test response recovered to static conditions after approximately 70 secs after slug test initiation.

Figure 7 shows the oscillatory response for slug withdrawal test #23 and pertinent analysis solution match using the high permeability underdamped method as described in Butler and Garnett (2000) and Butler et al. (2003). As shown, a good solution match was obtained using a response dampening parameter, C_D, value of 0.175. Similar test analysis results were obtained for slug injection test #22 (not shown), with hydraulic conductivity estimate values ranging between 6.0E3 and 6.9E3 m/day, for the two tests. It should be noted that the test interval length utilized in the analysis was based on a test interval of 0.3 m, which is reflective of the open interval exposed by the retracted dual-wall casing.

After completion of slug withdrawal test #23, two pneumatic slug withdrawal tests (tests #24 and #25) were conducted between 1033 and 1107 hours, PDT on September 5, 2003. The pneumatic slug tests were conducted by pressurizing the inner-casing diameter (I.D. = 0.1524 m) and the outside annular zone (at the same time) between the dual-wall casing. Both casing areas were pressurized to minimize any non-formational test system effects caused by the annular zone being hydraulically connected to the underlying test/depth interval. The pneumatic tests used applied stress (compressed gas) pressures ranging between 0.4 and 0.8 m for the individual tests, which was then rapidly released using the wellhead surface release valves. The pneumatic slug tests (#24 and #25) exhibited similar test results, as were obtained for the slugging-rod slug tests (#22 and #23). Figure 8 shows the oscillatory response for slug withdrawal test #24, and the associated analysis solution match using the high permeability underdamped method as described in Butler and Garnett (2000) and Butler et al. (2003). As shown, a good solution match was obtained using a response dampening parameter, C_D, value of 0.175. Identical test analysis results were obtained for slug withdrawal test #25 (not shown), with a hydraulic conductivity estimate value of 6.0E3 m/day, derived from the two tests.

6. Conclusions

Overall, general test results indicated that slug testing can be utilized rapidly and efficiently with a dual-wall, drill casing system to provide high-quality, vertically distributed hydraulic property characterization information. Results from discrete test/depth interval slug test characterization of the Hanford formation during construction of well 299-E27-22 indicate a wide range in hydraulic conductivity (Table 1), with estimates ranging from 0.04 to 6.9E3 m/day. These hydraulic conductivity estimates were derived for open borehole, test/depth thickness sections ranging from 0.3 to 0.9 m in length, which were calculated based primarily on the length to test formation exposed by retracting the dual-wall drilling casing upon reaching pre-designated drilling depths. Borehole instability and the test interval deformation, however, may significantly decrease or increase the test zone thickness characterized by the slug test methods employed. Because of the dependence of hydraulic conductivity on *actual* test interval length, a ±50% uncertainty is arbitrarily assigned to the hydraulic conductivity estimates derived from the slug test characterizations. This relatively high uncertainty is a function not only of the unstable, open borehole conditions, but also the relatively small test interval lengths utilized during characterization (i.e., test intervals ≤1 m).

The high hydraulic conductivity values determined for test zones exhibiting oscillatory, under-damped slug test behavior (i.e., Zone 2 and Zone 4), demonstrate the ability of the slug testing method to characterize highly permeable test formations, such as the Hanford formation. The estimated hydraulic conductivity values (i.e., 1.9E3 to 6.9E3 m/day) obtained for these high permeability test zones are well within the permeability range of 1.0E3 to 5.0E5 m/day assigned to the Hanford formation in this general area, based on site-wide groundwater flow, inverse calibration modeling (e.g., Figure 9). Generally such highly permeable formations cannot be characterized using short-duration (< 8 hours) constant-rate pumping tests within standard monitoring well facilities. This is primarily due to the extremely small drawdown produced (<0.1 m), which can be attributed to limitations in pumping capacity (i.e., within 0.1016 m I.D. casing ~100 L/min) and long saturated well-screen lengths (e.g., 10 m). As discussed in Spane et al. (2003b), the use of designed slug test characterization programs, however, where the test interval length (L) and well casing radius (r_c) can be manipulated offers significant promise for the characterization of highly permeable test formations. When combined with drill-and-test borehole programs, the opportunity of determining the vertical distribution of hydraulic conductivity can also be realized.

Because of the developmental nature of using slug test characterization methods with the Becker, dual-wall casing, air-percussion, hammer drilling method during the construction of well 299-E27-22, a number of conclusions were derived that relate to the performance evaluation of various slug test strategies and equipment systems. These conclusions are included in the following recommendations section that focuses on improving the drill-and-test slug test characterization method, when coupled with a dual-wall, drill casing percussion system.

7. Recommendations

Based on experience derived from evaluating the slug test characterization results obtained during the construction of well 299-E2-22, a number of slug testing strategy and equipment system design recommendations are provided for the improving the performance of drill-and-test characterization programs.

1. Slug test responses should be initiated and monitored within the inner casing string and not the outer annular zone within the dual-wall drill casing system. This is attributed primarily to the flow entry restriction that occurs within the drill bit that is connected directly to the base of annular zone. To eliminate any complicating effects during testing, the annular zone should be isolated from the inner casing area using a wellhead seal (i.e., when using pneumatic slug tests).

2. Slug tests initiated pneumatically using compressed air and physically using slugging rods, both produced high quality characterization information in high-permeability formations. Pneumatic slug tests provide greater flexibility in controlling slug test response over fixed-volume/stress tests produced by slugging rods.

3. To exercise more control on the test/depth interval section during testing (i.e., open borehole instability concerns), a retrievable packer/well screen should be utilized within the inner casing string, as was utilized during the testing of Zones 1 and 2. Pressure transducers used in monitoring of the imposed slug stress applications should located a short distance below (i.e., within 3 meters) the fluid-column surface within the casing that the slug test response takes place, and not in the test zone below the inflatable packer setting.

4. A variety of working string casing diameters (that are used to set the packer/well-screen assembly) should be available to control/manipulate slug test response for characterizing the full range of expected permeability conditions (e.g., small diameter casing for low permeability test zones; large diameters for high permeability intervals).

5. While acceptable test results were obtained for most test/depth intervals using the drilling rig compressor to initiate pneumatic slug tests, greater stability and control can be realized for these tests using compressed air cylinders and a high precision laboratory regulator system.

6. A real-time test software program should be utilized in the field in concert with the data acquisition system so that test responses can be more rapidly evaluated. This will improve the efficiency of running the test characterization program in the field.

8. References

Bouwer H and RC Rice. 1976. "A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells." *Water Resources Research* 12(3):423-428.

Butler JJ, Jr. 1998. *The design, performance, and analysis of slug tests*. Lewis Publishers, CRC Press, Boca Raton, Florida. .

Butler, JJ, Jr., GC Bohling, ZH Hyder, and CD McElwee. 1994. "The use of slug tests to describe vertical variations in hydraulic conductivity." *Journal of Hydrology* 156:137-162.

Butler, JJ, Jr. and EJ Garnett. 2000. *Simple procedures for analysis of slug tests in formations of high hydraulic conductivity using spreadsheet and Scientific Graphics Software*. Open-file Report 2000-40, Kansas Geological Survey, Lawrence, Kansas.

Butler, JJ, Jr., EJ Garnett, and JM Healey. 2003. "Analysis of slug tests in formations of high hydraulic conductivity." *Ground Water* 41(5):620-630.

McElwee CD and MA Zenner. 1998. "A nonlinear model for analysis of slug-test data." *Water Resources Research* 34(1):55-66.

Spane, FA. 2003. *Hydrologic test plan for slug test characterization activities for WMA-C well C4124 (299-E27-22)*. Letter report to Bruce Williams (Pacific Northwest National Laboratory), July 8, 2003, 8p.

Spane FA, Jr., PD Thorne, and LC Swanson. 1996. "Applicability of slug interference tests for hydraulic characterization of unconfined aquifer: (2) Field test examples." *Ground Water* 34(5):925-933.

Spane, F.A.. Jr., P.D. Thorne, and D.R. Newcomer. 2003a. "Results of detailed hydrologic characterization tests – FY 2002." PNNL-14186. Pacific Northwest National Laboratory, Richland, Washington

Spane FA, Jr., JJ Butler, MD White, and TJ Gilmore. 2003b. "Improving pulse/slug interference tests for contaminated site hydraulic property characterization." SERDP Fiscal Year 2004 Research Proposal, submitted February 25, 2003.

Springer RK and LW Gelhar. 1991. "Characterization of large-scale aquifer heterogeneity in glacial outwash by analysis of slug tests with oscillatory response, Cape Cod, Massachusetts." In U.S. Geological Survey Water Resources Investigations. Report 91-4034:36-40.

Wright, C. 2003. "Aquifer Test Setup." Personal e-mail communication to D.A. Myers and M. Connelly, June 17, 2003.

Wurstner SK, PT Thorne, MA Chamness, MD Freshley, and MD Williams. 1995. "Development of a three-dimensional groundwater model of the Hanford Site unconfined aquifer system: FY 1995 status report." PNL-10886, Pacific Northwest National Laboratory, Richland, Washington

Zubruchen, BR, VA Zlotnik, and JJ Butler, Jr. 2002. "Dynamic interpretation of slug tests in highly permeable aquifers." *Water Resources Research*, 38(3):10.1029/2001WR000354

Table 1. Slug-Test Results for Selected Test/Depth Intervals at Well 299-E27-22.

Test Zone	Test Parameters				Slug Test Response Model	Horizontal Hydraulic Conductivity, K_h,(b) m/d	
	Test Date	Slug Test #	Depth to Water, m bgs	Depth/Test Interval, m bgs		High-K (Oscillatory) Analysis Method (c)	Test History Matching/ Type-Curve Analysis Method(d)
Zone 1	9/3/03	1 - 4	~70.4	73.0 - 73.9 (0.9)	(a)	(a)	(a)
Zone 2	9/4/03	5 - 9	70.2	75.6 - 76.2 (0.6)	(a)	(a)	(a)
		10 -11		75.1 - 75.9 (0.8)	Oscillatory (under-damped)	1.9E3 - 2.1E3	NA
		12 – 14			(a)	(a)	(a)
Zone 3	9/4 - 5/03	15 - 21	70.7 (70.3)*	76.8 - 77.4 (0.6)	Exponential decay (over-damped)	NA	0.04
Zone 4	9/5/03	22 - 25	70.1	81.4 - 81.7 (0.3)	Oscillatory (under-damped)	6.0E3 - 6.9E3	NA

NA: Not applicable
* Depth to water measurement made on September 5, 2003 prior to initiating of pneumatic slug tests (#19 - #21).

(a) No successful tests were completed
(b) Assumed to be uniform within the well-screen test section.
(c) Oscillatory, High-K analysis method as presented in Butler and Garnett (2000) and Butler et al. (2003).
(d) Test history matching, utilizing superposition of sequential test responses. Individual test response predicted using the type-curveanalysis method, as presented in Butler (1998).

Figure 1. General Slug Test System Configuration (modified from Wright, 2003).

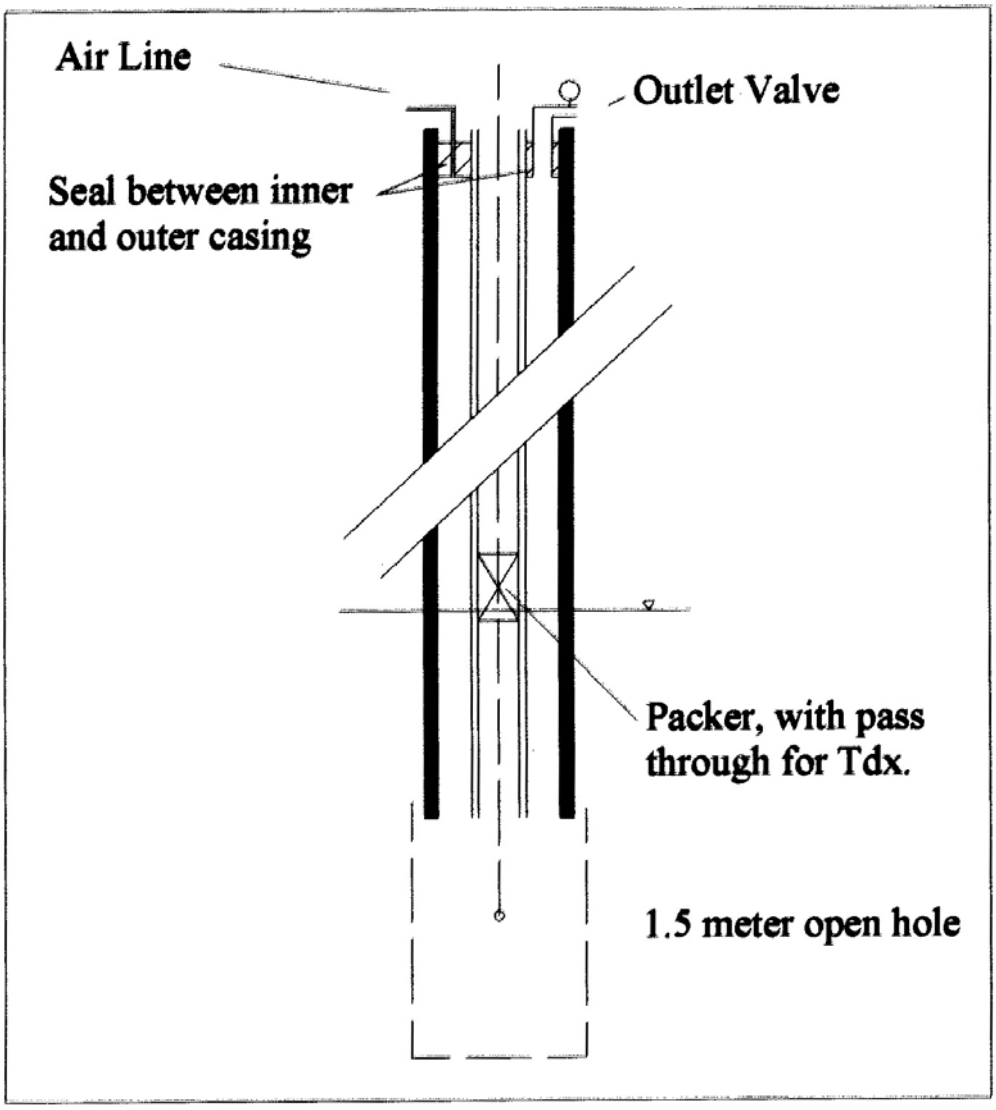


Figure 2. Diagnostic Slug Test Response (taken from Spane et al. (2003b)

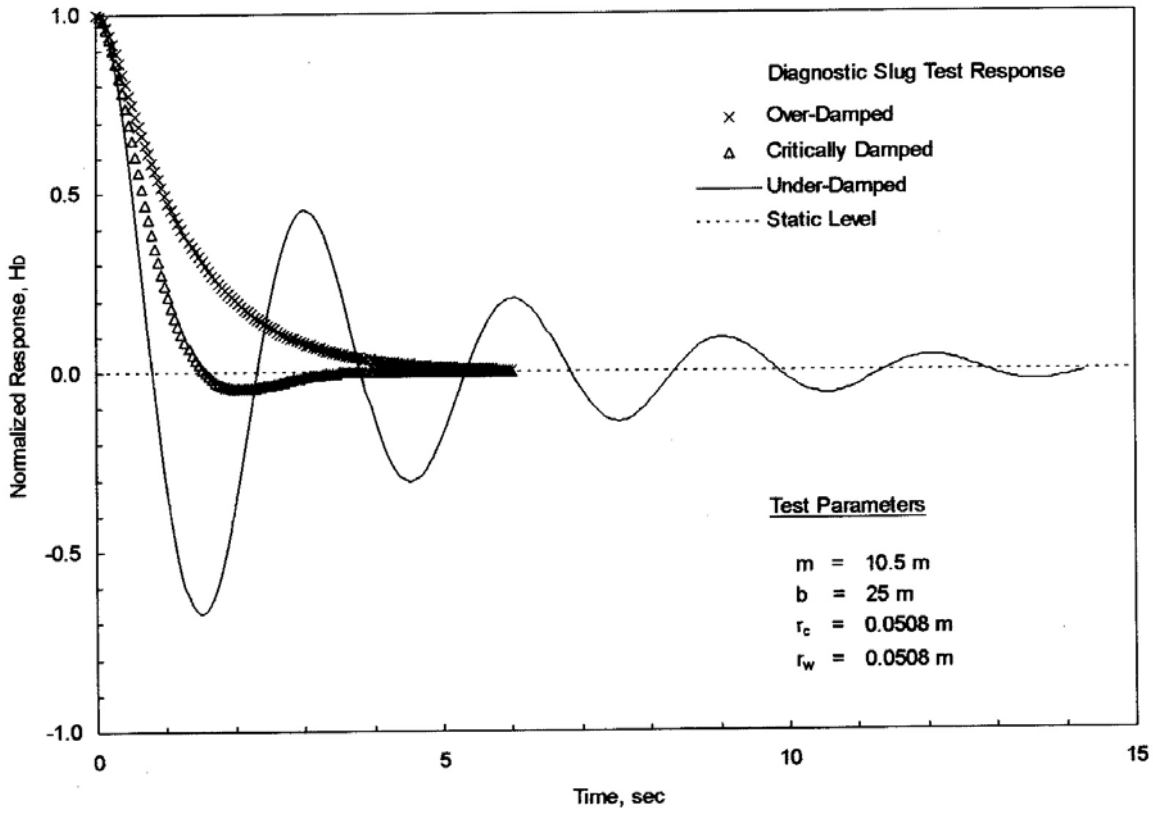


Figure 3. Predicted Over-Damped Slug Test Response as a Function of Test Interval Hydraulic Conductivity

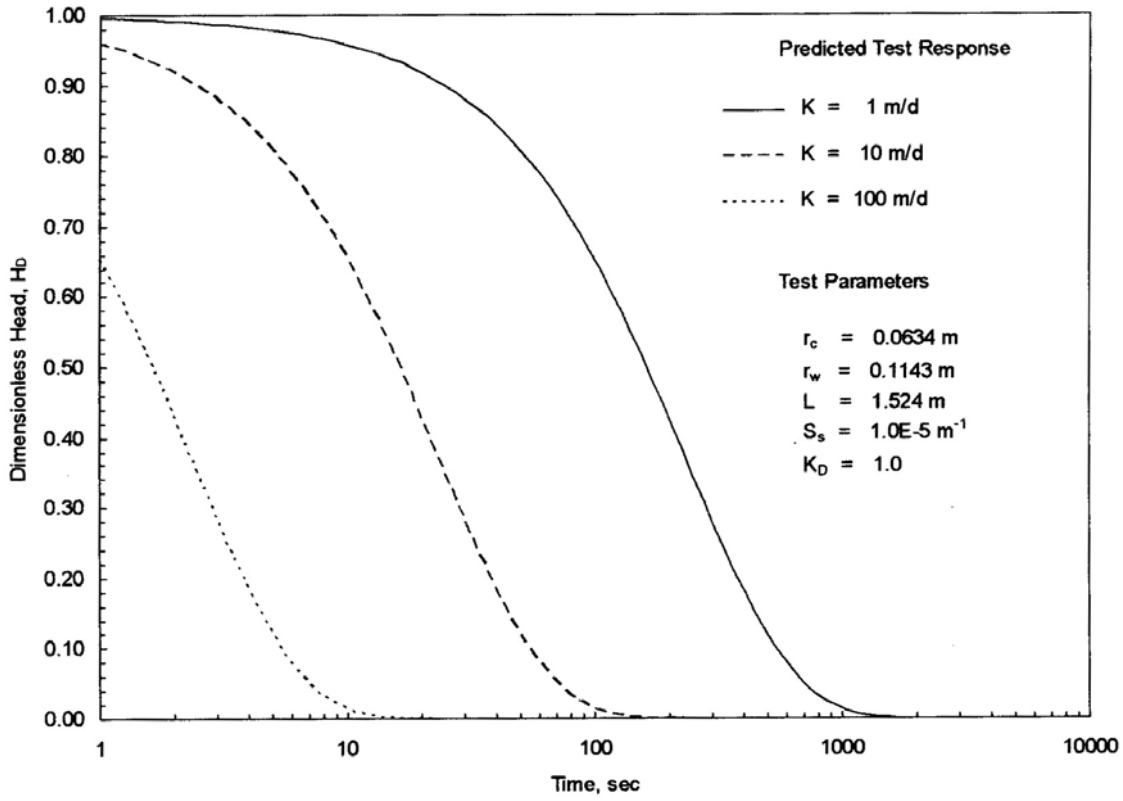


Figure 4. Test Zone 2 Observed Oscillatory Under-Damped Slug Withdrawal Test #10: Response and Analysis

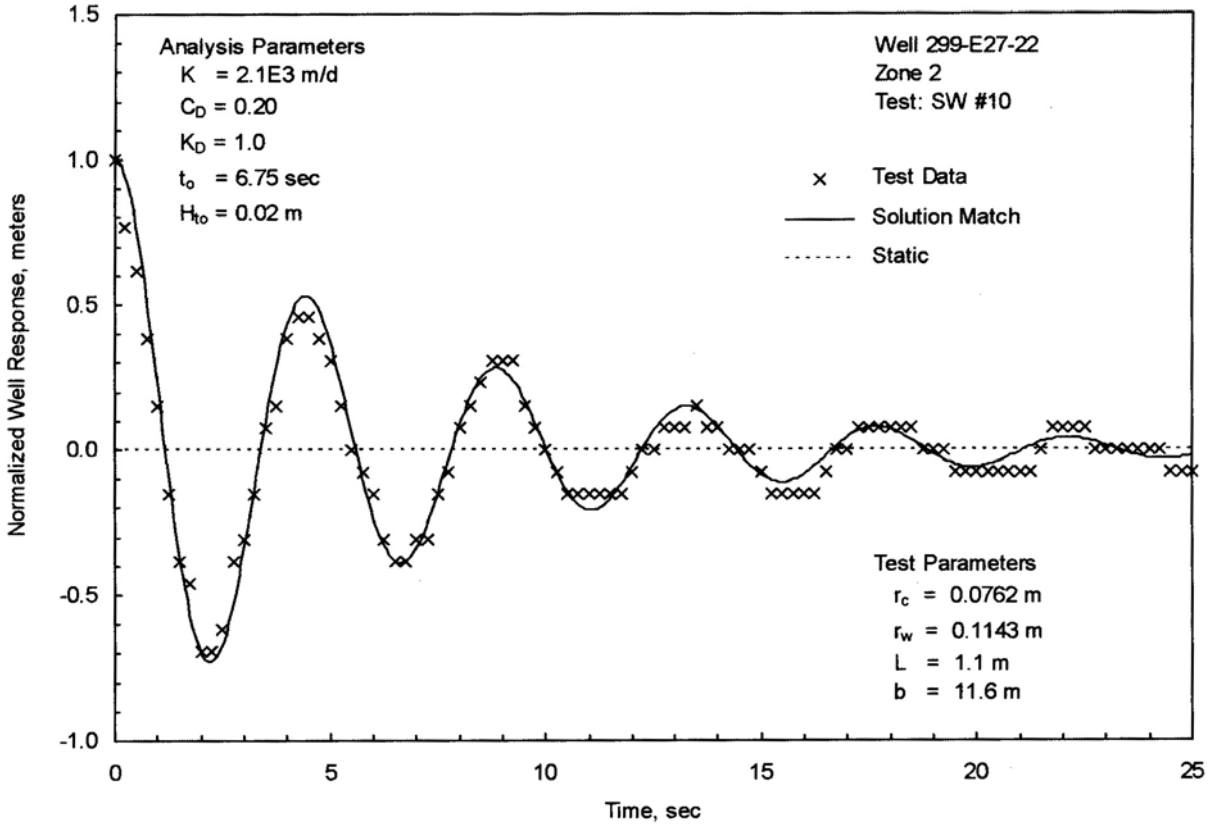


Figure 5. Test Zone 3 Observed Slug Testing Response Sequence, and Test History Match

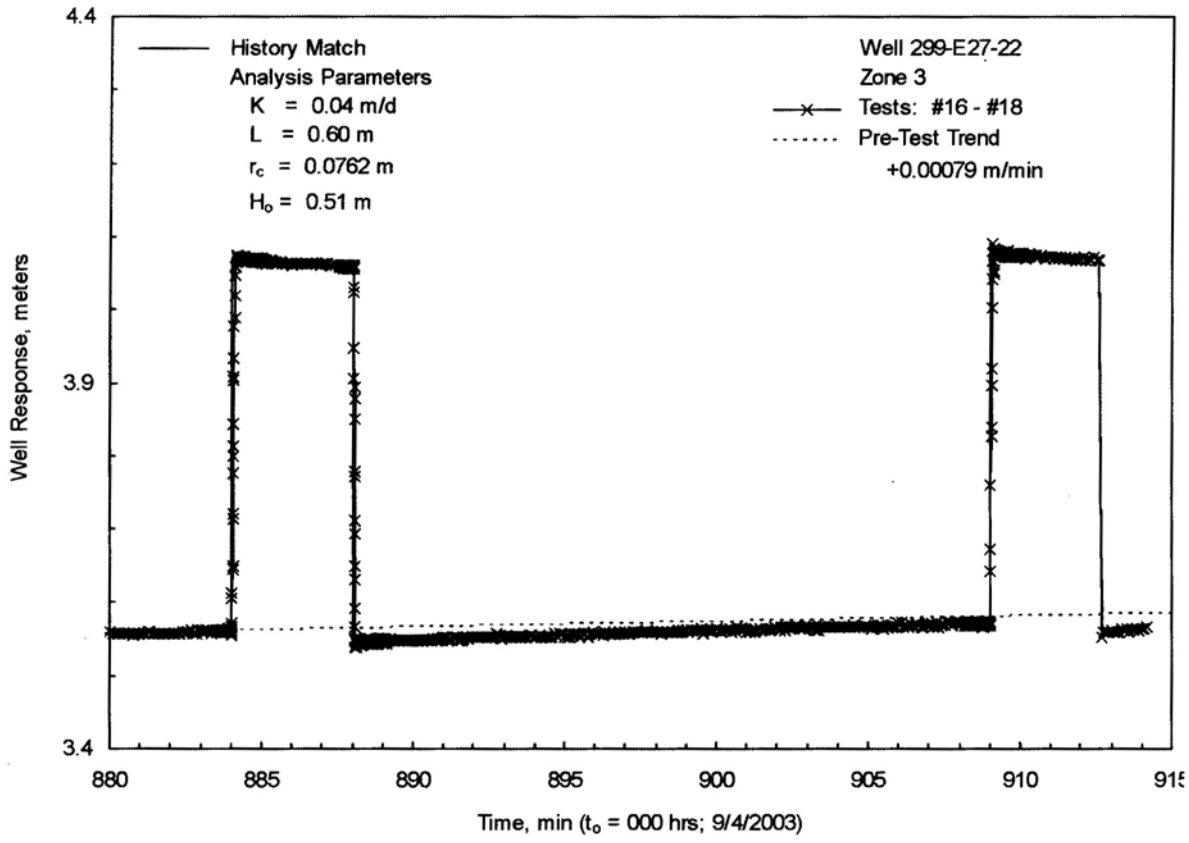


Figure 6. Test Zone 3 Observed Slug Testing Response Sequence, and Test History Match: Sensitivity to Varying K values (0.04, 0.4, and 4.0 m/day)

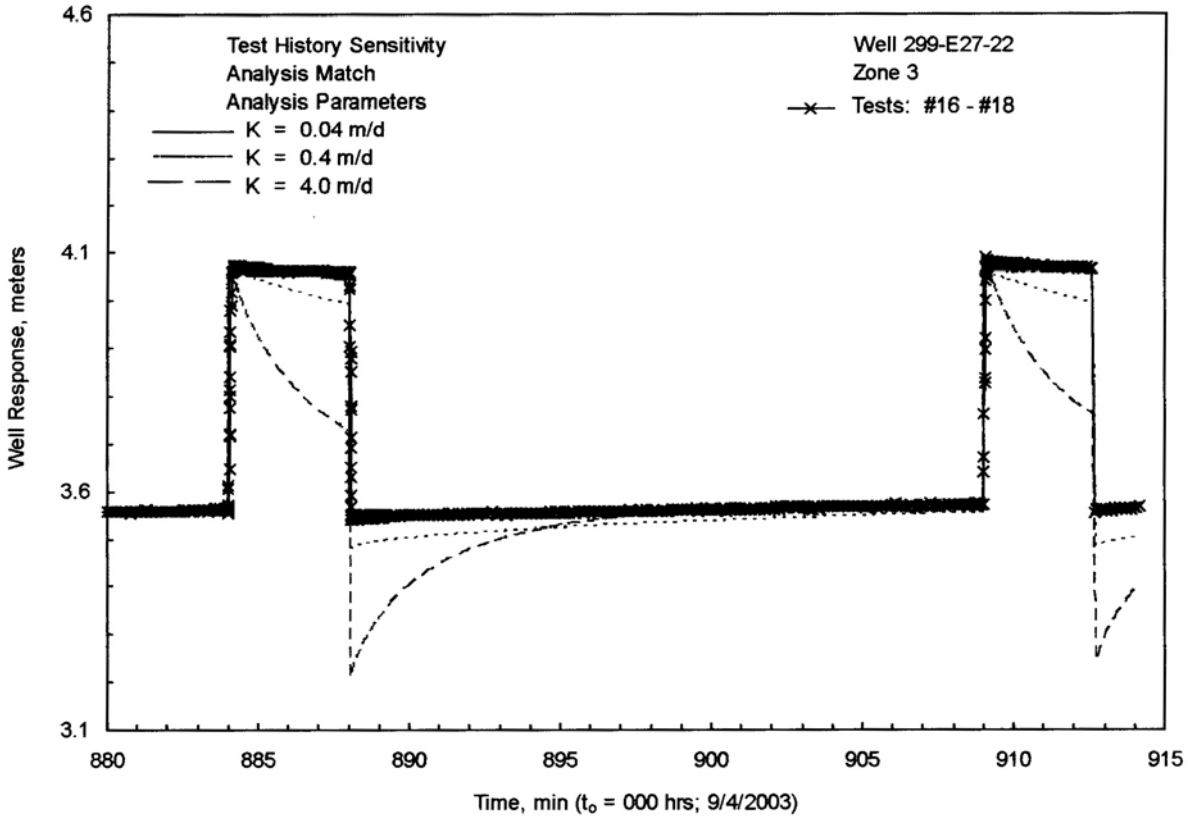


Figure 7. Test Zone 4 Observed Oscillatory Under-Damped Slug Withdrawal Test #23: Response and Analysis

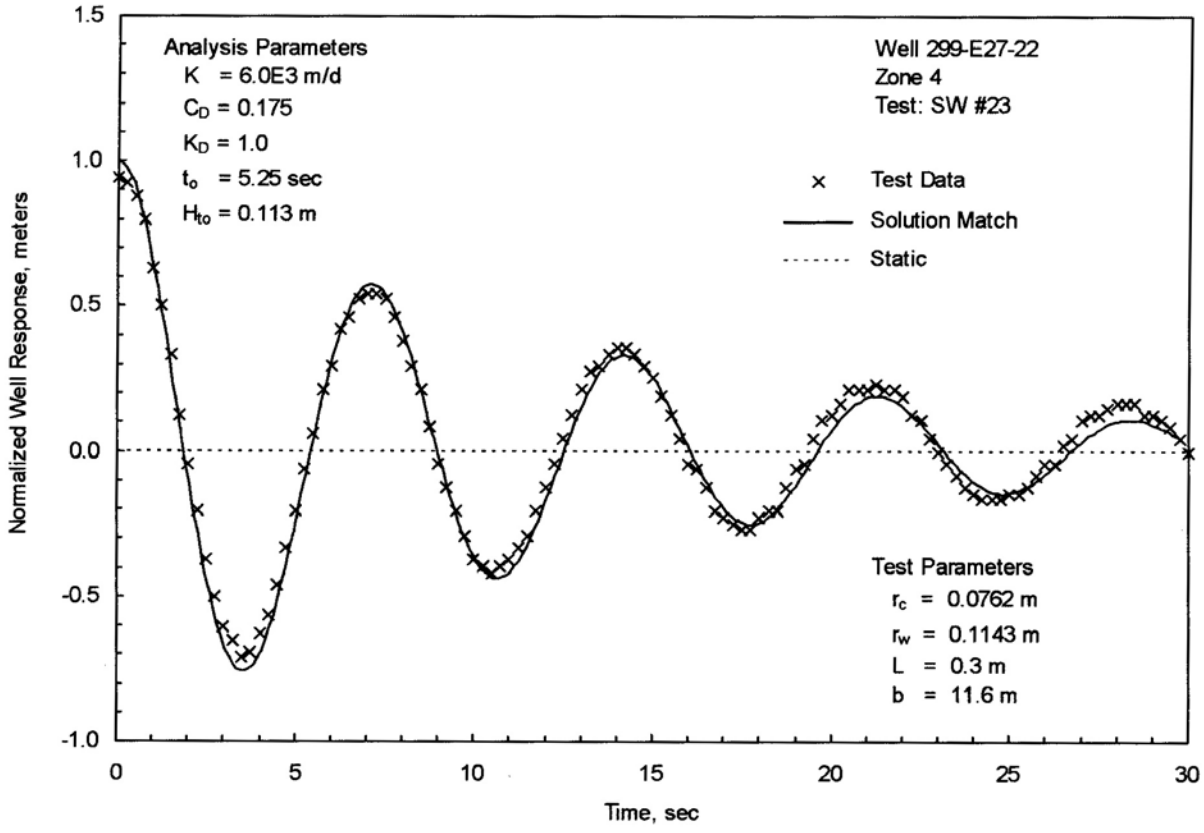


Figure 8. Test Zone 4 Observed Oscillatory Under-Damped Slug Withdrawal Test #24: Response and Analysis

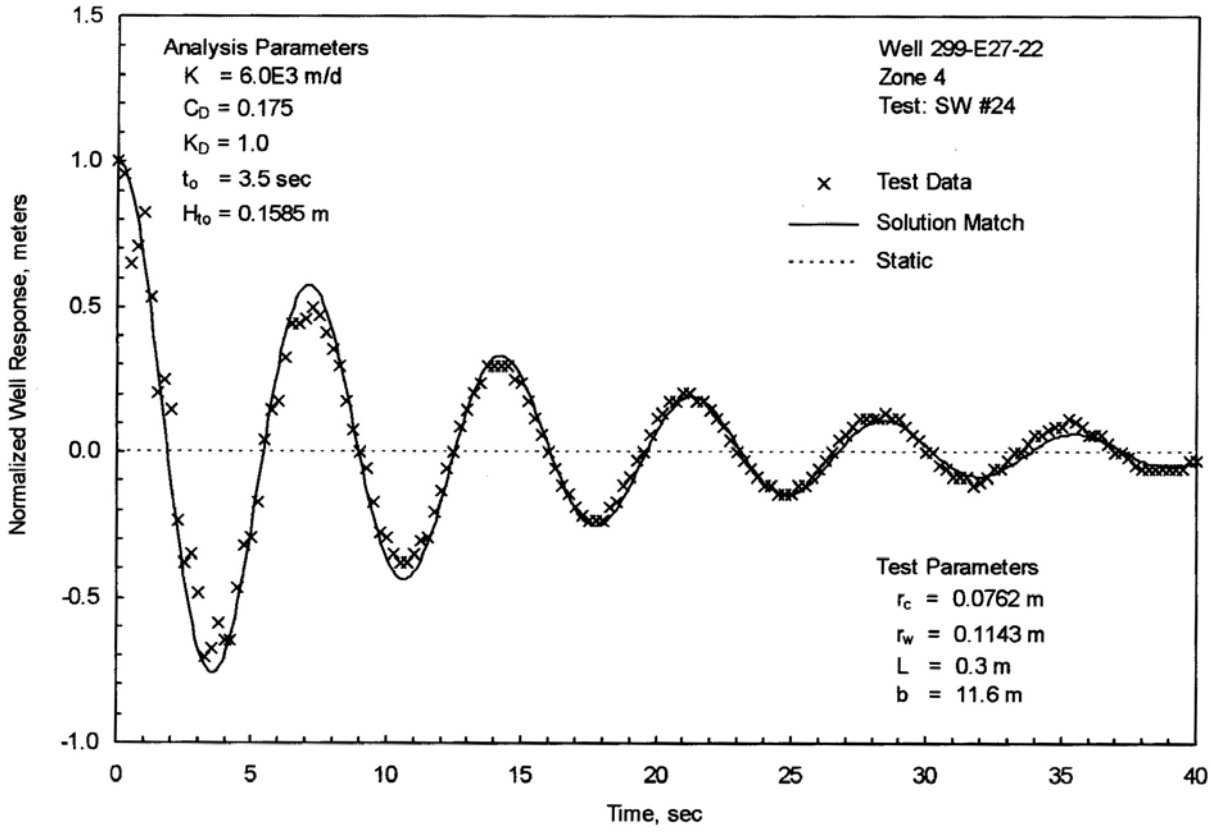
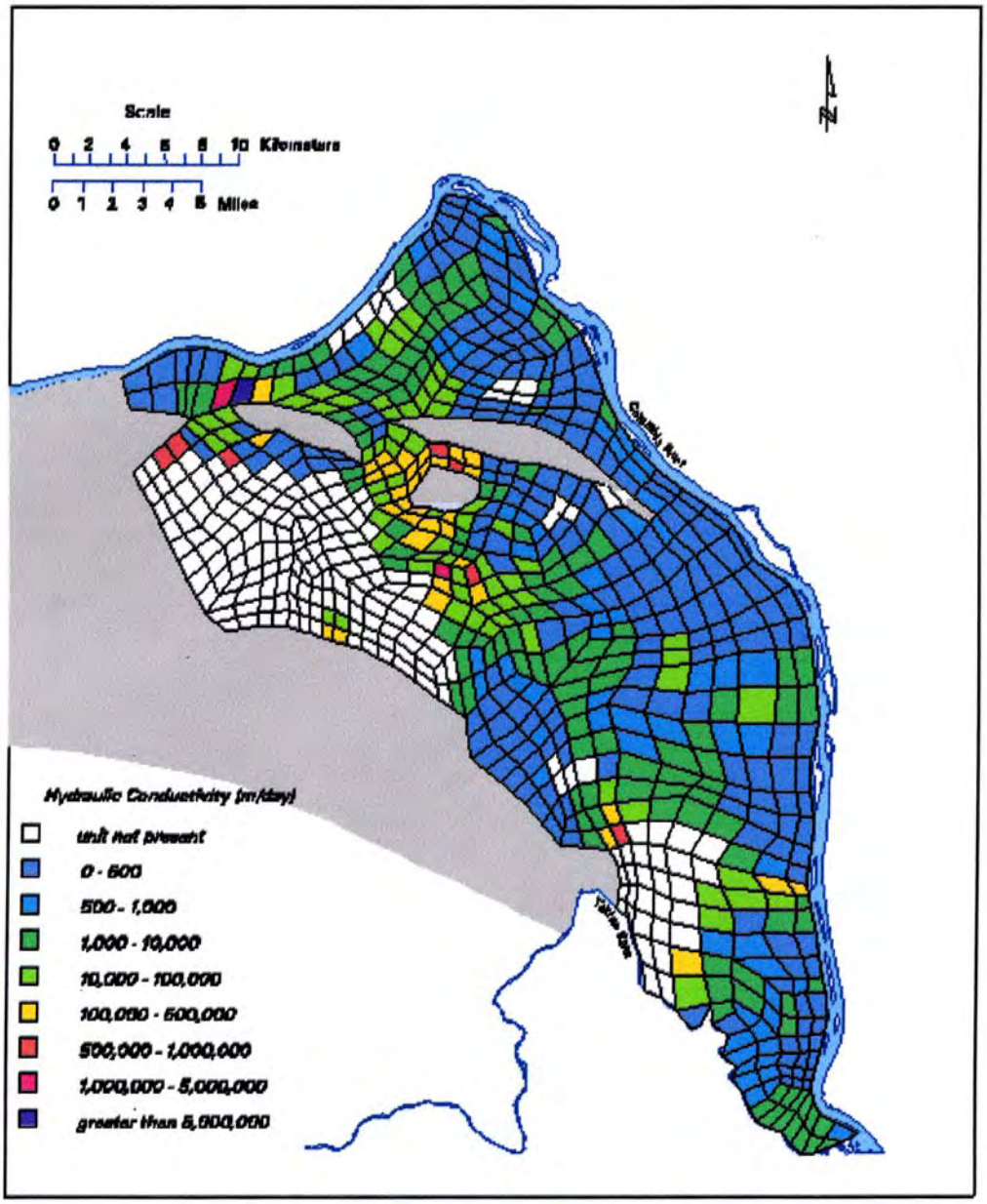


Figure 9. Hydraulic Conductivity Values Assigned to the Hanford Formation, Based on Hanford Site Groundwater Flow, Inverse Calibration Modeling (taken from Wurstner et al. 1995).



Distribution

No. of Copies

OFFSITE

Confederated Tribes and Bands of the
Yakama Indian Nation
Environmental Restoration/
Waste Management Program
P.O. Box 151
Toppenish, WA 98948
ATTN: R. Jim

Confederated Tribes of the Umatilla
Indian Reservation
P.O. Box 638
Pendleton, OR 97801
ATTN: B. Burke
T. Repasky

Nez Perce Tribe
Nez Perce Tribal Department of
Environmental Restoration and Waste
Management
P.O. Box 365
Lapwai, ID 83540
ATTN: D. Powaukee
D. Landeen

S. Van Verst
Washington State Department of Health
Division of Radiation Protection
P.O. Box 47827
Olympia, WA 98504-7827

ONSITE

4 **DOE Richland Operations Office**

R. D. Hildebrand A6-38
K. M. Thompson A6-38

No. of Copies

R. M. Yasek H6-60
Public Reading Room H2-53

2 **Fluor Hanford, Inc.**

J. V. Borghese E6-35

4 **CH2M HILL Hanford Group, Inc.**

F. J. Anderson E6-35
J.M. Faurote H6-62
C.R. Martinez H6-62
D.C. Weekes H6-62

U.S. Environmental Protection Agency

D. Faulk B5-01

4 **Washington State Department of Ecology**

J. A. Caggiano HO-57
S. L. Dahl-Crumpler HO-57
D. N. Goswami HO-57
F. Hodges HO-57

11 **Pacific Northwest National Laboratory**

C. J. Chou K6-81
D. G. Horton K6-81
S. P. Luttrell K6-96
S. M. Narbutovskih K6-96
F. A. Spane K6-96
D. Vela K6-96
B. A. Williams (3) K6-81
Hanford Technical Library (2) P8-55