LMS/CNT/S10873

2013 Well Completion Report for Corrective Action Unit 443 Central Nevada Test Area Nye County, Nevada

June 2014

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Abbreviations

API	American Petroleum Institute
AWG	American Wire Gauge
bgs	below ground surface
BLM	U.S. Bureau of Land Management
Boart	Boart Longyear Drilling Services
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAU	Corrective Action Unit
CNTA	Central Nevada Test Area
DOE	U.S. Department of Energy
DRI	Desert Research Institute
FFACO	Federal Facility Agreement and Consent Order
FMP	Fluid Management Plan
ft	feet
ft^3	cubic feet
gpm	gallons per minute
ID	inside diameter
ISMS	Integrated Safety Management System
JSA	job safety analysis
MDA	minimum detectable activity
MDC	minimum detectable concentration
mg/L	milligrams per liter
MV	monitoring/validation
NaBr	sodium bromide
NDEP	Nevada Division of Environmental Protection
NEPA	National Environmental Policy Act
NTU	nephelometric turbidity unit
OD	outside diameter
pCi/L	picocuries per liter
PVC	polyvinyl chloride
SHPO	State Historic Preservation Office

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Executive Summary

This report summarizes results from the drilling program that was conducted in 2013 as part of the corrective action strategy for Corrective Action Unit (CAU) 443 at the Central Nevada Test Area (CNTA). The drilling program included the installation of a monitoring/validation (MV) well (MV-6), replacing the electric submersible pump in well HTH-2, and removing electric submersible pumps from wells MV-4 and MV-5. A new well head and concrete well pad with locking steel well box was also installed at well UC-1-P-2SR. The corrective action strategy for the site is described in the Corrective Action Decision Document/Corrective Action Plan addendum (DOE 2008) that the Nevada Division of Environmental Protection approved (NDEP 2008).

The corrective action strategy and drilling programs conducted in 2009 and 2013 were designed to enhance monitoring of the alluvial aquifer. Head levels from the onsite wells (Figure 2) indicate that the most likely transport direction from the UC-1 detonation cavity is downward, toward densely welded tuff units in volcanic rocks below the detonation cavity. However, given the processes of prompt injection and convective mixing in the nuclear chimney, migration upward into the alluvial aquifer could not be ruled out. Alluvial wells are typically more productive than those in the deeper volcanic rocks, making the alluvial aquifer the most likely source for future groundwater development and, therefore, the most likely access path to potential receptors. The new well (MV-6) was designed and positioned inside the graben to monitor for potential contamination in the alluvial aquifer at a location east of the UC-1 detonation cavity (Figure 2). The new well was also designed to provide hydrogeologic head and groundwater chemistry data.

Samples of the drilling fluid and groundwater discharged during development were collected to be screened in the field for tritium using a Triathler liquid scintillation counter. The field screening results indicated no concentrations of tritium above the minimum detectable concentrations that ranged from 2,985 to 4,391 picocuries per liter (pCi/L). The field samples were reanalyzed at the Office of Legacy Management Environmental Sciences Laboratory using a PerkinElmer Tri-Carb liquid scintillation counter on October 7, 2013. The field samples were reanalyzed to allow an increased sample count time and lower minimum detectable concentration. The reanalyzed field samples indicated no concentrations of tritium above the minimum detectable concentration of 385 pCi/L.

The entire drilling program (mobilizing/demobilizing, drilling, well construction, well development, installing a pump in the new well, and removing and installing pumps in existing wells) was accomplished in 13 days (September 8 through 20, 2013). Operations were conducted 24 hours per day (working two 12-hour shifts) and 7 days per week for the duration of the project; for a few days during mobilization and demobilization of the project, work was done only during daylight hours.

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1.0 Introduction

This report summarizes the field activities and data collected during the drilling program that was conducted by the U.S. Department of Energy (DOE) Office of Legacy Management at the Central Nevada Test Area (CNTA). The well installation activities were done as part of the implementation of the Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP) Addendum for Corrective Action Unit (CAU) 443 at the CNTA (DOE 2008). The CADD/CAP addendum was revised in July 2013 with a Record of Technical Change to further enhance the well network and monitoring of the alluvial aquifer at the site. Field activities associated with the project were done as part of the Federal Facility Agreement and Consent Order (FFACO 1996) and in accordance with applicable Nevada Division of Environmental Protection (NDEP) policies and regulations. Investigation activities included drilling a borehole and installing a monitoring/validation (MV) well (MV-6), replacing the electric submersible pump in well HTH-2, and removing electric submersible pumps from wells MV-4 and MV-5. Additional activities included a modification of the UC-1-P-2SR well head, installation of a wellhead box on UC-1-P-2SR, and a well location survey to establish top-of-casing elevations for all wells on the site.

1.1 Site Location and Background

CNTA is north of U.S. Highway 6, approximately 30 miles north of Warm Springs in Nye County, Nevada (Figure 1). The U.S. Atomic Energy Commission (predecessor to DOE) acquired CNTA in the early 1960s to develop sites for underground nuclear testing that could serve as alternatives to the Nevada National Security Site (formerly known as the Nevada Test Site). Three emplacement boreholes—UC-1, UC-3, and UC-4—were drilled at CNTA for underground nuclear weapons testing. The initial underground nuclear test, Faultless, was emplaced in borehole UC-1 at a depth of 3,199 feet (ft) below ground surface (bgs) on January 19, 1968. The yield of the Faultless test was estimated to be 200 to 1,000 kilotons (DOE 2000). The test resulted in a down-dropped fault block (graben) that extends to land surface (Figure 2). No further nuclear testing was conducted at CNTA, and the site was decommissioned as a testing facility in 1973.

1.1.1 Summary of Corrective Action Activities

Surface and subsurface contamination resulted from the underground nuclear test at CNTA. Contamination at the surface was identified as CAU 417. Surface restoration was completed in 1999, and the remediation activities are described in the *Closure Report for Corrective Action Unit 417: Central Nevada Test Area Surface, Nevada* (DOE 2001). Contamination in the subsurface is identified as CAU 443. The corrective action process for the subsurface CAU 443 has not yet been completed. Site restoration activities associated with CAU 443 are summarized in the remainder of this section.

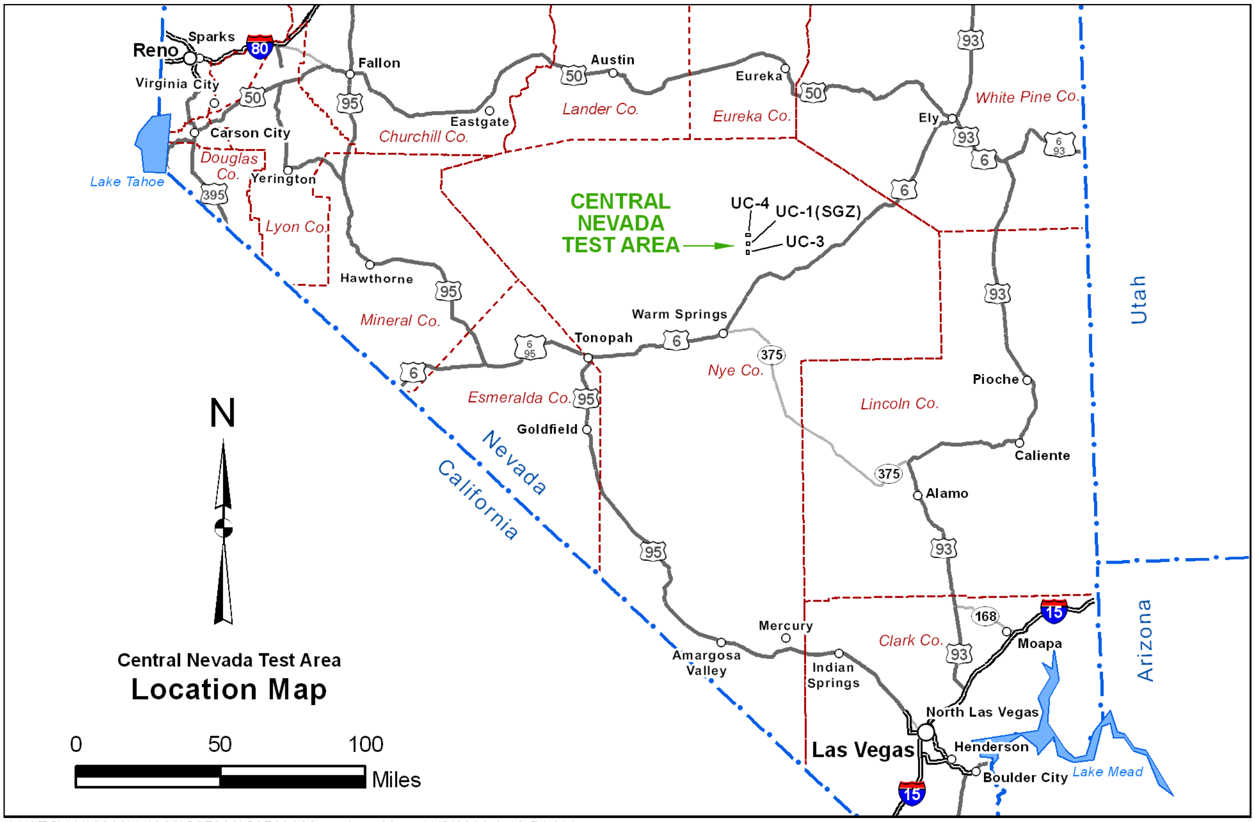

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Figure 1. CNTA Location Map

A Corrective Action Investigation Plan was developed and approved for CAU 443 in 1999 (DOE 1999). The objectives outlined in that document are as follows:

- Determine the characteristics of the groundwater flow system, sources of contamination, and transport processes, to acceptable levels of uncertainty.
- Develop a credible numerical model of groundwater flow and contaminant transport for the UC-1 Subsurface Corrective Action Site and downgradient areas.
- Develop stochastic predictions of the contaminant boundary at an acceptable level of uncertainty.

DOE accomplished these objectives by conducting a corrective action investigation. As part of the investigation, site data were used to develop a numerical flow and transport model, which was then used to calculate a site contaminant boundary (Pohlmann et al. 1999, Pohll et al. 2003).

Results of the corrective action investigation and the corrective action evaluation were presented in the Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) (DOE 2004). Modeling indicated that groundwater velocities at the site were very low (due to very low hydraulic conductivities) and that the contaminant boundary would be very small (within two to three radii of the cavity from the working point [DOE 2004]). A compliance boundary was negotiated that factored in modeling results and associated uncertainties with respect to the nuclear test's potential effects within the down-dropped fault block. The

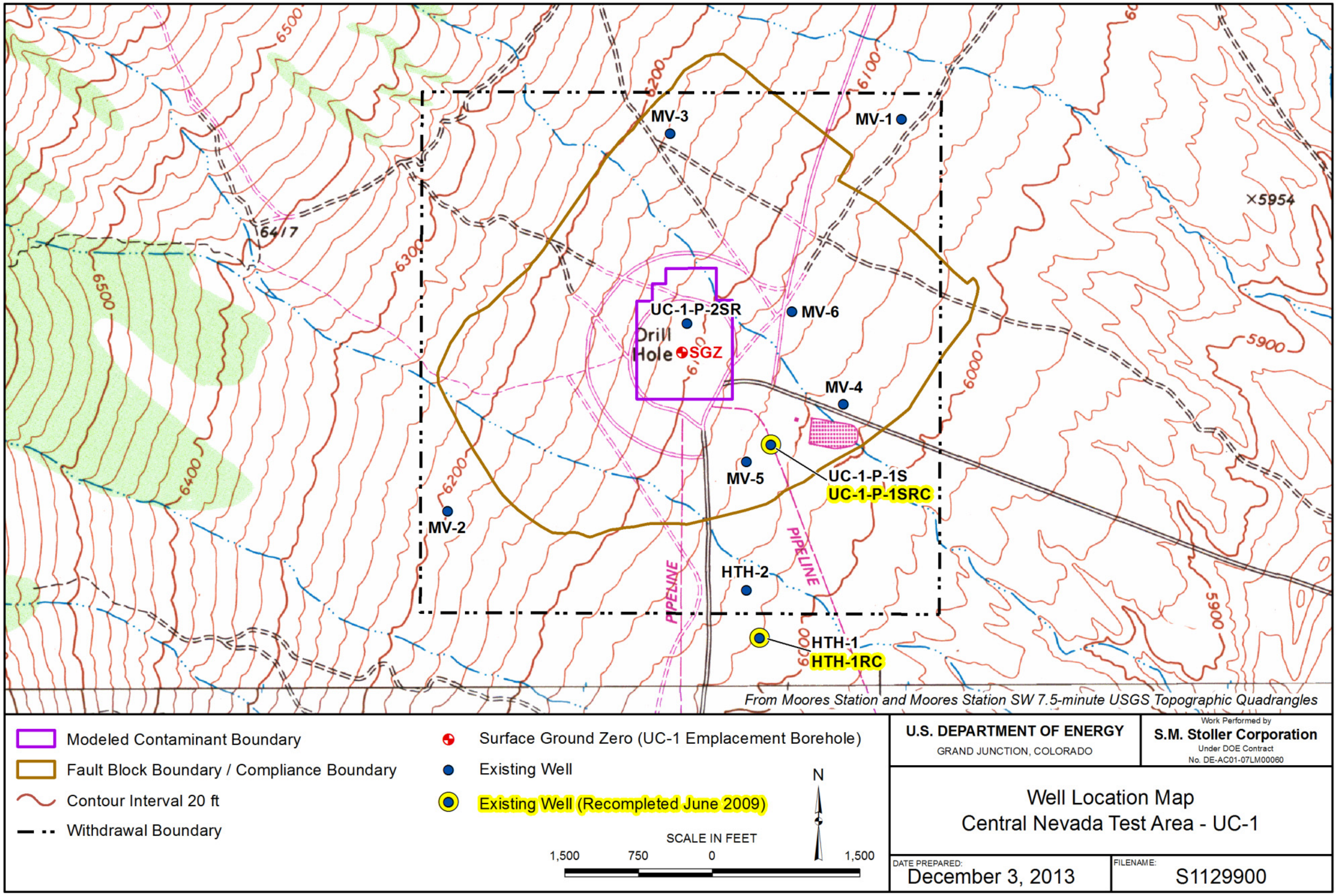

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Figure 2. Location Map of Monitoring Wells and Boundaries at CNTA

compliance boundary corresponds approximately to the surface expression of the fault block and is almost completely contained within the land withdrawal boundary (Figure 2). The preferred corrective action alternative selected in the CADD/CAP was proof-of-concept and monitoring with institutional controls.

Three monitoring/validation wells (MV-1, MV-2, and MV-3) were installed in 2005 to monitor radioisotope concentrations and hydraulic heads in groundwater and to validate the flow and transport model. Hydraulic heads observed in these wells were in significant disagreement with those predicted by the groundwater flow model, which meant that the model could not be validated. Instead of additional modeling, DOE proposed a revised corrective action/closure process in which the monitoring network would be enhanced by installing two new monitoring wells (MV-4 and MV-5), recompleting the existing wells HTH-1 (in the volcanic section) and UC-1-P-1S[1] (in the upper alluvium), and initiating a new 5-year proof-of-concept monitoring period to validate the compliance boundary (DOE 2007). The revised approach is described in a CADD/CAP addendum (DOE 2008) that was approved by NDEP (NDEP 2008).

The revised corrective action/closure process was designed to enhance the monitoring of the alluvial aquifer. The alluvial aquifer was previously not monitored except for water levels in the upper piezometers of wells MV-1, MV-2, and MV-3. Hydraulic heads from different depths at these locations (upper piezometer, lower piezometer, and well) indicate that the most likely transport direction from the UC-1 detonation zone is downward, toward densely welded tuff units below the detonation cavity. The well network was designed to monitor this most likely potential transport pathway. However, given the potential for processes like prompt injection and convective mixing in the nuclear chimney, migration upward into the alluvial aquifer cannot be ruled out. Alluvial wells are more productive than those in the deeper volcanic section, making the alluvial aquifer the most likely source for future groundwater development and, therefore, the most likely access path to potential receptors.

Two wells (MV-4 and MV-5) were installed, and two existing wells (HTH-1 and UC-1-P-1S) were recompleted in 2009 for the dual purposes of monitoring the alluvial aquifer and validating the compliance boundary at the site. The MV-4 and MV-5 wells were designed and positioned not only to monitor for potential contaminant migration in the alluvial aquifer but also to confirm that the southeast-bounding graben fault acts as a flow barrier. The wells were drilled in locations where they would penetrate the downthrown block within the graben and cross the fault into the upthrown block outside the graben. The wells were installed as dual completions with a piezometer in the shallow alluvial aquifer within the graben (downthrown block) and a well in the lower alluvial aquifer outside the graben (upthrown block). The wells were completed with dedicated electric submersible pumps for collecting groundwater samples and conducting aquifer tests. Monitoring of the existing wells MV-1, MV-2, and MV-3 was also enhanced in 2009 by removing the electric submersible pumps and installing low-flow bladder pumps. Results from the drilling program are in the Well Completion Report for CAU 443 (DOE 2009b).

Well UC-1-P-1S was recompleted to provide a reliable monitoring location within the upper alluvial aquifer inside the graben (downthrown block). An electric submersible pump was installed in the recompleted well, UC-1-P-1SRC,[2] for collecting groundwater samples.
Well HTH-1 was recompleted with two piezometers (upper and lower alluvial aquifer) and a

[1] *P* designates the post-shot hole; *S*, the substitute hole.
[2] *RC* indicates that the well has been recompleted.

well (upper volcanic section) to allow monitoring of three hydrostratigraphic units at this location. Hydraulic head data from the well and piezometers can be used to determine the vertical flow direction within the alluvial aquifer and between the upper volcanic section and lower alluvial aquifer. The horizontal flow direction in the lower alluvial aquifer southeast of the graben can be estimated using head data from the HTH-1 lower piezometer along with head data from the MV-4 and MV-5 wells. A low-flow bladder pump was installed in the HTH-1RC well for collecting water samples from the volcanic section south of the detonation (DOE 2009b). Initial monitoring results from HTH-1RC support a previous identification (based on flow logging) of an upward hydraulic gradient from the volcanic section to the alluvium (DOE 2010a). Figure 2 shows a map of the locations included in the enhanced monitoring network.

The revised corrective action/closure process, as outlined in the CADD/CAP addendum (DOE 2008), indicated that aquifer tests would be performed on the new wells MV-4 and MV-5 and on the recompleted well HTH-1RC. This strategy was modified slightly because the original well design for HTH-1RC was changed to include two piezometers and did not allow for the installation of a submersible pump or aquifer testing. To accommodate this change, an aquifer test was conducted on the recompleted well UC-1-P-1SRC. The results from aquifer tests suggest that the hydraulic conductivity of the alluvial aquifer decreases with depth, grading from a productive aquifer in the upper alluvium (hydraulic conductivity of 1.0 meter per day) to a poor producer in the lower alluvium (hydraulic conductivity of 0.00012 to 0.0005 meter per day). The decreasing hydraulic conductivity within the alluvial aquifer may be more a function of depth and overburden compression from the down-dropped fault block rather than sediment grain size. The low hydraulic conductivity of the lower part of the alluvial aquifer is more comparable to the results from densely welded tuff units tested in wells MV-1, MV-2, and MV-3 (8.5×10^{-6} to 6.7×10^{-5} meters per day) and is likely similar to the hydraulic conductivity of the upper part of the underlying volcanic sediments. The Hydrologic Testing Report for CAU 443 (DOE 2010b) provides a more detailed summary of results from the hydrologic testing.

1.2 Scope of Work and Technical Objectives

The scope of the drilling program at CNTA included:

- Construction of a well pad with infiltration basin.
- Drilling one borehole.
- Geophysical logging of the borehole.
- Construction of monitoring well MV-6.
- Development of monitoring well MV-6.
- Removal of electric submersible pumps from wells HTH-2, MV-4, and MV-5.
- Installation of electric submersible pumps in wells HTH-2 and MV-6.
- Installation of water access tubes and low-flow bladder pumps in wells MV-4 and MV-5.
- Installation of concrete pads with locking steel well boxes at wells MV-6 and UC-1-P-2SR.

The objective of this drilling program was to establish a new monitoring location for collecting hydrogeologic head and groundwater chemistry data and remove/replace electric submersible pumps in selected monitoring wells. To meet these objectives, the drilling program included the following:

- Drilling a borehole and installing a monitoring well (MV-6) in the upper alluvial unit inside the graben east-northeast of the UC-1 emplacement borehole. The borehole was logged, and the monitoring well was constructed with well screen installed through the deepest and most permeable zone within the borehole. A pump with water access tube was installed in the well after the well was developed to allow collection of hydraulic head data and groundwater samples for laboratory analysis.
- Removing and replacing the electric submersible pump in well HTH-2. The inoperable pump in this well needed replacement before the drilling program because well HTH-2 was designated as the water supply well for the drilling project.
- Removing the electric submersible pumps from wells MV-4 and MV-5 and replacing them with bladder pumps to allow the collection of samples using the low-flow sampling technique.

2.0 Drilling Program and Methods

The corrective action strategy for CNTA seeks to establish a well network that monitors potential contaminant transport pathways and verifies the adequacy of the compliance boundary for the site (Figure 2). The drilling program at CNTA was designed to further enhance the monitoring network by installing a well in the alluvial aquifer inside the graben.

The drilling program at CNTA had several requirements:

- A cultural resources inventory of potentially affected areas as required by Section 106 of the National Historic Preservation Act.
- The evaluation of potential impacts related to the drilling program and pad construction in compliance with the National Environmental Policy Act (NEPA).
- Permits and waivers required by the State of Nevada Division of Water Resources to install a well and to use water from existing monitoring wells.
- Construction of the well pad with infiltration basin.
- Establishing the methods to complete the drilling program.

The Fluid Management Plan (FMP) with site-specific fluid strategy letter and selection of a source of water for the drilling program (wells HTH-2 and UC-1-P-1SRC) were approved for the drilling program. The following sections summarize the activities leading up to the drilling program as well as the methods used during the drilling program.

2.1 Cultural Resources Inventory and NEPA Documentation

Desert Research Institute (DRI) did a cultural resource inventory of areas potentially disturbed during well pad construction and the associated drilling program at CNTA. No cultural resources were found during the field inventory, and a negative declaration (Cultural Resources Inventory Negative Report BLM 6-2848 [N]) to that effect was provided to the U.S. Bureau of Land Management (BLM), Tonopah Field Office, for a final determination. The Nevada State Historic Preservation Office (SHPO) authorized BLM to make determinations on behalf of the SHPO. BLM confirmed that the proposed project would not result in adverse impacts and provided an e-mail confirmation (August 13, 2013) that work could begin. BLM subsequently provided a copy of the negative declaration to the Nevada SHPO for their records on August 22, 2013.

DOE prepared and approved an abbreviated NEPA evaluation, called a Determination of NEPA Adequacy (LM#15-13), on August 14, 2013. The document was used to update prior NEPA evaluations related to pad construction and drilling groundwater monitoring wells. This document evaluated potential impacts related to the MV-6 drilling program and associated planned activities. The identified impacts were considered within the scope of impacts identified in earlier NEPA documents, and the conclusion was that no further NEPA evaluation or documentation was warranted. As part of the NEPA process, DOE contacted the BLM Tonopah Field Office for information related to listed species present at CNTA. The site is outside of the range for the federally listed desert tortoise, and no other species of concern were known to be in the area. The area has been highly disturbed by past activities.

2.2 FMP and Site-Specific Fluid Strategy Letter

An FMP and Site-Specific Fluid Strategy Letter were prepared for the drilling program at CNTA. The FMP guided the management of fluids and associated materials generated during the subsurface investigation activities and provided the standards that governed their final disposition. Although NDEP is not a signatory to the FMP, it is involved in the negotiation of the content and approves the conditions described within the plan. The FMP was approved on February 6, 2009. In accordance with the FMP, a Site-Specific Fluid Strategy Letter was prepared to provide the rationale for selecting the far-field fluid management strategy and address specific details regarding the nature and configuration of the fluid containment to be used at the well site (DOE 2013a). The Well-Site Fluid Management Strategy Letter provided qualitative and quantitative data that supported the far-field strategy and established the use of an infiltration basin for managing fluids and materials generated during drilling and other well site activities. NDEP approved the Well-Site Fluid Management Strategy on August 27, 2013.

2.3 Source Water for Pad Construction and Drilling Program

CNTA groundwater monitoring wells HTH-2 and UC-1-P-1SRC were selected as potential water sources to support pad construction and other activities associated with drilling MV-6. Both wells are screened through the upper portion of the alluvial aquifer and are equipped with electric submersible pumps, and well HTH-2 was used as a water source during the drilling programs in 2005 and 2009. These wells have also been sampled routinely as part of the annual site monitoring. The State of Nevada's Department of Conservation and Natural Resources, Division of Water Resources, requires an application for a waiver to use an existing groundwater monitoring well as a water source; the Division of Water Resources issued waiver WE-004 to DOE on August 8, 2013. Waivers for water use are limited to a 1-year use period. In addition, a separate type of waiver application is required for installing a monitoring well; the identification number provided by the State Division of Water Resources stays with the well permanently. Waiver number M/O-1897 was issued for well MV-6 on August 8, 2013.

Water from wells HTH-2 and UC-1-P-1SRC was used for soil compaction, dust control, and well installation. These activities required 48,400 gallons of water, which was the volume DOE reported in a letter to the State Division of Water Resources on January 29, 2014. A total of 22,300 gallons of water were obtained from well UC-1-P-1SRC for use during pad construction (16,500 gallons) and the start of drilling operations (5,800 gallons). A total of 26,100 gallons of water were obtained from well HTH-2 for use during drilling operations. Well HTH-2 was originally designated as the primary water source well for the drilling program, but because of difficulties during the pump replacement, well UC-1-P-1SRC was used at the start of the drilling program to set the surface casing.

Groundwater samples were collected from well HTH-2 after the pump became operational on September 11, 2013. The samples were analyzed for bromide, tritium, gamma-emitting radionuclides (by high-resolution gamma spectroscopy), gross alpha, and gross beta. The analytical results indicated concentrations of gross alpha of 3.19 picocuries per liter (pCi/L) and gross beta of 4.27 pCi/L. All remaining constituents were below the laboratory's minimum detectable concentration (radionuclides) or method detection limit (bromide). A water sample was also collected from the first water-truck load from well HTH-2 that was transported to the MV-6 well pad on September 12, 2013. The sample was analyzed for the same constituents as the earlier sample from the well. The sample from the water truck was collected after the sodium bromide (NaBr) tracer was added. Analytical results of this sample indicated concentrations of bromide of 44 milligrams per liter (mg/L), gross alpha of 6.37 pCi/L, and gross beta of 6.62 pCi/L. All remaining constituents were below the laboratory's minimum detectable concentration. Analytical results of samples collected from well HTH-2 and from the initial water-truck load are in Table A-1, Appendix A.

2.4 Construction of Drill Pad and Infiltration Basin

The existing right-of-way number N-85175 was amended to include construction of a drill pad with a single infiltration basin and establish access to the new well MV-6 at CNTA. BLM approved the amended right-of-way (number N-85175/B) on July 9, 2013. Construction of the drill pad was completed in August 2013, and the well MV-6 was installed in September 2013.

The size of the MV-6 drill pad was approximately 150 by 180 ft. The pad included one infiltration basin measuring approximately 35 by 80 ft, and approximately 5 ft deep. The infiltration basin was designed to contain five times the estimated volume of material to be displaced from the borehole. The MV-6 well is approximately 1,300 ft east-northeast of surface ground zero (Figure 2).

2.5 Drilling Method

Boart Longyear Drilling Services (Boart) is a licensed drilling contractor (license number 0021976) with the State of Nevada and was contracted for the drilling program at CNTA. After completing the required Notice of Intent to Drill (notice number 70625), Boart drilled borehole MV-6 using an LM-140 top head rotary drill rig. The borehole was advanced by conventional rotary and dual-tube reverse circulation drilling methods, using water- and polymer-based drilling fluids and a tricone mill-tooth bit. Selection of the drilling method was based on expected drilling conditions and past drilling programs at CNTA. Borehole deviation surveys were made approximately every 300 ft as the borehole was advanced; a geolograph recorded drilling parameters and penetration rates during the drilling. The daily drilling reports included penetration rates, the results of borehole deviation surveys, and other pertinent information.

Thirteen days (September 8 through 20, 2013) were spent mobilizing/demobilizing, drilling, constructing, developing, and installing pumps in wells HTH-2 and MV-6; and removing pumps and reinstalling water access tubes in existing wells MV-4 and MV-5. Operations were generally conducted 24 hours per day (working two 12-hour shifts) and 7 days per week, although for a few days during mobilization and demobilization, work was conducted only during daylight hours.

2.6 Sampling Methods

Geologic material, drilling fluid, and groundwater samples were collected during advancement of the borehole and development of well MV-6 as part of the drilling program. Samples included drill cuttings for description of the alluvial material and drilling fluid and groundwater for radiological monitoring and water quality analysis. Samples were collected in accordance with the FMP (DOE 2009a) and Field Instructions (DOE 2013b). The following sections describe the sampling methods.

2.6.1 Drill Cuttings Sampling Methods

Samples of the drill cuttings were collected during advancement of the borehole. These samples were collected from the drill rig shaker screen, washed, and composited for 10 ft intervals. A small portion of the washed cuttings was placed in a chip tray for description of the alluvial material. Samples of the cuttings were collected to describe characteristics of the alluvial material penetrated and to provide a detailed lithologic log as drilling progressed. The lithologic descriptions included grain size, mineralogy, alteration, color, fracturing, and other notable geologic characteristics. Unified Soil Classification System terminology and the Munsell Soil Color Chart were used to describe the cuttings.

2.6.2 Radiological Sampling Methods

Samples of the drilling fluid and groundwater discharged during well development were collected and analyzed onsite for tritium. A Triathler liquid scintillation counter was used to analyze the samples to ensure that fluid management controls were being implemented in accordance with the FMP and Site-Specific Fluid Strategy Letter. Samples were collected during drilling at approximately 30 ft intervals or approximately every hour from below the cyclone as fluid entered the mud tank. Samples were collected during well development from the discharge line approximately every 2 hours. All samples were analyzed, and the results were documented in accordance with the *Environmental Sciences Laboratory Procedures Manual* (LMS/PRO/S04343, continually updated).

Samples were collected from well HTH-2 and analyzed before each shift began (twice a day) to establish background concentrations for tritium. It was necessary to determine background levels of radiation in groundwater because many geologic strata contain naturally occurring radiation. The background concentrations were recorded and used for all counts during the respective shift. Background samples were collected, analyzed, and documented in accordance with the *Environmental Sciences Laboratory Procedures Manual*.

2.6.3 Bromide and Water Quality Sampling Methods

Samples of the drilling fluid and groundwater discharged during well development were collected and analyzed to monitor pH, temperature, specific conductance, bromide, and turbidity. Concentrations of bromide were obtained from the NaBr tracer that was added to the makeup/source water used during drilling, well construction, and well development operations. The NaBr tracer was added to each water truck that transported water from the source wells UC-1-P-1SRC and HTH-2 to the well pad for use during drilling, well construction, and development. Bromide concentrations in the makeup/source water were generally maintained between 20 and 50 mg/L. The purpose of the tracer was to assist in detecting perched water zones, assist in detecting the groundwater table, and provide a monitoring parameter to establish the effectiveness of well development.

Samples obtained during drilling operations were collected at approximately 30 ft intervals or every hour from below the cyclone as the fluid entered the mud tank. Samples obtained during well development were collected from the discharge line approximately every 2 hours. All of these samples were analyzed onsite using a YSI-63 water quality meter, an Orion 9635BNWP ion-selective electrode, and a turbidity meter.

2.7 Borehole Geophysical Logging Methods

Boart contracted Pacific Surveys to do borehole geophysical logging as part of the drilling program at CNTA. Pacific Surveys provided evidence of calibrations (pre-job/post-job) in accordance with American Petroleum Institute (API) guidance, manufacturer specifications, industry standards, and bench calibrations. The data obtained during the logging were set to a ground surface datum and not the drill rig floor. The wire-line logging truck was equipped with calibrated weight indicators and depth-control devices as required.

2.8 Well Location Survey

A Nevada-registered land surveyor with Basin Engineering was contracted to survey the new and existing well locations upon completion of the drilling program. Basin Engineering conducted the well location survey November 6 through 8, 2013. The survey provided northing and easting data for the site wells, concrete pads, ground surface control points, and provided top-of-casing elevations for measuring depth to groundwater. All survey data were documented in the Universal Transverse Mercator Zone 11 coordinate system, with horizontal data based on the North American Datum 1927 and vertical data based on the North American Vertical Datum 1929. Well locations are shown in Figure 2, and survey data are in Table A-2, Appendix A.

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3.0 CNTA Geology

Information on the regional and local geologic setting for CNTA was obtained from various sources such as site inspections, well geophysical data, seismic data, U.S. Geological Survey literature, and previous investigation reports. The following sections summarize the regional and local geologic settings.

3.1 Regional Geologic Setting

CNTA is in the northern portion of the Hot Creek Valley between the Hot Creek Range to the west and the Squaw Hills and Halligan Mesa to the east. Hot Creek Valley is an elongate graben filled with as much as 4,200 ft of Quaternary and Tertiary alluvium derived from the surrounding mountains. These valley-filling alluvial deposits overlie Tertiary volcanic formations that are laterally equivalent to the formations cropping out in the nearby Squaw Hills and Hot Creek Range (Snyder 1967). The Tertiary volcanic rocks in the Hot Creek Range and Squaw Hills were deposited on Paleozoic sedimentary rocks, which crop out farther to the south and north in the Hot Creek Range, and farther to the north in the Squaw Hills. However, in the hills and mountains adjacent to CNTA, volcanic rocks overwhelmingly dominate the exposed bedrock geology. Surface and subsurface geologic data indicate that CNTA is within the Hot Creek Valley caldera complex, which contains several overlapping volcanic cauldrons. This caldera complex has been disrupted by basin-and-range style normal faulting that formed the Hot Creek Valley graben. Normal faulting in the region still occurs, as evidenced by fault scarps on the surfaces of modern alluvial fans, as well as by the earthquake faults associated with the Faultless test of January 1968.

3.2 Local Geologic Setting

Detailed lithologic descriptions for boreholes UC-1, UC1-I-1, and UC1-I-2 at CNTA show the valley-fill alluvial deposits to be poorly sorted volcanic rock fragments and sparse Paleozoic carbonate, chert, and siltstone rock fragments enclosed within a matrix of sand-sized crystals and clay. These rock fragments are rounded to subrounded and range in size from gravel to boulders, although the average size is about 6 inches in diameter. Lithologic descriptions for boreholes HTH-1 and HTH-2 at CNTA indicate that the valley-fill alluvial deposits are similar to those in UC-1, but with a higher percentage of Paleozoic sedimentary rock fragments. In all five of these boreholes, the upper 1,000 ft is largely unconsolidated, and the degree of induration increases downward below this depth. The contact between the alluvium and the underlying volcaniclastic and tuffaceous sediments is approximately 2,400 ft bgs and is based variously on the first appearance of nonwelded tuff or the first appearance of conglomeratic tuffaceous sandstone interbedded with nonwelded tuff (Hoover 1968). The alluvium found in MV-1, MV-2, and MV-3 at CNTA is similarly described as poorly sorted, angular to subrounded silt, sand, gravel, and cobbles composed primarily of light to dark gray rhyolite, reddish-brown rhyolite, and minor amounts of dark gray to black limestone and dolomite, and tan and dark gray siltstone. Concentrations of lithic clasts vary, with silty and clay-rich layers interbedded with sandy layers and layers of gravel, cobbles, and boulders. At boreholes MV-1, MV-2, and MV-3, the contact with the underlying Tertiary volcaniclastic and tuffaceous sediments was at 2,352, 1,960, and 2,410 ft bgs, respectively. This contact in each of these three boreholes was based on the appearance of a grayish-yellow, argillically altered, nonwelded tuff with 18 to 25 percent phenocrysts (DOE 2006).

The Faultless test triggered numerous small earthquakes and aftershocks that resulted in surface subsidence and surface rupture along preexisting faults, caused strike-slip movement along previously unknown subsurface faults, and induced seismic activity as far away as 24 miles (McKeown and Dickey 1969). The Faultless test created a subsidence graben elongated to the northeast and parallel to numerous preexisting faults in the Quaternary valley-fill deposits (Figure 3). The graben is bounded by curved faults on the southeast, south, southwest, and northwest, with an apparent hinge line at the northeastern end of the graben (Ekren et al. 1973). Maximum subsidence at the time of the test was 14.8 ft. In some places along the south side of the graben, dip on the faults is 77 degrees to the north, based on fault intercepts in post-shot boreholes and post-shot map data. High-speed photography showed that subsidence occurred immediately following the test, indicating that subsidence resulted from the immediate release of tectonic stress that was triggered by the underground test, and not from the collapse of the test cavity (McKeown et al. 1968; McKeown and Dickey 1969). Collapse chimneys typically extend 4 to 6 cavity radii above the working point, whereas the Faultless test occurred at a depth estimated to be about 10 cavity radii below the surface (Glasstone and Dolan 1977). Analysis of post-shot seismic data indicates that minor strike-slip movement occurred along a buried north-striking fault in Moores Station Wash from 2 to 4 miles south of the Faultless test (Ekren et al. 1973; McKeown and Dickey 1969).

Approximately 7.8 miles of seismic reflection data (five individual lines) were acquired at CNTA during the fall of 2007. These seismic profiles were acquired along site roads that radiate from the centrally located UC-1 emplacement borehole and crossed all of the major faults associated with the graben as well as numerous Holocene faults exposed on the surface. The seismic data indicate that the faults defining the graben dip from about 72 degrees to 77 degrees toward the interior of the graben. These profiles also reveal a buried and previously unknown down-to-the-east normal fault to the west of the graben and another similar fault just to the southeast of the graben. Seismic reflections interpreted to represent the water table are offset across many of these faults, suggesting that some faults act as barriers to groundwater flow in the upper part of the alluvial aquifer and probably deeper. Additionally, the loss of coherence in most seismic reflectors immediately above the Faultless test cavity suggests that these strata have been intensely fractured and the bedding disrupted.

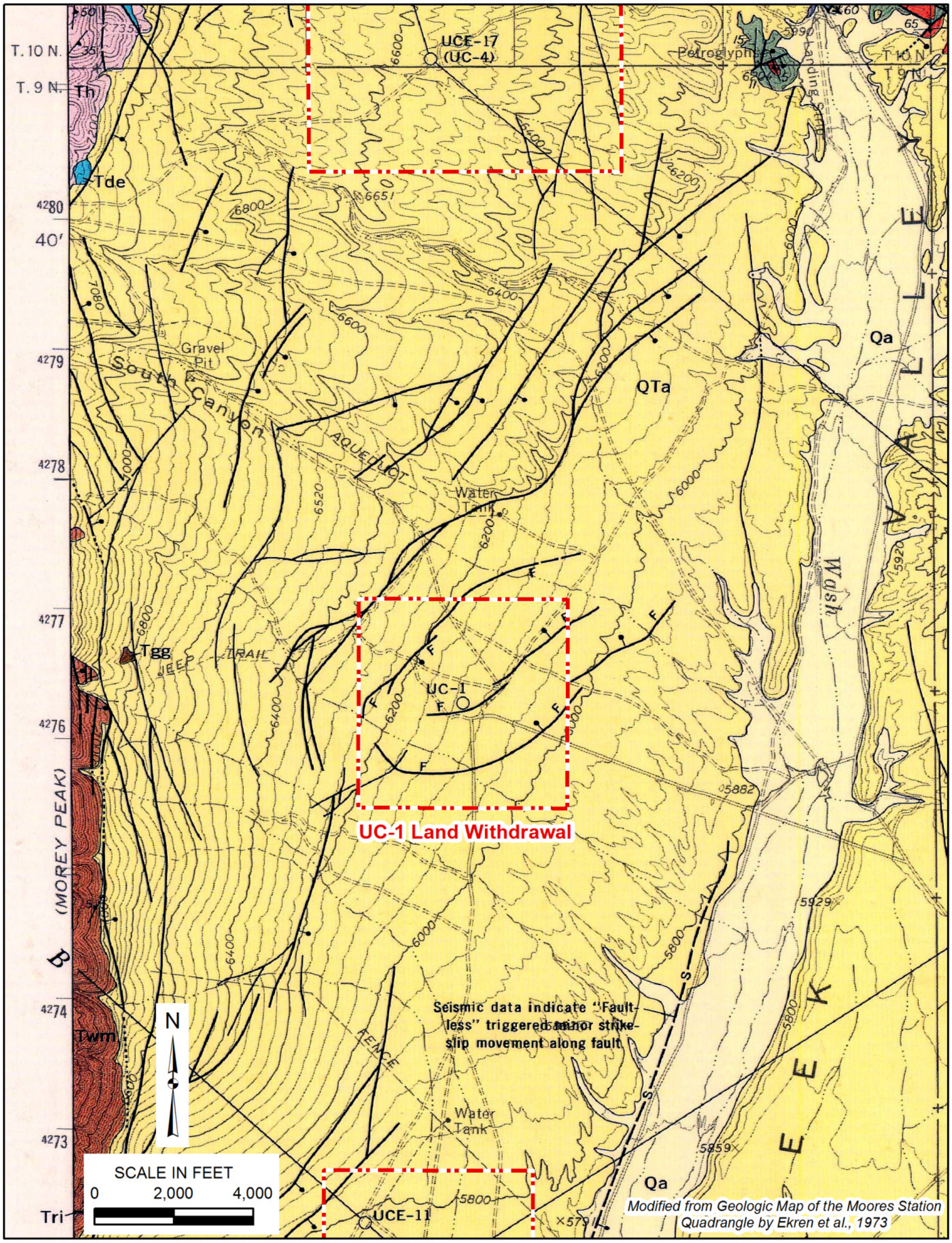

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Figure 3. Preexisting Faults and Faults Created by the Faultless Test in the Quaternary Valley-Fill Deposits

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4.0 Summary of Well MV-6 Activities

Well MV-6 was completed in the upper part of the alluvial aquifer approximately 1,300 ft east-northeast of surface ground zero (Figure 2). Borehole drilling operations started on September 11, 2013. The borehole was drilled to a total depth of 1,023 ft bgs on September 14, 2013. Geophysical logging of the borehole was done on September 15, 2013. Well construction began immediately following logging operations and was completed on September 16, 2013. Well development using airlift methods began on September 17 and was completed 28 hours later on September 18, 2013. Installation of the dedicated pump and final well development was on September 18, 2013. The following sections summarize the well construction, geophysical well logging, sampling, well development, and pump installation activities. Table B-1 in Appendix B gives a chronology of the drilling operations at well MV-6.

4.1 Well Drilling and Construction

Installation of well MV-6 included drilling an initial 19-inch-diameter borehole to a depth of 120 ft bgs to allow a 14-inch-diameter carbon-steel casing with fully welded joints to be installed as a surface casing and wellhead control apparatus. This casing was set to a depth of 98 ft bgs due to slough accumulation in the bottom of the 19-inch borehole. The casing was cemented in place using approximately 108 cubic feet (ft^3) of Portland Type II cement. The production borehole was drilled from 98 ft to the completion depth of 1,023 ft bgs using a 12.25-inch tricone mill-tooth bit. The well was constructed in the 12.25-inch borehole using 5.5-inch outside diameter (OD) internally ceramic/epoxy-coated carbon-steel casing. The well was screened from 838.02 to 1,000.66 ft bgs with manufactured 3- by -0.078-inch slotted openings on 6-inch centers staggered at 10 degrees with 18 slots per row. The selection of the well screen interval was based on geologic data collected while drilling and the geophysical logs. The well was completed to a total depth of 1,021.12 ft bgs, which included approximately 20 ft of blank casing below the well screen for a sump. Ten centralizers were placed around the well screen and casing at approximately 60 ft intervals to ensure that the well was centered in the borehole.

A graded filter pack was installed around the slotted interval of the well. Filter pack materials included ⅛- to ¼-inch clean gravel and No. 6/12 clean silica sand. The silica sand was placed above the gravel as transition material to prevent infiltration of cement into the filter pack. Gravel and sand filter pack materials were gravity-fed through an NQ tremie pipe using clear water to maintain flow. The gravel pack was placed from total borehole depth to 27 ft above the top of the screened casing (811 ft bgs). Four hours were spent swabbing the screened interval with a surge block after the gravel pack was installed to ensure total settling of the gravel around the screen before the transition sand was placed. Portland Type II cement was used to seal the annular space between the borehole wall and the well casing from the top of the transition sand (783 ft bgs) to ground surface. Cement was pumped down the NQ tremie, which was raised in stages during the placement of the stemming materials to help ensure proper placement without plugging or bridging. Table B-2 in Appendix B lists the well construction materials and volumes used to complete well MV-6. Figure 4 shows the as-built well construction details of MV-6.

4.2 Borehole Geophysical Logging

Pacific Surveys did geophysical logging of the borehole on September 15, 2013. All logging tools were run and recorded from 1,022 to 98 ft bgs (bottom of the surface casing). Five passes on the borehole were required to complete the logging program. In sequential order the following logs were run and recorded:

1. Temperature and differential temperature
2. Resistivity, natural gamma, and spontaneous potential
3. Sonic velocity
4. Caliper
5. Deviation

All logs were run without problem as the borehole remained open and stable with no bridging or obstructions. The borehole deviation survey indicates that overall borehole deviation was about 0.2 degree from vertical, placing the bottom of the borehole and bottom of the well about 4 ft east and 1 ft south from the surface collar location, as shown in the deviation plot in Figure 5. A condensed version of the geophysical logs obtained from well MV-6 is shown on the Monitoring Well Completion Log at the end of Appendix B.

4.3 Sampling

Geologic material and water quality samples were collected during advancement of the borehole, construction of the well, and development of the well. Samples included drill cuttings for description of the alluvial material, and drilling fluid and groundwater for water quality analysis. Samples were collected according to the FMP (DOE 2009a) and the Field Instructions (DOE 2013b). The following sections summarize the sampling activities.

4.3.1 Drill Cuttings Sampling

Samples of the drill cuttings were collected during advancement of the borehole. The cuttings were collected from the drill rig shaker screen, washed, and composited for 10 ft intervals. The alluvial material and the fault zone found during drilling are described below. The lithologic description of alluvial material from the cuttings collected from the MV-6 borehole is shown on the Monitoring Well Completion Log at the end of Appendix B.

QTa (Quaternary and Tertiary alluvium)
0–1,023 ft: This section is composed of alluvium and valley-fill deposits containing silt and clay, sand, gravel, cobbles, and boulders. The rock fragments in the alluvium predominantly contain subangular to subrounded clasts, with minor amounts of angular and rounded clasts. The angular clasts appear to outnumber the rounded clasts within these drill cuttings, but it is possible that this distribution based on clast rounding has been altered by the drilling process wherein the drill bit creates more angular clasts by breaking up larger rounded and subrounded clasts. The clasts themselves are composed almost entirely of densely welded rhyolitic and latitic tuff and very minor dark gray limestone and dolomite derived from the surrounding mountains. Although nonwelded to partly welded tuffs also occur within the surrounding mountains, these softer rocks typically are eroded away by flash floods on the surface of the alluvial fan and, thus, are underrepresented in these deposits. Concentrations of lithic clasts vary laterally and vertically, with silty and clayey layers interbedded with sandy and gravelly layers. Samples of drill cuttings from the valley-fill alluvium typically contain coarser detritus (gravel-size clasts and larger) in a matrix of silt and clay. While this may reflect the poorly sorted nature of alluvial deposits, some beds within the alluvium can be well sorted.

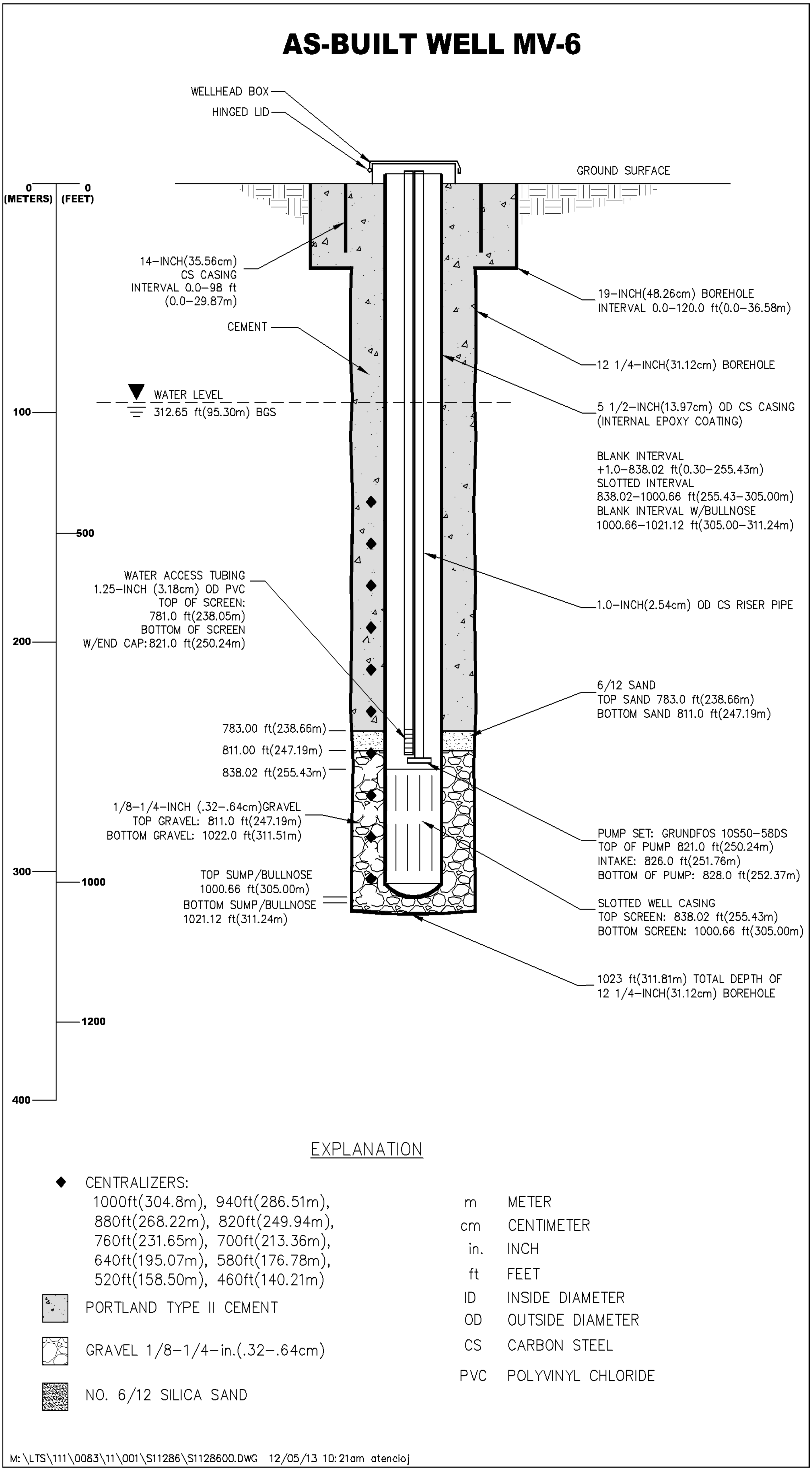

Figure 4. As-Built Well MV-6

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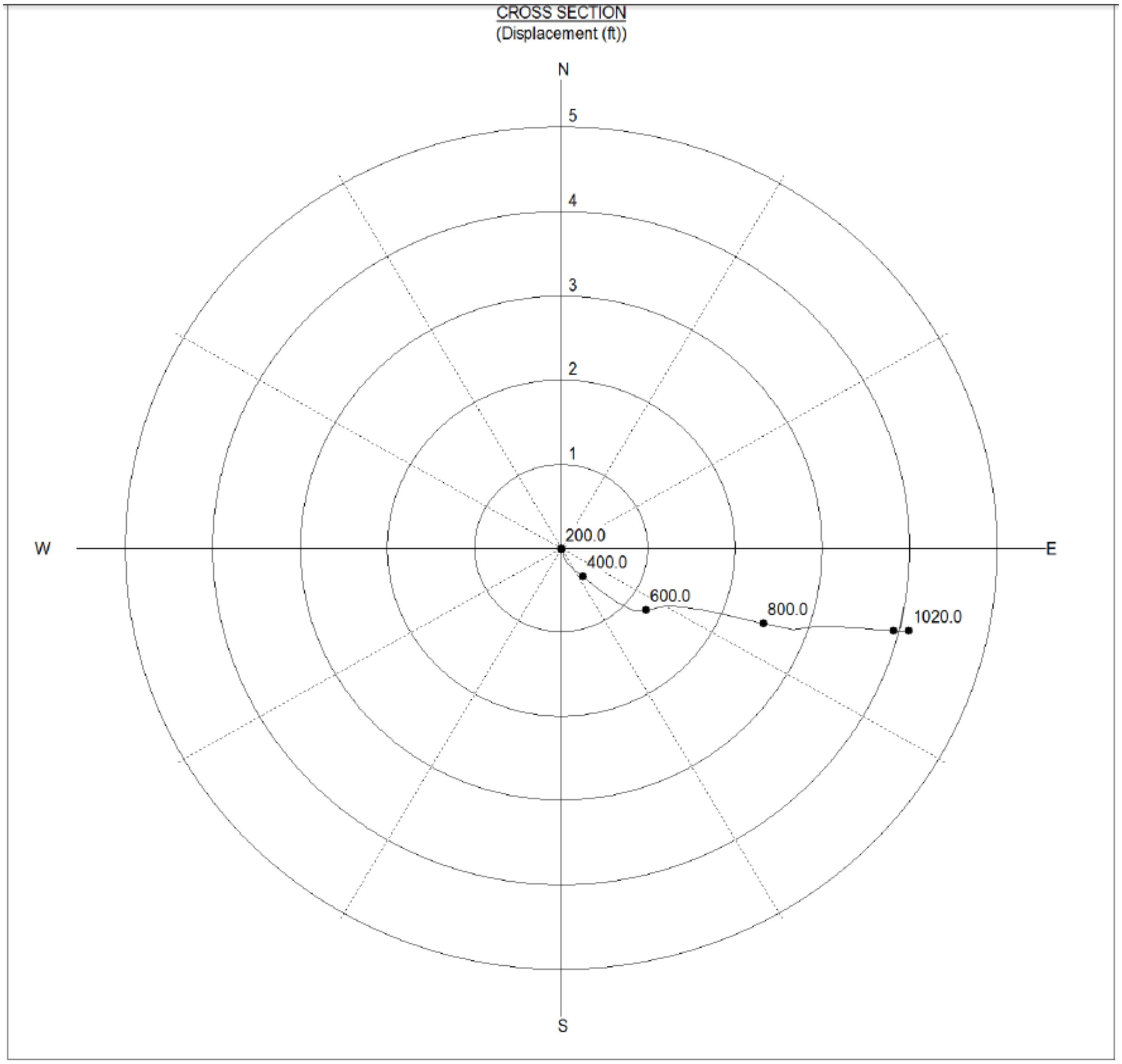

Figure 5. Deviation Plot for Well MV-6

Fault

450–600 ft: Fault. At the shallowest and deepest points of this interval, the drill cutting samples consisted of about 60% clay with lesser gravel and sand. Within the interval of about 490 to 550 ft, a high percentage of clay was in the cuttings. The deviation survey confirms inflection points at about 450 and 600 ft bgs. The temperature log indicates significant fluctuations within the interval in locations aligning with borehole irregularities shown on the caliper log to approach 2.5 inches over-gauge. Likewise, the sonic log and resistivity logs show marked differences in this interval compared to those above and below. It appears the borehole collar point was located near a high-angle fault. The borehole intersected the fault at about 430 to 450 ft bgs and followed the fault plane about 150 ft deeper to an exit point at about 600 ft bgs. A normal fault is shown in Figure 3 near the location of MV-6. The borehole for MV-6 likely intersected this fault, and the screened interval for the well is in the footwall side of the fault.

4.3.2 Radiological Sampling and Monitoring

Samples of the drilling fluid and groundwater discharged during development were collected to be screened in the field for tritium using a Triathler liquid scintillation counter. The field screening results indicated no concentrations of tritium above the minimum detectable concentrations that ranged from 2,985 to 4,391 pCi/L. The field samples were reanalyzed at the Office of Legacy Management Environmental Sciences Laboratory using a PerkinElmer Tri-Carb liquid scintillation counter on October 7, 2013. The field samples were reanalyzed to allow an increased sample count time and lower minimum detectable concentration. The reanalyzed field samples indicated no concentrations of tritium above the minimum detectable concentration of 385 pCi/L. Table B-3 in Appendix B provides the final screening results of tritium analyses for the samples obtained during the drilling and development of well MV-6.

4.3.3 Bromide and Water Quality Parameter Sampling

Samples of the drilling fluid and groundwater discharged during development were collected and analyzed to monitor pH, temperature, specific conductance, bromide, and turbidity. Concentrations of bromide in the drilling fluid ranged from 15 to 34 mg/L during drilling operations, from 0.4 to 18 mg/L during development using the airlifting method, and from 0.8 to 1.1 mg/L during development using an electric submersible pump. Section 4.4 summarizes the well development activities. The concentration of bromide in fluid during drilling and during development of MV-6 is shown in Figure 6. Water quality parameters and bromide results are shown in Table B-4 in Appendix B for samples taken during drilling and development of MV-6.

4.4 Airlift Well Development

Development of well MV-6 began on September 17, 2013. Well development was done by airlift methods using the LM-140 drilling rig and a 1,100 cubic feet per minute air compressor plumbed to an AQ (1.75-inch OD) airline with HQ (3.06-inch ID) eductor. Initial well development included approximately 28 hours of airlifting and surging. Fluid discharge rates averaged approximately 12.7 gallons per minute (gpm) and increased to about 22 gpm in the final hours, at the completion of airlift development. Concentrations of bromide obtained from samples analyzed during development ranged from 11 mg/L at startup to 0.4 mg/L at completion. A total of approximately 25,000 gallons of fluid were removed during airlift development of MV-6.

4.5 Pump Installation and Final Well Development

Well MV-6 was completed with a 4-inch stainless-steel submersible Grundfos pump, model 10S50-58DS, with a 5-horsepower Grundfos motor removed from well MV-4. The dedicated submersible electric pump was installed on September 18, 2013, using Boart's mobile crane. The installation included setting the pump, riser pipe, water-access tube, and electric supply cable. The intake of the pump was set at approximately 826 ft bgs. The pump is powered by an MS 4000, 5-horsepower, 480-volt, three-phase Grundfos motor. Power is supplied to the pump using number-4 AWG 600-volt, heavy-duty, flat submersible cable that is banded and clamped to the 1-inch OD carbon-steel API pipe with external upset ends. The water-access tube is also banded and clamped to the 1-inch-OD pump discharge pipe. The water-access tube is constructed with 1.25-inch-OD schedule-80 PVC pipe with flush joints. The water-access tube is completed with 40 ft of 0.020-inch slot screen that is set just above the top of the pump.

Table B-2 in Appendix B provides the pump and tubing specifications used to complete well MV-6.

Final development of well MV-6 was done on September 18, 2013, using the dedicated pump. The well was pumped for approximately 3.5 hours at a rate of 13 gpm. Results obtained from the final sample collected indicated concentrations of bromide at 0.8 mg/L, turbidity of 8 nephelometric turbidity units (NTU), and tritium below the minimum detectable concentration. Approximately 2,700 gallons of water were removed from the well during development using the dedicated pump. Figure 6 shows bromide concentrations compared to gallons of fluid removed during the development of well MV-6.

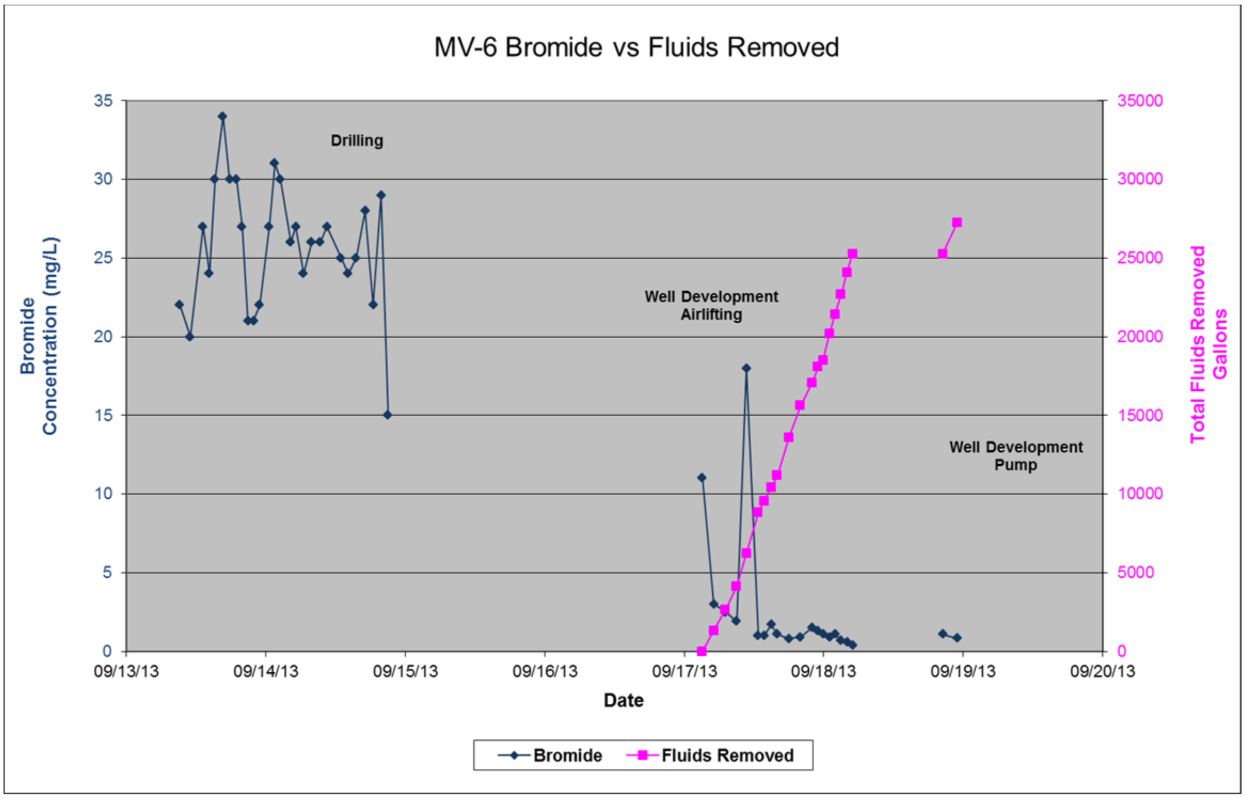

Figure 6. Bromide Concentration Compared to Fluid Removed during Drilling/Development of MV-6

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5.0 Summary of Miscellaneous Well Site Activities

Miscellaneous well site activities during the 2013 drilling program included:

- Replacing the electric submersible pump in well HTH-2.
- Removing the electric submersible pumps from wells MV-4 and MV-5.
- Installing a new well head with locking steel well box at UC-1-P-2SR.

5.1 Pump Replacement in Water Supply Well HTH-2

The electric submersible pump in well HTH-2 was replaced because the pump was not working and the well was designated as the water supply well for the drilling program. Pump removal activities began along with mobilization activities during daytime hours on September 9, 2013. Boart used a mobile crane to pull the existing pump, but after the initial setup it was determined that Boart did not have the correct lifter to remove the pump. Boart obtained the necessary lifter, and the pump and water access tubing were removed on September 10, 2013. The new pump was reinstalled to a depth of 697 ft bgs using the existing pump riser pipe, water access tube, and electric cable on September 11, 2013. The new Grundfos pump (model 85200-18) is powered by a 20-horsepower, three-phase, 460-volt Grundfos motor (Sand Solution model number 96168768). A functional test of the pump was done, and water from this well was used for the drilling program beginning late afternoon on September 11, 2013. A transducer was reinstalled in well HTH-2 on September 19, 2013.

5.2 Pump Removal in Existing Wells MV-4 and MV-5

The pumps in wells MV-4 and MV-5 were removed as part of the drilling program. At both wells, water access tubes were reinstalled, and top plates were set to accommodate the installation of low-flow bladder pumps at a later date. The pumps pulled from each well were three-phase, 460-volt Grundfos (model 10S50-58DS) pumps.

5.2.1 MV-4 Pump Removal

The pump in MV-4 was removed on September 18, 2013, and the 1¼-inch PVC water access tube was reinstalled to a depth of 700 ft. This pump was then placed in well MV-6. A top plate was constructed for MV-4 on September 19, and a transducer was installed in the well on September 20, 2013.

5.2.2 MV-5 Pump Removal

The pump in MV-5 was removed on September 12, 2013. Work resumed on MV-5 on September 19, 2013 when the water access tubing was reinstalled to a depth of 700 ft. A top plate was constructed later that day.

5.3 Wellhead Modification UC-1-P-2SR

The UC-1-P-2SR well head was modified by adding a riser pipe to the well to allow the area around the well to be filled in with native soil. A concrete well pad with locking well box was installed on September 19, 2013. The locking well box was installed to protect the well and prevent unauthorized access.

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6.0 Management of Investigation Derived Waste

During the drilling program, the contractor was responsible for environmental compliance, which included managing waste and managing fluids in accordance with the FMP. Copies of Safety Data Sheets for chemicals used during the drilling program were maintained onsite. Spill response equipment was also maintained onsite, and emergency contact information was made available to all employees at the site. The following sections summarize the waste management activities.

6.1 Waste Management

Construction debris and nonhazardous waste generated during the drilling program at CNTA were contained in a roll-off bin onsite and disposed of by Boart. Incidental spills occurred during drilling operations; however, no reportable spills (greater than 25 gallons) occurred. Secondary containment (e.g., plastic sheeting) was used under equipment to contain minor leaks that occurred during operations. Fuel was stored in approved containers with appropriate labeling and secondary containment systems. Boart managed and disposed of hydrocarbon liquids and solids. No hazardous or radioactive waste was generated during the drilling program.

6.2 Fluid Management

Fluids generated during drilling, well construction, and development were managed in accordance with the FMP (DOE 2009a). The fluid management strategy was based on process knowledge, which was verified through field screening and onsite monitoring. Fluids produced during drilling, well construction, and development were monitored onsite for tritium. Tritium levels of discharged fluids remained within the background range during drilling. An infiltration basin was constructed adjacent to well MV-6. The infiltration basin contained fluids and cuttings produced during drilling, construction, and development activities in accordance with the FMP (DOE 2009a). No fluids were discharged from the infiltration basin during the drilling program.

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7.0 Site Health and Safety

All work at CNTA was conducted in accordance with Title 10 *Code of Federal Regulations* Parts 835 and 851, the contractor's Integrated Safety Management System (ISMS), and the Field Instructions (DOE 2013b). Additionally, all activities were done in compliance with DOE orders and Occupational Safety and Health Administration regulations. The health and safety training requirements, project information, site and material characteristics, hazard analysis, site controls, site operations, and emergency procedures were given to the subcontractor before the drilling project started and were outlined in Section 01020 (Construction Health and Safety), Attachment 1 of the CNTA drilling statement of work. Before arriving onsite, all personnel that supported the CNTA project had appropriate and current health and safety training as specified in Section 01020, in the Job Safety Analyses (JSAs), or both. Documentation of training was kept onsite during the project.

The JSAs made for the project addressed the ISMS core functions—defining the scope of work and specific activities, analyzing the hazards associated with the activities, and developing and implementing the controls and protective equipment to mitigate those hazards. Two JSAs were prepared: one for monitoring well installation and activities associated with the drilling and one for the shuttle service. The JSAs were included as part of the required reading for the project, and all site personnel were required to sign them to indicate that they understood them. Contractor personnel conducted tailgate safety briefings and plan-of-the-day discussions at the beginning of each work shift throughout the project. All workers who attended the briefings and discussions signed the necessary attendance sheets. Visitors and delivery personnel were given a tailgate safety briefing and were informed of the general hazards associated with the planned activities.

The success of the health and safety program at CNTA is directly attributable to the ISMS. The system was correctly implemented at the beginning of the project and used throughout the project. Adhering to the program caused work to be performed safely and demonstrated the system's effectiveness.

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Appendix A

Well HTH-2/Water Truck Analytical Data and 2013 Well Survey Data

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Table A-1 Groundwater Quality Data by Location

General Water Quality Data by Location (USEE105) FOR SITE CNT01, Central Nevada Test Area Site

REPORT DATE: 03/06/2014

Location: HTH-2 WELL

Parameter	Units	Sample Date	Sample ID	Depth Range (ft bgs)	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/11/2013	N001	504 - 1000	15.4	NQ	U	#	14	9.02
Americium-241	pCi/L	09/11/2013	N001	504 - 1000	44.5	U		#	130	79.8
Antimony-125	pCi/L	09/11/2013	N001	504 - 1000	1.55	U		#	10	5.71
Bromide	mg/L	09/11/2013	N001	504 - 1000	0.2	U		#	0.2	
Cerium-144	pCi/L	09/11/2013	N001	504 - 1000	−3.82	U		#	24	14.5
Cesium-134	pCi/L	09/11/2013	N001	504 - 1000	−1.97	U		#	4	2.28
Cesium-137	pCi/L	09/11/2013	N001	504 - 1000	−0.878	U		#	4	2.32
Cobalt-60	pCi/L	09/11/2013	N001	504 - 1000	2.04	U		#	4	2.46
Europium-152	pCi/L	09/11/2013	N001	504 - 1000	−5.33	U		#	20	11.6
Europium-154	pCi/L	09/11/2013	N001	504 - 1000	−10.7	U		#	21	11.9
Europium-155	pCi/L	09/11/2013	N001	504 - 1000	0.541	U		#	17	10.2
Gross Alpha	pCi/L	09/11/2013	N001	504 - 1000	3.19			#	0.96	0.91
Gross Beta	pCi/L	09/11/2013	N001	504 - 1000	4.27			#	1.2	1.03
Lead-212	pCi/L	09/11/2013	N001	504 - 1000	3.42	U		#	13	7.46
Potassium-40	pCi/L	09/11/2013	N001	504 - 1000	67.7	U		#	120	70.9
Promethium-144	pCi/L	09/11/2013	N001	504 - 1000	1.6	U		#	2.4	1.46
Promethium-146	pCi/L	09/11/2013	N001	504 - 1000	0.928	U		#	4.8	2.87
Ruthenium-106	pCi/L	09/11/2013	N001	504 - 1000	−0.399	U		#	37	21.9
Thorium-234	pCi/L	09/11/2013	N001	504 - 1000	81.2	U		#	94	58.8
Tritium	pCi/L	09/11/2013	N001	504 - 1000	47.4	U		#	320	195
Uranium-235	pCi/L	09/11/2013	N001	504 - 1000	11.6	U		#	22	13.5
Yttrium-88	pCi/L	09/11/2013	N001	504 - 1000	2.95	U		#	4.6	2.85

Table A-1 (continued). Groundwater Quality Data by Location

General Water Quality Data by Location (USEE105) FOR SITE CNT01, Central Nevada Test Area Site

REPORT DATE: 03/06/2014

Location: WATER TRUCK TANK Tank sourced well water for HTH2

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/12/2013	N001	0	-	0	16	NQ	U	#	14	7.9
Americium-241	pCi/L	09/12/2013	N001	0	-	0	−5.13	U		#	37	21.9
Antimony-125	pCi/L	09/12/2013	N001	0	-	0	4.65	U		#	8.9	5.18
Bromide	mg/L	09/12/2013	N001	0	-	0	44			#	1	
Cerium-144	pCi/L	09/12/2013	N001	0	-	0	0.328	U		#	18	10.8
Cesium-134	pCi/L	09/12/2013	N001	0	-	0	−2.22	U		#	4.6	2.66
Cesium-137	pCi/L	09/12/2013	N001	0	-	0	−2.6	U		#	4.5	2.58
Cobalt-60	pCi/L	09/12/2013	N001	0	-	0	0.242	U		#	4.3	2.51
Europium-152	pCi/L	09/12/2013	N001	0	-	0	3.29	U		#	24	13.9
Europium-154	pCi/L	09/12/2013	N001	0	-	0	0.839	U		#	24	13.9
Europium-155	pCi/L	09/12/2013	N001	0	-	0	6.94	U		#	10	6.23
Gross Alpha	pCi/L	09/12/2013	N001	0	-	0	6.37			#	1.9	1.78
Gross Beta	pCi/L	09/12/2013	N001	0	-	0	6.62			#	2.1	1.74
Lead-212	pCi/L	09/12/2013	N001	0	-	0	−4.68	U		#	14	8.17
Potassium-40	pCi/L	09/12/2013	N001	0	-	0	48.2	U		#	120	74.9
Promethium-144	pCi/L	09/12/2013	N001	0	-	0	0.362	U		#	4.6	2.73
Promethium-146	pCi/L	09/12/2013	N001	0	-	0	−0.519	U		#	4.2	2.49
Ruthenium-106	pCi/L	09/12/2013	N001	0	-	0	−19	U		#	41	23.8
Thorium-234	pCi/L	09/12/2013	N001	0	-	0	34	U		#	120	74.9
Tritium	pCi/L	09/12/2013	N001	0	-	0	73.9	U		#	320	195
Uranium-235	pCi/L	09/12/2013	N001	0	-	0	1.64	U		#	28	16.7
Yttrium-88	pCi/L	09/12/2013	N001	0	-	0	4.45	U		#	4.8	3.03

Table A-1 (continued). Groundwater Quality Data by Location

SAMPLE ID CODES: 000X = Filtered sample (0.45 µm). N00X = Unfiltered sample. X = Replicate number.

LAB QUALIFIERS:

*	Replicate analysis not within control limits.
>	Result above upper detection limit.
A	Tentatively identified compound (TIC) is a suspected aldol-condensation product.
B	Inorganic: Result is between the IDL and CRDL. Organic: Analyte also found in method blank.
C	Pesticide result confirmed by GC-MS.
D	Analyte determined in diluted sample.
E	Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
H	Holding time expired, value suspect.
I	Increased detection limit due to required dilution.
J	Estimated.
N	Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: TIC.
P	> 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
U	Analytical result below detection limit.
W	Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
X,Y,Z	Laboratory defined qualifier; see case narrative.

DATA QUALIFIERS:

F	Low-flow sampling method used.	G	Possible grout contamination, pH > 9.
		J	Estimated value.
L	Less than 3 bore volumes purged prior to sampling.	Q	Qualitative result due to sampling technique.
		R	Unusable result.
U	Parameter analyzed for but not detected.	X	Location is undefined.

QA QUALIFIER: # Validated according to quality assurance guidelines.

Table A-2. 2013 Survey Data

Location Identification	Northing (ft)	Easting (ft)	TOC Elevation (ft)
HTH-1LPZ	1411444.79	629717.05	6011.305
HTH-1UPZ	1411444.36	629717.18	6011.273
HTH-1RC	1411444.64	629717.32	6011.703
HTH-2	1411931.43	629585.29	6026.054
MV-1	1416704.33	631162.17	6070.568
MV-1LPZ	1416704.03	631162.45	6069.913
MV-1UPZ	1416703.87	631163.00	6069.976
MV-2	1412731.89	626545.87	6190.659
MV-2LPZ	1412732.24	626545.52	6190.392
MV-2UPZ	1412731.65	626546.75	6190.664
MV-3	1416559.52	628809.43	6168.268
MV-3LPZ	1416559.87	628809.92	6167.691
MV-3UPZ	1416560.23	628810.40	6167.745
MV-4	1413816.79	630569.64	6019.572
MV-4PZ	1413817.18	630569.73	6019.454
MV-5	1413231.50	629584.81	6041.852
MV-5PZ	1413231.57	629585.30	6040.853
MV-6	1414770.90	630150.73	6053.843
UC-1-P-1SRC	1413403.26	629833.75	6031.583
UC-1-P-2SR	1414634.37	628979.66	6080.507

LPZ = Lower piezometer
UPZ = Upper piezometer
PZ = Piezometer
Ft = Feet
TOC = Top of casing (well/piezometer)
RC = Recompleted

Coordinate System: U.S. State Plane System 1927 (Nevada Central Zone)
Horizontal Datum – NAD27
Vertical Datum – NGVD29

Appendix B

MV-6 Data

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Table B-1. MV-6 Chronology

Date	Time	Depth (ft bgs)	Activity
09/08/13	NA	NA	Mobilization to CNTA
09/09/13	07:00	NA	Safety Meeting/Review JSA; delivery and setup of field office at MV-3; set up field lab, drilling equipment, and drill rig on MV-6
09/09/13	11:00	NA	Crane inspection and lift plan finalized for removal/replacement of pump at HTH-2; operations pending arrival of 3½-inch pump column elevators, continue setup activities at MV-6
09/09/13	13:00	NA	Delivery and setup of field office generators at MV-3 and light plants at MV-3 and MV-6
09/09/13	16:00	NA	Pump 500-gallons of water from UC-1-P-1SRC for MV-6 setup activities
09/10/13	07:00	NA	Safety meeting; installation of electrical panel and power to field office
09/10/13	08:00	NA	Continue setup of MV-6 drill pad and assembly of 20½-inch bottom hole assembly (BHA) for surface casing
09/10/13	11:30	NA	Set up for pump removal at HTH-2; inspect generators and light plants
09/10/13	14:00	NA	Initiate pump removal from HTH-2, continue setup for drilling operations at MV-6 and pumping water at UC-1-P-1SRC
09/11/13	07:00	NA	Safety meeting; orientation of new Stoller crew; materials delivery; set up to install new pump at HTH-2
09/11/13	09:00	NA	Begin installing pump at HTH-2; final electrical connections made to lab trailer; continue rigging up to drill at MV-6
09/11/13	12:00	NA	Shift change/safety meeting; inventory drilling materials; continue pump installation at HTH-2 and rigging-up at MV-6
09/11/13	14:30	NA	Conduct pre-drill rig and drill pad inspection—no deficiencies noted; finalize preparations for drilling; finish pump installation at HTH-2, start pumping water into 15,000-gallon tank, and collect raw water samples from HTH-2 for offsite analysis
09/11/13	19:30	0	Begin drilling operations at MV-6—20½-inch pilot hole for surface casing
09/11/13	22:00	20	Lay-down pilot hole assembly and trip-in 19-inch bit and reamer assembly, continue advancing the borehole to 40 feet depth
09/12/13	00:00	40	Shift change/safety meeting; haul water from HTH-2, mix drilling fluid, and collect samples from water truck for offsite analysis
09/12/13	04:00	40	Begin mud-rotary drilling operations in 19-inch borehole, continue hauling water and mixing polymer drilling fluid
09/12/13	08:00	120	19-inch surface casing borehole advanced to 120 feet bgs; trip-out to install surface casing
09/12/13	09:00	120	Begin running-in and welding 14-inch carbon steel surface casing; begin pump removal operations at MV-5
09/12/13	12:00	120	Shift change/safety meeting; land surface casing at 98 feet bgs due to borehole slough; run-in tremie pipe to cement casing
09/12/13	15:30	120	Cement 14-inch surface casing; State inspection of MV-6 operations; finish pump removal at MV-5; 3.5 hours standby for lightning
09/12/13	22:00	120	Surface casing cementing operations completed; lay-out 12¼-inch BHA, install flow line on surface casing
09/13/13	00:00	120	Shift change/safety meeting; continue preparations for drilling, pick-up and run-in the 12¼-inch BHA
09/13/13	06:30	120	Advance 12¼-inch BHA out of surface casing to 106 feet depth; install inner tubes for flooded reverse-circulation drilling
09/13/13	09:30	140	Advance 12¼-inch borehole 140 feet bgs, install hydraulic roughneck on drill table, continue to drill ahead
09/13/13	12:00	220	Shift change/safety meeting; continue drilling ahead; State and DOE Inspection of operations; initiate drilling fluid sampling for tritium, NaBr, temperature, pH, and specific conductance
09/13/13	16:30	320	Deviation survey at 300 feet (0.5° inclination); continue drilling advance, logging cuttings, and sampling/analyzing drilling fluids
09/14/13	00:00	550	Shift change/safety meeting; continue standard drilling operations in volcanic alluvium

Table B-1 (continued). MV-6 Chronology

Date	Time	Depth (ft bgs)	Activity
09/14/13	03:00	620	Deviation survey at 600 feet (1.0° inclination); continue normal drilling operations
09/14/13	06:00	700	Drilling parameters steady, continue drilling advance, normal operations
09/14/13	12:00	840	Shift change/safety meeting; continue drilling advance, Pacific Surveys to conduct geophysical logging (onsite by 24:00)
09/14/13	16:00	920	Deviation survey at 900 feet (0.25° inclination); continued clayey, gravelly sand alluvium; drilling advance continues
09/14/13	21:00	1,023	TD borehole MV-6 at 1,023 feet bgs in alluvium; circulate and trip-out drill pipe
09/15/13	00:00	1,023	Shift change/safety meeting; lay-down BHA and prepare for logging operations; Pacific Surveys standing-by, review JSA
09/15/13	03:00	NA	Borehole geophysical logging commences; 5 passes, top of water ~325 feet bgs, TD 1,022.5 feet bgs
09/15/13	06:30	NA	Review geophysical logs and plan well design (20 feet sump, 160 feet screen); confirm well design with Stoller and DRI; run-in 1¾-inch ID tremie pipe, stage well screen and casing, stage completion materials
09/15/13	09:00	NA	Well construction begins; run-in 600 feet of 5½-inch carbon steel screen and casing, maintain pipe tally
09/15/13	12:00	NA	Shift change/safety meeting; finish installing casing, land bullnose and hang well at 1,021.12 feet bgs
09/15/13	14:30	NA	Begin installing gravel pack (4.5 super-sacks, >⅛ <¼-inch gravel) to 805 feet bgs, about 33 feet above the top of screen
09/15/13	21:00	NA	Trip-in surge block on tremie pipe and swab well to settle gravel pack
09/16/13	00:00	NA	Shift change/safety meeting; finish swabbing screen interval, tag top of gravel at 811 feet bgs, about 27 feet above screen; tremie in 6/12 transition sand and tag at 783 feet bgs, about 28 feet above the top of gravel; set up for cementing operations
09/16/13	06:00	NA	Begin cementing operations with a 43 feet hot-batch lift of Portland cement; continue cementing after hot-batch cures
09/16/13	12:00	NA	Shift change/safety meeting; continue cementing the annular space around the well
09/16/13	16:00	NA	Cement to surface, well construction complete; clean up equipment and prepare for well development operations; run-in HQ and BQ drill rod eductor system for air-lift development; set up and connect diverter
09/17/13	00:00	NA	Shift change/safety meeting; initiate air-lift development on MV-6; sample well development fluids and test for water quality; disassemble and clean drilling equipment
09/17/13	12:00	NA	Shift change/safety meeting; continue well development; continue cleaning drilling equipment and stage for demobilization
09/18/13	00:00	NA	Shift change/safety meeting; continue well development operations and demobilization preparations
09/18/13	05:00	NA	Complete well development and collect a final water sample for field analysis; remove the eductor system from the well and move the rig to the staging area
09/18/13	08:00	NA	Begin pump removal operations at MV-4
09/18/13	12:00	NA	Shift change/safety meeting; remove pump from MV-4 and install 700 feet of water access tubing into the well
09/18/13	15:00	NA	Install pump from MV-4 into MV-6, set pump at ~828 ft bgs, static water level in MV-6 at 312.65 feet bgs; inventory materials
09/18/13	20:30	NA	Begin pumping well MV-6 with flow at 13 gpm and completed development after about 3.5 hours; final turbidity was 8.32 NTU and Br was 0.82 mg/L
09/19/13	06:00	NA	Day shift safety meeting; install 700 feet of water access tubing in well MV-5; electricians disconnect power supply from field office; pack-up field office and lab; install transducers in wells MV-6 and HTH-2; install concrete pads and well boxes at MV-6 and UC-1-P-2SR; load drilling equipment onto two transports and demobilize; demobilize field lab
09/20/13	08:00	NA	Day shift safety meeting; load two transports of drilling equipment, install transducer in well MV-4; demobilize from site

NA = Not applicable

Table B-2. CNTA MV-6 Well Construction Materials

Construction	Material	Type	Interval (ft)	Stemming Material	Volume (ft^3)	Interval (ft)
Surface Casing	14-inch CS Casing	Blank	0.0–98.0	Cement Seal	108	0.0–120.0
Monitoring Well Casing	5.5-inch Casing (CS with Internal Ceramic/Epoxy Coating)	Blank	+ 1.0–838.02	Cement Seal	512	0.0–783
		Screen	838.02–1,000.66	6/12 Sand Pack	18.3	783–811
		Sump with Bullnose	1,000.66–1,021.12	1/8–1/4-inch Gravel Pack	139	811–1,023.00
Submersible pump	Grundfos 10S50-58DS Pump	Top	821	NA		
		Intake	826	NA		
		Bottom	828	NA		
Pump Riser Pipe	1.0-inch CS EUE	Blank	+1.12–821	NA		
Water Access Tubing	1.25-inch Flush Joint Schedule 80 PVC	Blank	+1.0–781	NA		
		Screen w/end cap	781–821	NA		

CS = Carbon steel
ft = Feet
ft^3 = Cubic feet
NA = Not applicable
PVC = Polyvinyl chloride
EUE = External upset ends

Table B-3. MV-6 Tritium Results

Sample Identification	Date	Time	Depth (ft)	Tritium (pCi/L)	MDC (pCi/L)
Well Drilling					
MV-6-01	09/13/13	09:10	130	<385	385
MV-6-02	09/13/13	11:00	160	<385	385
MV-6-03	09/13/13	13:10	220	<385	385
MV-6-04	09/13/13	14:15	265	<385	385
MV-6-05	09/13/13	15:14	300	<385	385
MV-6-06	09/13/13	16:35	330	<385	385
MV-6-07	09/13/13	17:45	360	<385	385
MV-6-08	09/13/13	18:55	400	<385	385
MV-6-09	09/13/13	19:55	435	<385	385
MV-6-10	09/13/13	20:55	470	<385	385
MV-6-11	09/13/13	21:55	500	<385	385
MV-6-12	09/13/13	22:55	525	<385	385
MV-6-13	09/14/13	00:35	565	<385	385
MV-6-14	09/14/13	01:30	590	<385	385
MV-6-15	09/14/13	02:30	620	<385	385
MV-6-16	09/14/13	04:15	650	<385	385
MV-6-17	09/14/13	05:10	680	<385	385
MV-6-18	09/14/13	06:30	710	<385	385
MV-6-19	09/14/13	07:50	740	<385	385
MV-6-20	09/14/13	09:20	770	<385	385
MV-6-21	09/14/13	10:30	800	<385	385
MV-6-22	09/14/13	12:55	850	<385	385
MV-6-23	09/14/13	14:10	880	<385	385
MV-6-24	09/14/13	15:30	910	<385	385
MV-6-25	09/14/13	17:05	940	<385	385
MV-6-26	09/14/13	18:30	970	<385	385
MV-6-27	09/14/13	19:50	1000	<385	385
MV-6-28	09/14/13	21:00	1020	<385	385
Well Development – Air					
MV-6-01D	09/17/13	03:05	NA	<385	385
MV-6-02D	09/17/13	05:00	NA	<385	385
MV-6-03D	09/17/13	07:05	NA	<385	385
MV-6-04D	09/17/13	09:00	NA	<385	385
MV-6-05D	09/17/13	10:45	NA	<385	385
MV-6-06D	09/17/13	12:42	NA	<385	385
MV-6-07D	09/17/13	13:44	NA	<385	385
MV-6-08D	09/17/13	15:00	NA	<385	385
MV-6-09D	09/17/13	16:00	NA	<385	385
MV-6-10D	09/17/13	18:00	NA	<385	385
MV-6-11D	09/17/13	20:00	NA	<385	385
MV-6-12D	09/17/13	22:00	NA	<385	385
MV-6-13D	09/17/13	23:00	NA	<385	385
MV-6-14D	09/17/13	23:53	NA	<385	385

Table B-3 (continued). MV-6 Tritium Results

Sample Identification	Date	Time	Depth (ft)	Tritium (pCi/L)	MDC (pCi/L)
Well Development – Air					
MV-6-15D	09/18/13	01:00	NA	<385	385
MV-6-16D	09/18/13	02:00	NA	<385	385
MV-6-17D	09/18/13	03:00	NA	<385	385
MV-6-18D	09/18/13	04:00	NA	<385	385
MV-6-19D	09/18/13	05:00	NA	<385	385
Well Development – Pump					
MV-6-20D	09/18/13	20:30	NA	<385	385
MV-6-21D	09/18/13	23:00	NA	<385	385

ft = Feet
NA = Not applicable
pCi/L = Picocuries per liter
MDC = Minimum detectable concentration

Table B-4. MV-6 Water Quality Parameter Results

Date	Time	Depth (ft)	pH (SU)	Temperature (°C)	Conductivity (µS/cm)	Br^- (mg/L)	Turbidity (NTU)
Well Drilling							
09/13/13	09:10	130	9.00	24.1	6340	22	NA
09/13/13	11:00	160	8.94	21.5	6100	20	NA
09/13/13	13:10	220	8.99	24.4	5850	27	NA
09/13/13	14:15	265	9.12	24.3	3840	24	NA
09/13/13	15:14	300	9.15	24.5	5190	30	NA
09/13/13	16:35	330	9.16	24.0	4810	34	NA
09/13/13	17:45	360	9.14	23.5	4250	30	NA
09/13/13	18:55	400	9.25	22.6	4240	30	NA
09/13/13	19:55	435	9.19	22.9	4210	27	NA
09/13/13	20:55	470	9.20	22.1	3100	21	NA
09/13/13	21:55	500	9.14	22.3	3060	21	NA
09/13/13	22:55	525	9.15	21.6	2920	22	NA
09/14/13	00:35	565	9.01	21.7	2980	27	NA
09/14/13	01:30	590	9.12	20.2	2820	30	NA
09/14/13	02:30	620	9.11	21.2	2700	31	NA
09/14/13	04:15	650	9.00	20.5	2660	26	NA
09/14/13	05:10	680	9.10	20.4	2550	27	NA
09/14/13	06:30	710	8.99	20.1	2450	24	NA
09/14/13	07:50	740	8.89	20.6	2400	26	NA
09/14/13	09:20	770	8.93	21.0	2270	26	NA
09/14/13	10:30	800	8.86	21.3	2280	27	NA
09/14/13	12:55	850	8.71	23.6	2000	25	NA
09/14/13	14:10	880	8.71	22.7	1965	24	NA
09/14/13	15:30	910	8.69	23.1	1910	25	NA
09/14/13	17:05	940	8.67	22.6	1891	28	NA
09/14/13	18:30	970	8.69	22.7	1904	22	NA
09/14/13	19:50	1000	8.68	22.7	1859	29	NA
09/14/13	21:00	1020	8.80	22.3	1878	15	NA
Well Development – Air							
09/17/13	03:05	NA	8.53	23.7	848	11	>1000
09/17/13	05:00	NA	8.15	21.4	465	3.0	>1000
09/17/13	07:05	NA	8.01	20.7	319	2.5	>1000
09/17/13	09:00	NA	7.84	20.9	310	1.9	>1000
09/17/13	10:45	NA	8.21	23.8	491	18	>1000
09/17/13	12:42	NA	7.71	22.2	251	1.0	335
09/17/13	13:44	NA	7.85	20.6	249	1.0	456
09/17/13	15:00	NA	7.86	20.9	243	1.7	>1000
09/17/13	16:00	NA	7.73	21.3	323	1.1	>1000
09/17/13	18:00	NA	7.33	21.2	239	0.8	389
09/17/13	20:00	NA	7.15	20.3	248	0.9	302
09/17/13	22:00	NA	7.40	19.2	218	1.5	>1000
09/17/13	23:00	NA	7.19	20.1	251	1.3	319
09/17/13	23:53	NA	6.53	19.1	259	1.1	548
09/18/13	01:00	NA	7.53	20.0	226	0.9	158

Table B-4 (continued). MV-6 Water Quality Parameter Results

Date	Time	Depth (ft)	pH (SU)	Temperature (°C)	Conductivity (µS/cm)	Br^- (mg/L)	Turbidity (NTU)
09/18/13	02:00	NA	7.41	19.2	225	1.1	373
Well Development – Air							
09/18/13	03:00	NA	7.62	19.0	244	0.7	97
09/18/13	04:00	NA	7.70	19.1	222	0.6	71
09/18/13	05:00	NA	7.25	18.5	243	0.4	28
Well Development – Pump							
09/18/13	20:30	NA	6.88	21.0	232	1.1	59
09/18/13	23:00	NA	7.41	20.9	202	0.8	8

Br– = Bromide
ft = Feet
mg/L = Milligrams per liter
NA = Not analyzed/Not applicable
NTU = Nephelometric turbidity unit
SU = Standard unit
µS/cm = Microsiemens per centimeter

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MONITORING WELL COMPLETION LOG CNT01-MV-6

PROJECT Nevada Offsites
LOCATION Nevada
SITE Central Nevada Test Area Site
DRILLING METHOD Mud Rotary
DRILL COMPANY Boart Longyear
RIG TYPE LM 140

WELL NUMBER CNT01-MV-6
NORTH COORD. (FT) 1414770.90
EAST COORD. (FT) 630150.73
HOLE DEPTH (FT/bgs) 1023.00
WELL DEPTH (FT/bgs) 1021.12
WATER LEVEL (FT BTOC) 312.65

DATE DRILLED 9/11/2013 to 9/14/2013
SURFACE ELEV. (FT NGVD) 6052.97
TOP OF CASING (FT) 6053.84
MEAS. PT. ELEV. (FT) 6053.84
SLOT SIZE (IN) 0.078
BIT SIZE(S) (IN) 19.0 / 12.25

WATER LEVEL DATE 9/18/2013
DRILLER Jacobo, L.
LOGGED BY Goodknight, C., Rupp, R.
SAMPLING METHOD Grab
DATE DEVELOPED 9/18/2013

	WELL INSTALLATION	INTERVAL (FT)		
BLANK CASING:	5.5 in. Carbon Steel (CS)	-0.87	to	838.02
WELL SCREEN:	5.5 in. Slotted CS	838.02	to	1000.66
SUMP/END CAP:	5.5 in. CS	1000.66	to	1021.12
SEAL:	Cement	0.0	to	783.0
UPPER PACK:	#6/12 Sand	783.0	to	811.0
WELL PACK	1/8" - 1/4" Gravel	811.0	to	1023.0

REMARKS Centralizers: 1.000', 940', 880', 820', 760', 700', 640', 580', 520', and 460'.

Lithological Description

0 - 20 Alluvium, WELL GRADED GRAVEL WITH SAND, GW, gravel ~60 - 70%, medium to coarse grain sand ~20 - 30%, silt and fines < 10 %. Wide range in clast size of gravel (as large as 6" diameter)

20 - 120 Alluvium, brown (7.5YR 5/4), POORLY GRADED SAND, SP, mostly coarse grain sand ~70% and some medium grain sand 20%, fine sand and finer grain material <10%

6000

120 - 130 Alluvium, brown (7.5YR 4/3), WELL GRADED SAND, SW, wide range of grain sizes for sand, ~10% gravel, ~5% clay

130 - 140 Alluvium, WELL GRADED SAND, SW, as above, no clay

140 - 150 Alluvium, WELL GRADED SAND, SW, as above, trace clay

5900

150 - 160 Alluvium, WELL GRADED SAND, SW, as above, no clay

160 - 180 Alluvium, brown (7.5YR 4/3), LEAN CLAY WITH SAND AND GRAVEL, CL, ~10% gravel and 10% sand, clay is moderate-highly plastic

180 - 190 Alluvium, brown (7.5YR 4/3), WELL GRADED SAND WITH GRAVEL, SW, wide range of grain sizes for sand, ~5% clay

190 - 200 Alluvium, WELL GRADED SAND WITH GRAVEL, SW, as above, ~80% sand and trace clay

200 - 210 Alluvium, brown (7.5YR 4/3), POORLY GRADED SAND, SP, ~5% gravel, no clay

210 -220 Alluvium, brownish yellow (10YR 6/6), CLAYEY SAND, SC, mostly fine grain sand, trace gravel

ELEVATION (ft)

220 - 250 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND WITH GRAVEL, SW, wide range of sand sizes, gravel ~15%

5800

250 - 260 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND, SW, wide range of sand sizes, gravel ~10%, ~5% clay

260 - 280 Alluvium, brown (7.5YR 5/4), CLAYEY SAND, SC, mostly fine grain sand, gravel ~10%, clay is moderately plastic

280 - 300 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND, SW, wide range of sand sizes, gravel ~10%, ~5% moderately plastic clay

300 - 310 Alluvium, WELL GRADED SAND, SW, as above, no clay

310 - 320 Alluvium, brown (7.5YR 5/4), CLAYEY SAND, SC, mostly fine grain sand, gravel ~10%, moderately plastic clay

320 - 330 Alluvium, brown (7.5YR 5/4), LEAN CLAY WITH SAND, CL, ~20% medium grain sand, ~5% gravel, moderately plastic clay

330 - 340 Alluvium, WELL GRADED SAND WITH GRAVEL, SW, wide range of sand sizes, ~20% gravel, trace clay

340 - 350 Alluvium, WELL GRADED SAND, SW, as above, with ~10% gravel

5700

350 - 360 Alluvium, WELL GRADED SAND, SW, as above, with ~5% clay

360 - 370 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND, SW, wide range of sand sizes, ~10% gravel, no clay

370 - 390 Alluvium, WELL GRADED SAND, SW, as above, ~5% clay

390 - 400 Alluvium, WELL GRADED SAND, SW, as above, no clay

400 - 410 Alluvium, WELL GRADED SAND, SW, as above, ~5% gravel

410 - 420 Alluvium, POORLY GRADED SAND, SP, mostly medium-coarse grain sand, trace gravel, no clay

420 - 430 Alluvium, WELL GRADED SAND, SW, wide range of sand sizes, ~5% gravel, no clay

430 - 440 Alluvium, WELL GRADED SAND, SW, wide range of sand sizes, ~10% gravel, no clay

440 - 450 Alluvium, brown (7.5YR 5/4), SANDY LEAN CLAY WITH GRAVEL, CL, ~60% clay, 20% sand, 20% gravel, medium to coarse grain, sub-angular to angular, moderately sorted sand

5600

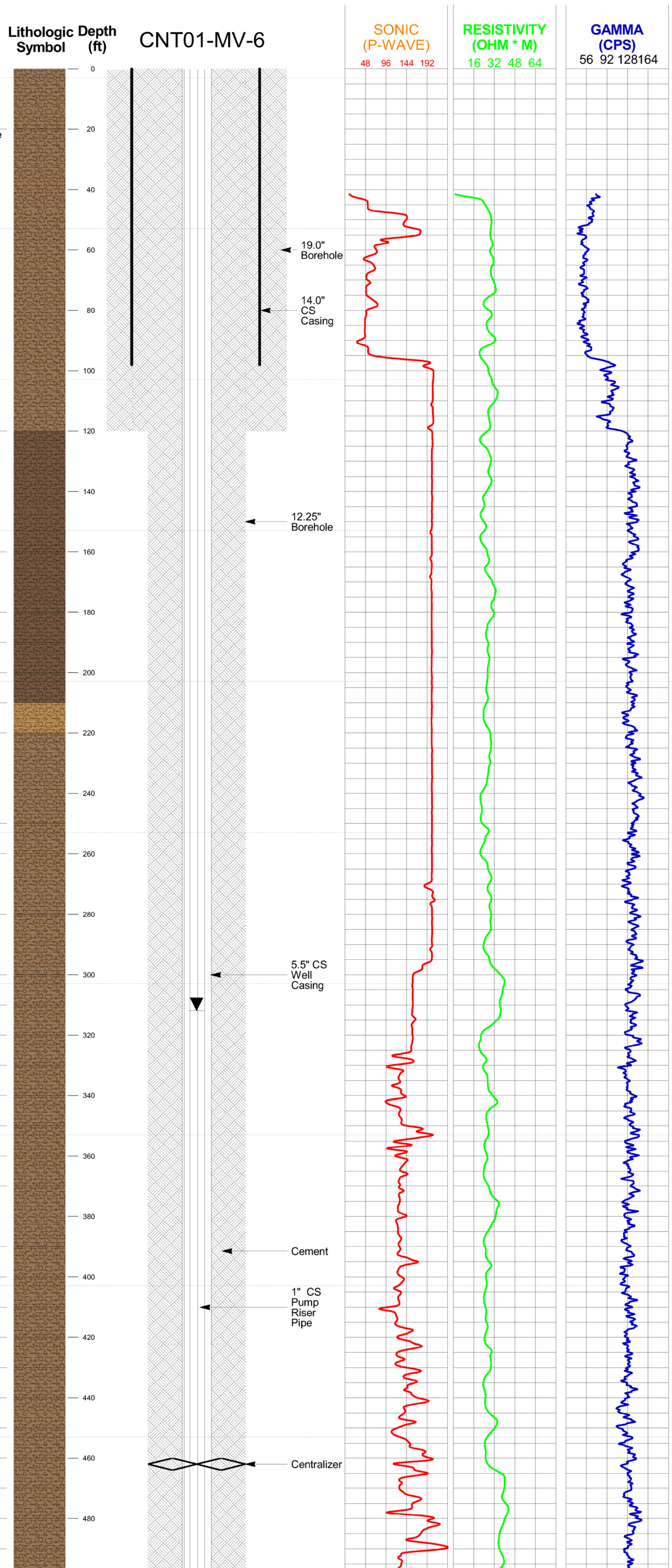
450 - 460 Alluvium, POORLY GRADED SAND WITH GRAVEL, SP, fine to medium grain, rounded to sub-angular sand, 10 - 20% gravel, trace clay

460 - 470 Alluvium, WELL GRADED SAND, SW, mostly fine to medium grain with some coarse grain sand, rounded to sub-angular sand, trace clay

470 - 480 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND WITH GRAVEL, SW, medium to coarse grain, sub-angular sand, increasing gravel ~20%, angular gravel to 3 cm, trace clay

480 - 490 Alluvium, POORLY GRADED SAND, SP, medium and coarse grain sand with < 10% gravel, ~5% clay

490 - 500 Alluvium, brown (7.5YR 5/4), CLAYEY SAND/SANDY LEAN CLAY, SC/CL, 50% sand, 50% clay, trace gravel



CNTA GEO/BH/WELL LARGE LOG REV2 LNG LITH CNT01-7903 MV6.GPJ SHIP.GDT 2/3/14

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MONITORING WELL COMPLETION LOG CNT01-MV-6

Lithological Description

500 - 520 Alluvium, CLAYEY SAND WITH GRAVEL, SC, 70% sand and gravel, 30% clay, medium to very coarse , sub-angular to angular sand

520 - 530 Alluvium, SANDY LEAN CLAY, CL, 60% clay, 40% fine to coarse sand, trace gravel

530 - 540 Alluvium, WELL GRADED SAND, SW, 90% sand, 10% gravel, large range of sand grain size, very fine to very coarse, angular

540 - 550 Alluvium, LEAN CLAY WITH SAND, CL, 80% clay, 20% sand, plastic clay, fine to coarse sand, trace gravel

5500

550 - 570 Alluvium, brown (7.5YR 5/4) to strong brown (7.5YR 5/6), WELL GRADED SAND WITH GRAVEL, SW, fine to very coarse grain angular sand, trace clay

570 - 580 Alluvium, WELL GRADED SAND WITH GRAVEL, SW, as above, increasing broken, angular gravel to 3 cm

580 - 600 Alluvium, WELL GRADED SAND WITH GRAVEL, SW, very fine to very coarse grain sand, gravel mostly 1 cm as broken, angular fragments, trace clay from 595' - 600'

600 - 610 Alluvium, SANDY LEAN CLAY, CL, ~60% clay, 40% sand, sand is well graded medium to very coarse, some angular broken gravel, no significant color change

610 - 630 Alluvium, CLAYEY SAND, SC, well graded sand, some medium gravel, increasing clay 615' - 620'

630 - 650 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND, SW, fine to very coarse grain size, sub-angular to angular

5400

650 - 660 Alluvium, LEAN CLAY, CL, 90% clay, 10% medium to coarse sand

660 - 735 Alluvium, WELL GRADED SAND, SW, 80% - 90% sand with some gravel and intermittent clay, fine to very coarse grain angular sand, small gravel, no significant color change, increasing gravel 720' - 730'

735 - 740 Alluvium, LEAN CLAY, CL, plastic, < 10% sand

740 - 750 Alluvium, WELL GRADED SAND WITH GRAVEL, SW, 80% sand, 20% gravel, fine to very coarse, angular gravel, large gravel, likely cobbles and boulders

5300

750 - 780 Alluvium, WELL GRADED SAND WITH CLAY AND GRAVEL, SW-SC/WELL GRADED GRAVEL WITH CLAY AND SAND, GW-GC, fine to very coarse sand, fine to coarse gravel, ~10% clay lenses, drill string bouncing and slow penetration at times - probable boulders

ELEVATION (ft)

780 - 800 Alluvium, multi-colored lithic sand with a general brown (7.5YR 5/4) coloration, CLAYEY SAND, SC, 80% sand, 20% clay, well graded, fine to very coarse sand, sub-angular to angular

800 - 810 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND WITH GRAVEL, SW, wide range of sand sizes, ~10-15% gravel, ~5% moderately plastic clay

810 - 820 Alluvium, WELL GRADED SAND WITH CLAY AND GRAVEL, SW-SC, as above, 5-10% gravel, 5-10% clay

820 - 840 Alluvium, brown (7.5YR 5/4) to yellowish brown (10YR 5/4), POORLY GRADED SAND, SP, mostly medium to coarse grain sand, ~10% gravel, no clay

840 - 850 Alluvium, brown (7.5YR 5/4) to yellowish brown (10YR 5/4), WELL GRADED SAND WITH CLAY, SW-SC, wide range of sand sizes, ~10% gravel, ~10% clay

5200

850 - 860 Alluvium, WELL GRADED SAND, SW, as above, ~10% gravel, no clay

860 - 880 Alluvium, WELL GRADED SAND, SW, as above, ~10% gravel, ~5% clay

880 - 900 Alluvium, WELL GRADED SAND WITH GRAVEL, SW, as above, ~20% gravel, no clay

900 - 920 Alluvium, brown (7.5YR 5/4) to yellowish brown (10YR 5/4), CLAYEY SAND, SC, mostly fine grain sand and silt, ~30% clay, 5% gravel, moderately plastic clay

920 - 930 Alluvium, brown (7.5YR 5/4), WELL GRADED SAND, SW, wide range of sand sizes, ~10% gravel, ~5% clay

930 - 940 Alluvium, brown (7.5YR 5/4), SILTY SAND, SM, ~10% silt, ~10% clay, ~5% gravel, slightly plastic clayey silty sand

940 - 950 Alluvium, brown (7.5YR 5/4) to yellowish brown (10YR 5/4), WELL GRADED SAND WITH GRAVEL, SW, wide range of sand sizes, ~20% gravel, trace clay

5100

950 - 960 Alluvium, WELL GRADED SAND WITH GRAVEL, SW, as above except no clay

960 - 970 Alluvium, yellowish brown (10YR 5/4), SILTY SAND, SM, wide range of sand sizes, gravel 5-10%, clay 10%, silt 10%, slightly plastic clayey silt

970 - 980 Alluvium, yellowish brown (10YR 5/4), SILTY SAND, SM, wide range of sand sizes, gravel ~5%, clay ~10%, silt ~15%, slightly plastic clayey silt

980 - 990 Alluvium, yellowish brown (10YR 5/4), WELL GRADED SAND, SW, wide range of sand sizes, gravel ~10%, no clay

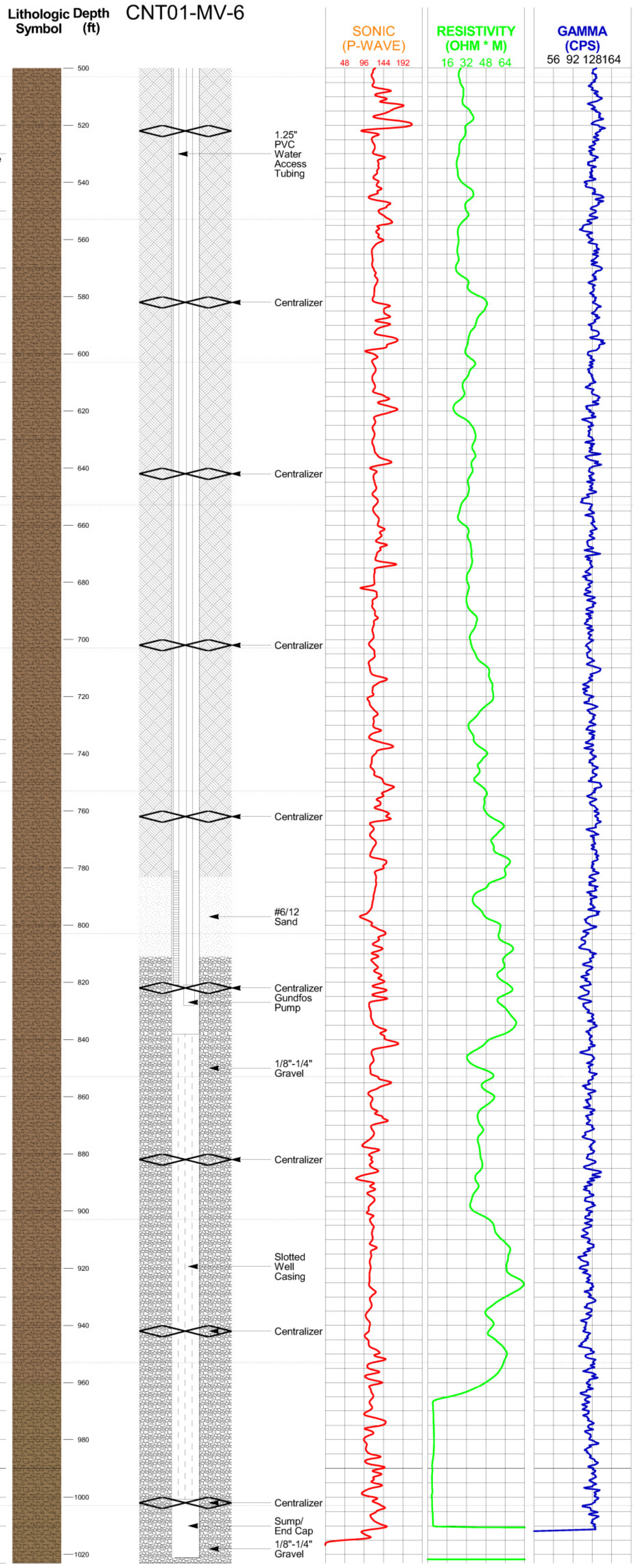
990 - 1000 Alluvium, yellowish brown (10YR 5/4), WELL GRADED SAND WITH SILT AND GRAVEL, SW-SM, wide range of sand sizes, gravel ~15%, silt ~10%, slightly plastic silt

1000 - 1010 Alluvium, yellowish brown (10YR 5/4), WELL GRADED SAND WITH GRAVEL, SW, wide range of sand sizes, gravel ~15%, no clay

1010 - 1020 Alluvium, yellowish brown (10YR 5/4), WELL GRADED SAND, SW, wide range of sand sizes, trace gravel and trace clay

Total Depth 1023 ft.

5000



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