LMS/CNT/S11448

2013 Groundwater Monitoring Report Central Nevada Test Area Subsurface Corrective Action Unit 443

May 2014

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Abbreviations

bgs	below ground surface
BSZ	bottom of open interval/screen zone
^{14}C	carbon-14
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAU	Corrective Action Unit
CNTA	Central Nevada Test Area
DOE	U.S. Department of Energy
ft	feet
ft msl	feet above mean sea level
^{129}I	iodine-129
LM	DOE Office of Legacy Management
LPZ	lower piezometer
µmho/cm	micromhos per centimeter
MV	monitoring/validation
NDEP	Nevada Division of Environmental Protection
pCi/L	picocuries per liter
PZ	piezometer
RDL	required detection limit
ROTC	record of technical change
SGZ	surface ground zero
TOC	top of casing
TSZ	top of open interval/screen zone
UPZ	upper piezometer

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Executive Summary

The Central Nevada Test Area was the site of a 0.2- to 1-megaton underground nuclear test in 1968. The surface of the site has been closed, but the subsurface is still in the corrective action process. The corrective action alternative selected for the site was monitoring with institutional controls. Annual sampling and hydraulic head monitoring of the well network are conducted as part of the subsurface corrective action strategy for the site. The monitoring well network was enhanced in 2013with the installation of a new well MV-6. The site is currently in the fifth year of the 5-year proof-of-concept monitoring period.

Analytical results from the 2013 monitoring are consistent with those of previous years indicating no tritium or ^{14}C concentrations above the required detection limits. Water level data from new wells MV-4 and MV-5 and recompleted well HTH-1RC indicate that hydraulic heads are still recovering from installation and testing. Data from wells MV-4 and MV-5 also indicate that head levels have not yet recovered from the 2011 sampling event during which several thousand gallons of water were purged. Low-flow bladder pumps were installed during the November 2013 sampling event to reduce the well purge volumes and the impact purging has on the water levels during sampling. The new bladder pumps allow the collection of groundwater samples using the low-flow sampling method and will allow head levels to recover to steady-state conditions. Despite the lack of steady-state groundwater conditions, hydraulic head data collected from site continue to support the conceptual model that the southeast-bounding graben fault acts as a barrier to groundwater flow at the site.

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1.0 Introduction

This report presents the 2013 groundwater monitoring results collected by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) for the Central Nevada Test Area (CNTA) Subsurface Corrective Action Unit (CAU) 443. Responsibility for the environmental site restoration of CNTA was transferred from the DOE Office of Environmental Management to LM on October 1, 2006. The environmental restoration process and corrective action strategy for CAU 443 are conducted in accordance with the Federal Facility Agreement and Consent Order (1996, as amended) and all applicable Nevada Division of Environmental Protection (NDEP) policies and regulations. The site is currently in the fifth year of the 5-year proof-of-concept monitoring period. This report summarizes investigation activities associated with CAU 443 that LM conducted at the site from October 2012 through November 2013.

2.0 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 conducted in borehole UC-1 at a depth of 3,199 feet (ft) (975 meters) below ground surface (bgs) on January 19, 1968. The yield of the Faultless test was estimated to be 0.2 to 1 megaton. The test resulted in a down-dropped fault block 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.

2.1 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.

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.

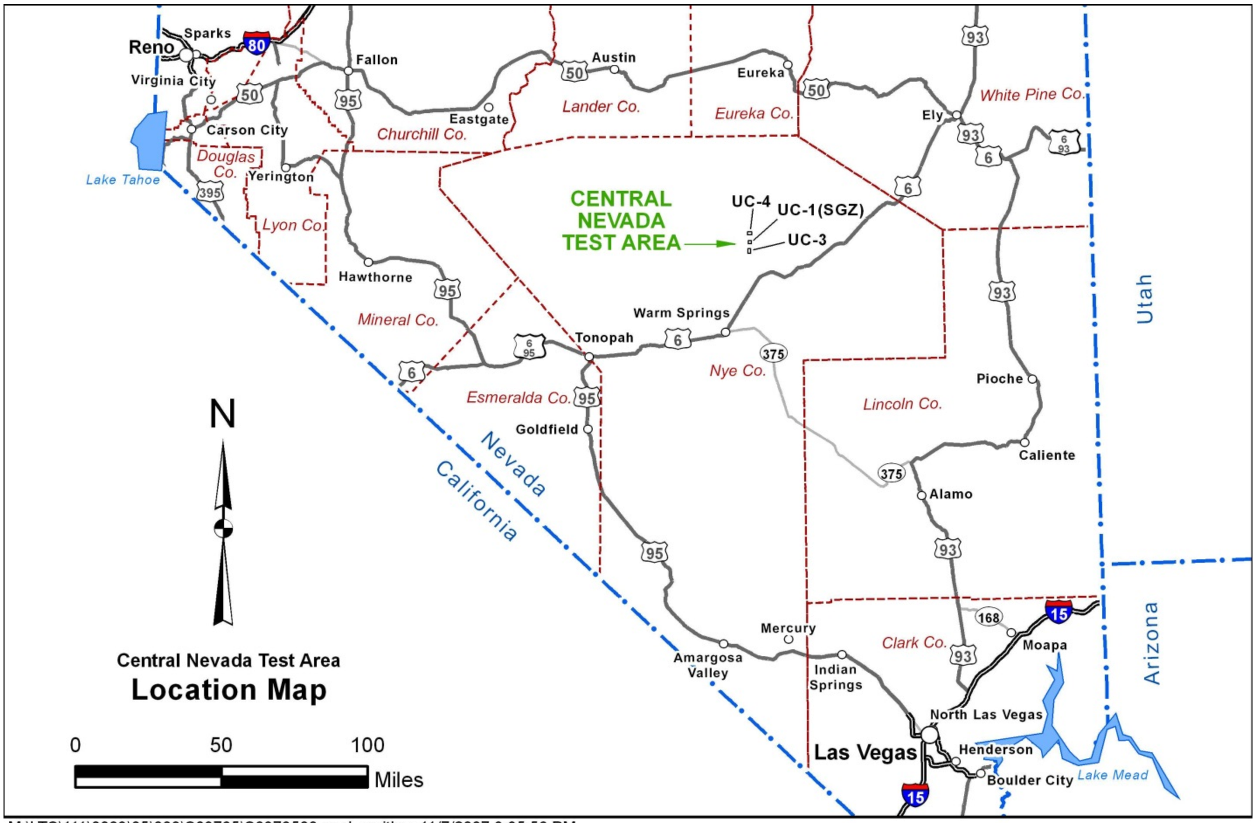

Figure 1. CNTA Location Map

These objectives were accomplished 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 compliance boundary corresponds approximately to the surface expression of the fault block and is all most 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

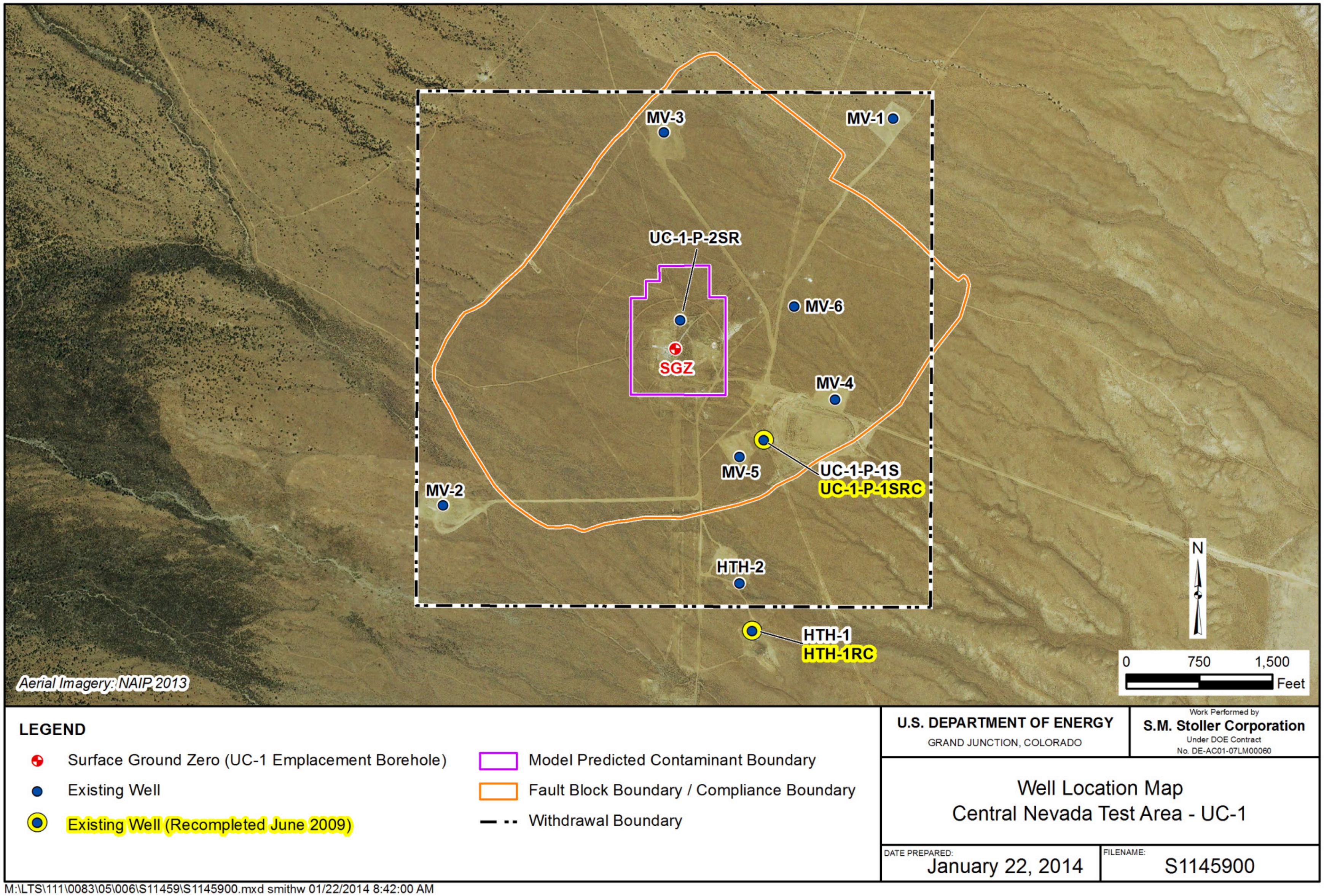

Figure 2. Location Map of Monitoring Wells and Boundaries at CNTA

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 down, 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 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 provided 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 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.

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

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.

The CADD/CAP addendum was revised in July 2013 with a Record of Technical Change (ROTC) to enhance the monitoring well network with a new well at the site. The new well (MV-6) was installed in September 2013 to monitor the upper alluvial aquifer inside the graben. The well was completed with a dedicated electric submersible pump for collecting groundwater samples and conducting aquifer tests. Monitoring of the existing wells MV-4 and MV-5 was enhanced by removing the electric submersible pumps and installing low-flow bladder pumps. The electric submersible pump in well HTH-2 that has historically not been operable was also replaced in 2013. The new well MV-6 and existing wells/piezometers were surveyed to obtain new top of casing measuring point elevations as part of the drilling program. Results from the 2013 drilling program will be provided in a Well Completion Report for CAU 443.

3.0 Geologic and Hydrologic Setting

CNTA is in Hot Creek Valley (Figure 3), a north-south trending graben that is 68 miles long and located in the Basin and Range physiographic province. Hot Creek Valley varies in width from 5 to 19 miles and contains two major stratigraphic units—a thick sequence of Quaternary- and Tertiary-age alluvial deposits (alluvium) underlain by a thick section of Tertiary-age volcanic rocks (volcanics). Log information from wells MV-1, MV-2, and MV-3 indicates that the thickness of the alluvium in the vicinity of UC-1 (location of the Faultless test) ranges from 1,960 to 2,410 ft. The Tertiary volcanics below the alluvium include tuffaceous sediments, welded and nonwelded tuffs, and rhyolite lavas.

The Faultless test took place in the very low permeability volcanic section, creating a cavity and a subsequent collapse chimney that extends into the overlying alluvium. The reentry well, UC-1-P-2SR, was directionally drilled into the chimney from a surface location approximately 300 ft north of surface ground zero (SGZ) a few weeks after the detonation in 1968. The directional survey indicates that well UC-1-P-2SR began to build angle below 1,500 ft to intersect the chimney. Elevations for well UC-1-P-2SR are not corrected for total vertical depth; consequently, elevations based on measured depth below 1,500 ft (4,600 feet above mean sea

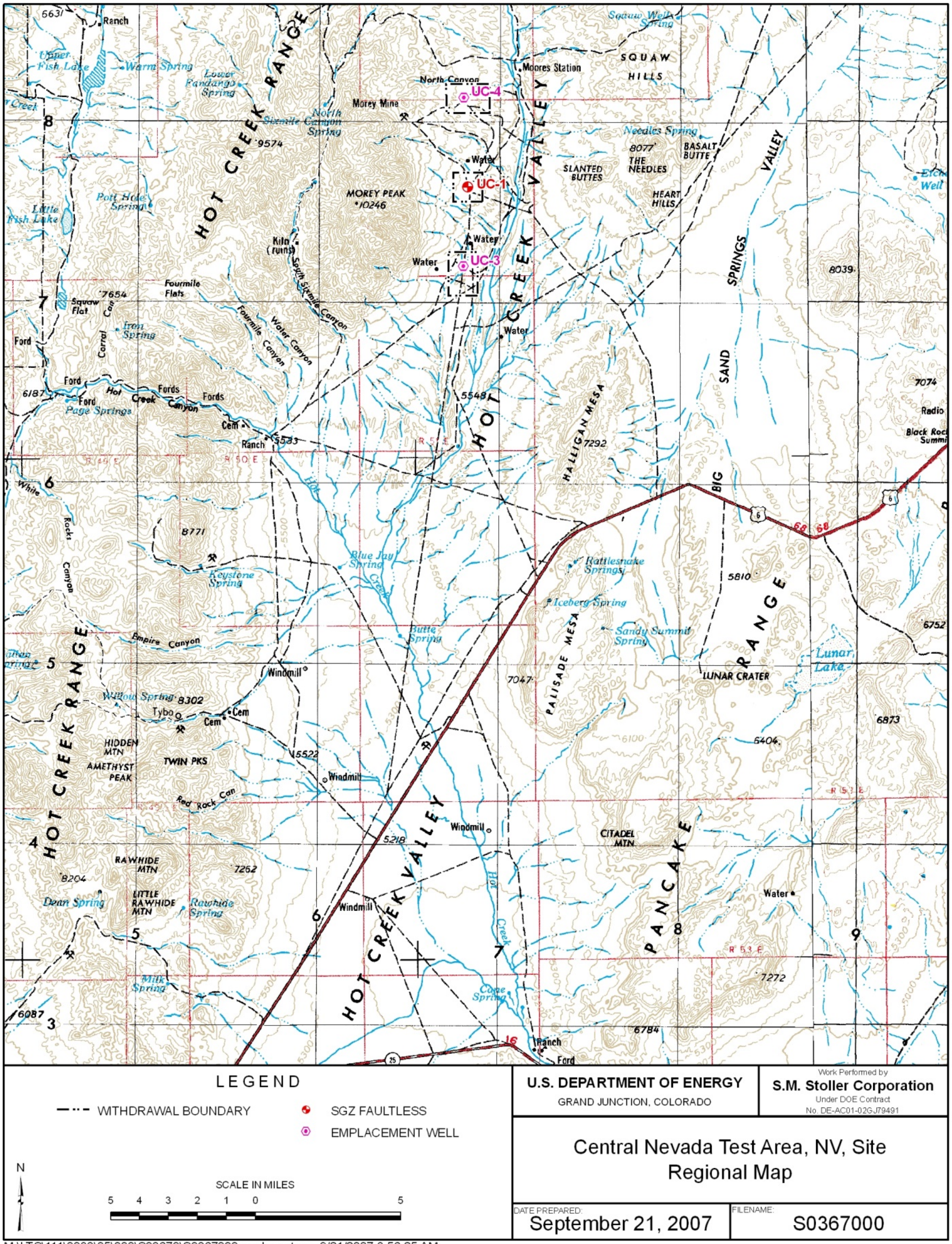

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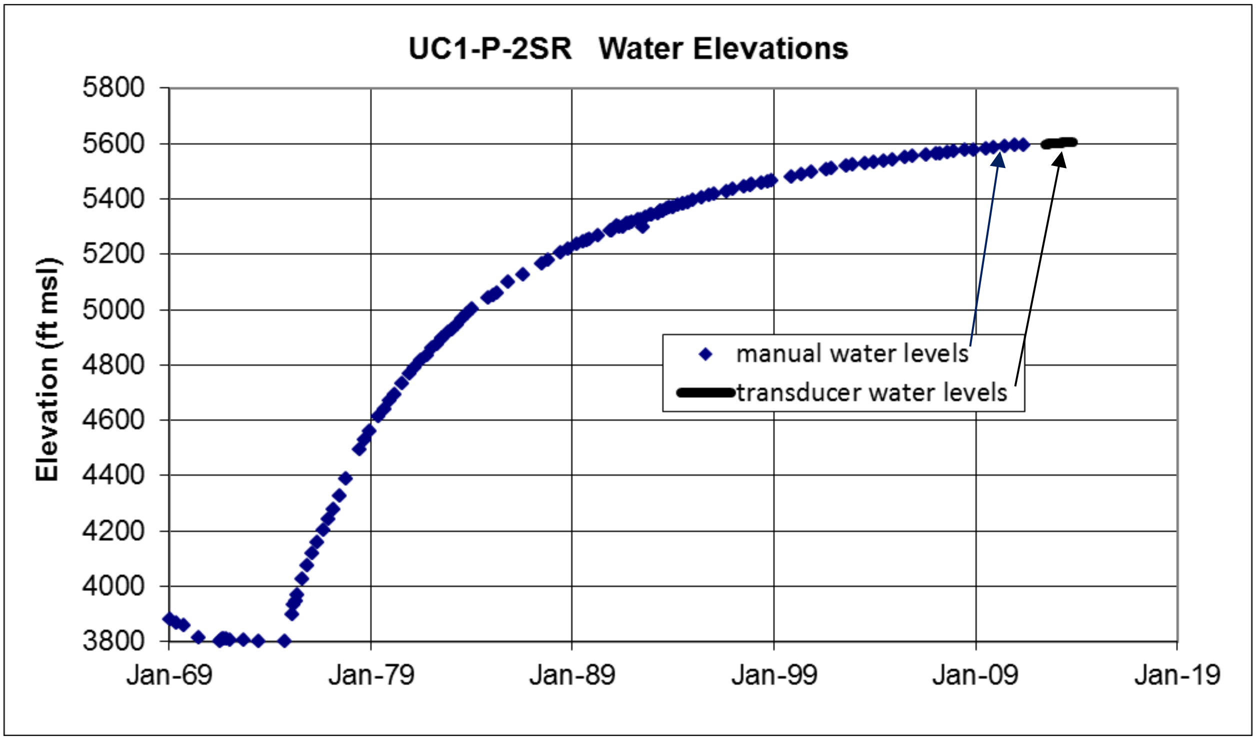
Figure 3. Physiographic Features near CNTA

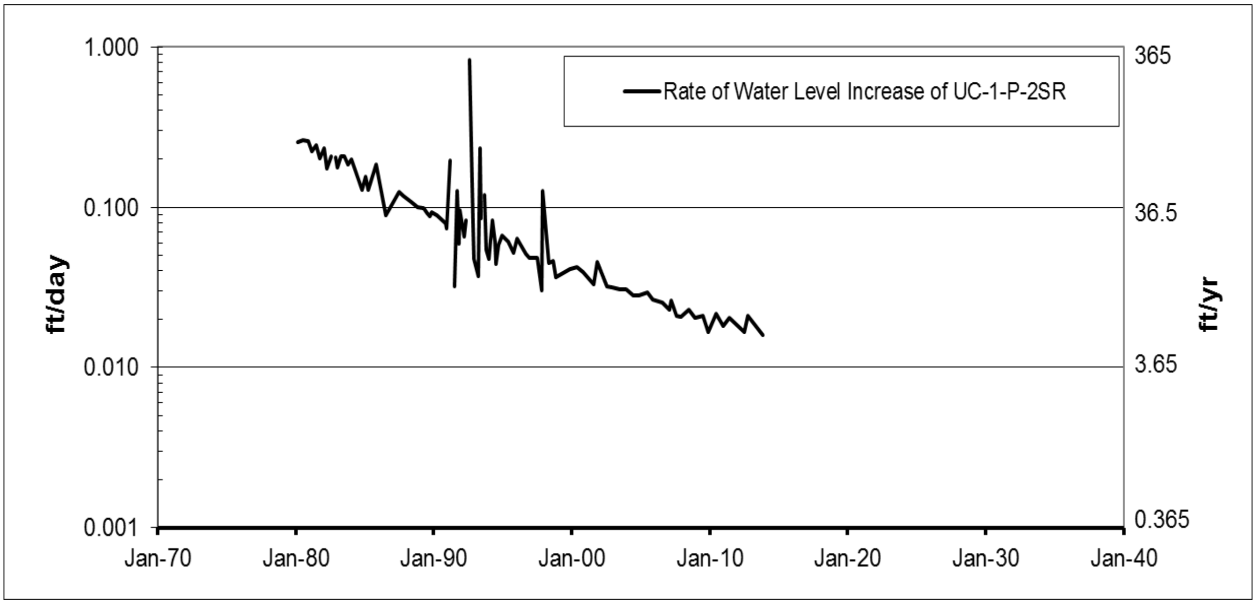
level [ft msl]) are low by up to 41 ft at the bottom of the well (3,554 ft bgs) and about 33 ft at the bottom of the perforated interval. Well UC-1-P-2SR was perforated from measured depths of 1,148 to 2,792 ft.

The water levels in UC-1-P-2SR are still recovering from the dewatering effects of the detonation (Figure 4). The water level has increased more than 1,800 ft in the last 40 years and is expected to rise another 160 to 165 ft to the elevation of water levels in the alluvial aquifer in this area (from the elevation of 5,605 ft msl measured in late 2013 to approximately 5,765 to 5,770 ft msl). The rate of water level rise in UC-1-P-2SR is decreasing as the recovery proceeds, indicating that it will be a number of decades before water levels stabilize (Figure 5).



Note: UC-1-P-2SR elevations not true-vertical-depth (TVD) corrected. The hole is essentially straight to a depth of 1,500 ft (4,600 ft msl). No TVD correction necessary for water levels after 1980 and less than a 14 ft correction for water levels at 3,800 ft msl.

Figure 4. Water Level Elevations in Reentry Well UC-1-P-2SR (http://nevada.usgs.gov/doe_nv/sitepage_temp.cfm?site_id=383806116125951)



Note: The *y* axis is logarithmic.

Figure 5. Declining Rate of Water Level Increase in Well UC-1-P-2SR

4.0 Monitoring Objectives and Activities

The primary objectives of the monitoring program are to (1) detect any migration of contaminants from the detonation zone and (2) evaluate the overall stability (quasi-steady state) of the groundwater flow system to ensure that monitoring wells are located along potential migration pathways. The monitoring program and objectives were established in the CADD/CAP, and the program was initiated after NDEP approved the CADD/CAP and wells MV-1, MV-2, and MV-3 were installed in 2005. The monitoring program was enhanced after the numerical model could not be verified against data obtained from wells MV-1, MV-2, and MV-3. Enhancements to the monitoring program required an addendum to the CADD/CAP and included the installation of two monitoring wells (MV-4 and MV-5) and the recompletion of two existing wells (HTH-1RC and UC-1-P-1SRC). The CADD/CAP addendum was revised in July 2013 with an ROTC to further enhance the monitoring well network with the installation of well MV-6. The current monitoring activities are specified in the CADD/CAP addendum (DOE 2008) and associated ROTC (incorporated as an attachment to the CADD/CAP addendum) and include the collection of hydraulic head data and groundwater samples for radioisotope analyses. These monitoring activities are consistent with the primary objectives in the original CADD/CAP (DOE 2004).

The 2013 monitoring program was enhanced to include the new well MV-6 and supplemental activities that were specified in the November 2013 Environmental Sampling notification letter (DOE 2013) that was provided to NDEP. Sections 4.1 through 4.4 below describe results from the monitoring program, and Section 5.0 provides results from the supplemental activities.

4.1 Radioisotope Monitoring

Groundwater samples were collected from wells MV-1, MV-2, MV-3, MV-4, MV-5, MV-6, HTH-2, and UC-1-P-1SRC as part of the annual monitoring program conducted in November 2013. A sample was not collected from well HTH-1RC during this monitoring event because of an obstruction that caused the bladder pump not to operate. Monitoring wells MV-1, MV-2, MV-3, MV-4, and MV-5, which are completed with bladder pumps, were purged to remove stagnant water from the pump tubing prior to sample collection. Monitoring wells MV-6, HTH-2, and UC-1-P-1SRC were purged prior to sampling using the dedicated electric submersible pumps. Field parameters (temperature, pH, and specific conductance) were allowed to stabilize before samples were collected. The *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351) was used to guide quality assurance and quality control, and the *Fluid Management Plan, Central Nevada Test Area Corrective Action Unit 443* (DOE 2009a) was used to guide the handling and discharge of monitoring well purge water during the annual monitoring event. Table A-1 in Appendix A provides the field parameter measurements obtained during well-purging activities.

Groundwater samples collected as part of the annual monitoring event were analyzed for tritium, carbon-14 (^{14}C), and iodine-129 (^{129}I). During the 5-year proof-of-concept period that began with the 2009 sampling event, the CADD/CAP addendum (DOE 2008) specifies that water samples will be analyzed for tritium every year and for ^{14}C and ^{129}I in the first and fifth years. Tritium is currently the primary analyte of concern because of its initial abundance and mobility. After a few hundred years, tritium will decay to insignificant levels (it has a half-life of 12.3 years), and the longer-lived radionuclides, ^{14}C and ^{129}I, will become the primary focus of long-term post-closure monitoring. The ^{14}C and ^{129}I analyses will provide baseline levels of these constituents for comparison with long-term monitoring results. Sample volumes collected in 2009 were insufficient for ^{129}I analysis, and as a result, water samples collected in 2010 were analyzed for ^{129}I.

The CADD/CAP (DOE 2004) and CADD/CAP addendum (DOE 2008) established groundwater compliance levels for CNTA of 20,000 picocuries per liter (pCi/L) for tritium, 2,000 pCi/L for ^{14}C, and 1 pCi/L for ^{129}I. Transport modeling (Pohlmann et al. 1999, Pohll et al. 2003) was used to establish a contaminant boundary (DOE 2004) at which predicted concentrations of these constituents would remain below current compliance levels. The contaminant boundary is well within the compliance boundary (Figure 2), the boundary beyond which compliance levels of these constituents are not to be exceeded. Although the flow model was not validated by data from wells MV-1, MV-2, and MV-3, the model-predicted contaminant boundary is supported by hydraulic conductivity data from these wells.

4.2 Radioisotope Results

Table 1 presents radioisotope sampling results for 2013 along with the results from previous sampling events dating back to 2010. Analytical results obtained from when the original CADD/CAP monitoring program began in 2006 through the present are provided in Appendix B (Table B-1). Laboratory analytical results from the 2013 sampling event (Table 1) indicate that Tritium, ^{14}C, and ^{129}I concentrations at the sampled locations were below the required detection limits (RDLs) of 400 pCi/L, 5 pCi/L, and 0.1 pCi/L, respectively. The RDLs were established in the CADD/CAP (DOE 2004) and were maintained in the CADD/CAP addendum (DOE 2008).

Table 1. Radioisotope Sampling Results 2010 through 2013

Monitoring Location	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
MV-1	6/09/2010	NS	<RDL (10.4 × 10^{-10})	<RDL
	6/09/2010[b]	NS	<RDL (10.8 × 10^{-10})	<RDL
	5/10/2011	NS	NS	<RDL
	6/26/2012	NS	NS	<RDL
	11/06/2013	<RDL (4.76 × 10^{-2}[c])	<RDL (1.75 x 10^{-10})	<RDL
MV-2	6/08/2010	NS	<RDL (10.9 × 10^{-10})	<RDL
	5/11/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/07/2013	<RDL (2.20 × 10^{-2}[c])	<RDL (1.24 x 10^{-10})	<RDL
MV-3	6/08/2010	NS	<RDL (14.2 × 10^{-9})	<RDL
	5/10/2011	NS	NS	<RDL
	6/26/2012	NS	NS	<RDL
	11/05/2013	<RDL (6.58 × 10^{-2}[c])	<RDL (7.32 x 10^{-10})	<RDL
MV-4	8/30/2010	NS	<RDL (7.50 × 10^{-11})	<RDL
	5/10/2011	NS	NS	<RDL
	5/10/2011[b]	NS	NS	<RDL
	6/26/2012	NS	NS	NW
	11/07/2013	<RDL (2.54 × 10^{-3}[c])	<RDL (1.80 x 10^{-11})	<RDL
MV-4PZ[a]	6/26/2012	NS	NS	<RDL
MV-5	5/26/2010	NS	<RDL (5.70 × 10^{-11})	<RDL
	5/11/2011	NS	NS	<RDL
	6/26/2012	NS	NS	NW
	11/07/2013	<RDL (7.81 × 10^{-3}[c])	<RDL (8.90 x 10^{-11})	<RDL
MV-5PZ[a]	6/26/2012	NS	NS	<RDL
MV-6	11/06/2013	<RDL (4.87 × 10^{-2}[c])	<RDL (9.00 x 10^{-11})	<RDL
	11/06/2013[b]	NS	NS	<RDL
HTH-1RC	6/09/2010	NS	<RDL (11.0 × 10^{-11})	<RDL
	5/11/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/08/2013	PF	PF	PF
HTH-2	6/09/2010	NS	PF	PF
	5/11/2011	NS	NS	PF
	6/27/2012	NS	NS	PF
	11/06/2013	<RDL (8.52 × 10^{-2}[c])	<RDL (6.20 x 10^{-11})	<RDL
UC-1-P-1SRC	5/22/2010	NS	<RDL (5.20 × 10^{-11})	<RDL
	5/10/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/06/2013	<RDL (9.54 × 10^{-2}[c])	<RDL (1.08 x 10^{-10})	<RDL

[a] Sample was collected using a depth-specific bailer.
[b] Duplicate sample (not required for ^{14}C and ^{129}I).
[c] Calculated based on the total alkalinity concentration.
NS = not sampled because the radioisotope was not part of the analytical suite.
NW = not sampled to allow water levels in the well time to recover.
PF = pump failed and a sample could not be collected.
<RDL = below required detection limit (laboratory result in parentheses; RDL is 400 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I [DOE 2004])

An ROTC was submitted to NDEP and approved in March 2012 to change the RDL for tritium from 300 pCi/L to 400 pCi/L in the CADD/CAP and CADD/CAP Addendum. The minimum detectable concentration values reported by the laboratory for tritium have historically ranged from <313 to <390 pCi/L using the conventional method to analyze for tritium. The analytical results were validated in accordance with the *Environmental Procedures Catalog* (LMS/POL/S04325), "Standard Practice for Validation of Environmental Data." All analyses were completed, and the samples were prepared and analyzed in accordance with accepted procedures that were based on the specified methods. The laboratory radiochemical minimum detectable concentration reported with these data is an a priori estimate of the detection capability of a given analytical procedure, not an absolute concentration that can or cannot be detected. A copy of the Data Validation Package is maintained in the LM records and is available on request. Refer to Table A-2 in Appendix A for the ^{14}C calculations with the apparent age date of the samples.

4.3 Hydraulic Head Monitoring

Transducers are installed in all wells and piezometers in the monitoring network to monitor hydraulic head. The transducer data are calibrated to manual water level measurements taken during sampling events and site inspections. As stated in the CADD/CAP, "Hydraulic head will be used to monitor the quasi-steady state of the groundwater system; i.e., to determine if mean hydraulic head values remain constant through time, given fluctuations caused by natural temporal stresses and stresses related to well drilling, construction, and testing. This requires first determining when heads have stabilized following drilling and testing activities, then quantifying the natural mean and temporal variation in hydraulic head, and comparing subsequent monitoring measurements to that range."

4.4 Hydraulic Head Results

Table 2 lists the most recent water level data (November 2013) from site wells and piezometers, along with the screened interval elevations and the screened geologic unit. Piezometers are distinguished from the wells at these monitoring locations by the notation "PZ." For locations with two piezometers, "UPZ" and "LPZ" are used to denote the upper piezometer and lower piezometer, respectively.

Figure 6 through Figure 9 present hydrographs of the hydraulic head data. Head data collected using a water level tape appear as individual symbols, and data collected with transducers appear as lines due to the recording frequency of every few hours. The hydrographs are grouped by comparable monitored interval and location: alluvial wells southeast of the southeast-bounding graben fault, including well HTH-1RC in the upper volcanic section (Figure 6); alluvial wells northwest of the southeast-bounding graben fault (Figure 7); the volcanic section with open intervals near the detonation level (Figure 8); and the volcanic section with open intervals below the detonation level (Figure 9). Data gaps in the hydrographs are the result of transducers being removed for well-site activities or for the replacement of damaged transducers or cable.

Table 2. Construction and 2013 Hydraulic Head Data for Wells in the CNTA Monitoring Network

Well/ Piezometer	TSZ Elevation[a] (ft)	BSZ Elevation[a] (ft)	Geologic Unit	TOC Elevation[a] (ft)	Date	Water Depth (ft)	Water Level Elevation[a] (ft)
MV-1UPZ	5,190.19	5,130.19	Alluvium	6,069.98	11/05/2013	317.39	5,752.59
MV-1LPZ	3,067.19	3,007.19	Volcanics	6,069.91	11/05/2013	44.69	6,025.22
MV-1	2,319.19	2,159.63	Volcanics	6,070.57	11/05/2013	507.65	5,562.92
MV-2UPZ	5,229.73	5,179.73	Alluvium	6,190.66	11/05/2013	403.02	5,787.64
MV-2LPZ	2,643.23	2,583.23	Volcanics	6,190.39	11/05/2013	403.20	5,787.19
MV-2	3,150.24	2,987.49	Volcanics	6,190.66	11/05/2013	365.06	5,825.60
MV-3UPZ	5,286.98	5,226.98	Alluvium	6,167.75	11/05/2013	372.68	5,795.07
MV-3LPZ	2,866.98	2,746.98	Volcanics	6,167.69	11/05/2013	196.00	5,971.69
MV-3	2,120.98	1,959.23	Volcanics	6,168.27	11/05/2013	601.26	5,567.01
MV-4[b]	4,300.32	3,996.22	Alluvium	6,019.57	11/05/2013	504.61	5,514.96
MV-4PZ[b]	5,101.20	5,041.20	Alluvium	6,019.45	11/05/2013	275.16	5,744.29
MV-5[b]	4,203.12	3,878.69	Alluvium	6,041.85	11/05/2013	558.81	5,483.04
MV-5PZ[b]	5,023.17	4,963.17	Alluvium	6,040.85	11/05/2013	289.03	5,751.82
MV-6[d]	5,214.95	5,052.31	Alluvium	6,053.84	11/05/2013	312.78	5,741.06
HTH-1UPZ[b]	5,032.63	4,972.63	Alluvium	6,011.27	11/05/2013	543.14	5,468.13
HTH-1LPZ[b]	4,112.66	4,052.66	Alluvium	6,011.31	11/05/2013	541.55	5,469.76
HTH-1RC[b]	3,653.90	3,353.60	Volcanics	6,011.70	11/05/2013	487.11	5,524.59
HTH-2	5,521.70	5,025.70	Alluvium	6,026.05	11/05/2013	556.62	5,469.43
UC-1-P-1SRC[b]	5,519.55	5,457.81	Alluvium	6,031.58	11/05/2013	281.43	5,750.15
UC-1-P-2SR[c]	4,931[c]	3,289[c]	Chimney	6,080.51	11/05/2013	474.80[c]	5,605.71[c]

[a] All elevations reported in units of feet above mean sea level.
[b] Added in 2009.
[c] UC-1-P-2SR elevations not true-vertical-depth corrected. The hole is essentially straight to a depth of 1,500 ft (no TVD correction necessary for water levels since 1980).
[d] Added in 2013.
BSZ = bottom of open interval/screen zone
TOC = top of casing
TSZ = top of open interval/screen zone
Note = The new well MV-6 and existing wells/piezometers were surveyed to establish new top of casing elevations after the 2013 drilling program.

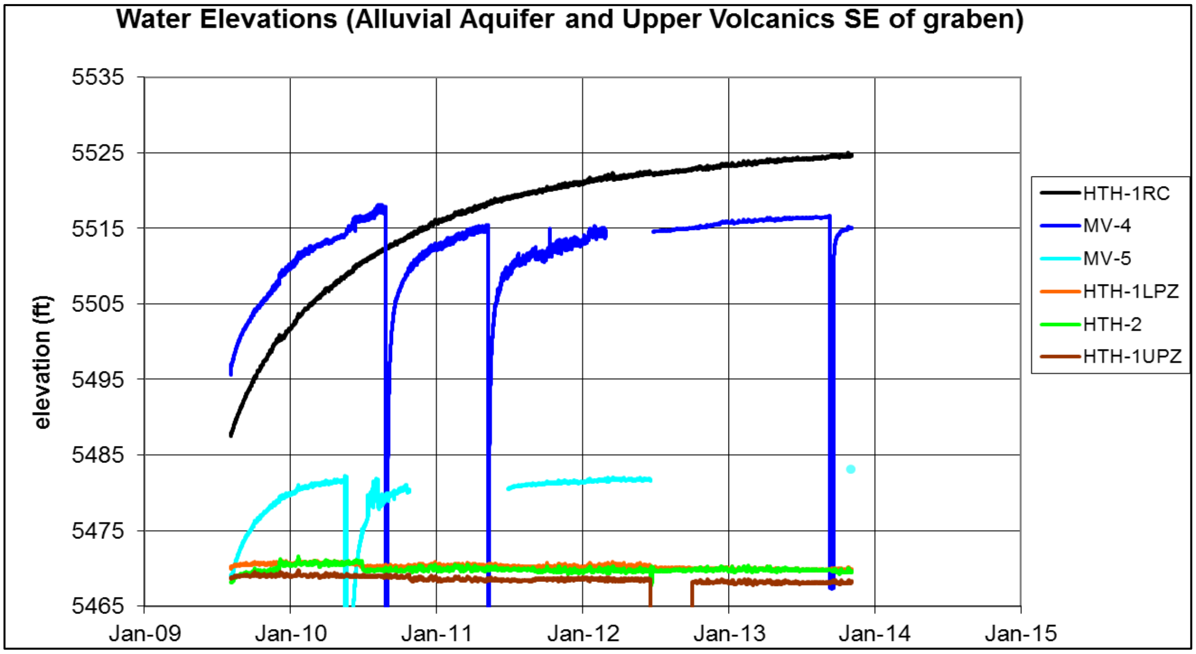


Figure 6. Water Level Elevations for the Alluvial Wells and Well HTH-1RC (Upper Volcanics) Southeast of the Down-Dropped Graben at the Screened Horizon

Figure 6 shows the hydrographs of alluvial wells and piezometers southeast of the graben (MV-4, MV-5, HTH-2, HTH-1UPZ, and HTH-1LPZ) along with well HTH-1RC (screened in the upper volcanic section below the alluvium). These data indicate that wells MV-4 and MV-5 are still recovering from the 2010 aquifer testing and from the 2011 yearly sampling event. Low-flow bladder pumps were installed in wells MV-4 and MV-5 during the November 2013 sampling event to reduce the well purge volumes and the impact purging has on the water levels during sampling (Section 5.2). The bladder pumps will allow head levels to recover to steady-state conditions. Based on the slow recovery of well MV-4, it will likely take 3 to 5 years to equilibrate to steady-state conditions after switching to low-flow sampling. Well MV-5 recovers faster and should equilibrate in about 2 years as estimated from the limited data set. The transducers in well MV-5 (one connected to telemetry and one installed as a backup) were stuck in the water access tube above the water level in the well when the telemetry system was being removed in June 2012. This resulted in a data gap from June 2012 to November 2013. The previous data gap (last quarter 2010 to mid-2011) was due to a failed transducer. The transducers were removed, water level was measured, and the transducer was reinstalled in well MV-5 during the annual sampling in November 2013. Water levels in well HTH-1RC continue to equilibrate after the recompletion in 2009 at approximately the same rate as in MV-4. Prior to its recompletion, HTH-1 was perforated across its entire saturated section and displayed a composite water level that could not be attributed to one particular hydrogeologic unit. The recompletion isolated zones in the upper and lower alluvium (HTH-1UPZ and HTH-1LPZ) and in the upper volcanic section (HTH-1RC). The hydraulic head in the volcanic portion of HTH-1 is higher than water levels measured in both the upper and lower alluvial piezometers at this location. This observation confirms that an upward gradient from the volcanic section to the alluvium exists in this area, as indicated by flow logging performed by Desert Research Institute in HTH-1 prior to the well's recompletion (DOE 2008).

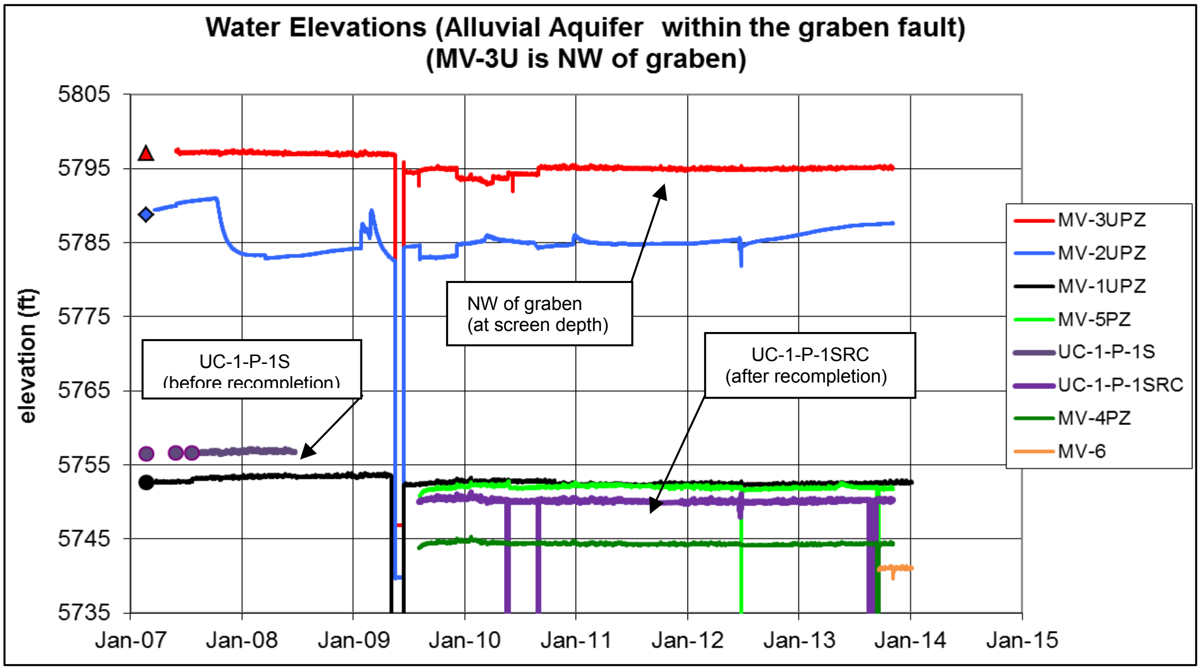


Figure 7. Water Level Elevations for the Alluvial Wells Northwest of the Southeast-Bounding Graben Fault

Figure 7 shows the hydrographs of alluvial piezometers and wells within and northwest of the graben, including the new well MV-6. Erratic water levels in upper piezometer MV-2UPZ (Figure 7) are attributed to damage during its installation. The lower hydraulic heads observed after mid-2009 in the upper piezometers MV-1UPZ and MV-3UPZ are the results of attempts to further develop these piezometers. The recompletion of well UC-1-P-1S resulted in a roughly 7 to 8 ft decrease in hydraulic head (Figure 7). This suggests that the well is now isolated from the influence of deeper horizons where hydraulic heads have been larger. The hydraulic heads in the piezometers MV-4PZ and MV-5PZ (screened inside the down-dropped graben block) are approximately 250 ft higher than those in the wells MV-4 and MV-5 that are screened outside the graben to the southeast (Figure 6). Given these results, alluvial aquifer hydrographs were separated into two groups based on their screened location relative to the southeast-bounding graben fault. Hydraulic head data from the MV-4 and MV-5 wells and piezometers continue to support the conceptual model that the southeast-bounding graben fault acts as a barrier to flow at the site.

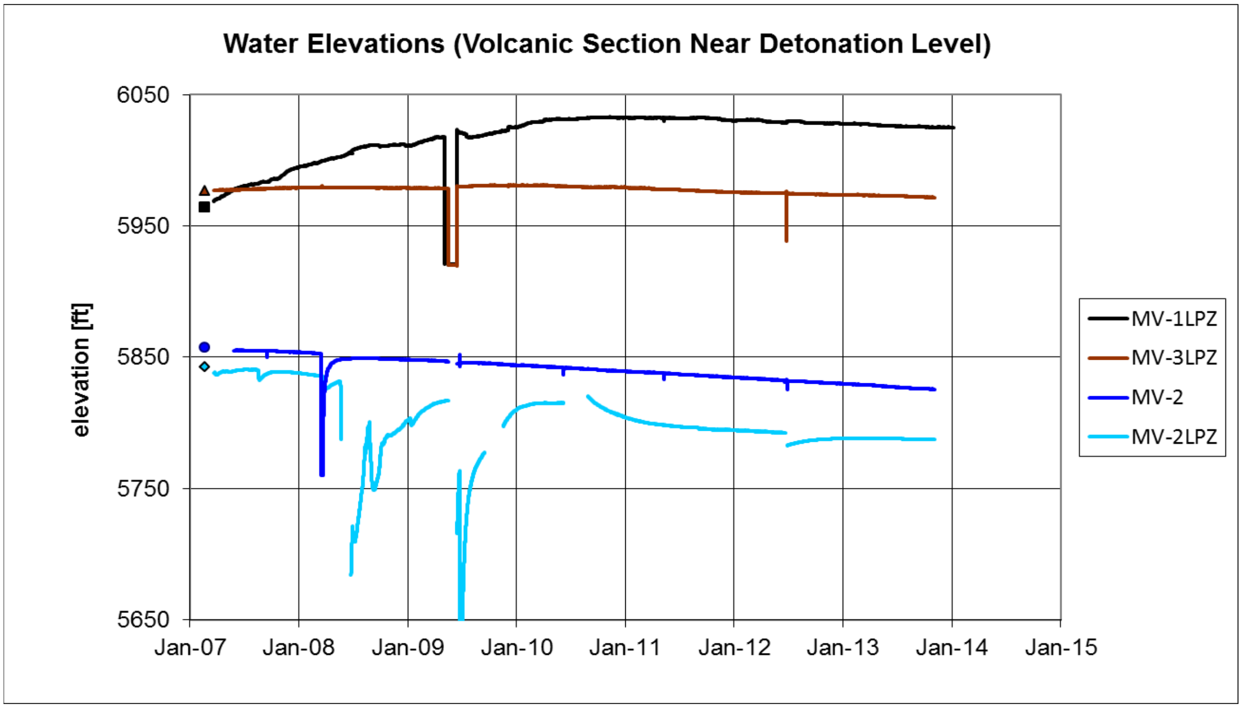


Figure 8. Water Level Elevations for the Well and Piezometers Screened in the Volcanic Section at or near the Level of the Detonation

Figure 8 shows hydrographs of the well and piezometers with open intervals near the detonation level. Rising water levels in the lower piezometer MV-1LPZ stabilized in 2011 and have begun to slightly decline. On August 5, 2008, Desert Research Institute ran a temperature log, collected a bailed sample, and measured the depth of the lower piezometer MV-2LPZ to investigate the cause of rapid water level declines and recoveries at this location. Sediment was found 75 ft above the top of the screened interval. In the summer of 2009, the MV-2LPZ was further developed, lowering the sediment fill to the top of the screen. The transducer was not functioning in MV-2LPZ from September to November of 2009 and from June to the end of August 2010. Head levels that were steadily declining in MV-2LPZ (at a decreasing rate) during 2011 into 2012 dropped approximately 10 ft when the MV-2 well was sampled, and the downward trend has reversed to a recovering trend. The head levels in the MV-2 well continue to decline at a rate of about 5 ft per year. The removal of sediment from MV-2LPZ may not have completely solved the erratic head changes in this piezometer. The proximity of the MV-2 piezometer screened interval to the northwestern bounding graben fault is the likely cause of its erratic water levels. It is expected that heads southeast of this fault (within the graben) are higher than heads to the northwest, outside the graben.

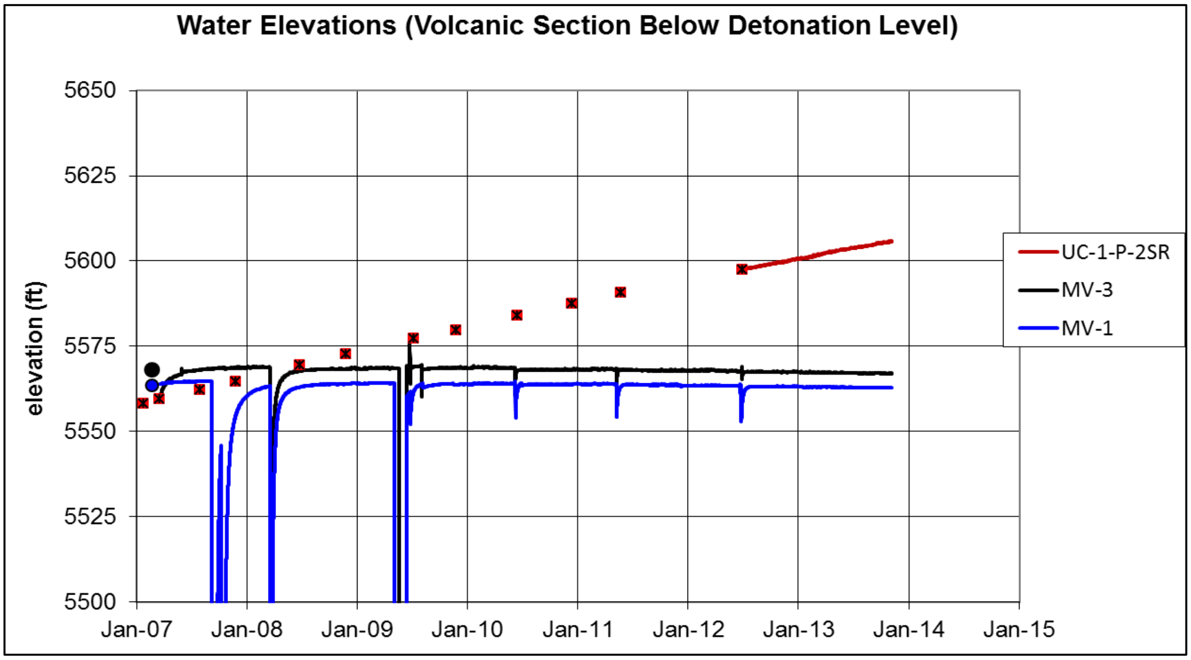


Figure 9. Water Level Elevations for the Wells Screened in the Volcanic Section Below the Level of the Detonation
(Water level elevations for reentry well UC-1-P-2SR [drilled into the chimney] are shown for reference.)

Figure 9 shows the hydrographs of wells with open intervals below the detonation level and reentry well UC-1-P-2SR. The composite head level from UC-1-P-2SR (chimney and alluvium overlying the detonation area) is higher than in the densely welded tuff units below the detonation zone and continues to increase. The composite head level (5,605.71 ft msl on November 5, 2013) continues to increase, though at a slowing rate over the long term (Figure 5). Well UC-1-P-2SR has perforations as high as 1,148 ft bgs in the alluvium, and its water level is expected to eventually reach a steady-state elevation of approximately 5,750 ft msl (similar to other alluvial wells and piezometers within the graben).

A hand-contoured potentiometric map of the upper part of the alluvial aquifer within the graben (Figure 10) was constructed using the November 2013 head levels from MV-4PZ, MV-5PZ, MV-6, UC-1-P-1SRC, MV-1UPZ, and MV-2UPZ, all of which are screened at depths ranging from 600 to 1,000 ft bgs. Contouring of the potentiometric surface (Figure 10) was restricted to the area within the graben. Contours near SGZ are based on the water level from reentry well UC-1-P-2SR, which is perforated from the depths of 1,148 ft to 2,792 ft (4,931 to 3,289 ft msl) and spans the alluvium into the chimney. The interpretation shown on Figure 10 suggests that horizontal flow in the upper alluvium is toward the chimney near SGZ. Away from the influence of the chimney, horizontal flow is to the east-southeast and is likely deflected by the southeast-bounding graben fault that is acting as a barrier to flow. As drawn, the contours indicate a dip reversal between the detonation and MV-6 that will gradually go away as heads in the alluvium above the detonation zone recover. Groundwater flow within the graben will eventually be to the east-southeast. Depiction of groundwater flow directions within the graben has an inherent degree of uncertainty given the structural complexity caused by the detonation and the limited data available within the graben.

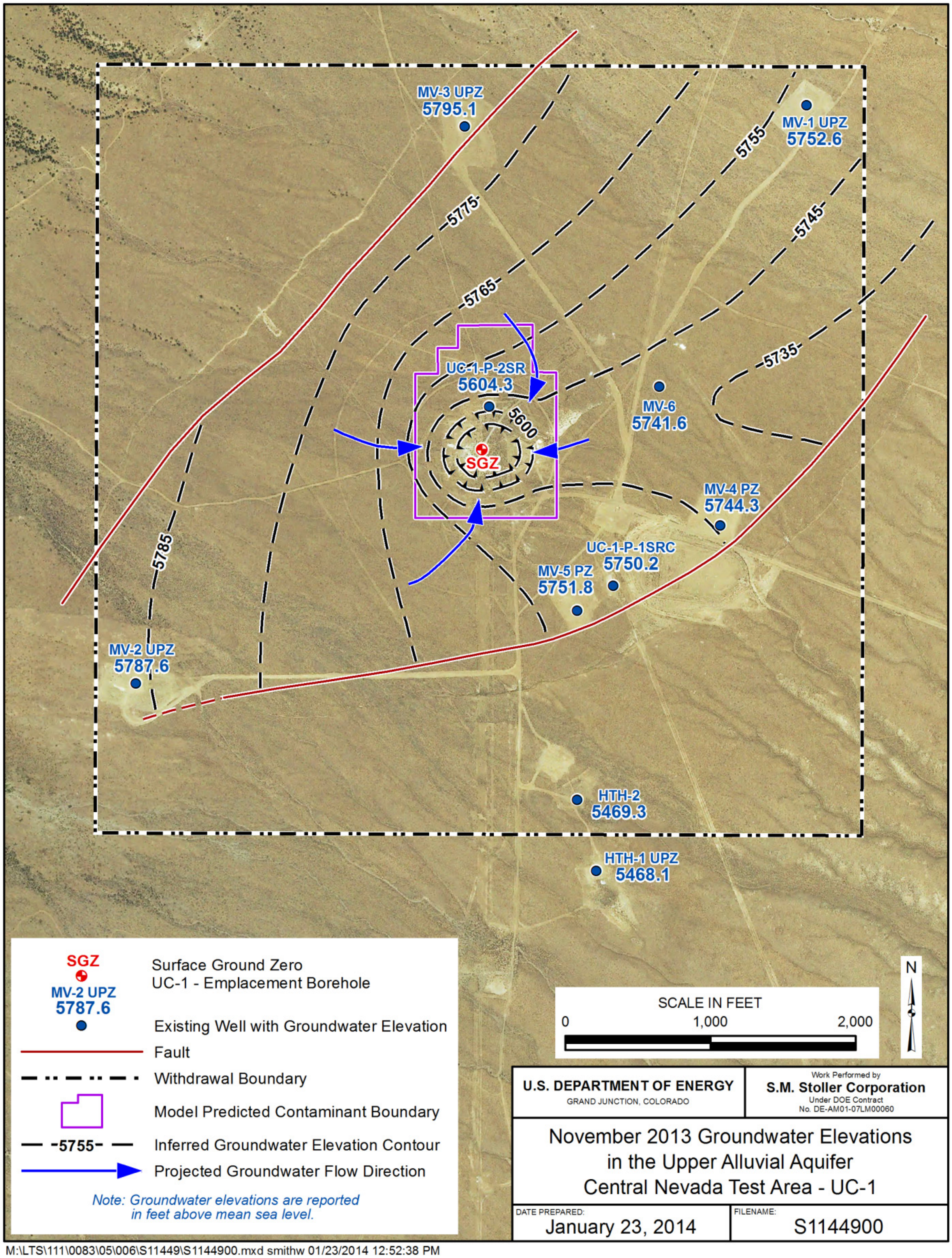


Figure 10. November 2013 Groundwater Elevations in the Upper Alluvial Aquifer Central Nevada Test Area—UC-1

Wells MV-4 and MV-5 were completed in the lower part of the alluvial aquifer outside the graben block (at depth) to confirm that the southeast-bounding graben fault acts as a flow barrier and for compliance monitoring at a depth nearer the detonation zone.

5.0 Site Inspection and Supplemental Site Activities

A site inspection and supplemental site activities were conducted during the November 2013 sampling event. The site inspection included the inspection of roads, well heads, the mud pit cap, and the monument at SGZ for signs of damage. The revegetation of the well pads (fall 2010) was observed to be progressing as expected. The roads, well heads, and monument were also observed as being in good condition at the time of the inspection. Supplemental site activities performed during this annual monitoring period included an enhanced analytical suite for the new well MV-6 and installing low-flow bladder pumps in wells MV-4 and MV-5. Results from the supplemental site activities are provided in the following sections.

5.1 Enhanced Sample Analytical Suite

The sampling event was enhanced by adding analyses for major ions and stable isotopes of oxygen and hydrogen for the new well MV-6. The samples were analyzed to provide information on the geochemical and isotopic properties of the groundwater that will contribute to the evaluation of results with respect to sample location and depth. Samples from well MV-6 were also analyzed for bromide, gamma-emitting radionuclides (using high-resolution gamma spectrometry), gross alpha, and gross beta. Bromide was added to the analytical suite because a bromide tracer was used in the drilling fluids during the well installation to help monitor the well's development. The radiochemical analyses were added to the analytical suite to establish a baseline for the new monitoring location. The analytical results indicated bromide concentrations of 0.59 and 0.65 milligram per liter (mg/L), gross alpha concentrations of 1.66 and 1.99 pCi/L, gross beta concentrations of 1.21 and 1.59 pCi/L, and no detections of radioisotopes above the laboratory minimum detectable concentration using high-resolution gamma spectrometry. Refer to Table A-3 in Appendix A for a summary of the water chemistry, stable isotope data, bromide, and last set of field parameters (pH, temperature, and specific conductance) and Table A-4 in Appendix A for a summary of the radioisotope, gross alpha, and gross beta results.

5.2 Bladder Pump Installation

Low-flow bladder pumps were installed in wells MV-4 and MV-5 during the November 2013 sampling event. Water level data from these wells indicate that hydraulic heads are still recovering from installation and aquifer testing. The data also indicate that head levels have not recovered from the 2011 sampling event during which several thousand gallons of water were purged. Low-flow bladder pumps were installed to reduce the well purge volumes and the impact purging has on the water levels during and after sampling. The new bladder pumps allow the collection of samples using the low-flow sampling method and allow head levels to recover to steady-state conditions. The pump drop tubes/sample inlets were set in wells MV-4 and MV-5 at 1,800 and 2,095 ft bgs, respectively.

6.0 Summary

The 2009 drilling program enhanced the CNTA monitoring network with seven new monitoring locations (wells and piezometers) in the alluvial aquifer and one in the upper volcanic section. The monitoring well network was further enhanced in 2013 with the installation of a new well (MV-6) completed in the upper alluvial aquifer inside the graben. Detection monitoring results indicate that radioisotope levels in groundwater continue to remain below the RDLs in all wells in the monitoring network. Water level data from wells MV-4, MV-5, and recompleted well HTH-1RC indicate that hydraulic heads are still recovering from installation and testing. The data from wells MV-4 and MV-5 also indicate that head levels have not recovered from the 2011 sampling event during which several thousand gallons of water were purged. Low-flow bladder pumps were installed to reduce the well purge volumes and the impact purging has on the water levels during sampling. The new bladder pumps allow the collection of samples using the low-flow sampling method and allow head levels to recover to steady-state conditions. Despite the lack of steady-state groundwater conditions, hydraulic head data collected from the site continue to support the conceptual model. This is evident in that groundwater levels in UC-1-P-2SR continue to recover from the dewatering effects of the detonation and that horizontal groundwater flow in the upper alluvial aquifer near SGZ is toward the detonation chimney. Head data from well UC-1-P-2SR also suggest a downward gradient (Figure 9) that continues to increase as the water levels in this well recover. Head data from wells MV-4 and MV-5 completed in the lower part of the alluvial aquifer outside the graben confirm that the southeast-bounding graben fault acts as a barrier to groundwater flow (Figure 10). Depiction of groundwater flow directions within the graben has an inherent degree of uncertainty given the structural complexity caused by the detonation and subsequent collapse of the graben.

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Appendix A

Well Purging, Carbon-14 Calculation Data, Water Chemistry, and Stable Isotope Data

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Table A-1. Monitoring Well Purge Data

Well Identification	Date Sampled	Purged Volume (gallons)	Temperature (°C)	pH (s.u.)	Specific Conductance (µmho/cm)
HTH-1RC	NS	NS	NS	NS	NS
HTH-2	11/6/2013	1,950	19.40	7.56	306
			19.38	7.55	306
			19.38	7.54	307
MV-1	11/6/2013	10	15.3	9.52	682
MV-2	11/7/2013	8	14.2	10.68	1015
MV-3	11/5/2013	10.9	14.7	7.07	940
MV-4	11/7/2013	4.8	15.18	11.28	580
MV-5	11/7/2013	5.2	13.38	11.28	638
MV-6	11/6/2013	1,500	19.50	7.81	256
			19.74	7.78	255
			20.28	7.85	250
UC-1-P-1SRC	11/6/2013	420	17.78	7.42	317
			17.84	7.45	317
			17.93	7.45	317

s.u. = standard unit
µmho/cm = micromhos per centimeter
NS = the well was not sampled (due to pump failure)

Table A-2. Dissolved Inorganic Carbon-14 Radioisotope Calculation and Age Data

Well ID	Sample Date	Mass Concentration Carbon (mg)	Fraction Modern Carbon	±1 s	Carbon-14 (pCi/L)[a]	Apparent Age (years)
MV-1	11/6/2013	24.12	0.3214	0.0026	4.76×10^{-2}	9,117
MV-2	11/8/2013	30.84	0.1164	0.0018	2.20×10^{-2}	17,280
MV-3	11/5/2013	46.20	0.2322	0.0022	6.58×10^{-2}	11,730
MV-4	11/7/2013	6.96	0.0594	0.0016	2.54×10^{-3}	22,680
MV-5	11/7/2013	21.60	0.0589	0.0014	7.81×10^{-3}	22,750
HTH-2	11/6/2013	19.44	0.7147	0.0048	8.52×10^{-2}	2,698
UC-1-P-1SRC	11/6/2013	18.96	0.8201	0.0046	9.54×10^{-2}	1,593
MV-6	11/6/2013	16.68	0.4756	0.0035	4.87×10^{-2}	5,969

[a] Modern ^{14}C standard at AD 1950 has activity of 13.6 disintegrations per minute per gram C = 2.27×10^{-4} disintegrations per second (dps) per milligram (mg) C.
1 microcurie (µCi) = 3.7×10^{4} dps; therefore, modern ^{14}C standard at AD 1950 has activity of 6.135×10^{-9} µCi/mg.
The mass concentration of dissolved inorganic carbon was calculated from the total alkalinity concentration.
MC = modern carbon; s = standard deviation

Example activity calculation (MV-1)

$$24.12\,\frac{mg\ C}{1\ L}\left(0.3214\,\frac{mg\ MC}{mg\ C}\right)\left(6.135\times 10^{-9}\,\frac{\mu Ci}{mg\ MC}\right)\left(1\times 10^{6}\,\frac{pCi}{\mu Ci}\right)=4.76\times 10^{-2}\,\frac{pCi}{L}$$

Table A-3. Well MV-6 Water Chemistry and Stable Isotope Data from 2013 Sampling Event

Monitoring Location	Sample Date	Temperature* (°C)	pH* (s.u.)	Specific Conductance* (µmho/cm)	Silica (mg/L)	Silicon (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Bicarbonate (mg/L)	Nitrate (mg/L)	Bromide (mg/L)	Stable Isotope Ratio Hydrogen ($^0/_{00}$)	Stable Isotope Ratio Oxygen ($^0/_{00}$)
MV-6	11/06/2013	20.28	7.85	250	26	12	29	2.3	24	1.7	4.6	7.2	130	0.36	0.59	-105.05	-14.11
	11/06/2013**	NA	NA	NA	27	12	29	2.3	25	1.7	4.7	7.3	130	0.33	0.65	NA	NA

* = Indicates it is the last field measurement before the sample was collected.
** = Indicates a duplicate sample (duplicate sample not required for the stable isotopes of hydrogen and oxygen).
$^0/_{00}$ = per mil (parts per thousand parts)
NA = Not Analyzed
s.u. = Standard Unit
µmho/cm = micromhos per centimeter
mg/L = milligrams per liter
pCi/L = picocuries per liter

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Table A-4. Well MV-6 Radioisotope Data from 2013 Sampling Event

Analytical Method	Radioisotope	MV-6 (duplicate)	MV-6
Gamma Spectrometry (pCi/L)	Actinium-228	<14	<18
	Americium-241	<5.4	<5.4
	Antimony-125	<9.1	<9.7
	Cerium-144	<14	<15
	Cesium-134	<3.8	<4.4
	Cesium-137	<3.7	<4.4
	Cobalt-60	<4.3	<5.4
	Europium-152	<20	<27
	Europium-154	<22	<26
	Europium-155	<12	<7.5
	Lead-212	<10	<12
	Potassium-40	<110	<120
	Promethium-144	<4.2	<4.9
	Promethium-146	<4.1	<4.6
	Ruthenium-106	<34	<41
	Thorium-234	<66	<77
	Uranium-235	<14	<16
	Yttrium-88	<4.3	<8.5
Gross Alpha (pCi/L)	Gross Alpha	1.66	1.99
Gross Beta (pCi/L)	Gross Beta	1.21	1.59

pCi/L = picocuries per liter

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Appendix B

Analytical Data: 2006 Through the Present

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Table B-1. Radioisotopic Sample Results

Monitoring Location	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
MV-1	2/14/2006[b]	<RDL (1.12 x 10^{-2})	<RDL (1.51 x 10^{-7})	<RDL
	9/21/2006[b]	<RDL (5.61 x 10^{-2})	<RDL (2.90 x 10^{-7})	<RDL
	2/22/2007	NS	NS	NS
	10/10/2007	<RDL (7.40 x 10^{-3}[d])	<RDL (5.70 x 10^{-11})	<RDL
	3/19/2008	NS	NS	PF
	6/26/2009	<RDL (2.46 x 10^{-2}[d])	NR	<RDL
	6/09/2010	NS	<RDL (10.4 x 10^{-10})	<RDL
	6/09/2010[c]	NS	<RDL (10.8 x 10^{-10})	<RDL
	5/10/2011	NS	NS	<RDL
	6/26/2012	NS	NS	<RDL
	11/06/2013	<RDL (4.76 x 10^{-2}[e])	<RDL (1.75 x 10^{-10})	<RDL
MV-2	3/16/2006[b]	<RDL (9.92 x 10^{-2})	<RDL (2.58 x 10^{-7})	<RDL
	9/22/2006[b]	<RDL (1.30 x 10^{-2})	<RDL (2.60 x 10^{-7})	<RDL
	2/22/2007	<RDL (1.54 x 10^{-3}[d])	<RDL (9.70 x 10^{-11})	<RDL
	2/22/2007[c]	<RDL (1.84 x 10^{-3}[d])	<RDL (11.1 x 10^{-11})	<RDL
	3/19/2008	NS	NS	<RDL
	6/26/2009	<RDL (5.55 x 10^{-3}[d])	NR	<RDL
	6/08/2010	NS	<RDL (10.9 x 10^{-10})	<RDL
	5/11/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/07/2013	<RDL (2.20 x 10^{-2}[e])	<RDL (1.24 x 10^{-10})	<RDL
MV-2LPZ[a] – Sample depth 490 ft	8/5/2008	NS	NS	<8,000
MV-2LPZ[a] – Sample depth 3,471 ft	8/5/2008	NS	NS	<8,000
MV-3	3/16/2006[b]	<RDL (3.95 x 10^{-2})	<RDL (2.10 x 10^{-7})	<RDL
	9/22/2006[b]	<RDL (5.11 x 10^{-2})	<RDL (2.20 x 10^{-7})	<RDL
	2/22/2007	<RDL (1.01 x 10^{-2}[d])	<RDL (14.0 x 10^{-11})	<RDL
	3/19/2008	NS	NS	<RDL
	6/25/2009	<RDL (3.87 x 10^{-2}[d])	NR	<RDL
	6/08/2010	NS	<RDL (14.2 x 10^{-9})	<RDL
	5/10/2011	NS	NS	<RDL
	6/26/2012	NS	NS	<RDL
	11/05/2013	<RDL (6.58 x 10^{-2}[e])	<RDL (7.32 x 10^{-10})	<RDL
MV-4	6/24/2009	<RDL (9.17 x 10^{-4}[d])	NR	<RDL
	8/30/2010	NS	<RDL (7.50 x 10^{-11})	<RDL
	5/10/2011	NS	NS	<RDL
	5/10/2011[c]	NS	NS	<RDL
	6/26/2012	NS	NS	NW
	11/07/2013	<RDL (2.54 x 10^{-3}[e])	<RDL (1.80 x 10^{-11})	<RDL
MV-4PZ[a]	6/26/2012	NS	NS	<RDL

Table B-1 (continued). Radioisotopic Sample Results

Monitoring Location	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
MV-5	6/25/2009	<RDL (2.30 x 10^{-3}[d])	NR	<RDL
	5/26/2010	NS	<RDL (5.70 x 10^{-11})	<RDL
	5/11/2011	NS	NS	<RDL
	6/26/2012	NS	NS	NW
	11/07/2013	<RDL (7.81 x 10^{-3}[e])	<RDL (8.90 x 10^{-11})	<RDL
MV-5PZ[a]	6/26/2012	NS	NS	<RDL
MV-6	11/06/2013	<RDL (4.87 x 10^{-2}[e])	<RDL (9.00 x 10^{-11})	<RDL
	11/06/2013[c]	NS	NS	<RDL
HTH-1RC	6/25/2009	<RDL (2.75 x 10^{-3}[d])	NR	<RDL
	6/09/2010	NS	<RDL (11.0 x 10^{-11})	<RDL
	5/11/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/08/2013	PF	PF	PF
HTH-2	6/25/2009	<RDL (7.98 x 10^{-2}[d])	NR	<RDL
	6/09/2010	NS	PF	PF
	5/11/2011	NS	NS	PF
	6/27/2012	NS	NS	PF
	11/06/2013	<RDL (8.52 x 10^{-2}[e])	<RDL (6.20 x 10^{-11})	<RDL
UC-1-P-1SRC	6/24/2009	<RDL (1.07 x 10^{-1}[d])	NR	<RDL
	5/22/2010	NS	<RDL (5.20 x 10^{-11})	<RDL
	5/10/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/06/2013	<RDL (9.54 x 10^{-2}[e])	<RDL (1.08 x 10^{-10})	<RDL

[a] Sample was collected using a depth-specific bailer; sample depths from lower piezometer of MV-2 are provided with the well name.
[b] Sample results for tritium were obtained by the enriched tritium method, and the analytical results are from the Desert Research Institute Monitoring Report (DRI 2006).
[c] Duplicate sample (not required for ^{14}C and ^{129}I).
[d] Estimated based on sample volume of 200 milliliters.
[e] Calculated based on the total alkalinity concentration.
NR = not analyzed because of insufficient sample volume.
NS = not sampled because the radioisotope was not part of the analytical suite.
NW = not sampled to allow water levels in the well time to recover.
PF = pump failed and a sample could not be collected.
<RDL = below required detection limit (laboratory result in parentheses; RDL is 400 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I [DOE 2004])

Appendix C

NDEP Correspondence with Record of Review and Response to Comments

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ndep
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
protecting the future for generations

STATE OF NEVADA
Department of Conservation & Natural Resources
DIVISION OF ENVIRONMENTAL PROTECTION

Brian Sandoval, Governor
Leo M. Drozdoff, P.E., Director
Colleen Cripps, Ph.D., Administrator

April 3, 2014

Mr. Mark Kautsky
Site Manager
U. S. Department of Energy
Office of Legacy Management
2597 Legacy Way
Grand Junction, CO 81503

RE: Draft 2013 Groundwater Monitoring Report for Corrective Action Unit (CAU) 443: Project CNTA Area – Subsurface
Federal Facility Agreement and Consent Order

Dear Mr. Kautsky:

The Nevada Division of Environmental Protection, Bureau of Federal Facilities (NDEP) has reviewed the U. S. Department of Energy, Office of Legacy Management's *Draft 2013 Groundwater Monitoring Report for Corrective Action Unit (CAU) 443: Project CNTA Area - Subsurface,* (Report) received on March 12, 2014. While this letter serves as a Notice of Completion for the March 14, 2014 Milestone Deadline for the "Draft 2013 Monitoring Report," the NDEP has the following comments on the Report which should be addressed in the Final version of the Report:

1. Executive Summary, First Paragraph, Last Sentence and Page 1, Section 1.0, Second Last Sentence: According to the Addendum to Corrective Action Decision Document/ Corrective Action Plan (CADD/CAP) for Corrective Action Unit (CAU) 443: Central Nevada Test Area (CNTA) – Subsurface Central Nevada Test Area, Nevada, DOE/NV-977, January 2008 and the installation of MV-4 and MV-5 in 2009, the site is currently in the fifth year of the 5-year Proof of Concept Monitoring Period. No document has ever been submitted, nor approved, to state that this site is in the "conceptual model evaluation phase of the corrective action strategy in support of site closure." Please change the language of these two sentences to reflect the language used in currently approved documents.

2. Executive Summary, Second Paragraph, Last Sentence: In order to be consistent with the 2012 Groundwater Monitoring Report, please insert "that the southeast-bounding graben fault acts as a barrier to groundwater flow at the site" after "the conceptual model."

3. Page 10, Table 1, Table 1 and Pages B-1 and B-2, Table B-1: For the 11/06/13 MV-6 entry, Carbon-14 and Iodine-129 duplicate samples are indicated as "not sampled because the radioisotope was not part of the analytical suite." However, based on a March 27, 2014 conference call discussion, these duplicates were not sampled because only Tritium requires a duplicate sample. This clarification needs to be explained in the text or as a footnote on the Table.

4. Page 10, Table 1, and Pages B-1 and B-2, Table B-1: Starting with the 2014 Annual Sampling Report, "<RDL" should be used for all analytes when appropriate.

5. Page 12, Table 2: "TSZ," "BSZ," and "TOC" are used as abbreviations. These abbreviations are not included on page iii, Abbreviations. They were included in the 2012 Report. Please add them to page iii for consistency. In addition, values in TOC column have all changed slightly compared to the 2012 Report. Please explain why they have changed either in the text or as a footnote.

6. Page A-3, Appendix A, Table A-3: An explanation should be provided in either the text or footnote as to why the duplicate samples for Hydrogen and Oxygen were not analyzed?

7. Page A-5, Appendix A, Table A-4: "NA" does not need to be included in the footnotes for this Table.

If you would like to discuss these comments, please contact Chris Andres at 702-486-2850, ext. 232.

Sincerely,

Chris Andres for

T. H. Murphy
Chief
Bureau of Federal Facilities

THM/CDA

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U.S. Department of Energy Office of Legacy Management

Record of Review

Due Date	Review No.	Project	Type of Review
	1	Central Nevada Test Area	Draft Report - Technical Review

Document Title and\or Number and Revision
2013 Groundwater Monitoring Report, Central Nevada Test Area, Corrective Action Unit 443

Author
Mark Kautsky

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Chris D. Andreas for T.H. Murphy

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Reviewers' Recommendation

- ☐ Release Without Comment
- ☐ Consider Comments
- ☒ Resolve Comments and Reroute for Review

Refer to the NDEP letter dated April 3, 2014

Signature of Reviewer and Date

- ☒ Comments Have Been Addressed

Digitally signed by Mark Kautsky
Date: 2014.04.29 13:29:17 -06'00'

Signature of Author and Date

- ☒ Comment Resolution Satisfactory
- ☐ Comment Resolution Unsatisfactory

Chris Andres 5/4/14

Signature of Reviewer and Date

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
1	Executive Summary, First Paragraph, Last Sentence and Page 1, Section 1.0, Second Last Sentence: According to the Addendum to Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for Corrective Action Unit (CAU) 443: Central Nevada Test Area (CNTA) - Subsurface Central Nevada Test Area, Nevada, DOE/NV-977, January 2008 and the installation of MV-4 and MV-5 in 2009, the site; is currently in the fifth year of the 5-year Proof of Concept Monitoring Period. No document has ever been submitted, nor approved, to state that this site is in the "conceptual model evaluation phase of the corrective action strategy in support of site closure." Please change the language of these two sentences to reflect the language used in currently approved documents.	Y	1	The requested sentence in the Executive Summary and Section 1.0 were replaced with the following: "The site is currently in the fifth year of the 5-year proof-of-concept monitoring period."
2	Executive Summary, Second Paragraph, Last Sentence: In order to be consistent with the 2012 Groundwater Monitoring Report, please insert "that the southeast-bounding graben fault acts as a barrier to groundwater flow at the site" after "the conceptual model."	Y	2	The change was made as requested.

Record of Review (continuation)

Review No.	Project

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
3	Page 10, Table 1, Table 1 and Pages B-1 and B-2, Table B-1. For the 11/06/13 MV-6 entry, Carbon-14 and.Iodine-129 duplicate samples are indicated as "not sampled because the radioisotope was not part of the analytical suite." However, based on a March 27, 2014 conference call discussion, these duplicates were not sampled because only Tritium requires a duplicate sample. This clarification needs to be explained in the text or as a footnote on the Table.	Y	3	The footnote for the duplicate samples on page 10, Table 1, and page B-2, Table B-1 were revised to state the following: "Duplicate sample (not required for ^{14}C and ^{129}I)."
4	Page 10, Table 1, and Pages B-1 and B-2, Table B-1: Starting with the 2014 Annual Sampling Report, "<RDL" should be used for all analytes when appropriate.	Y	4	The change will be made in the 2014 report.
5	Page 12, Table 2 "TSZ," "BSZ," and "TOC" are used as abbreviations. These abbreviations are not included on page iii, Abbreviations. They were included in the 2012 Report. Please add them to page iii for consistency. In addition, values in TOC column have all changed slightly compared to the 2012 Report. Please explain why they have changed either in the text or as a footnote.	Y	5	The abbreviations "TSZ", "BSZ", and "TOC" were added to the list of abbreviations on page iii as requested. A sentence was added to the last paragraph in Section 2.1 and a footnote added to Table 2 stating that the wells were surveyed to establish new top of casing elevations after the drilling program in 2013.
6	Page A-3, Appendix A, Table A-3: An explanation should be provided in either the text or footnote as to why the duplicate samples for Hydrogen and Oxygen were not analyzed?	Y	6	The footnote for duplicate sample on page A-3, Table A-3, was revised to state the following: "Indicates a duplicate sample (not required for stable isotopes of hydrogen and oxygen)."
7	Page A-5, Appendix A, Table A-4. "NA" does not need to be included in the footnotes for this Table.	Y	7	The footnote "NA" was removed as requested.

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