LMS/CNT/S09647

2012 Groundwater Monitoring Report Central Nevada Test Area, Subsurface Corrective Action Unit 443

April 2013

U.S. DEPARTMENT OF ENERGY | Legacy Management

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
Telephone: 800.553.6847
Fax: 703.605.6900
E-mail: orders@ntis.gov
Online Ordering: http://www.ntis.gov/help/ordermethods.aspx

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Phone: 865.576.8401
Fax: 865.576.5728
Email: reports@adonis.osti.gov

LMS/CNT/S09647

2012 Groundwater Monitoring Report
Central Nevada Test Area,
Subsurface Corrective Action Unit 443

April 2013

This page intentionally left blank

Contents

Figures

Tables

Appendixes

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	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
SGZ	surface ground zero
TOC	top of casing
TSZ	top of open interval/screen zone
UPZ	upper piezometer

This page intentionally left blank

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 are conducted as part of the subsurface corrective action strategy. The site is currently in the fourth year of the 5-year proof-of-concept period that is intended to validate the compliance boundary.

Analytical results from the 2012 monitoring are consistent with those of previous years. Tritium remains at levels below the laboratory minimum detectable concentration in all wells in the monitoring network. Samples collected from reentry well UC-1-P-2SR, which is not in the monitoring network but was sampled as part of supplemental activities conducted during the 2012 monitoring, indicate concentrations of tritium that are consistent with previous sampling results. This well was drilled into the chimney shortly after the detonation, and water levels continue to rise, demonstrating the very low permeability of the volcanic rocks. 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. It has been recommended that a low-flow sampling method be adopted for these wells to allow head levels to recover to steady-state conditions. Despite the lack of steady-state groundwater conditions, hydraulic head data collected from alluvial wells installed in 2009 continue to support the conceptual model that the southeast-bounding graben fault acts as a barrier to groundwater flow at the site.

This page intentionally left blank

1.0 Introduction

This report presents the 2012 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 corrective action strategy for the site includes proof-of-concept monitoring in support of site closure. This report summarizes investigation activities associated with CAU 443 that were conducted at the site from December 2011 through October 2012. It also represents the fourth year of the enhanced monitoring network and the 5-year proof-of-concept monitoring period that is intended to validate the compliance boundary.

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.

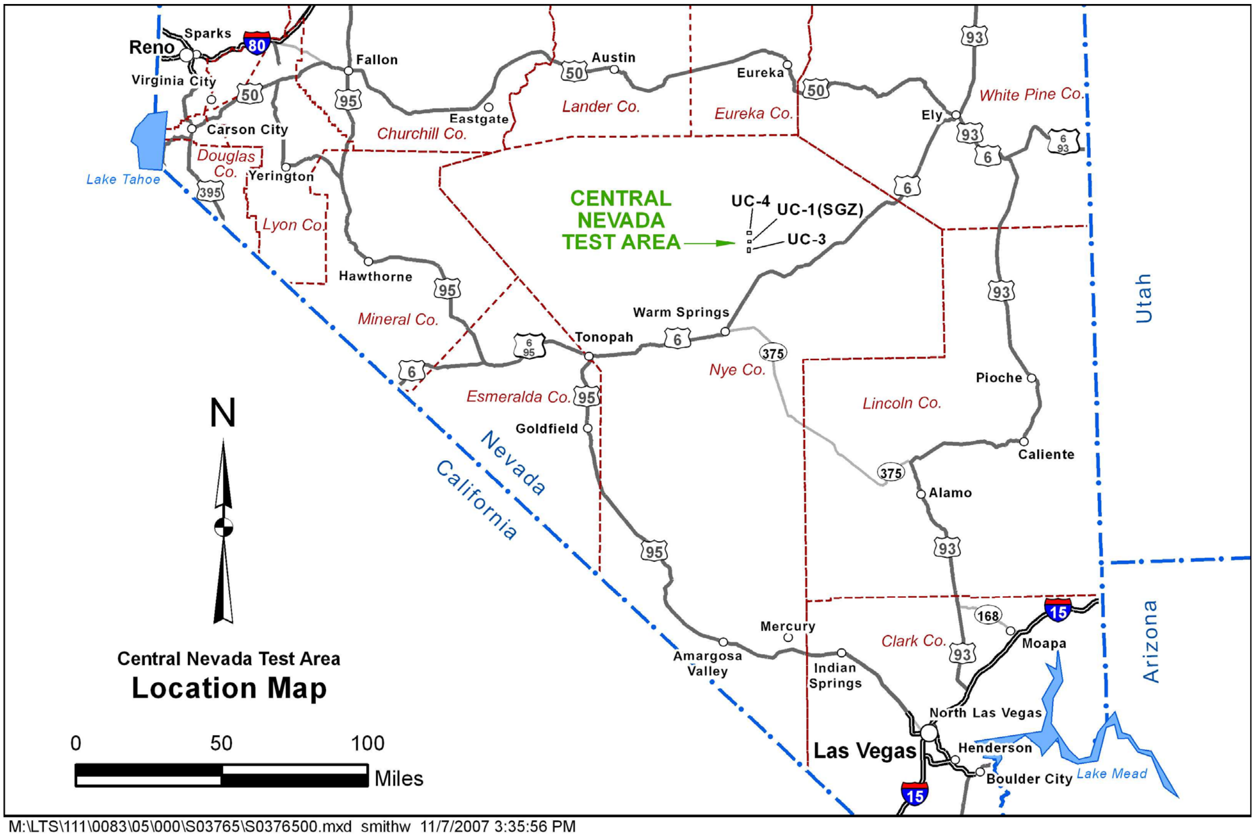
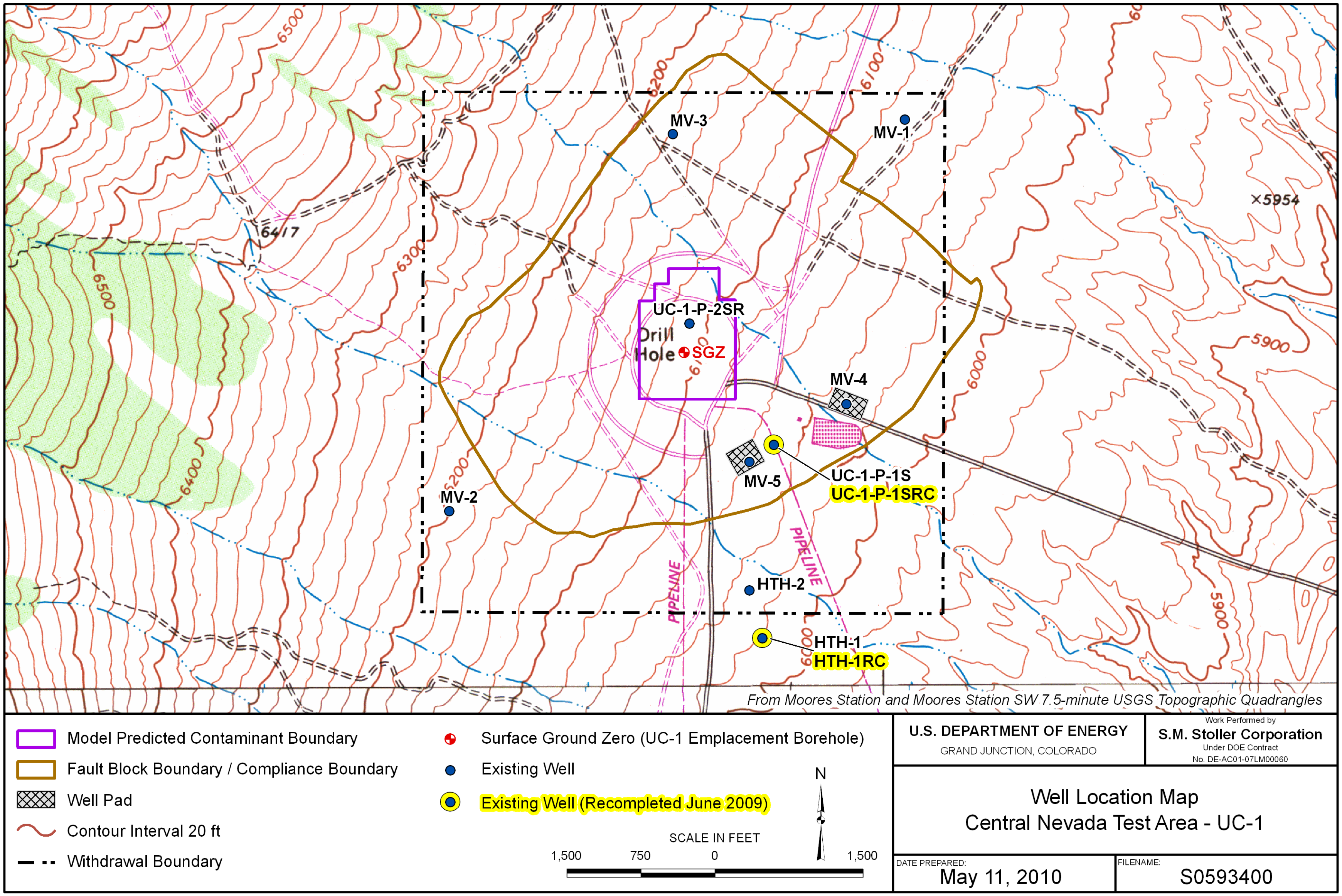


Figure 1. CNTA Location Map

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



M:\LTS\111\0083\05\002\S05934\S0593400.mxd smithw 5/11/2010 8:19:56 AM

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 2008a) 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 2009a).

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 the 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 2009a). 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). Refer to Figure 2 for a map of the locations included in the enhanced monitoring network.

[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 2008a), 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} meter per day) and is likely similar to the hydraulic conductivity of the upper part of the underlying volcanic sediments. A more-detailed summary of the results from the hydrologic testing is provided in the Hydrologic Testing Report for CAU 443 (DOE 2010b).

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 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 over 1,800 ft in the last 40 years and is expected to rise another 175 to 180 ft to the elevation of water levels in the alluvial aquifer in this area (from the elevation of 5,590 ft msl measured in mid-2011 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).

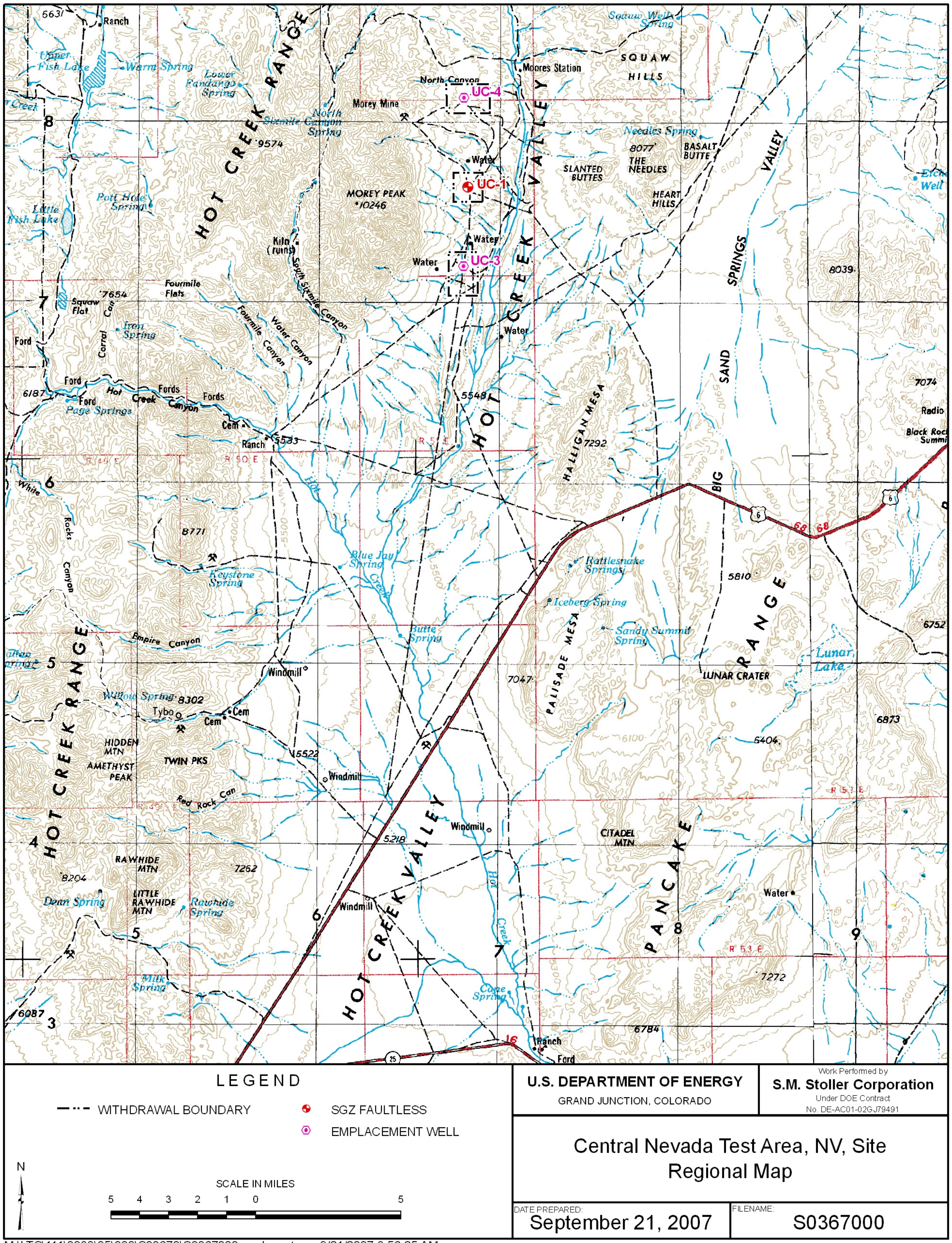
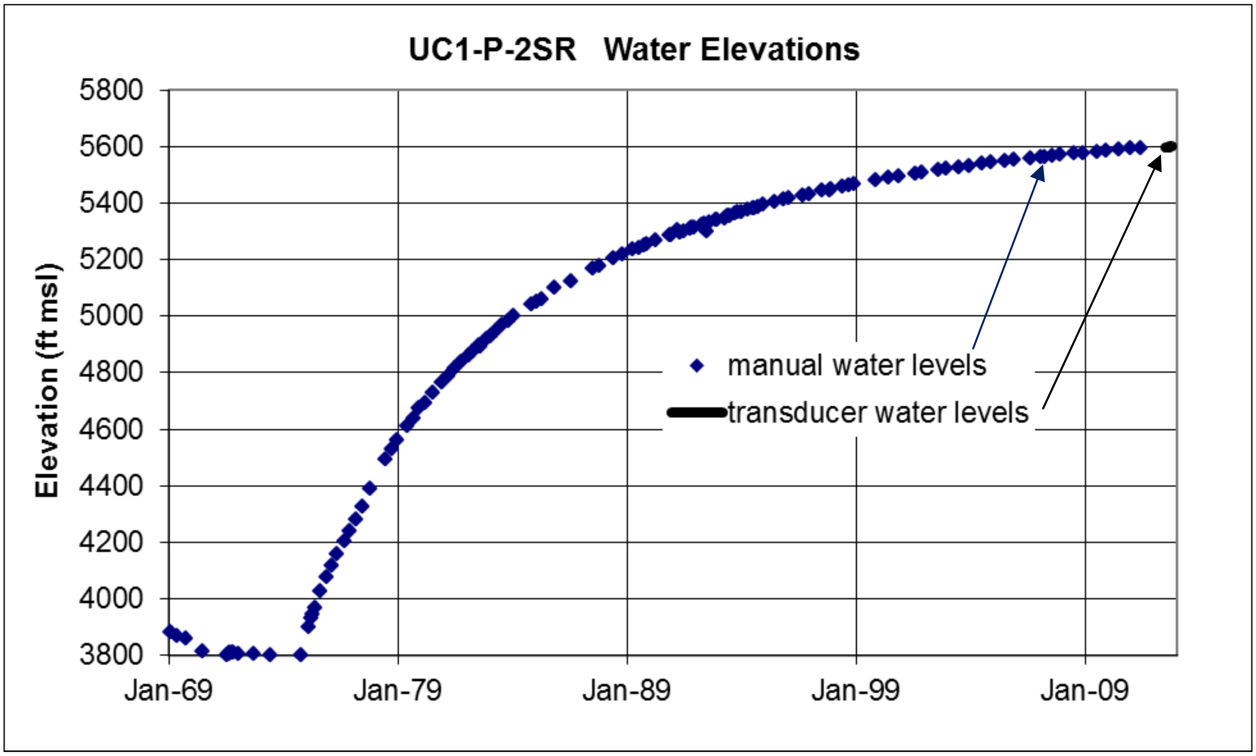
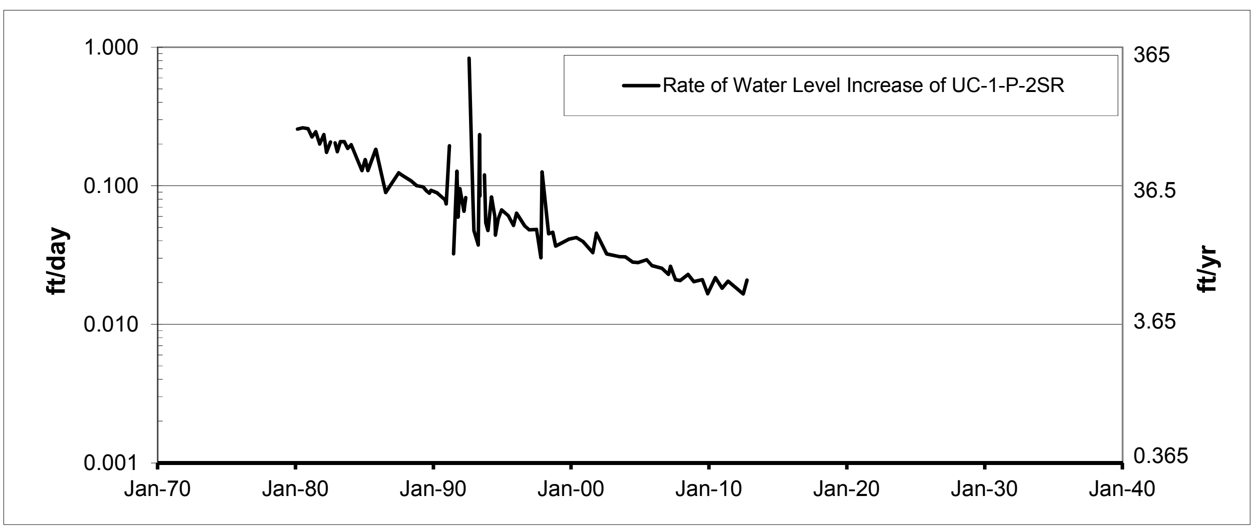


Figure 3. Physiographic Features near CNTA



Note: UC-1-P-2SR elevations not true-vertical-depth (TVD) corrected. The hole is essentially straight to a depth of 1500 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 new monitoring wells (MV-4 and MV-5) and the recompletion of two existing wells (HTH-1RC and UC-1-P-1SRC). The current monitoring activities are specified in the CADD/CAP addendum (DOE 2008a) and include the collection of hydraulic head data and groundwater samples for radioisotope analyses, but the primary objectives of the monitoring program have not changed.

The 2012 monitoring program was enhanced to include supplemental activities that were specified in the June 2012 Environmental Sampling notification letter (DOE 2012) that was provided to NDEP for the site. Results from the monitoring program are provided below, and results from the supplemental activities are provided in Section 5.0.

4.1 Radioisotope Monitoring

Groundwater samples were collected from wells MV-1, MV-2, MV-3, UC-1-P-1SRC, and HTH-1RC, and piezometers MV-4PZ and MV-5PZ as part of the annual monitoring program conducted in June 2012. A sample was not collected from well HTH-2 during this monitoring event because the dedicated pump is currently inoperable. Samples were also not collected from wells MV-4 and MV-5 to allow water levels at these locations time to recover from last year's sampling event. NDEP approved this temporary change in the sampling network with the condition that the piezometers MV-4PZ and MV-5PZ be sampled in their place. Piezometers MV-4PZ and MV-5PZ were sampled using a depth-specific bailer because they are not completed with dedicated submersible pumps. Monitoring wells MV-1, MV-2, MV-3, and HTH-1RC that are completed with bladder pumps were purged to remove stagnant water from the bladder pump tubing prior to sample collection. Monitoring well UC-1-P-1SRC was purged prior to sampling using the dedicated submersible pump. 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* (DOE 2008b) was used to guide quality assurance and quality control; and the *Fluid Management Plan, Central Nevada Test Area Corrective Action Unit 443* (DOE 2009b) was used to guide the handling and discharge of monitoring well purge water during the annual monitoring event. 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. During the 5-year proof-of-concept period that began with the 2009 sampling event, the CADD/CAP addendum (DOE 2008a) specifies that water samples will be analyzed for tritium every year and for carbon-14 (^{14}C) and iodine-129 (^{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. Inadequate sample volumes were collected in 2009 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 2008a) 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 2012 along with the results from previous sampling events dating back to 2009. Analytical results obtained from when the original CADD/CAP monitoring program began in 2006 through the present are provided in Appendix B. Tritium concentrations for 2012 are below the laboratory minimum detectable concentration, as in previous sampling events. The analytical results were validated in accordance with the *Environmental Procedures Catalog* (LMS/PRO/S04325), "Standard Practice for Validation of Laboratory Data." All analyses were completed, and the samples were prepared and analyzed in accordance with accepted procedures that were based on the specified methods. Required detection limits (RDLs) for the parameters being monitored were established in the CADD/CAP (DOE 2004) and were maintained in the CADD/CAP addendum (DOE 2008a). The radiochemical minimum detectable concentration values reported by the laboratory were less than the RDLs for all analytes except tritium. The LM-contract-required RDL for tritium is 400 pCi/L, which is slightly higher than the RDL of 300 pCi/L established in the CADD/CAP. A record of technical change was submitted to NDEP and approved in March 2012 to address this change in the CADD/CAP and CADD/CAP Addendum. 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.

4.3 Hydraulic Head Monitoring

Transducers are installed in all wells and piezometers in the monitoring network to monitor hydraulic head. A transducer was installed in well UC-1-P-2SR during the June 2012 monitoring event to enhance the monitoring of hydraulic head at the site. 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."

Table 1. Radioisotope Sampling Results

Monitoring Location	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
MV-1	6/26/2009	<RDL (2.46E-02)	NR	<370
	6/09/2010	NS	<RDL (10.4E-10)	<360
	6/09/2010[c]	NS	<RDL (10.8E-10)	<360
	5/10/2011	NS	NS	<340
	6/26/2012	NS	NS	<340
MV-2	6/26/2009	<RDL (5.55E-03)	NR	<380
	6/08/2010	NS	<RDL (10.9E-10)	<360
	5/11/2011	NS	NS	<340
	6/27/2012	NS	NS	<340
MV-3	6/25/2009	<RDL (3.87E-02)	NR	<380
	6/08/2010	NS	<RDL (14.2E-09)	<370
	5/10/2011	NS	NS	<340
	6/26/2012	NS	NS	<340
MV-4	6/24/2009	<RDL (9.17E-04)	NR	<370
	8/30/2010	NS	<RDL (7.5E-11)	<330
	5/10/2011	NS	NS	<340
	5/10/2011[c]	NS	NS	<330
	6/26/2012	NS	NS	NW
MV-4PZ[a]	6/26/2012	NS	NS	<340
MV-5	6/25/2009	<RDL (2.30 E-03)	NR	<370
	5/26/2010	NS	<RDL (5.7E-11)	<360
	5/11/2011	NS	NS	<330
	6/26/2012	NS	NS	NW
MV-5PZ[a]	6/26/2012	NS	NS	<340
HTH-1RC	6/25/2009	<RDL (2.75E-03)	NR	<390
	6/09/2010	NS	<RDL (11.0E-11)	<360
	5/11/2011	NS	NS	<340
	6/27/2012	NS	NS	<340
HTH-2	6/25/2009	<RDL (7.98E-02)	NR	<380
	6/09/2010	NS	PF	PF
	5/11/2011	NS	NS	PF
	6/27/2012	NS	NS	PF
UC-1-P-1SRC	6/24/2009	<RDL (1.07E-01)	NR	<360
	5/22/2010	NS	<RDL (5.2E-11)	<370
	5/10/2011	NS	NS	<330
	6/27/2012	NS	NS	<340

[a] Sample was collected using a depth-specific bailer.
[c] Duplicate sample.
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 RDL (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])

4.4 Hydraulic Head Results

Table 2 lists the most recent water level data (October 2012) 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.

Table 2. Construction and 2012 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	6,069.94	10/02/2012	317.58	5,752.36
MV-1LPZ	3,067.19	3,007.19	Volcanics	6,069.88	10/02/2012	42.31	6,027.57
MV-1	2,319.19	2,159.63	Volcanics	6,070.54	10/02/2012	507.38	5,563.16
MV-2UPZ	5,229.73	5,179.73	Alluvium	6,190.62	10/02/2012	405.19	5,785.43
MV-2LPZ	2,643.23	2,583.23	Volcanics	6,190.35	10/02/2012	403.31	5,787.04
MV-2	3,150.24	2,987.49	Volcanics	6,190.62	10/02/2012	359.75	5,830.86
MV-3UPZ	5,286.98	5,226.98	Alluvium	6,167.75	10/02/2012	372.83	5,794.92
MV-3LPZ	2,866.98	2,746.98	Volcanics	6,167.70	10/02/2012	193.56	5,974.14
MV-3	2,120.98	1,959.23	Volcanics	6,168.28	10/02/2012	600.83	5,567.45
MV-4[b]	4,300.32	3,996.22	Alluvium	6,019.65	10/02/2012	504.65	5,515.00
MV-4PZ[b]	5,101.20	5,041.20	Alluvium	6,019.45	10/02/2012	275.32	5,744.13
MV-5 [b,d]	4,203.12	3,878.69	Alluvium	6,041.69	9/07/2011	560.58	5,481.11
MV-5PZ[b]	5,023.17	4,963.17	Alluvium	6,040.87	10/02/2012	289.16	5,751.71
HTH-1UPZ[b]	5,032.63	4,972.63	Alluvium	6,011.23	10/02/2012	543.11	5,468.12
HTH-1LPZ[b]	4,112.66	4,052.66	Alluvium	6,011.26	10/02/2012	541.35	5,469.91
HTH-1RC[b]	3,653.90	3,353.60	Volcanics	6,011.65	10/02/2012	488.85	5,522.80
HTH-2	5,521.70	5,025.70	Alluvium	6,026.44	10/02/2012	556.14	5,469.73
UC-1-P-1SRC[b]	5,519.55	5,457.81	Alluvium	6,031.59	10/02/2012	281.64	5,749.95
UC-1-P-2SR[c]	4,931[c]	3,289[c]	Chimney	6,079.22	10/02/2012	479.7[c]	5,599.37[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] Transducers stuck in well. Cannot download or take water level until removed.
BSZ = bottom of open interval/screen zone
TOC = top of casing
TSZ = top of open interval/screen zone

Figure 6 through Figure 9 present hydrographs of the hydraulic head data. A continuous line indicates water levels from a transducer. 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.

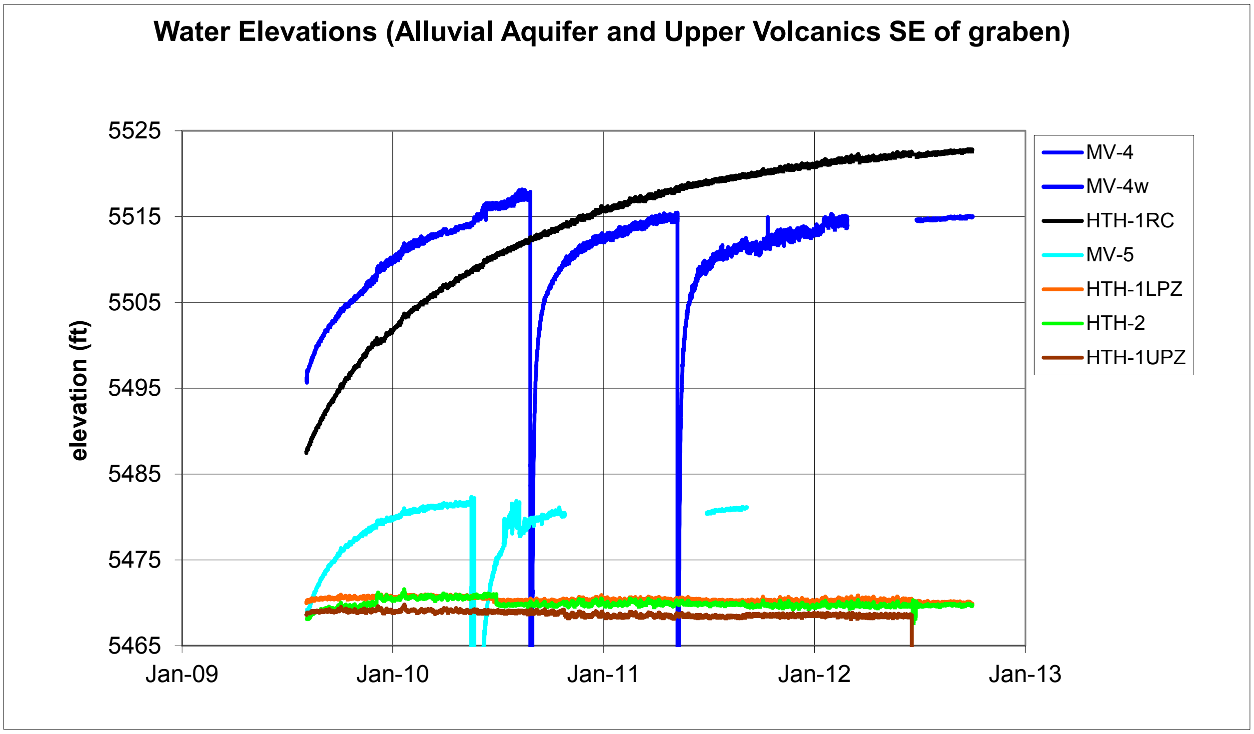


Figure 6. Water Level Elevations for the Alluvial Wells and Well HTH-1RC (Upper Volcanics) Southeast of the Down-Dropped Graben at the Screened Horizon

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. The low permeability of the alluvium at these depths will require switching to a low-flow sampling method that allows head levels to recover to steady-state conditions. Based on the slow recovery of 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 the MV-5 well were stuck when the telemetry system was being removed in June 2012. The last data download and water level measurement were in September 2011, and the previous data gap (last quarter 2010 to mid-2011) was due to a failed transducer. Water levels in well HTH-1RC continue to equilibrate after the recompletion in 2009 at approximately the same rate as 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 2008a).

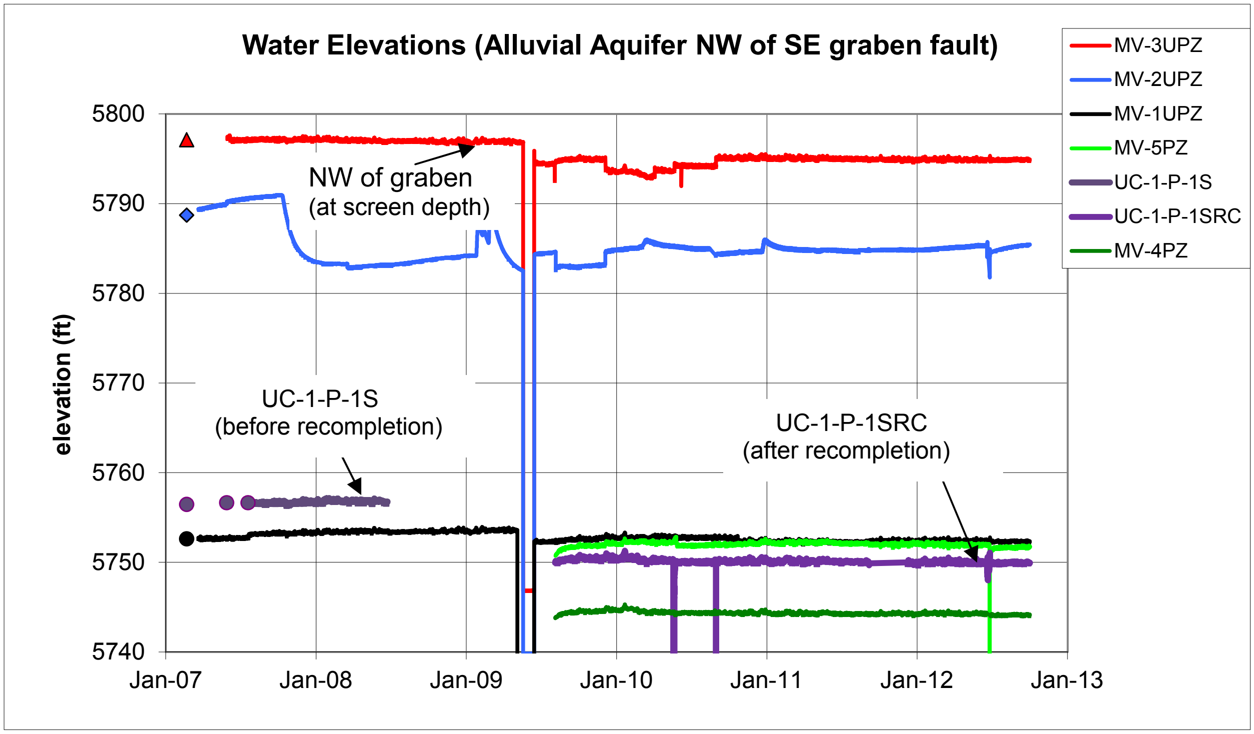


Figure 7. Water Level Elevations for the Alluvial Wells Northwest of the Southeast-Bounding Graben Fault

Figure 7 shows the hydrographs of alluvial piezometers and wells within and northwest of the graben. Erratic water levels in MV-2UPZ (Figure 7) are attributed to damage during its installation. The lower hydraulic heads observed after mid-2009 in MV-1UPZ and MV-3UPZ are the result of attempts to further develop these piezometers. The recompletion of 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 MV-4PZ and MV-5PZ (screened inside the down-dropped graben block) are approximately 250 ft higher than those in the MV-4 and MV-5 wells 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.

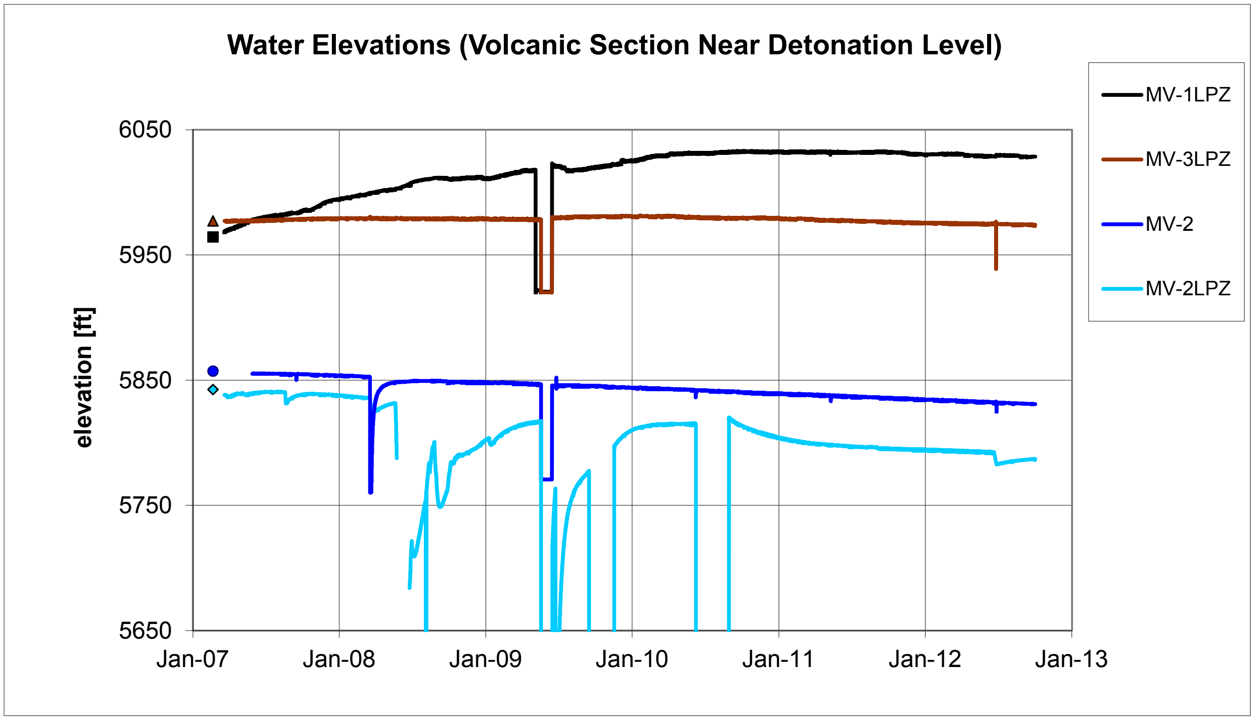


Figure 8. Water Level Elevations for the Well and Piezometers Screened in the Volcanic Section, at or near the Level of the Detonation

Figure 8 shows hydrographs of the well and piezometers with open intervals near the detonation level. Water levels in MV-1LPZ have stabilized over the past year. On August 5, 2008, Desert Research Institute ran a temperature log, collected a bailed sample, and measured the depth of 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, 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 graben bounding fault is a likely cause of its erratic water levels.

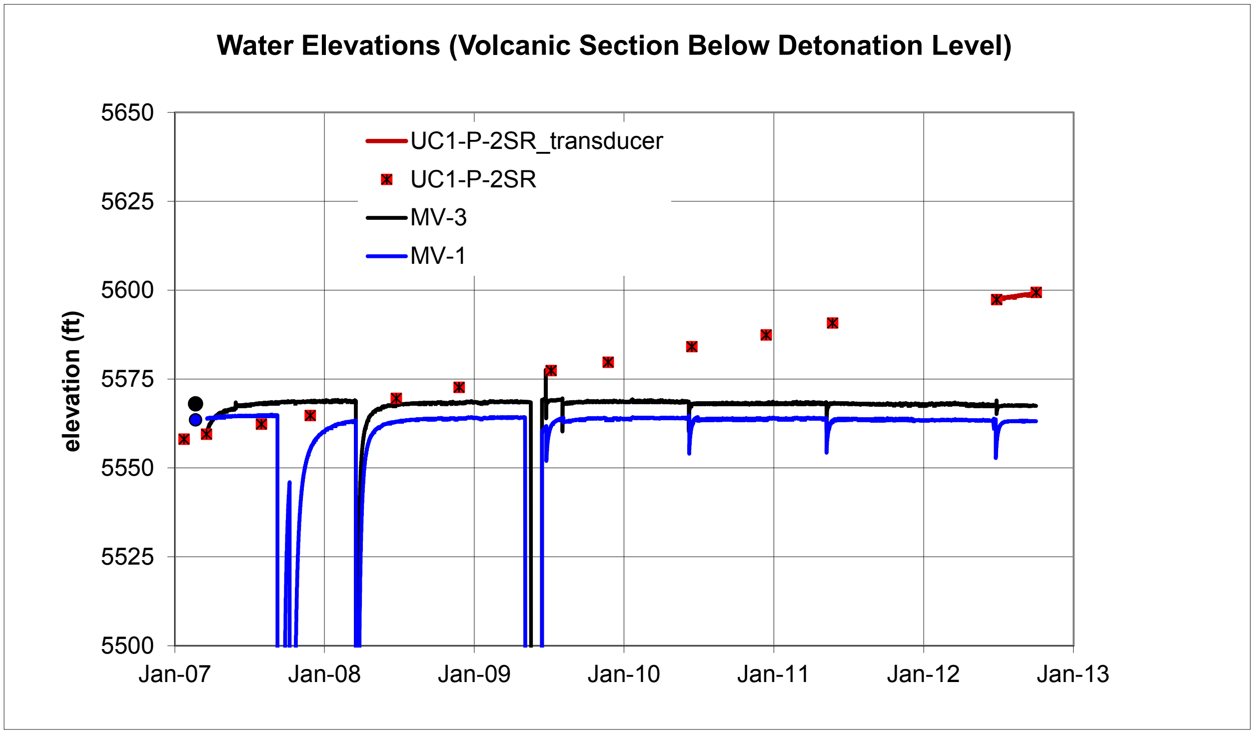
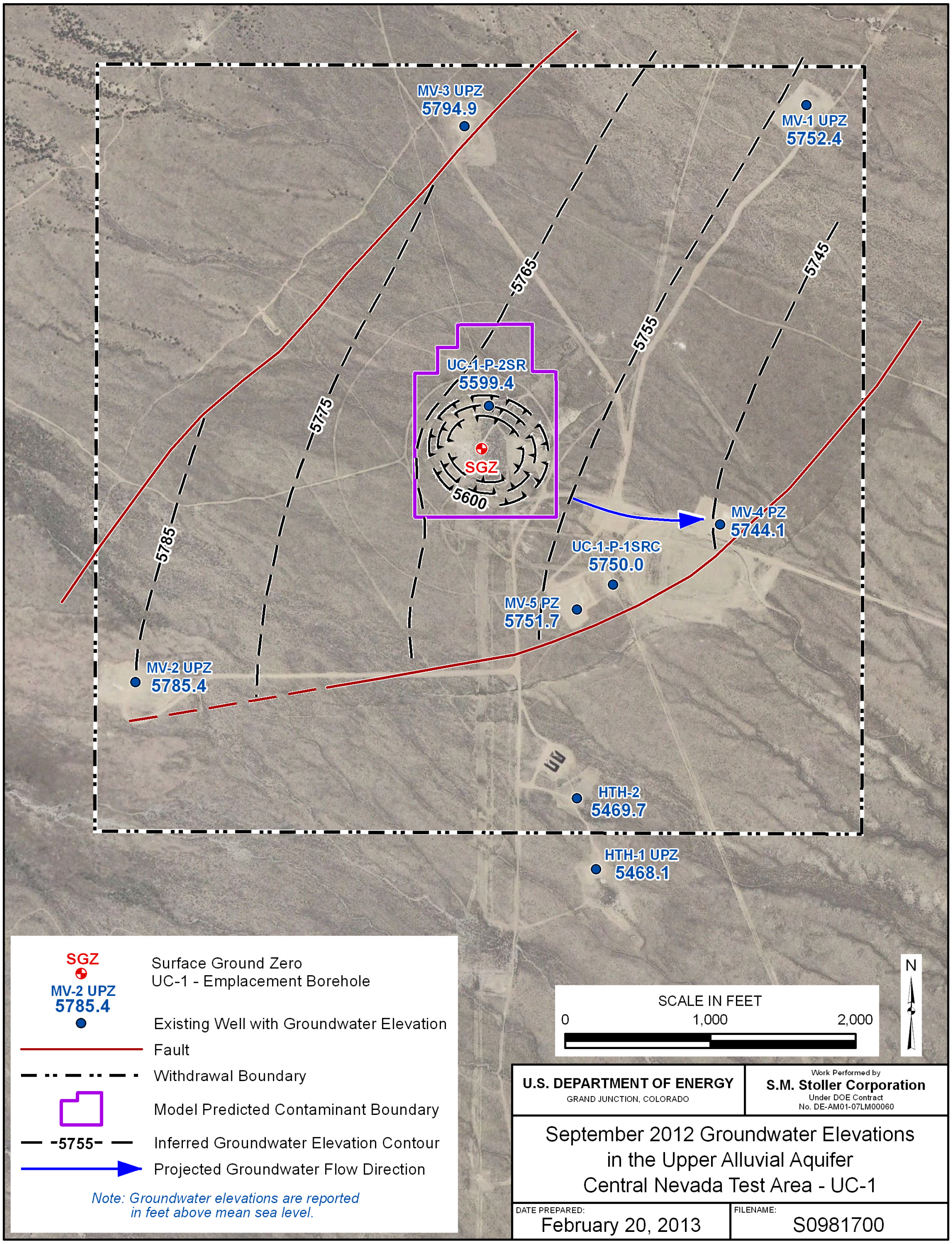


Figure 9. Water Level Elevations for the Wells Screened in the Volcanic Section Below the Level of the Detonation
(Water level elevations for reentry well UC-1-P-2SR [drilled into the chimney] are shown for reference.)

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 (5,599.37 ft msl on October 2, 2012) continues to increase approximately 7.0 ft per year, 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 of about 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 October 2012 head levels from MV-4PZ, MV-5PZ, UC-1-P-1SRC, MV-1UPZ, and MV-2UPZ, all of which are screened at depths ranging from 600 to 1,000 ft. 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. It should be noted that there is an inherent degree of uncertainty in the depiction of groundwater flow directions within the graben given the structural complexity caused by the detonation and the limited data available within the graben.



M:\LTS\111\0083\05\005\S09817\S0981700.mxd smithw 02/20/2013 4:36:08 PM

Figure 10. September 2012 Groundwater Elevations in the Upper alluvial Aquifer Central Nevada Test Area—UC-1

The new 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 June 2012 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 sampling and hydrologic logging of well UC-1-P-2SR, an enhanced analytical suite for the wells/piezometers, and removing telemetry equipment from the wells/piezometers at the site. Results from the supplemental site activities are provided in the following sections.

5.1 Sampling and Hydraulic Logging of Well UC-1-P-2SR

The June sampling event was enhanced by including hydrologic logging and collection of discrete samples from the reentry well UC-1-P-2SR. The discrete samples were collected from selected depths that were sampled by Desert Research Institute in 1993 through 1997 (depths are below land surface as feet/meters): 780/238, 1,590/485, 2,192/668 (DRI 2006). Samples were not collected from near the total depth of the well at 2,579/786 because the well extends into the upper part of the chimney, and radiological contamination is extensive within the chimney. Hydrologic logging was conducted to determine temperature, pH, and electrical conductivity from the groundwater surface to a depth of 2,200 ft bgs, but an equipment failure prevented the pH and electrical conductivity logs from being collected. Groundwater flow logging was also conducted to focus on previous flow meter measurement depths. All discrete samples were analyzed for major ions, stable isotopes of hydrogen and oxygen, and tritium (Table A–2, Appendix A). Samples collected from selected depths were also analyzed for gamma-emitting radionuclides (using high-resolution gamma spectrometry), gross alpha, gross beta, and ^{14}C (Table A–3, Appendix A).

Desert Research Institute evaluated the data from UC-1-P-2SR with historical data and determined that the logs and analytical results are consistent with previous results. The flow logging indicates that groundwater continues to enter the well from approximately 1,450 to 1,640 ft bgs, with flow upward and downward from this zone. Tritium results from the sampled intervals are also consistent with historical results and/or within the range of laboratory uncertainty. The chemical and isotopic content of the groundwater from the sampled intervals continues to be similar, though more dilute, than groundwater from the volcanic aquifer. Refer to Tables A–2 and A–3 in Appendix A for the complete analytical suite for this well. Refer to Appendix C for a detailed summary of the hydrologic logging and sampling data obtained from well UC-1-P-2SR.

5.2 Enhanced Analytical Suite and Sampling Network

The sampling event was enhanced by including locations that are not sampled (MV-4PZ, MV-5PZ, and UC-1-P-2SR) and by adding analyses for major ions and stable isotopes of oxygen and hydrogen for all sampled locations. The samples were collected and analyzed to provide current 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. Desert Research Institute evaluated these data with historical data and determined that the geochemical and isotopic properties of the groundwater from wells completed in the alluvium and volcanic section were consistent with historical results. It was further determined that chemical and isotopic differences between wells completed in the alluvium and wells completed in the underlying volcanic units continue to be consistent with the interpretation of a lack of communication between the alluvial and volcanic aquifers. Refer to Table A–3 in Appendix A for a summary of the water chemistry, stable isotope data, and last set of field parameters (pH, temperature, and specific conductance) obtained from the 2012 annual sampling event. Refer to Appendix C for a detailed summary of the enhanced analytical suite data.

5.3 Remove Site Telemetry Stations

The telemetry stations and associated equipment from the wells and piezometers were removed from the site the week of June 18, 2012. NDEP agreed that the telemetry equipment, used to transmit head data on a daily basis, could be removed or phased out as part of future monitoring activities at the site. The telemetry stations were removed to reduce the visual exposure of equipment near the monitoring well locations. Removing the telemetry equipment will not change the frequency for monitoring head levels at the site. Hydraulic head data will continue to be measured using transducers that are installed in the wells and piezometers, and the data will be downloaded during the semiannual visits and included in the annual monitoring reports for the site. The main telemetry station at well MV-3 remains at the site to transmit soil moisture data that is collected as part of the post-closure monitoring of the UC-1 Central Mud Pit.

6.0 Summary and Recommendations

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. Detection monitoring results indicate that radioisotope levels in groundwater continue to remain below laboratory minimum detectable concentration in all wells in the monitoring network. Samples collected from the reentry well UC-1-P-2SR, which is not in the monitoring network but was sampled as part of the supplemental activities, indicate concentrations of tritium that are consistent with previous sampling results. Water level data from the new wells, MV-4 and 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. It has been recommended that a low-flow sampling method be adopted for these wells to allow head levels to recover to steady-state conditions. Despite the lack of steady-state groundwater conditions, hydraulic head data collected from alluvial wells installed in 2009 continue to support the conceptual model that the southeast-bounding graben fault acts as a barrier to groundwater flow at the site.

LM recommends that the following activities be performed during the next annual monitoring period:

- Remove electric submersible pumps from wells MV-4, MV-5, and UC-1-P-1SRC, and replace them with low-flow bladder pumps.
- Replace the electric submersible pump in well HTH-2.

7.0 References

DOE (U.S. Department of Energy, Nevada Operations Office), 1999. *Corrective Action Investigation Plan for the Central Nevada Test Area Subsurface Sites (Corrective Action Unit No. 443)*, DOE/NV-483-Rev. 1, Las Vegas, Nevada, February.

DOE (U.S. Department of Energy, National Nuclear Security Administration/Nevada Site Office), 2001. *Closure Report for Corrective Action Unit 417: Central Nevada Test Area Surface*, *Nevada*, DOE/NV-743, Rev. 1, Las Vegas, Nevada, November.

DOE (U.S. Department of Energy, National Nuclear Security Administration/Nevada Site Office), 2004. *Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 443: Central Nevada Test Area (CNTA)—Subsurface*, Rev. 0, DOE/NV-977, Las Vegas, Nevada.

DOE (U.S. Department of Energy), 2007. *Corrective Action Plan Path Forward Proposal, Central Nevada Test Area*, Office of Legacy Management, Grand Junction, Colorado, April.

DOE (U.S. Department of Energy), 2008a. *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*, DOE−LM/1555-2007, Office of Legacy Management, Grand Junction, Colorado, January.

DOE (U.S. Department of Energy), 2008b. *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites*, LMS/PLN/S04351, Office of Legacy Management, Grand Junction, Colorado.

DOE (U.S. Department of Energy), 2009a. *Well Completion Report for Corrective Action Unit 443 Central Nevada Test Area Nye County, Nevada*, LMS/CNT/S05827, Office of Legacy Management, Grand Junction, Colorado, December.

DOE (U.S. Department of Energy), 2009b. *Fluid Management Plan Central Nevada Test Area Corrective Action Unit 443*, LSM/CNT/S03736, Office of Legacy Management, Grand Junction, Colorado, January.

DOE (U.S. Department of Energy), 2010a. *2009 Groundwater Monitoring Report Central Nevada Test Area, Corrective Action Unit 443*, LMS/CNT/S05935, Office of Legacy Management, Grand Junction, Colorado, September.

DOE (U.S. Department of Energy), 2010b. *Hydrologic Testing Report Central Nevada Test Area, Corrective Action Unit 443*, LMS/CNT/S06916, Office of Legacy Management, Grand Junction, Colorado, November.

DOE (U.S. Department of Energy), 2012. *June 2012 Environmental Sampling at Central Nevada Test Area, Nevada*, Office of Legacy Management, Grand Junction, Colorado, June.

DRI (Desert Research Institute), 2006. *Central Nevada Test Area Monitoring Report*, Publication No. 45222, DOE/NV/13609-52, September.

Environmental Procedures Catalog (LMS/PRO/S04325), continually updated. Prepared by S.M. Stoller Corporation for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado.

NDEP (Nevada Division of Environmental Protection), 2008. *Approval of Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) Addendum to: Corrective Action Unit (CAU) 443: Central Nevada Test Area (CNTA)—Subsurface Central Nevada Test Area, Nevada, DOE/NV-977*, DOE-LM/1555-2007, January 17.

Pohll, G., K. Pohlmann, J. Daniels, A. Hassan, and J. Chapman, 2003. *Contaminant Boundary at the Faultless Underground Nuclear Test*, Desert Research Institute Publication No. 45196, U.S. Department of Energy, Nevada Operations Office Report DOE/NV/13609-24, Las Vegas, Nevada.

Pohlmann, K.F., J. Chapman, A. Hassan, and C. Papelis, 1999. *Evaluation of Groundwater Flow and Transport at the Faultless Underground Nuclear Test, Central Nevada Test Area*, Publication No. 45184, U.S. Department of Energy, Nevada Operations Office report DOE/NV/13609-13, Las Vegas, Nevada: Desert Research Institute, Division of Hydrologic Sciences.

Appendix A

Well Purging, Water Chemistry, Stable Isotope, and Radioisotope Data

This page intentionally left blank

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	6/27/2012	7	16.14	8.16	607
HTH-2	NS	NS	NS	NS	NS
MV-1	6/26/2012	10	15.99	9.26	685
MV-2	6/27/2012	9	17.62	10.88	1617
MV-3	6/26/2012	10.5	16.4	7.23	946
MV-4	NS	NS	NS	NS	NS
MV-4PZ	6/26/12	1	NM	8.36	201
MV-5	NS	NS	NS	NS	NS
MV-5PZ	6/26/2012	1	28.21	8.13	197
UC-1-P-1SRC	6/27/2012	400	17.99	7.16	326
			17.92	7.24	325
			18.02	7.28	326

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

This page intentionally left blank

Table A–2. Water Chemistry and Stable Isotope Data from 2012 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)	Tritium (pCi/L)	Stable Isotope Ratio	
																Hydrogen ($^0/_{00}$)	Oxygen ($^0/_{00}$)
HTH-1RC	6/27/2012	16.14	8.16	607	67	31	3.2	0.055	130	1.8	21	37	220	0.01	<340	–118.33	–15.39
MV-1	6/26/2012	15.99	9.26	685	100	48	2.6	0.066	150	2.1	46	6.5	97	0.01	<340	–117.28	–15.21
MV-2	6/27/2012	17.62	10.88	1617	120	55	1.5	0.016	270	46	220	100	50	0.01	<340	–115.91	–14.94
MV-3	6/26/2012	16.4	7.23	946	67	31	20	0.33	220	3.7	19	0.61	480	0.01	<340	–113.82	–15.37
MV-4PZ	6/26/2012	NA	8.36	201	11	4.9	13	0.55	24	1.7	2.9	5.2	83	0.26	<340	–105.77	–13.95
MV-5PZ	6/26/2012	28.10	8.13	197	19	8.8	20	0.84	20	1.4	3.9	5.7	91	0.26	<340	–105.54	–13.91
UC-1-P-1SRC	6/27/2012	18.02	7.28	326	31	14	48	5.5	15	1.5	2.3	6	160	0.29	<340	–108.12	–14.21
UC-1-P-2SR (Sampled at 780 ft)	6/26/2012	NA	9.53	309	12	5.4	1.5	0.093	60	1.2	4.9	20	61	0.01	2,650	–115.41	–15.1
UC-1-P-2SR (Sampled at 1,590 ft)	6/27/2012	NA	9.36	313	19	8.7	1.6	0.06	62	1.2	4.8	23	67	0.011	3,070	–114.67	–15.12
UC-1-P-2SR (Sampled at 1,590 ft)**	6/27/2012	NA	NA	NA	18	8.3	1.6	0.062	61	1.2	4.8	23	74	0.01	2,740	NA	NA
UC-1-P-2SR (Sampled at 2,192 ft)	6/27/2012	NA	9.02	368	30	14	2.8	0.072	74	0.99	6.1	30	110	0.01	234,000	–116.37	–15.2

* = Indicates it is the last field measurement before the sample was collected.
** = Indicates a duplicate sample.
$^0/_{00}$ = 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
Note: Samples collected from piezometers MV-4PZ and MV-5PZ were analyzed for bromide and the concentrations were 0.2 mg/L in both samples.

This page intentionally left blank

Table A–3. Radioisotope and Carbon-14 data from 2012 Sampling of UC-1-P-2SR

Analytical Method	Radioisotope	UC-1-P-2SR (Sampled at 1,590 ft)	UC-1-P-2SR (Sampled at 2,192 ft)
Gamma Spectrometry (pCi/L)	Actinium-228	NA	<15
	Americium-241	NA	<24
	Antimony-125	NA	<11
	Cerium-144	NA	<21
	Cesium-134	NA	<5.2
	Cesium-137	NA	<5.1
	Cobalt-60	NA	<5.8
	Europium-152	NA	<32
	Europium-154	NA	<28
	Europium-155	NA	<12
	Lead-212	NA	<13
	Potassium-40	NA	<150
	Promethium-144	NA	<5
	Promethium-146	NA	<5.8
	Ruthenium-106	NA	<62
	Thorium-234	NA	<140
	Uranium-235	NA	<21
	Yttrium-88	NA	<12
Gross Alpha (pCi/L)	Gross Alpha	NA	1.47
Gross Beta (pCi/L)	Gross Beta	NA	1.97
Dissolved Inorganic Carbon (apparent age in years)	Carbon-14	18,630	NA

NA = not analyzed
pCi/L = picocuries per liter

This page intentionally left blank

Appendix B

Analytical Data: 2006 Through the Present

This page intentionally left blank

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 (1.12E-02)	<RDL (1.51E-7)	<RDL (<3)
	9/21/2006[b]	<RDL (5.61E-02)	<RDL (2.9E-7)	<RDL (<45)
	2/22/2007	NS	NS	NS
	10/10/2007	<RDL (7.40E-03[d])	<RDL (5.7E-11)	<313
	3/19/2008	NS	NS	PF
	6/26/2009	<RDL (2.46E-02)	NR	<370
	6/09/2010	NS	<RDL (10.4E-10)	<360
	6/09/2010[c]	NS	<RDL (10.8E-10)	<360
	5/10/2011	NS	NS	<340
	6/26/2012	NS	NS	<340
MV-2	3/16/2006[b]	<RDL (9.92E-02)	<RDL (2.58E-7)	<RDL (<3)
	9/22/2006[b]	<RDL (1.3E-02)	<RDL (2.6 E-7)	<RDL (<45)
	2/22/2007	<RDL (1.54E-03[d])	<RDL (9.7E-11)	<357
	2/22/2007[c]	<RDL (1.84E-03[d])	<RDL (11.1E-11)	<353
	3/19/2008	NS	NS	<320
	6/26/2009	<RDL (5.55E-03)	NR	<380
	6/08/2010	NS	<RDL (10.9E-10)	<360
	5/11/2011	NS	NS	<340
	6/27/2012	NS	NS	<340
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 (3.95E-02)	<RDL (2.10E-7)	<RDL (<3)
	9/22/2006[b]	<RDL (5.11E-02)	<RDL (2.2 E-7)	<RDL (<45)
	2/22/2007	<RDL (1.01E-02[d])	<RDL (14.0E-11)	<359
	3/19/2008	NS	NS	<320
	6/25/2009	<RDL (3.87E-02)	NR	<380
	6/08/2010	NS	<RDL (14.2E-9)	<370
	5/10/2011	NS	NS	<340
	6/26/2012	NS	NS	<340
MV-4	6/24/2009	<RDL (9.17E-04)	NR	<370
	8/30/2010	NS	<RDL (7.5E-11)	<330
	5/10/2011	NS	NS	<340
	5/10/2011[c]	NS	NS	<330
	6/26/2012	NS	NS	NW
MV-4PZ[a]	6/26/2012	NS	NS	<340
MV-5	6/25/2009	<RDL (2.30 E-03)	NR	<370
	5/26/2010	NS	<RDL (5.7E-11)	<360
	5/11/2011	NS	NS	<330
	6/26/2012	NS	NS	NW
MV-5PZ[a]	6/26/2012	NS	NS	<340
HTH-1RC	6/25/2009	<RDL (2.75E-03)	NR	<390
	6/09/2010	NS	<RDL (11.0E-11)	<360
	5/11/2011	NS	NS	<340
	6/27/2012	NS	NS	<340
HTH-2	6/25/2009	<RDL (7.98E-02)	NR	<380
	6/09/2010	NS	PF	PF
	5/11/2011	NS	NS	PF
	6/27/2012	NS	NS	PF

Table B−1 (continued). Radioisotopic Sample Results

Monitoring Location	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
UC-1-P-1SRC	6/24/2009	<RDL (1.07E-01)	NR	<360
	5/22/2010	NS	<RDL (5.2E-11)	<370
	5/10/2011	NS	NS	<330
	6/27/2012	NS	NS	<340

[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 were obtained from the Desert Research Institute Monitoring Report (DRI 2006).
[c] Duplicate sample.
[d] Estimated based on sample volume of 200 milliliters.
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 RDL (laboratory result in parentheses; RDL is 300 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I [DOE 2004])

Appendix C

DRI Field Report

This page intentionally left blank

Summary of Field Activities at the Central Nevada Test Area, Faultless Site, June 26–28, 2012

Prepared for

Stoller

Prepared by
Brad Lyles and Jenny Chapman
Desert Research Institute

October 2012

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

INTRODUCTION

Desert Research Institute and S.M. Stoller Corporation performed groundwater sampling and hydrologic logging at the Central Nevada Test Area (CNTA) between June 26 and 28, 2012. Part of this effort included routine site monitoring and maintenance that will be reported in the annual monitoring report. Supplemental activities were directed at assessing the status of groundwater flow into well UC-1-P-2SR and the current chemical and radiochemical conditions in that well, and identifying the chemical and radiochemical properties of MV-4PZ and MV-5PZ. UC-1-P-2SR is completed within the Faultless nuclear chimney and provides insight into the ongoing recovery of the hydrologic system in the area of the Faultless nuclear test. The chemical and isotopic composition of groundwater from site wells and piezometers provides information about the sampling horizons of the monitoring wells and the aquifers they intercept.

HYDROLOGIC LOGGING AND SAMPLING ACTIVITIES AND DATA INTERPRETATION

Well: MV4-PZ

A water level was measured via temperature/electrical conductivity tool, TT2; all measurements were made relative to the top of casing. Water level measured June 26 at 09:00 was 275.55 feet (ft) below top of casing; total depth equaled 946.3 ft. The wireline was decontaminated with Reno tap water on the first trip into the well. Water samples were collected from 932 ft via motorized discrete samples; two trips were made with a total volume of approximately 2.4 liters. The wireline was decontaminated on the final trip out of the well.

Well: MV5-PZ

No water level or total depth measurements were performed. Water samples were collected from 1047 ft via motorized discrete sampler, June 26, 2012, at 13:34; two trips were made with a total volume of approximately 2.4 liters. The wireline was decontaminated on the final trip out of the well.

Well: UC-1-P-2SR

A water level was measured via wireline with the temperature/electrical conductivity tool, TT2; all measurements were made relative to the top of casing. Water level measured June 27 at 14:00 was 482.25 ft below top of casing. Water levels are still recovering from the effects of the Faultless test; manual water level measurements performed by the USGS are shown with the water level from this study in Figure 1.

A temperature log was attempted with tool TT2, June 27, 2012; however, due to unknown electronic problems, the log was deemed unusable. Therefore, the log was repeated with a temperature logging tool, 20-Pulse. The 20-Pulse temperature log was run from 483 to 2202 ft, June 27, 2012; the results of this log are shown in comparison to a temperature log performed October 24, 1997 (Mihevc and Lyles 1998) in Figure 2. The log from 1997 was performed with a logging tool referred to as the ChemTool and was run from 642 to 2792 ft, much deeper than the log run in this study. Water levels are higher now than in 1997 due to post-shot water level recovery. Temperatures from the water table to approximately 1200 ft are very similar; slightly cooler and a reduced thermal gradient. Based on the crossover point of the thermal gradient and the log measurement, water may be entering the well near 1500 ft, with groundwater flowing both upward and downward from that point, exiting at 1220 and 1960 ft, respectively. Temperatures are approximately 2 °C warmer now than in 1997; however, inter-tool calibration errors may account for some differences.

An electrical conductivity (EC) log was performed with logging tool TT2; conductivity readings were temperature corrected to 25 °C using similar depth temperature readings from the 20-Pulse tool. Results of the 2012 conductivity log differed radically from those performed in 1997, as shown in Figure 3. In 1997, the EC was nearly uniform from approximately 650 ft to 1950 ft, at 300 microsiemens (µS). During this survey, the EC was lower from 482 to 655 ft; measurements ranged from 125 to 136 µS, then increased to a high of 440 µS at 1000 ft, then gradually decreased to 390 µS at 2000 ft. Discrete samples were collected at three depths (780, 1590, and 2192 ft), and EC measurements match closely with the 1997 measurements. Therefore, the electrical problems that affected the temperature measurements with logging tool TT2 most likely affected the EC measurements, and the 2012 log is of no value.

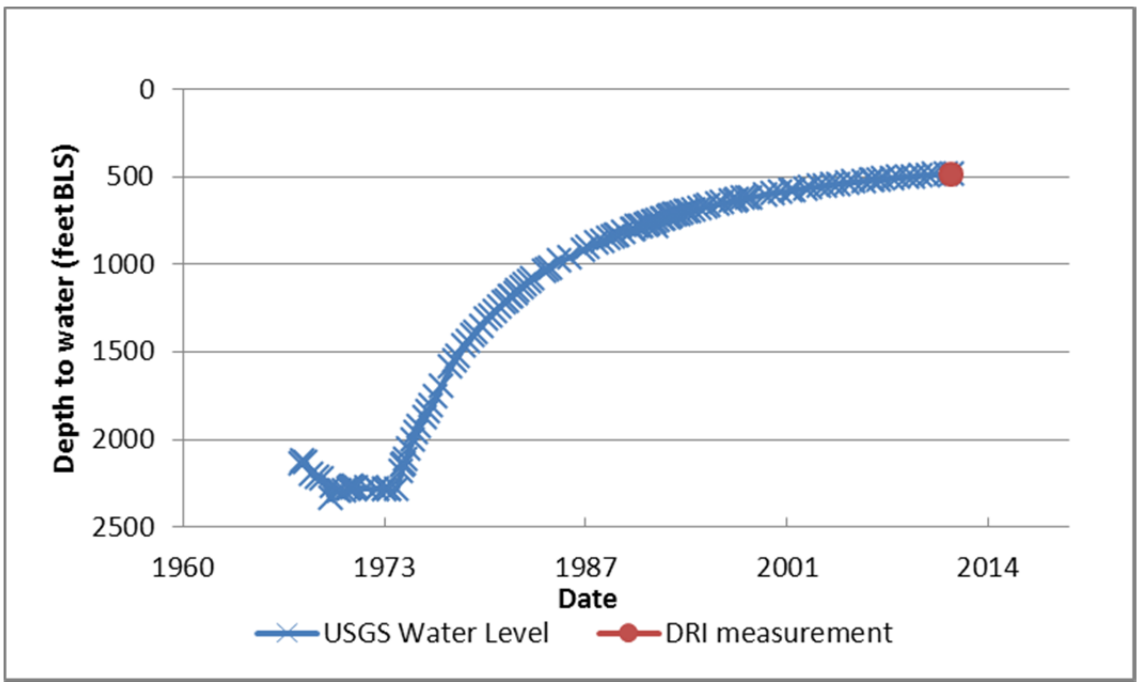


Figure 1. UC-1-P-2SR water level measurements, 1968 to 2012

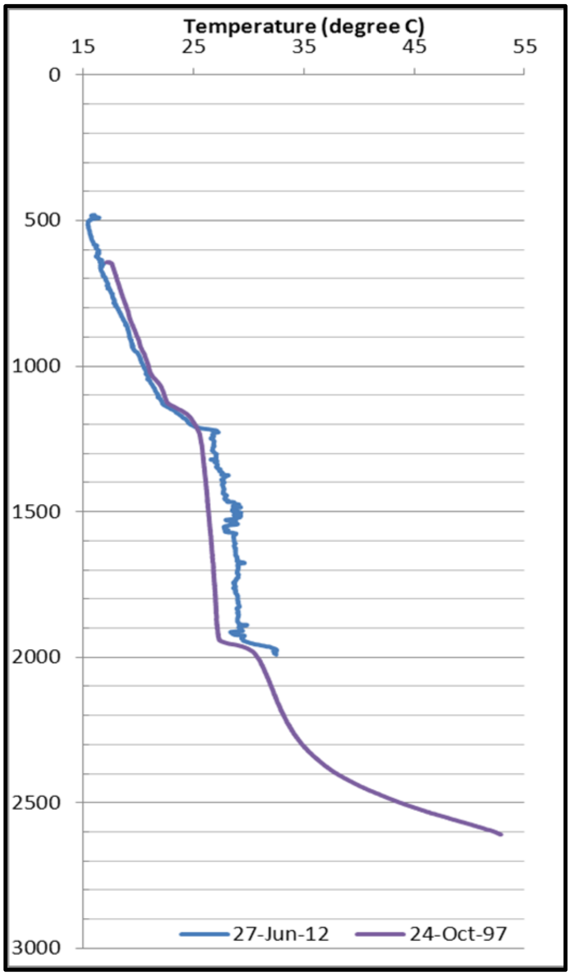


Figure 2. CNTA UC-1-P2SR temperature log comparison. The 1997 log is from Mihevc and Lyles (1998).

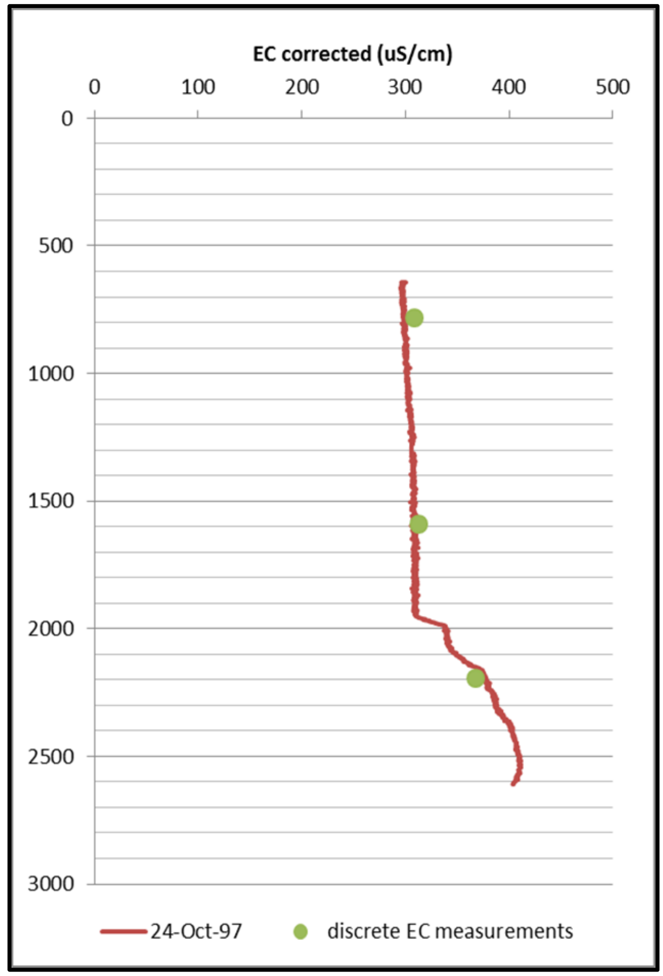


Figure 3. CNTA UC-1-P2SR electrical conductivity log comparison. The 1997 log is from Mihevc and Lyles (1998).

Water samples were collected from three depths (780, 1590, and 2192 ft) via a wireline motorized discrete sampler.

Thermal flow meter (TFM) surveys were performed using well-logging tool TFM3; the 2-inch flow-through cell was equipped with 4-inch disks, 6-inch peddles, and a weight bar. Measurements were performed at seven stations (Table 1); choice of measurement locations was based on previous measurement depths and on interpretations from the 20-pulse temperature log. Flow is entering the well between 1450 and 1640 ft; approximately 2 gallons per minute (gpm) flows upward, and 7 gpm flows downward from this point. When compared to TFM results from 1997, similar inflow/outflow zones were identified; however, the flow rates are nearly an order of magnitude greater now than in 1997 (Figure 4). It is not clear why flow rates have changed.

Table 1. Results from thermal flow meter survey.

Depth	Diameter	Response Time	sdev	Flowrate	sdev	Velocity	sdev	
(ft)	(inches)	(sec)		(gpm)	(gpm)	(ft/min)	(ft/min)	
1245	5.5	2.02	0.62	2.5	1.52	2.01	1.24	
1450	5.5	2.43	0.40	2.0	0.64	1.59	0.52	
1640	5.5	–1.30	0.32	–6.9	3.46	–5.63	2.81	**
1725	5.5	–1.24	0.09	–7.6	1.10	–6.16	0.89	**
1885	5.5	–1.30	0.07	–6.9	0.75	–5.63	0.61	**
2025	5.5	10.00	20.00	0.0	0.00	0.00	0.00	*
2204	5.5	10.00	20.00	0.0	0.00	0.00	0.00	*

Note: response time, flow rate, and velocity greater than zero, assume upward flow; negative values assume downward flow; * = response time is greater than maximum calibration limits, assume no flow; ** = response time is less than calibration limits, assume flow rate greater than 6 gpm. The wireline was decontaminated on the final trip out of the well.

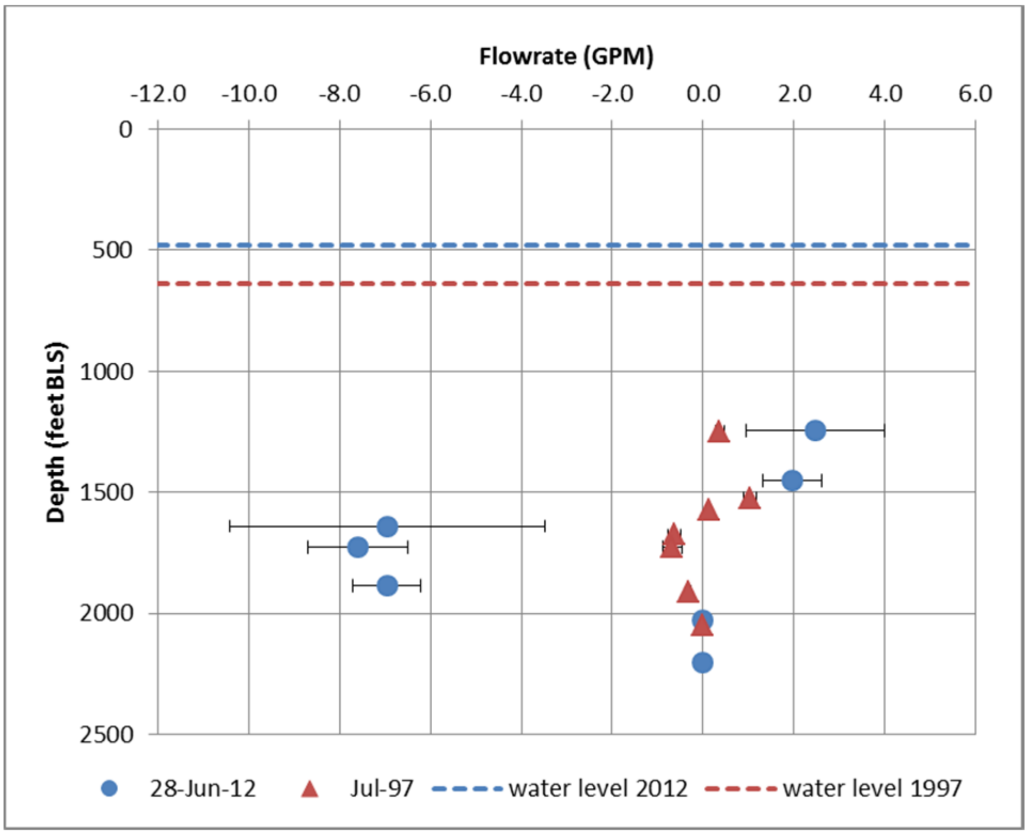


Figure 4. UC-1-P-2SR borehole vertical flow rate measured by thermal flow meter; whiskers represent 2 standard deviations about the mean flow rate. Water level during surveys is shown with dashed lines. Note: positive flow rates indicate upward flow; negative flow rates represent downward flow.

CHEMICAL AND ISOTOPIC DATA AND INTERPRETATIONS

Groundwater samples were collected from eight site wells during late June 2012 (Table 2). Wells HTH-1RC, MV-1, MV-2, MV-3, and IC-1-P-1SRC were all sampled by Stoller using submersible pumps. Wells MV-4PZ, MV-5PZ, and multiple depths in UC-1-P-2SR were sampled by DRI using a depth-discrete bailer. After transfer to appropriate bottles, the bailed samples were delivered in the field to Stoller for measurement of field parameters and for packaging and shipping to laboratories.

Major Ions

Previous work (Mihevc et al. 1996; Lyles et al. 2006) determined that groundwater in the shallow alluvium at CNTA has a calcium bicarbonate (Ca-HCO_3) character and a stable isotopic content enriched in heavy oxygen and hydrogen isotopes in comparison to water from the volcanic aquifer. In contrast, groundwater from the volcanic aquifer is a sodium bicarbonate (Na-HCO_3) type with relatively depleted stable isotopes.

The MV wells were sampled for major ions in 2006, shortly after the wells were drilled and developed. The three wells, all completed in fractured volcanic tuff, produced water in the expected Na-HCO_3 chemical facies. The 2012 samples of the same wells continue to exhibit the dominance of the Na cation, but there is a spread in the anion results such that MV-3 has virtually no SO_4, and MV-2 has very little HCO_3 (Figure 5). It is likely that MV-2 has considerably more carbonate, but a CO_3 analysis was not performed. At the high pH of this well (10.88), carbonate speciation should result in substantial CO_3 (the 2006 sample from MV-2 had 115 mg/L CO_3). The near absence of SO_4 in MV-3 is unexplained.

The recompleted UC-1-P-1S retains a chemical character consistent with groundwater in the alluvium (Figure 6). Its composition is more similar to that of water from HTH-2 than the prior sample from UC-1-P-1S. Groundwater from MV-5PZ also has relative ion percentages consistent with groundwater from alluvium (Figure 5). MV-4PZ is technically a Na-HCO_3 type rather than the Ca-HCO_3 type characteristic of the alluvium, but the relative percentages of Ca and Na are more similar to the groundwater from the alluvium than to groundwater of the volcanic aquifers (Figure 5).

All of the sampled depths from UC-1-P-2SR yield groundwater in the volcanic Na-HCO_3 facies (Figure 6) despite being collected at perforations in the alluvium. Mihevc et al. (1996) noted that groundwater in UC-1-P-2SR is chemically similar to the deep volcanic groundwater at HTH-1, though the lower salinity of samples higher in the UC-1-P-2SR borehole suggests some dilution by fresher water (Figure 7).

Table 2. Analytical results for major cations, anions, tritium, and stable isotopes for CNTA 2012 sampling and previous analyses from the same locations (Chapman et al. 1994, Lyles et al. 2006).

	Site / ID	Depth (feet)	Date	Temp (deg C)	EC (µS/cm)	pH	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Bicarbonate (mg/L)	CO3 (mg/L)	Nitrate (mg/L)	Silicon (mg/L)	Tritium (pCi/L)	δD (‰)
	HTH-1RC	pumped	6/27/2012	16.14	607	8.16	3.2	0.055	130	1.8	21	37	220		0.01	31	<340	-118.33
		2799	10/27/1997	18.4	603	8.36	2.9	<0.1	136	1.54	20.5	36.2	260	1.1	<0.01	69.9	<5	
	MV-1	pumped	6/26/2012	15.99	685	9.26	2.6	0.066	150	2.1	46	6.5	97		0.01	48	<340	-117.28
		3830	2/14/2006		790	9.59	3.21	<0.1	179	3.22	56.7	63.5	76.1	57.6	<0.01		<3	-116
	MV-2	pumped	6/27/2012	17.62	1617	10.88	1.5	0.016	270	46	220	100	50		0.01	55	<340	-115.91
		3120	3/16/2006		898	9.79	2.3	<0.1	182	26.4	66.8	47.7	90.3	115	<0.01		<3	-117
	MV-3	pumped	6/26/2012	16.4	946	7.23	20	0.33	220	3.7	19	0.61	480		0.01	31	<340	-113.82
		4127	3/16/2006		648	8.35	4.52	0.16	155	1.93	18.8	31.8	277	0.8	<0.01		<3	-118
	MV-4PZ	932	6/26/2012		201	8.36	13	0.55	24	1.7	2.9	5.2	83		0.26	4.9	<340	-105.77
	MV-5PZ	1047	6/26/2012	28.1	197	8.13	20	0.84	20	1.4	3.9	5.7	91		0.26	8.8	<340	-105.54
	UC-1-P-1SRC	pumped	6/27/2012	18.02	326	7.28	48	5.5	15	1.5	2.3	6	160		0.29	14	<340	-108.12
	UC-1-P-1S	750	5/23/1993		217	8.16	23.1	1.7	23	1.36	2.9	0.64	134		1.37	24.5	<5	-105
	UC-1-P-2SR	780	6/26/2012		309	9.53	1.5	0.093	60	1.2	4.9	20	61		0.01	5.4	2650	-115.41
		781	5/24/1993		277	9.86	1.4	0.22	59.9	1.32	7.6	16.6	58	38.9	<0.04	6	8680	-114
	UC-1-P-2SR	1590	6/27/2012		313	9.36	1.6	0.06	62	1.2	4.8	23	67		0.011	8.7	3070	-114.67
		1591	10/23/1997		253	9.74	1.69	<0.1	59.8	1.06	4.5	22.1	63.4	35.1	0.09	17.6	4020	
		1591	5/24/1993		282	9.86	1.8	0.22	61.6	1.15	5	21.1	53.6	41.1	<0.04	15.4	5210	-114
	UC-1-P-2SR	2192	6/27/2012		368	9.02	2.8	0.072	74	0.99	6.1	30	110		0.01	14	234,000	-116.37
		2192	5/24/1993		343	9.1	2.69	<0.1	78.1	0.8	6.1	30.7	124	19.8	<0.04	30.6	220,000	-115
for reference																		
	HTH-2	974	7/29/1992	20.5	299	7.94	40.8	5.49	18.4	1.44	2.6	4.08	197		2.22	29.5		-107

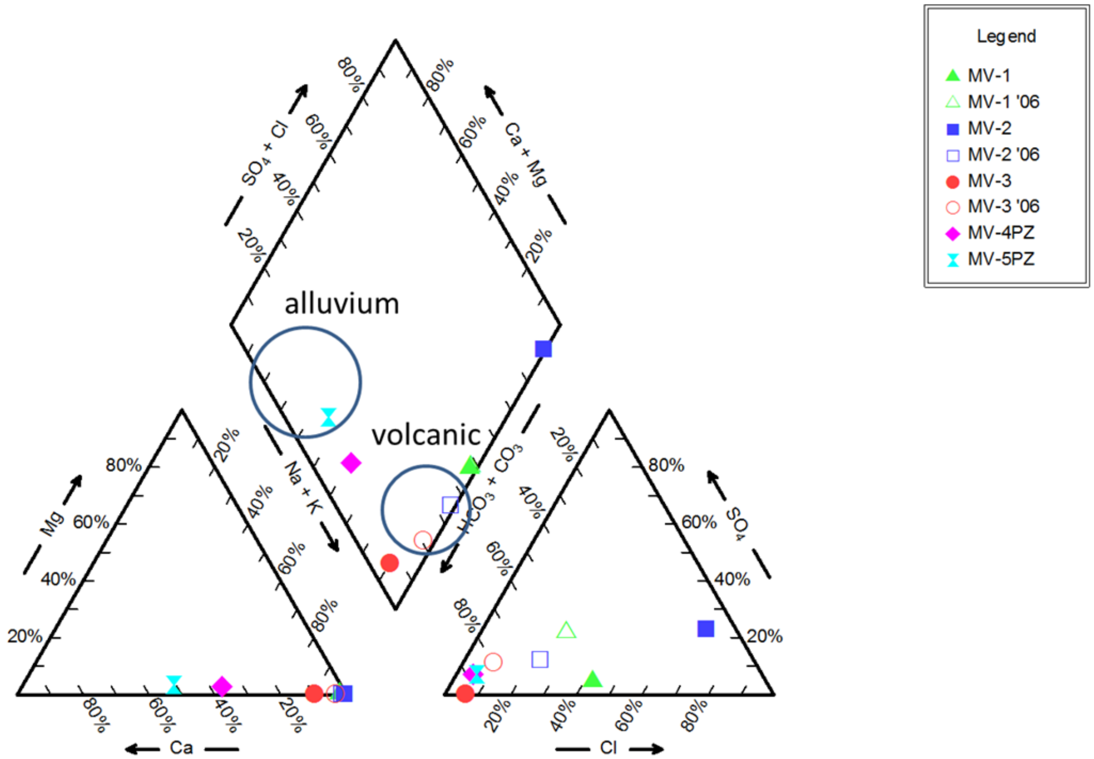


Figure 5. Piper diagram of water chemistry from the MV wells, displaying analyses from 2006 and 2012.

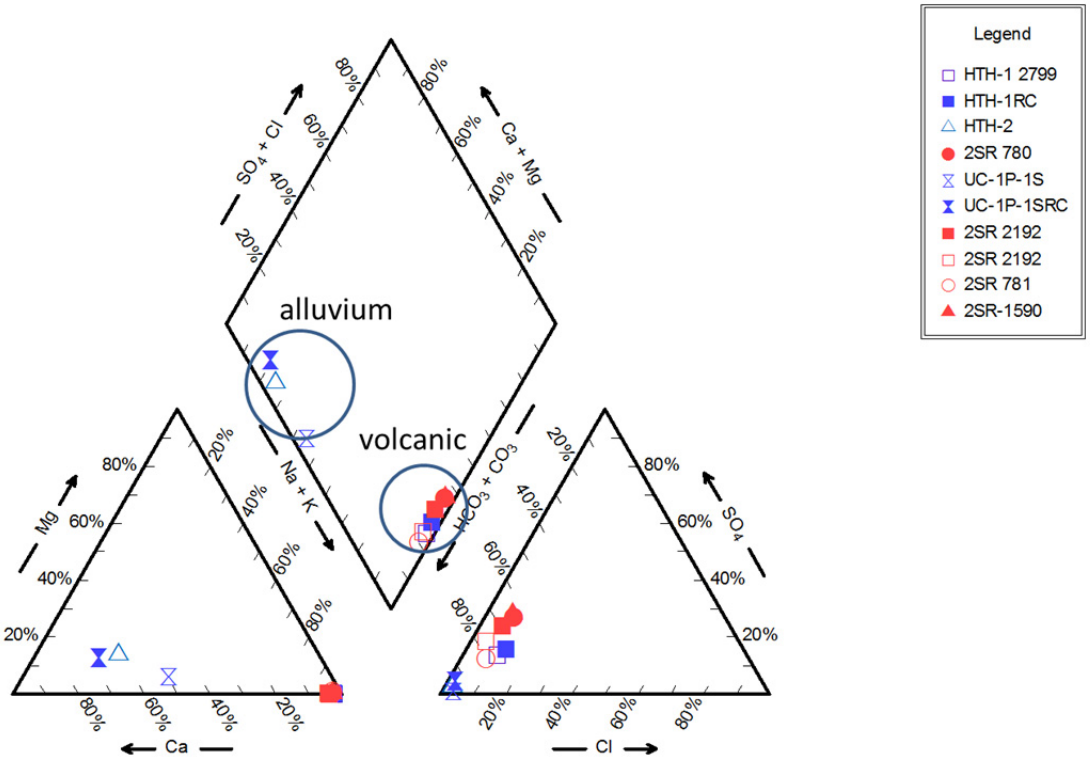


Figure 6. Piper diagram of water chemistry from HTH-1, HTH-2, UC-1-P-1S, and UC-1-P-2SR (referenced as “2SR” in legend, along with sampling depth in feet).

Stable Isotopes of Hydrogen and Oxygen

The stable isotope analyses support the distinction between groundwater from alluvium and groundwater from volcanic aquifers. The lighter isotopic nature of the volcanic groundwater suggests recharge under cooler conditions, for example from snowfall at higher elevations than precipitation recharging groundwater in the alluvium. The cooler conditions could also reflect a different recharge climate in the past. If a previous sample from HTH-2 represents groundwater distinctive of the alluvium, wells UC-1-P-1SRC, MV-4PZ, and MV-5PZ all have stable isotopic compositions indicative of the alluvium (Figure 8). Samples from the MV wells, UC-1-P-2SR, and HTH-1RC have the lighter isotopic composition identified for the deeper volcanic aquifers. Similar to the major ion content, the stable isotopes of samples from UC-1-P-2SR are consistent with volcanic groundwater rather than the alluvium where they were collected. There is good consistency in the stable isotopic analyses through time for those wells with more than one isotopic sampling event. The one exception is the increase in deuterium of about 4 per mil at MV-3.

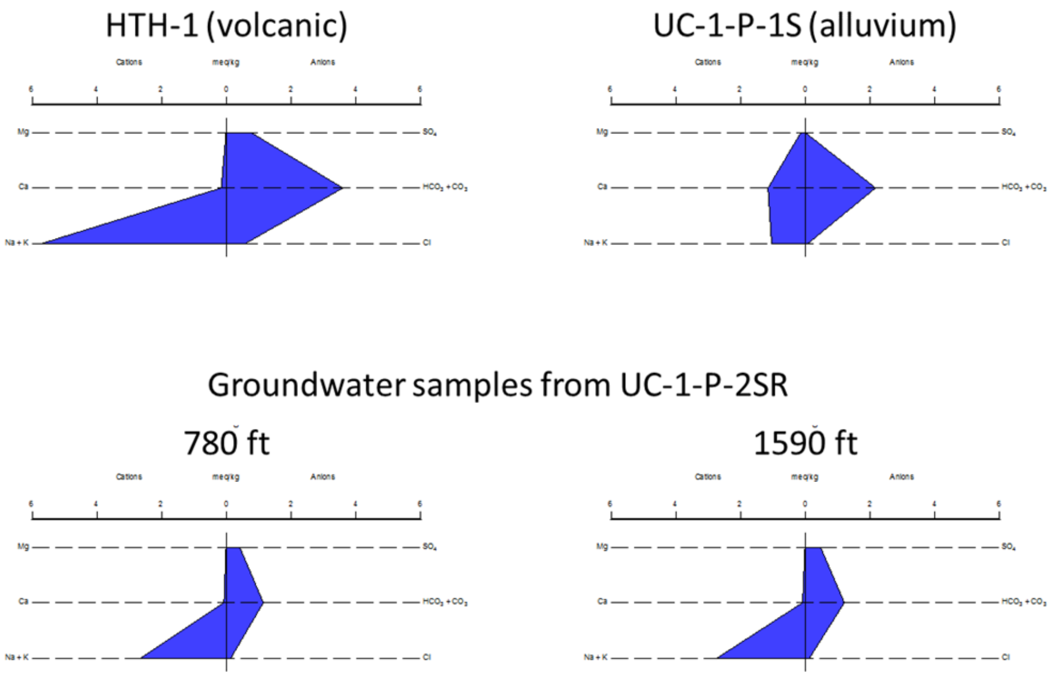


Figure 7. Stiff diagrams for groundwater from HTH-1RC, UC-1-P-1SRC, and two depths in UC-1-P-2SR.

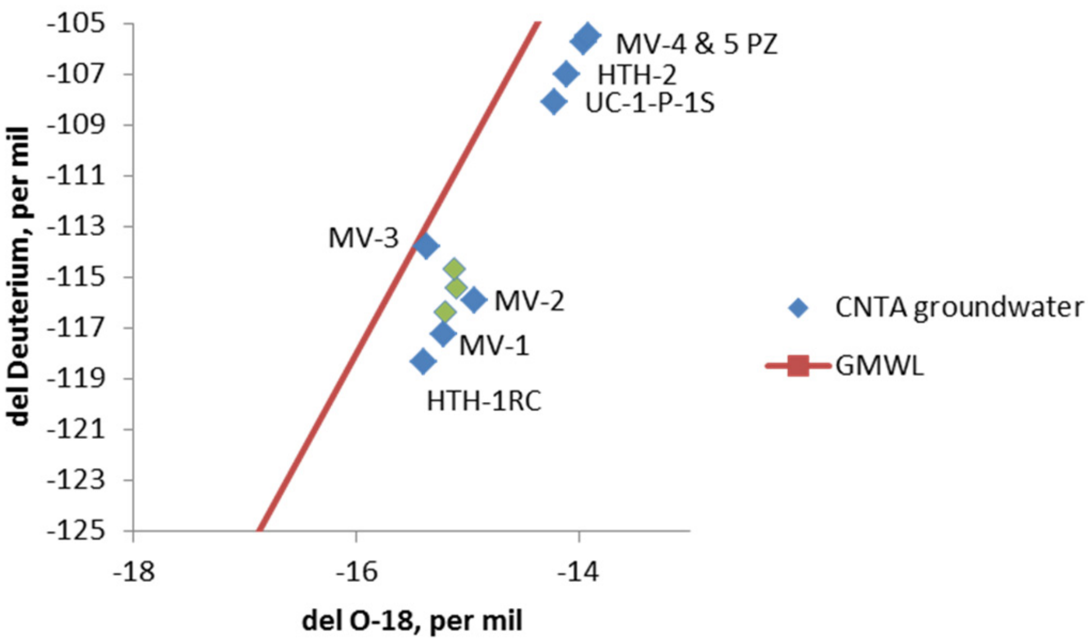


Figure 8. Stable isotope analyses from the 2012 sampling of CNTA wells. The Global Meteoric Water Line (GMWL) is shown for reference. The green, unlabeled points in the lower group are all from UC-1-P-2SR.

Carbon-14

A radiocarbon analysis (Table 3) was performed for the intermediate-depth sample from UC-1-P-2SR (depth of 1590 ft). The ^{13}C value of −5.8 per mil indicates the addition of carbon from dissolution of carbonate rocks, which dilutes the ^{14}C and leads to an apparent age older than the time the water entered a system closed to atmospheric CO_2. Without correcting for the "dead" carbon, the apparent age of the groundwater sample is 18,630 years before present. Correcting per the $\delta^{13}C$ value and assuming a starting $\delta^{13}C$ consistent with desert C4 plants (an assumed $\delta^{13}C$ of −15 per mil) reduces groundwater age to about 11,000 years. If the more common C3 plant type is considered ($\delta^{13}C$ of −25 per mil), the age is further reduced to 6900 years.

Table 3. Carbon-14 analytical results

AA	Lab #	Sample ID	MASS	$\delta^{13}C$ value	Run date	F (–25)	DF (–25)	pMC	^{14}C age BP	$\delta^{14}C$ age
AA99703	X23828A	UC-1-P-2SR.1590	2.07 mg	–5.8	N09-19-12	0.0984	0.0014	9.8	18,630	110

Tritium

Tritium results continue to show that the only tritium above the detection limit is found in the well drilled into the nuclear chimney after the test, UC-1-P-2SR. Results from the shallowest sampling horizon at 780 ft below ground surface show a decline in tritium concentration consistent with radioactive decay (Figure 9a). Though previous samples from a depth of 1590 ft were also consistent with radioactive decay, the 2012 sample contains about 1000 pCi/L more tritium than would be expected from decay alone (Figure 9b). This suggests some addition of tritium to this horizon, though the overall trend is consistent with decay. The sample collected from 2192 ft (Figure 9c) has a higher tritium concentration than would be expected if the concentrations measured in previous samples had simply decayed. However, the three previous samples varied widely in tritium concentration, which could relate either to transient borehole conditions at this depth or to conditions strongly dependent on relatively small-scale spatial variations in the borehole. In other words, the tritium variations could represent large shifts in concentration through time, or they could result from large differences in tritium concentration within a small region of the borehole. In the latter case, each sampling event might not sample exactly the same location or condition (as a result of sampler placement with the wireline, logging or sampling in the borehole prior to sampling, or the rate and timing of sampler filling).

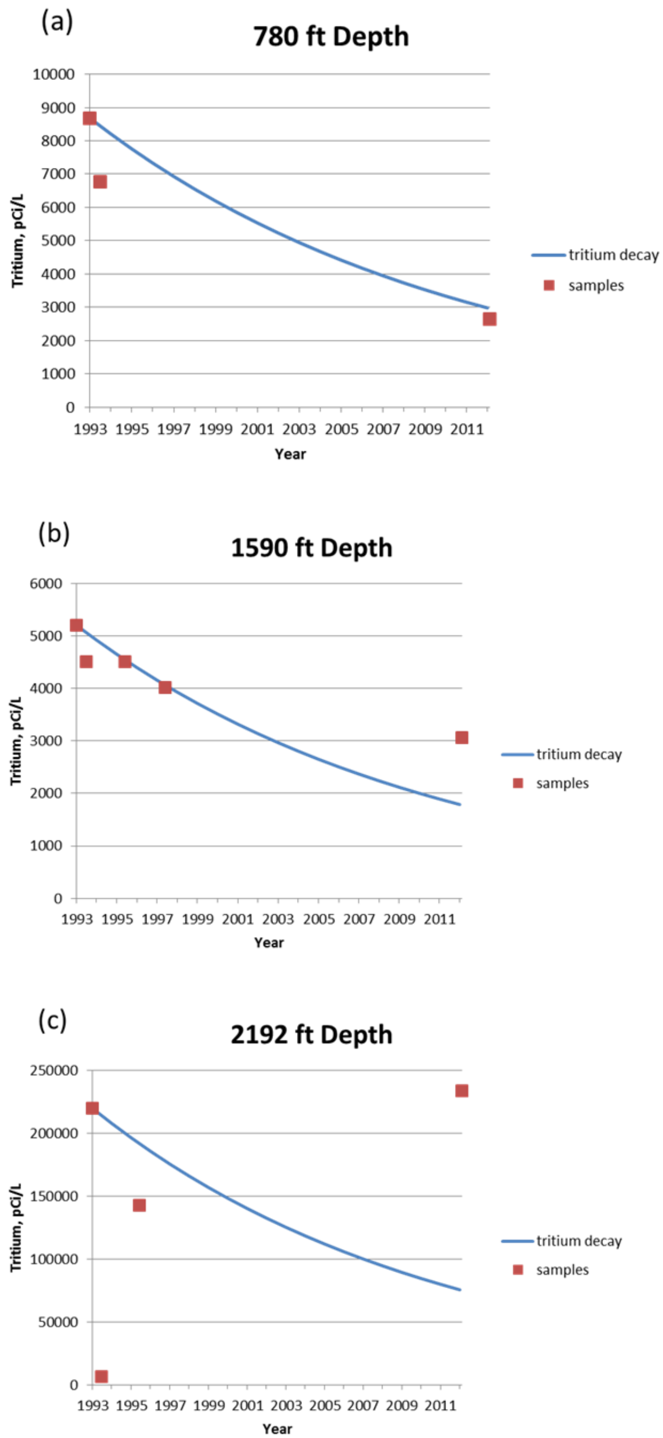


Figure 9. Tritium analyses for samples collected since 1993 at UC-1-P-2SR for the depths of (a) 780 ft, (b) 1590 ft, and (c) 2192 ft below ground surface. The concentration trend expected as a result of radioactive decay of the 1993 sample concentrations is also shown.

CONCLUSIONS

Measurements within the wellbore of UC-1-P-2SR are basically consistent with previous measurements and interpretations that identify inflow to the well between the depths of 1450 and 1640 ft below ground surface. Flow continues to be indicated both upward and downward from that zone, with outflow at depths of 1220 and 1960 ft, but flow rates are higher now than when measured last in 1997, particularly downward. Differences in flow within this zone have been noted in the past, with varying temperature profiles indicating fluctuations in upward and downward flow (Mihevc 1996).

The interpreted absence of flow above 1640 ft is consistent with the tritium measurements for the shallower depths in the well (780 and 1590 ft). The decline of tritium concentrations at those depths is generally consistent with radioactive decay as the primary process, suggesting little advective movement of groundwater. The tritium observed may have been brought to those depths during previous activities in the well, and concentration has been declining due to decay ever since (the upper 1150 ft of borehole is in blank casing.) Conversely, the variations noted in tritium concentration in the samples collected through time at the depth of 2192 ft suggest a more complex and/or unstable environment in the wellbore at this depth.

The chemical and isotopic content of the groundwater sampled in UC-1-P-2SR continues to be similar, though more dilute, than groundwater from the volcanic aquifer. This is despite the sampling intervals being in the shot-perforated section of the wellbore in the alluvium. This suggests water sampled by the post-shot well originates in the deeper volcanic section of the nuclear chimney, but has significant mixing with a more-dilute water. The ion ratios, stable isotopic composition, and ^{14}C content do not suggest significant dilution of volcanic-aquifer groundwater by groundwater from alluvium. Infiltration of a previously undetected dilute recharge may contribute to the chimney infill, or water may have been "distilled" by vaporization in the nuclear cavity and subsequently condensed higher in the chimney, serving to dilute the volcanic water without substantially changing the ion ratios. The well also has a complex history of drilling and completion and a complex construction (the inner casing is hung, and shot perforations were executed through it and an outer, cemented string), and a significant volume of fluid may have been introduced into the well in that process.

Other than UC-1-P-2SR, chemical and isotopic differences between wells completed in alluvium and wells completed in the underlying volcanic units are consistent with a lack of communication between the shallow and deep aquifers. New piezometers MV4-PZ and MV5-PZ and recompleted well UC-I-P-1SRC have chemical and isotopic characteristics consistent with the aquifer in the alluvium of Hot Creek Valley. Wells MV-1, -2, and -3 and HTH-1RC are consistent with the Na-HCO_3 and light, stable isotopic composition of water from the deeper volcanic aquifers.

REFERENCES

Chapman, J.B., T. Mihevc, and B. Lyles, 1994. *The Application of Borehole Logging to Characterize the Hydrogeology of the faultless Site, Central Nevada Test Area*. DOE/NV/10845-35, DRI Publication No. 45119.

Lyles, B., P. Oberlander, D. Gillespie, D. Donithan, and J. Chapman, 2006. *Hydrologic Data and Evaluation from Wells near the Faultless Underground Nuclear Test, Central Nevada Test Area*. DOE/NV/13609-49, DRI Publication No. 45219.

Mihevc, T., 1996. Summary of October 1995 Field Activities at CNTA-Faultless. Letter report from Desert Research Institute to Janet Appenzeller-Wing, DOE Nevada Operations Office.

Mihevc, T., J. Chapman, and B. Lyles, 1996. "The Application of Borehole Logging to Characterize the Hydrogeology of the Faultless Nuclear Test Site, Nevada, USA." *Hydrogeology Journal*, 4 (4): 83–97.

Mihevc, T., and B. Lyles, 1998. Summary of Field Activities at the Faultless Site, Nevada. Desert Research Institute, Water Resources Center, Letter Report prepared for the U.S. Department of Energy Nevada Operations Office, Las Vegas, NV.

This page intentionally left blank

Appendix D

NDEP Correspondence with Record of Review and Response to Comments

This page intentionally left blank

March 27, 2013

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

RE: Draft 2012 Groundwater Monitoring Report, Subsurface Corrective Action Unit 443, Central Nevada Test Area, Nevada, February 2013
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 (OLM) *Draft 2012 Groundwater Monitoring Report, Subsurface Corrective Action Unit 443, Central Nevada Test Area, Nevada* (Report) received on March 18, 2013. While this letter serves as a Notice of Completion for the March 15, 2013 Milestone Deadline for the "Draft 2012 Monitoring Report," the NDEP has the following comments on the Report which should be addressed in the Final version of the Report:

1. Page 9, Section 4.2, Third Last Sentence – The Record of Technical Change referenced in this sentence was finalized in March 2012. The verb tense of this sentence should be changed to reflect this fact.

2. Page 8, Section 4.1, First Paragraph, Third Sentence, Page 10, Table 1 and Page B-1, Table B-1 – In the two tables, the 6/26/2012 Tritium sample results are listed as "NS," which according the footnotes means "not sampled because the radioisotope was not part of the analytical suite." However, the text on Page 8 states, "Samples were also not collected from wells MV-4 and MV-5 to allow water levels at these locations time to recover from last year's sampling event." As such, the "NS" should be changed to another acronym which reflects the actual reason the wells were not sampled.

3. Page 11, Section 4.4, First Paragraph, First Sentence and Table 2 – The first sentence and "Date" listed in the table state 2012 yet the header of the Table states "2011." The Table header should be corrected.

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

Sincerely,

T. H. Murphy
Chief
Bureau of Federal Facilities

THM/CDA: *cda*

cc: FFACO Group, PSG, NNSA/NSO, Las Vegas, NV
N-I Central Files, MS, NSF 156, Las Vegas, NV
NSTEC Correspondence Control, MS NLV008, Las Vegas, NV
R. F. Boehlecke, NNSA/NSO, Las Vegas, NV
Jeffrey Fraher, DTRA/CXTS, Kirtland AFB, NM
J. B. Chapman, DRI, Las Vegas, NV
D. Crawford, Stoller, Grand Junction, CO
R. Findley, Stoller, Grand Junction, CO
R. Hutton, Stoller, Grand Junction, CO

U.S. Department of Energy Office of Legacy Management

Record of Review

Due Date	Review No.	Project	Type of Review
4/22/2013	1	Offsites Project - CNTA	Draft Report - Technical Review

Document Title and\or Number and Revision
2012 Draft Groundwater Monitoring Report CNTA, NV CAU 443 S09647

Author
Mark Kautsky

Author's Organization
Legacy Management

Author's Phone
(970) 248-6018

Reviewer
Chris D. Andres for T.H. Murphy

Reviewer's Organization
Nevada Division of Environmental Protection

Reviewer's Phone
(702) 486-2863

Reviewers' Recommendation

☐ Release Without Comment

☐ Consider Comments

☒ Resolve Comments and Reroute for Review

Refer to the NDEP letter dated March 27, 2013

Signature of Reviewer and Date

☒ Comments Have Been Addressed

Mark Kautsky — Digitally signed by Mark Kautsky Date: 2013.04.04 11:50:31 -06'00'

Signature of Author and Date

☒ Comment Resolution Satisfactory

☐ Comment Resolution Unsatisfactory

Chris Andres 4/5/13

Signature of Reviewer and Date

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
1	Page 9, Section 4.2, Third Last Sentence- The Record of Technical Change referenced in this sentence was finalized in March 2012. The verb tense of this sentence should be changed to reflect this fact.			The sentence was revised as follows: "A record of technical change was submitted to NDEP and approved in March 2012 to address this change in the CADD/CAP and CADD/CAP Addendum."
2	Page 8, Section 4.1, First Paragraph, Third Sentence, Page 10, Table 1 and Page B-1, Table B-1– In the two tables, the 6/26/2012 Tritium sample results are listed as "NS," which according the footnotes means "not sampled because the radioisotope was not part of the analytical suite." However, the text on Page 8 states, "Samples were also not collected from wells MV-4 and MV-5 to allow water levels at these locations time to recover from last year's sampling event." As such, the "NS" should be changed to another acronym which reflects the actual reason the wells were not sampled.			The requested acronym was changed to "NW" and the footnote "NW = not sampled to allow water levels in the well time to recover" was added to the table footnotes.
3	Page 11, Section 4.4, First Paragraph, First Sentence and Table 2– The first sentence and "Date" listed in the table state 2012 yet the header of the table states "2011." The table header should be corrected.			The Table 2 header/title was changed to replace "2011" with "2012".

LMS 1696e
11/2007

Record of Review (continuation)

Review No.	Project Offsites Project

Library Distribution List

	Copies
U.S. Department of Energy Office of Scientific and Technical Information P.O. Box 62 Oak Ridge, TN 37831-0062 865-576-8401	1 (Uncontrolled, electronic copy -PDF)
Southern Nevada Public Reading Facility c/o Nuclear Testing Archive P.O. Box 98521, M/S 400 Las Vegas, NV 89193-8521	2 (Uncontrolled, electronic copies -CDs)
Manager, Northern Nevada FFACO Public Reading Facility c/o Nevada State Library & Archives 100 N Stewart Street Carson City, NV 89701-4285 775-684-3313	1 (Uncontrolled, electronic copy -CD)
Librarian Tonopah Public Library 167 Central Street Tonopah, NV 89049 775-482-3374	1 (Uncontrolled)

This page intentionally left blank