RECORD OF TECHNICAL CHANGE

Technical Change No. DOE-LM/1555-2007 CADD/CAP Addendum-ROTC 1

Project/Job No. Offsites/Corrective Action Unit 443 Date March 12, 2012

Project/Job Name Offsites/Corrective Action Decision Document/Corrective Action Plan Addendum for Corrective Action Unit 443: Central Nevada Test Area - Subsurface, Nevada, Revision No. 0, January 2008 (DOE-LM/1555-2007)

The following technical changes (including justification) are requested by:

Mark Kautsky (Name)

Department of Energy/Office of Legacy Management (Site Manager)

Description of Change:

Page 15 of the Addendum to the CADD/CAP, change footnote 1 at the bottom of the page to read: Minimum detectable concentrations: Tritium (400 pCi/L), Carbon-14 (5 pCi/L), Iodine-129 (0.1 pCi/L).

Justification:

The DOE-LM contracted RDL for tritium is 400 pCi/L.

The project time will be unchanged.

Applicable Project-Specific Document(s):

Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 443: Central Nevada Test Area - Subsurface, Nevada, Revision No. 0

Approved By: Mark Kautsky Date 3-23-2012

DOE-LM Offsites Site Manager

Christi Andres Date 3/22/12

NDEP

RECORD OF TECHNICAL CHANGE

Technical Change No. **DOE-LM/1555-2007 ROTC-2** Page 1 of 3

Activity Name Central Nevada Test Area – ROTC for the CADD/CAP Addendum Date June 12, 2013

The following technical changes (including justification) are requested by:

Mark Kautsky — Department of Energy/Office of Legacy Management (Site Manager)

Description of Change:

Throughout Document: The terms "5-year", "Proof of Concept", and "5-year Proof of Concept Monitoring" should be replaced with "Conceptual Model Evaluation". The exceptions are the first sentence of the first paragraph in Section 5.6 and the Section 5.6.6 heading title. The term "Proof of Concept" shall not be replaced in these sections because they are direct references to the corrective action alternative or approach that was accepted in the original CADD/CAP and not part of this Record of Technical Change.

Justification:

LM and NDEP agreed that terms "Proof of Concept" and "5-year Proof of Concept Monitoring" should be replaced because they are no longer used as part of the Corrective Action Strategy outlined in Appendix VI of the FFACO. A detailed explanation on how the Corrective Action Strategy and terminology have evolved during the corrective action process at CNTA will be provided in the Closure Report.

Description of Change:

Page 9, Section 5.6.2, First Paragraph, Third Sentence: Replace the third sentence with the following sentence: "The monitoring network will be enhanced by adding three wells and two piezometers screened in the alluvium in the regional direction of groundwater flow within the alluvium to allow for detection of radionuclides that could have migrated upward into the alluvium."

Page 9, Section 5.6.3, Second Paragraph, First and Second Sentences: Replace the first and second sentences with the following sentences: "The proposed monitoring network enhancement includes three wells to be installed and screened within the alluvium and the additional monitoring of several existing wells (Figure 7). The new wells will be placed within the compliance boundary southeast and northeast of the nuclear test in the regional direction of groundwater flow within the alluvium (the analysis of the lateral gradients in the alluvium is presented in Appendix C)."

Page 9, Section 5.6.3, Third Paragraph: Replace the third paragraph with the following paragraph: "The pre-drill plan is to install a well and piezometer within the same borehole at the two locations southeast of the detonation (Figure 7). The wells (MV-4 and MV-5) at these locations will be screened in the lower alluvium, and the piezometers will be screened in the upper alluvium (Table 2). This will allow the alluvium nearest the detonation zone to be monitored and the vertical gradient within the alluvium to be estimated at these locations. A well will be installed in the borehole northeast of the detonation (Figure 7). The well (MV-6) at this location will be screened in the upper alluvium (Table 2). This will allow groundwater flow directions to be estimated in the upper alluvium. The alluvium is expected to be greater than 2,000 ft thick at the planned locations. Proposed design and engineering specifics for the new wells are presented in Appendix E."

Page 12, Figure 7: The figure should be revised to include the proposed well location (MV-6) northeast of the detonation. The revised Figure 7 is provided as an attachment to this Record of Technical Change.

Justification:

LM and NDEP agreed that a new monitoring well (MV-6) should be installed in the upper alluvium northeast of the

Description of Change:

Page 13, Section 5.6.3, First Paragraph, Second Sentence: Replace the sentence with the following: "Tritium will be monitored yearly in wells MV-1, MV-2, MV-3, HTH-1, and HTH-2 and in the new wells in the alluvium during the Conceptual Model Evaluation period."

Page 13, Table 2: The table should be revised to include: under **Location**, "MV-6 (New Well)"; under **Proposed Network**, "Head/Radionuclides"; and under **Screened/Open Unit**, "Alluvium." The revised Table 2 is provided as an attachment to this Record of Technical Change.

Justification:

LM and NDEP agreed that the monitoring well (MV-6) would be installed in the upper alluvium northeast of the detonation and would be part of the enhanced monitoring network that includes monitoring for head and radionuclides.

Description of Change:

Page 13, Section 5.6.4, First Paragraph, Fourth Sentence: Replace the sentence with the following: "Aquifer tests will be conducted on the new wells (screened in the alluvium)."

Justification:

LM and NDEP agreed that an aquifer test would not be performed on well HTH-1 because the recompleted well could not be equipped with an electric submersible pump.

Description of Change:

Page 14, Section 5.6.4, First Paragraph, Last Sentence of the Paragraph: Replace the last sentence of the paragraph with the following: "The sampling of well MV-2 shall continue as per the original CADD/CAP requirement, however, if low-flow bladder pumps can be installed in the monitoring network wells samples shall be collected utilizing the low-flow sampling methodology with agreement from NDEP."

Justification:

LM and NDEP agreed that with the installation of the low-flow bladder pumps, the preferred sampling option would be the low-flow sampling method.

Description of Change:

Page 16, Figure 8: The project schedule should be revised to include the installation of the new well (MV-6) and new dates for completing the Conceptual Model Evaluation and Closure Report. The revised Figure 8 is provided as an attachment to this Record of Technical Change.

Justification:

LM and NDEP agreed that the schedule for monitoring well (MV-6) would be conditional based on funding.

Description of Change:

Page E-3, Appendix E, First Sentence of the First Paragraph: Replace the first sentence with the following: "Three wells will be drilled as part of this amendment to the corrective action for CAU443."

Page E-3, Appendix E, Second Paragraph: The following coordinates for the approximate locations of the new wells should be used to replace the existing coordinates provided as the second paragraph. The original coordinates for wells MV-4 and MV-5 were incorrect. "MV-4: 630500, 1413850"; "MV-5: 629700, 1413200"; "MV-6: 630000, 1414750".

Page E-3, Appendix E, First Sentence of the Fourth Paragraph: Replace the first sentence with the following: "The pre-drill plan is to install a well and piezometer within the MV-4 and MV-5 boreholes."

Page E-3, Appendix E: Include the following sentence as the last paragraph on the page: "The pre-drill plan is to install a well in the MV-6 borehole (Figure E-3)." Figure E-3 is provided as an attachment to this Record of Technical Change and

should be inserted after Figure E-2 in Appendix E.

Justification:

LM and NDEP agreed that monitoring well (MV-6) would be completed in the upper alluvium northeast of the detonation.

Description of Change:

Appendix C, Page C-5, Section C3.0, Include the following sentences as the last paragraph on the page: "An additional case (Case 3) was developed to include a scenario for when groundwater levels in the area of the detonation recover. In this scenario, groundwater flow in the upper alluvial unit near the detonation is diverted by the southern graben fault that acts as a barrier to groundwater flow. This results in a groundwater flow near the detonation that is toward the east-northeast and is depicted in Figure C-4." Figure C-4 is provided as an attachment to this Record of Technical Change.

Justification:

LM and NDEP agreed that when groundwater levels in the area of the detonation recover groundwater flow near the detonation may be diverted to the east-northeast by the southern graben fault and that the placement of well MV-6 is positioned to monitor this potential flow path.

Installation of the new monitoring well (MV-6) will increase the duration of the corrective actions at CNTA by approximately 264 business days or 370 calendar days. A revised schedule (Figure 8) of the corrective actions is provided as an attachment to this Record of Technical Change.

Applicable Activity-Specific Document(s):

Addendum to: Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for Corrective Action Unit (CAU) 443: Central Nevada Test Area (CNTA) - Subsurface, Nevada, DOE/NV-977 January 2008

Approved By: Digitally signed by Mark Kautsky Date: 2013.07.29 16:09:47 -06'00' Date _____

Site Manager
DOE/LM

Christ Andres Date 7/31/13

NDEP

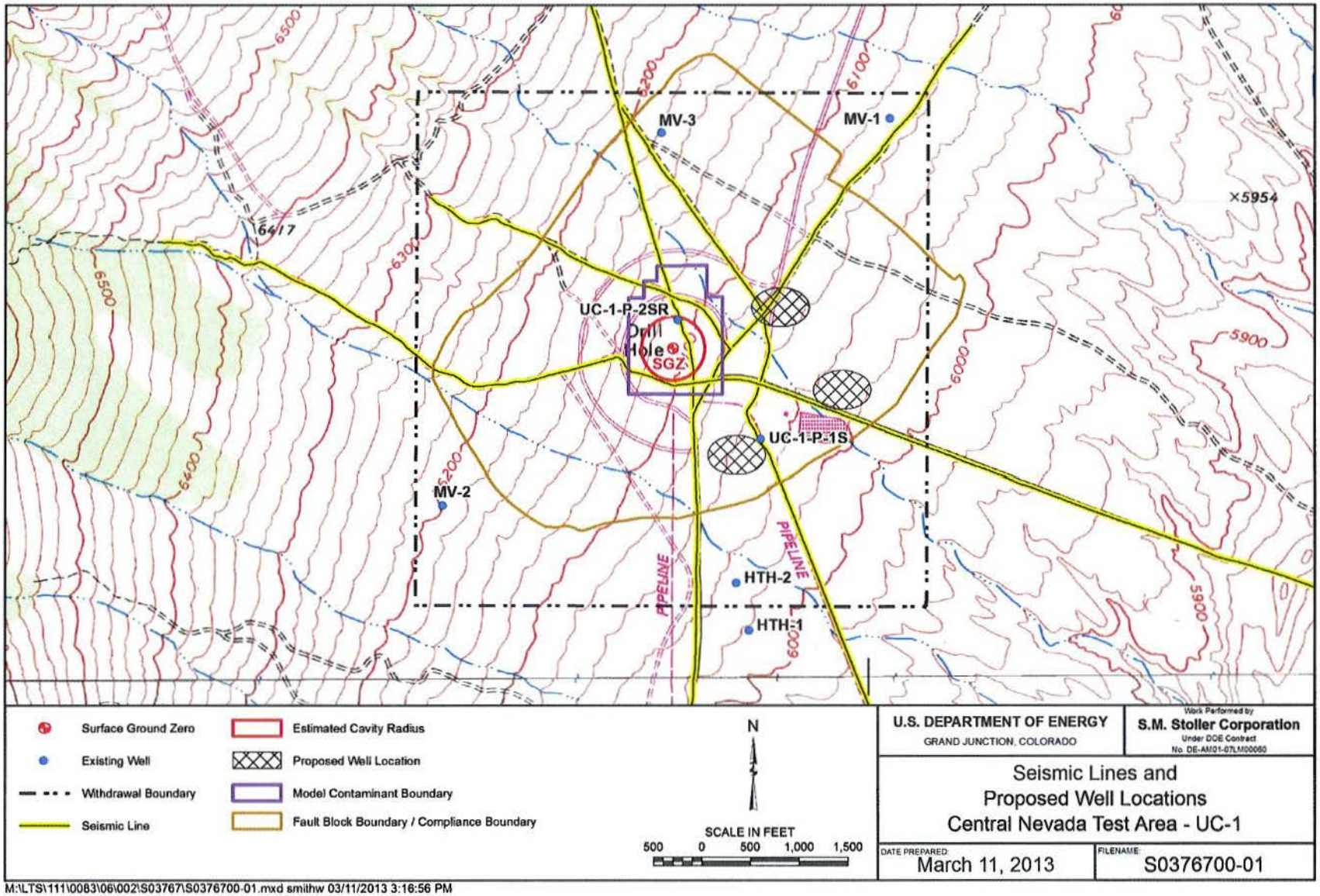


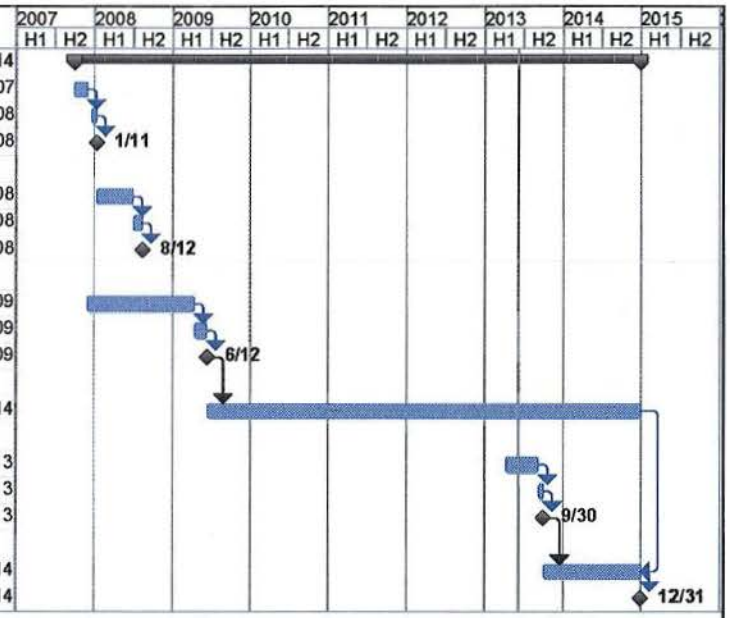
Figure 7. Proposed locations of the three new alluvial wells and five seismic lines acquired in October 2007.

Table 2. Summary of the Current and Revised Monitoring Networks.

Location	Current Network	Proposed Network	Screened/Open Unit
MV-1-Upper Piezometer	Head	Head	Alluvium
MV-1-Lower Piezometer	Head	Head	Volcanics (tuffaceous sediments)
MV-1-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
MV-2-Upper Piezometer	Head	Head	Alluvium
MV-2-Lower Piezometer	Head	Head	Volcanics (DWtuff)
MV-2-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
MV-3-Upper Piezometer	Head	Head	Alluvium
MV-3-Lower Piezometer	Head	Head	Volcanics (tuffaceous sediments)
MV-3-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
HTH-2		Head/Radionuclides	Alluvium
HTH-1		Radionuclides	Volcanics
UC1-P-1S		Head	Alluvium
MV-4 (New Piezometer)		Head	Alluvium
MV-4 (New Well)		Head/Radionuclides	Alluvium
MV-5 (New Piezometer)		Head	Alluvium
MV-5 (New Well)		Head/Radionuclides	Alluvium
MV-6 (New Well)		Head/Radionuclides	Alluvium

DWtuff = Densely welded tuff.
Note: Head data from well UC1-P-2SR is measured by USGS.

ID	Task Name	Duration	Start	Finish
1	**CNTA CORRECTIVE ACTION**	**1893 days**	**Mon 10/1/07**	**Wed 12/31/14**
2	CNTA CADD/CAP to NDEP	45 days	Mon 10/1/07	Fri 11/30/07
3	Prepare Final CNTA CADD/CAP to NDEP	16 days	Fri 12/21/07	Fri 1/11/08
4	Submit Final CNTA CADD/CAP to NDEP	0 days	Fri 1/11/08	Fri 1/11/08
5				
6	Surface Prep Planning	123 days	Fri 1/11/08	Tue 7/1/08
7	Surface Prep	30 days	Wed 7/2/08	Tue 8/12/08
8	Complete Surface Prep	0 days	Tue 8/12/08	Tue 8/12/08
9				
10	Monitor Well Prefield Planning	359 days	Fri 11/30/07	Wed 4/15/09
11	Monitor Well Field Work	42 days	Thu 4/16/09	Fri 6/12/09
12	Complete Monitor Well Field Work	0 days	Fri 6/12/09	Fri 6/12/09
13				
14	Annual Monitoring/Conceptual Model Evaluation	1448 days	Mon 6/15/09	Wed 12/31/14
15				
16	Monitor Well Prefield Planning	110 days	Tue 4/9/13	Mon 9/9/13
17	Monitor Well Field Work	15 days	Tue 9/10/13	Mon 9/30/13
18	Complete Monitor Well Field Work	0 days	Mon 9/30/13	Mon 9/30/13
19				
20	Concept Analysis/Prepare Closure Report	325 days	Thu 10/3/13	Wed 12/31/14
21	Issue Closure Document	0 days	Wed 12/31/14	Wed 12/31/14



Project: CNTA CADD_CAP Addendum
Date: Fri 6/7/13

Task		Project Summary		Manual Summary Rollup	
Milestone		Group By Summary		Manual Summary	
Summary		Inactive Task		Start-only	
Rolled Up Task		Inactive Task		Finish-only	
Rolled Up Milestone		Inactive Milestone		Progress	
Rolled Up Progress		Inactive Summary		Deadline	
Split		Manual Task			
External Tasks		Duration-only			

Figure 8. Project Schedule.

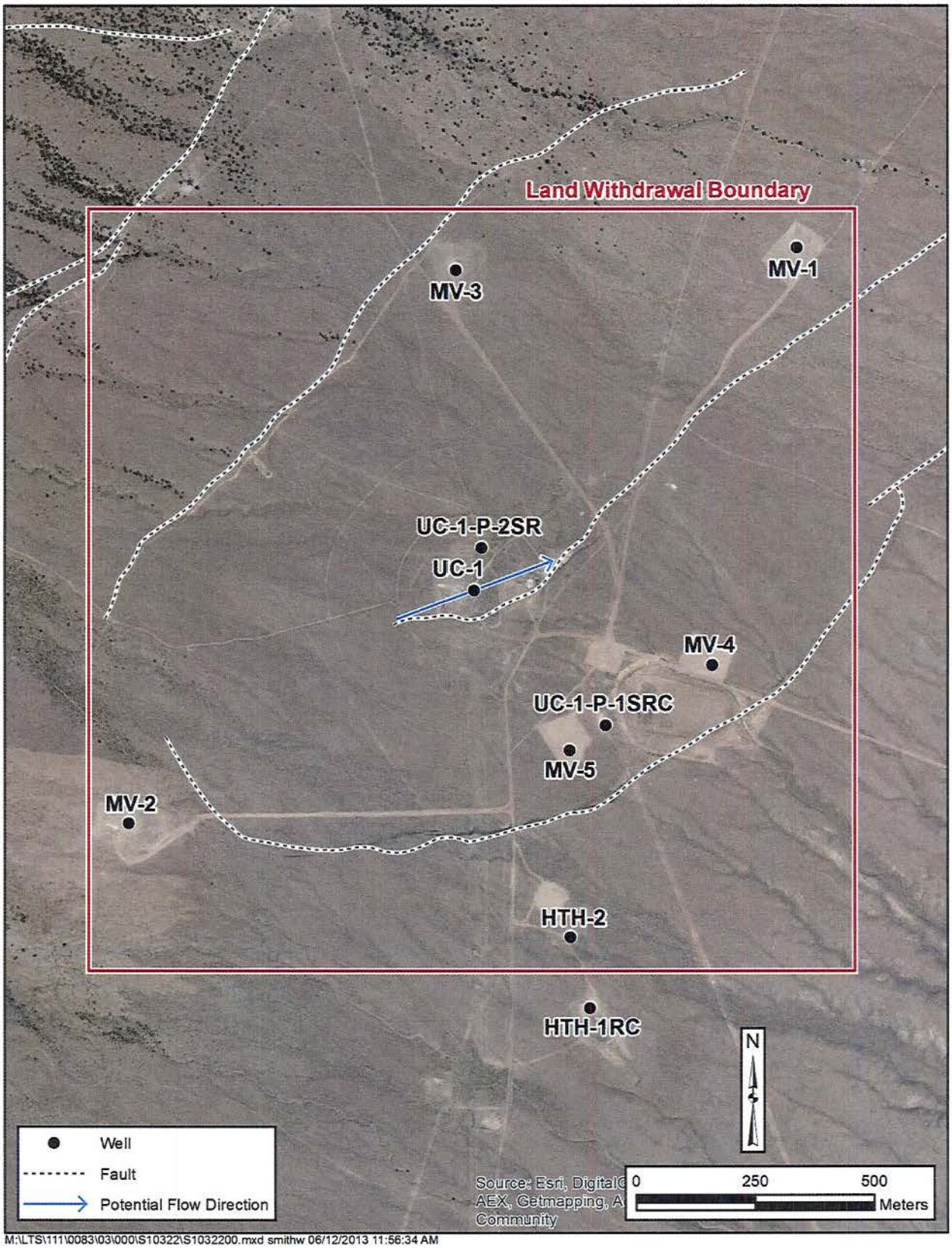


Figure C–4. Groundwater Flow Directions Estimated for Case 3. Scenario for when groundwater levels in the area of the detonation recover.

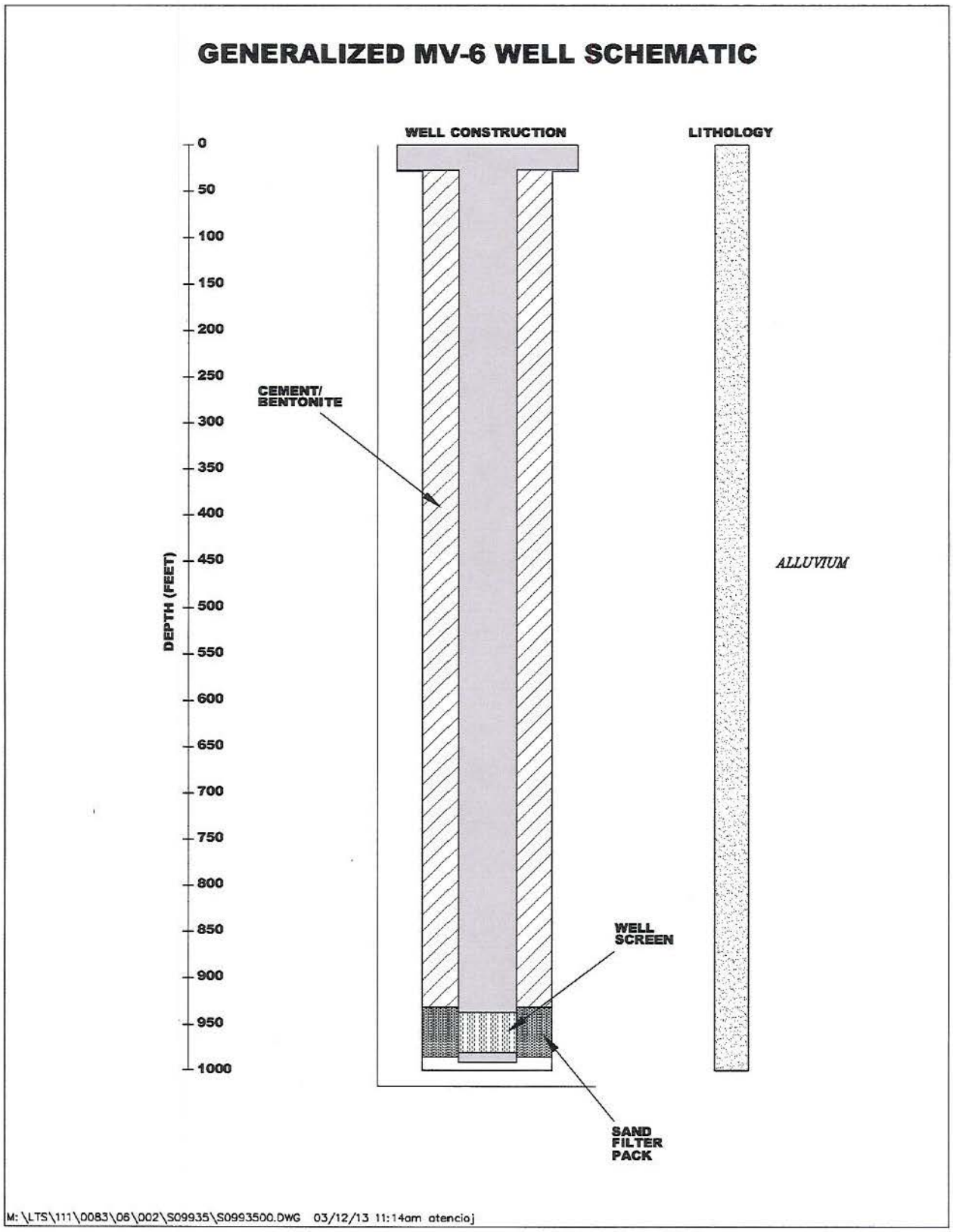


Figure E–3. Generalized MV-6 Well Schematic.

DOE–LM/1555–2007

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

U.S. Department of Energy

Office of Legacy Management

Work Performed Under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management.
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DOE−LM/1555-2007

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

Work Performed by S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado

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Acronyms and Abbreviations

AMSL	above mean sea level
bgs	below ground surface
CADD/CAP	Corrective Action Decision Document/Corrective Action Plan
CNTA	Central Nevada Test Area
EC	electrical conductance
FFACO	Federal Facilities Agreement and Consent Order
ft	foot (feet)
gpm	gallons per minute
m	meter(s)
mg/L	milligrams per liter
MV	monitoring/validation
µS/cm	microsiemens per centimeter
SU	standard units
NDEP	Nevada Division of Environmental Protection
UGTA	Underground Test Area
USGS	U.S. Geological Survey

End of current text

Preface

The environmental remediation closure process for the nuclear test at the Central Nevada Test Area (CNTA) has progressed from the approved Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) to this addendum. The closure process required the installation of three monitoring/validation (MV) wells and validation analysis of the flow and transport model. The model validation analysis led to the conclusion that the hydraulic heads simulated by the flow model did not adequately predict observed heads at the MV-1, MV-2, and MV-3 validation points (wells and piezometers). The observed heads from screened intervals near the test horizon were higher than the model predicted and are believed to be the result of detonation-related effects that have persisted since the nuclear test. These effects, which include elevated heads out from the detonation zone and lower heads in the immediate vicinity of the detonation, are seen at other nuclear tests and typically dissipate within a few years. These effects were not included in the initial head distribution of the model. The head variations at CNTA are believed to have persisted due to the very low permeability of the material at the detonation level.

The UGTA flowchart in Appendix VI of the Federal Facilities Agreement and Consent Order (FFACO) leads to an action of proposing a new strategy if data collected during Proof of Concept are not acceptable. This addendum to the CADD/CAP describes the revised strategy that would validate the compliance boundary through monitoring rather than validation of a flow model. The stability of the groundwater system and lack of transport will be demonstrated through the Proof of Concept Monitoring period for an enhanced monitoring network that includes the most likely transport path in the volcanic section and the most likely receptor-access path in the alluvium.

The monitoring network specified in the original CADD/CAP consists of wells MV-1, MV-2, and MV-3, which are screened in densely welded tuff within the volcanic section. Head levels in these wells indicate a lateral flow component to the north-northeast. When compared with head levels in zones screened near the detonation level, a downward flow component is also indicated. This suggests that the most likely potential transport path from the cavity is down to the more permeable densely welded tuff units below the detonation zone. Head levels in the immediate vicinity of the detonation zone (cavity and chimney) are measured in well UC1-P-2SR, which was drilled into the chimney after the detonation. Head levels in this zone were originally depressed by over 1,500 feet (ft) due to the detonation and have been slowly recovering, only recently reaching the head levels measured in the densely welded tuff at the MV wells located to the north and northeast. This suggests that both the horizontal and vertical gradients in the immediate vicinity of the detonation have historically been toward the detonation, reducing the probability of radionuclide migration from the detonation zone. However, given the processes of prompt injection and convective mixing in the nuclear chimney, migration into the alluvial aquifer cannot be ruled out. Wells in the alluvial aquifer are cheaper to drill and operate, and are typically 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. The alluvium is not currently monitored except for head levels in the upper piezometers of wells MV-1, MV-2, and MV-3. Additional wells in the alluvium are recommended to enhance the overall monitoring network at CNTA.

This document is intended as an extension to the original CADD/CAP (DOE NNSA NSO 2004) providing summaries of the initial corrective action activities and model validation. This document also outlines the new strategy that was provided in the corrective action plan Path Forward document (DOE 2007) developed by the DOE Office of Legacy Management and agreed on by the Nevada Division of Environmental Protection (NDEP). The Path Forward document and the model validation analysis (Hassan et al., 2006) include details in addition to those presented here. This document begins at Section 5.6 as a continuation of the "Implementation of the Corrective Action Plan" of the original CADD/CAP.

5.6 Findings of the Initial Corrective Action and Recommended Changes to the Plan

As described in Section 4.0 of the CADD/CAP, the accepted corrective action alternative for CAU 443 is Proof of Concept Monitoring with Institutional Controls. This action was initiated in 2005 with the drilling and construction of three MV wells. These wells are located close to the target locations presented in Appendix A of the original CADD/CAP, though there are some differences as a result of pad construction considerations (Table 1, Figure 1). The wells were constructed with a main well screened across a densely welded tuff horizon, a piezometer screened in the alluvium, and a piezometer screened in the volcanic section.

Table 1. Locations for wells drilled in 2005. The locations are for the main well and are given in meters (UTM11, NAD27) and feet (State Plane, Nevada Central, NAD27).

Well	Easting (meters)	Northing (meters)	Elevation (meters)
MV-1	568977.31	4277003.05	1,850.12
MV-2	567574.96	4275787.44	1,886.85
MV-3	568260.56	4276956.30	1,879.90
	Easting (feet)	**Northing (feet)**	**Elevation (feet)**
MV-1	631164.00	1416702.98	6069.95
MV-2	626547.46	1412730.46	6190.45
MV-3	628811.31	1416558.1	6167.65

Well drilling began in April 2005 and was completed in August 2005. The low productivity of the wells required a lengthy period of well development that was completed in February 2006. Drilling and development details are presented in DOE (2006). Aquifer tests were conducted during development, and water samples were collected at the completion of development. Hydrologic data for the wells can be found in Lyles et al. (2006) and monitoring data in Lyles et al. (2007).

Data collected from the MV wells were used to assess the model as specified in Section 5.5 of the original CADD/CAP. The validation analysis is presented in detail in Hassan et al. (2006) and summarized below, leading to the recommended changes in the corrective action alternative.

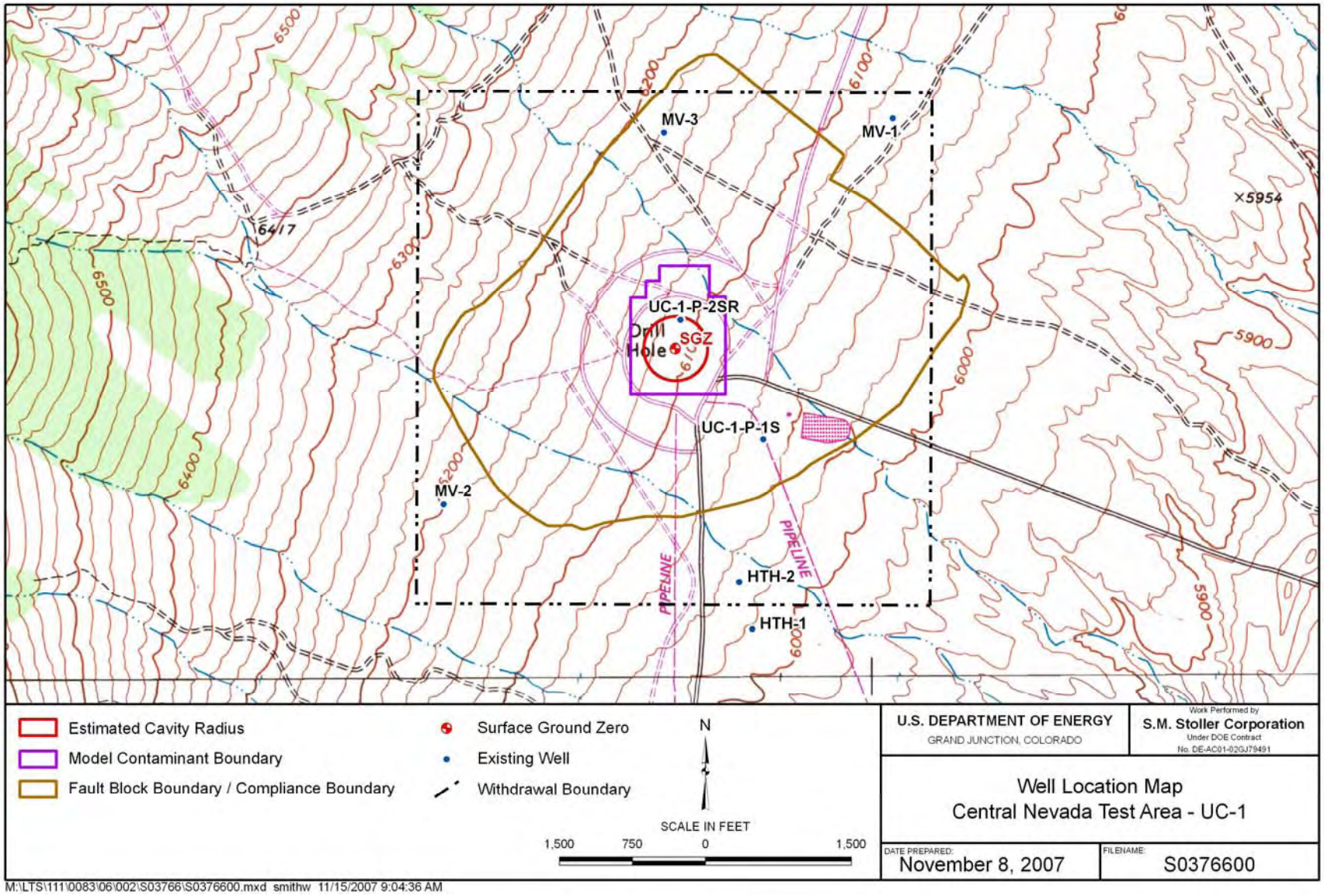


Figure 1. Location of the three new MV wells drilled in 2005, and four existing wells, near the Faultless underground nuclear test.

5.6.1 Summary of the Validation Analysis

The validation data reveal a hydrogeologic system characterized by low permeability in the volcanic section and the absence of lithologic units that could provide rapid contaminant flow-paths. This supports the radionuclide transport model in that no far-field transport is expected to occur in the 1,000-year time frame. However, the groundwater flow model for CNTA was not validated by the head data from the MV wells in that the measured head values are much higher than those predicted by the model. The high heads near the detonation level are interpreted as remnant effects from the nuclear test that persist due to the low hydraulic conductivity of the system. The flow model was not constructed to represent transient hydraulic impacts from the nuclear test, assuming they would dissipate over the timescale of interest. Hydraulic head is a fundamental aspect of groundwater flow and validation cannot be claimed for a groundwater model whose predictions do not match measured heads. The validation data and analysis are summarized below.

5.6.1.1 Validation Data

Three wells and six piezometers provide model validation data for CNTA. Hydrogeologic units were characterized by analyzing cuttings and geophysical logs. Aquifer tests were performed in the three wells, and water levels were monitored in all wells and piezometers. Groundwater samples were collected from the wells after purging and analyzed for chemical, isotopic, and radiochemical constituents. A total of 19 real-number validation targets are used in the analysis (nine values of hydraulic head, four values of hydraulic conductivity, and six hydraulic gradients). In addition, the lithologic data provide binary-type validation targets where the lithologic category associated with the vertical profiles of the wells can be compared to the categories used in the model.

5.6.1.2 Model Validation Results

The validation process described in the original CADD/CAP was followed, beginning with the evaluation of calibration accuracy, the performing of various statistical tests, and the development of acceptance criteria and composite scores. All of the calculated measures scored low and indicate a deficiency in the model in regard to hydraulic head values and some flow directions. In all three wells and all three measuring depths in each well, the measured hydraulic head is much higher than that estimated by the groundwater model, and outside the uncertainty bounds on head estimated by the model (Figure 2).

The elevated heads in the tuffaceous sediments at the elevation of the cavity are believed to be due to the nuclear test itself. This hypothesis was tested with a preliminary model in the validation analysis (Hassan et al., 2006). The persistence of the high heads almost 40 years after the Faultless test can be attributed to the very low permeability of the volcanic rocks and the faulting associated with the down-dropped fault block that may have created (or accentuated) barriers to flow. These factors may not have allowed the pressure pulse around the cavity to dissipate, contrary to observations at other nuclear test locations.

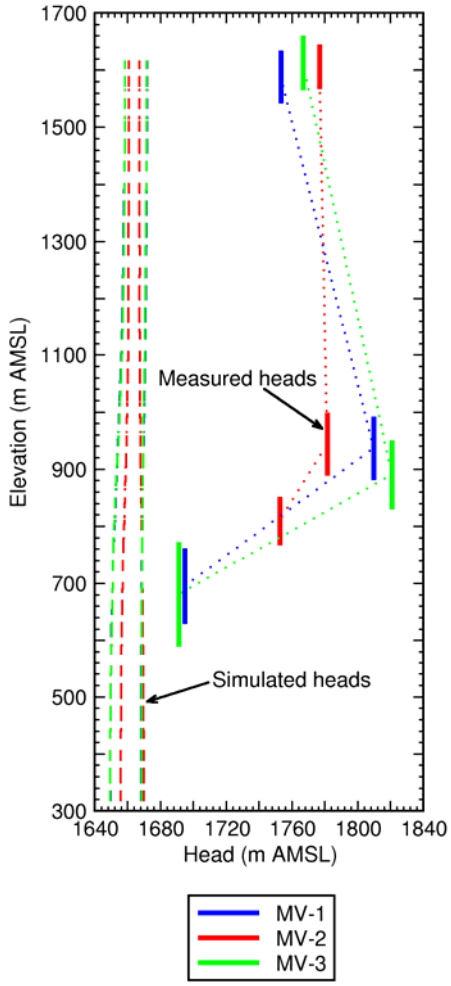


Figure 2. Measured heads in the three vertical horizons of each MV well, as compared to the heads simulated in the model. This figure (without the measured heads) was present as Figure 5–17 in the CADD/CAP.

The original model focused on far-field transport, intentionally neglecting nuclear test impacts that were assumed transient over short time scales. In addition, local structural features, such as faults, were not explicitly included due to the absence of information regarding their subsurface orientations and hydraulic characteristics. The observations of high hydraulic head in the MV wells and piezometers (Figure 2) indicate that they have been impacted by the nuclear test and the down-dropped block. That these impacts have persisted indicates the possibility that they are long-term and not just temporary as originally perceived. It is also possible that the faults reactivated by the nuclear test always behaved as natural hydraulic barriers dividing the alluvial aquifer, in particular, into compartments of similar head separated by zones with very high gradients.

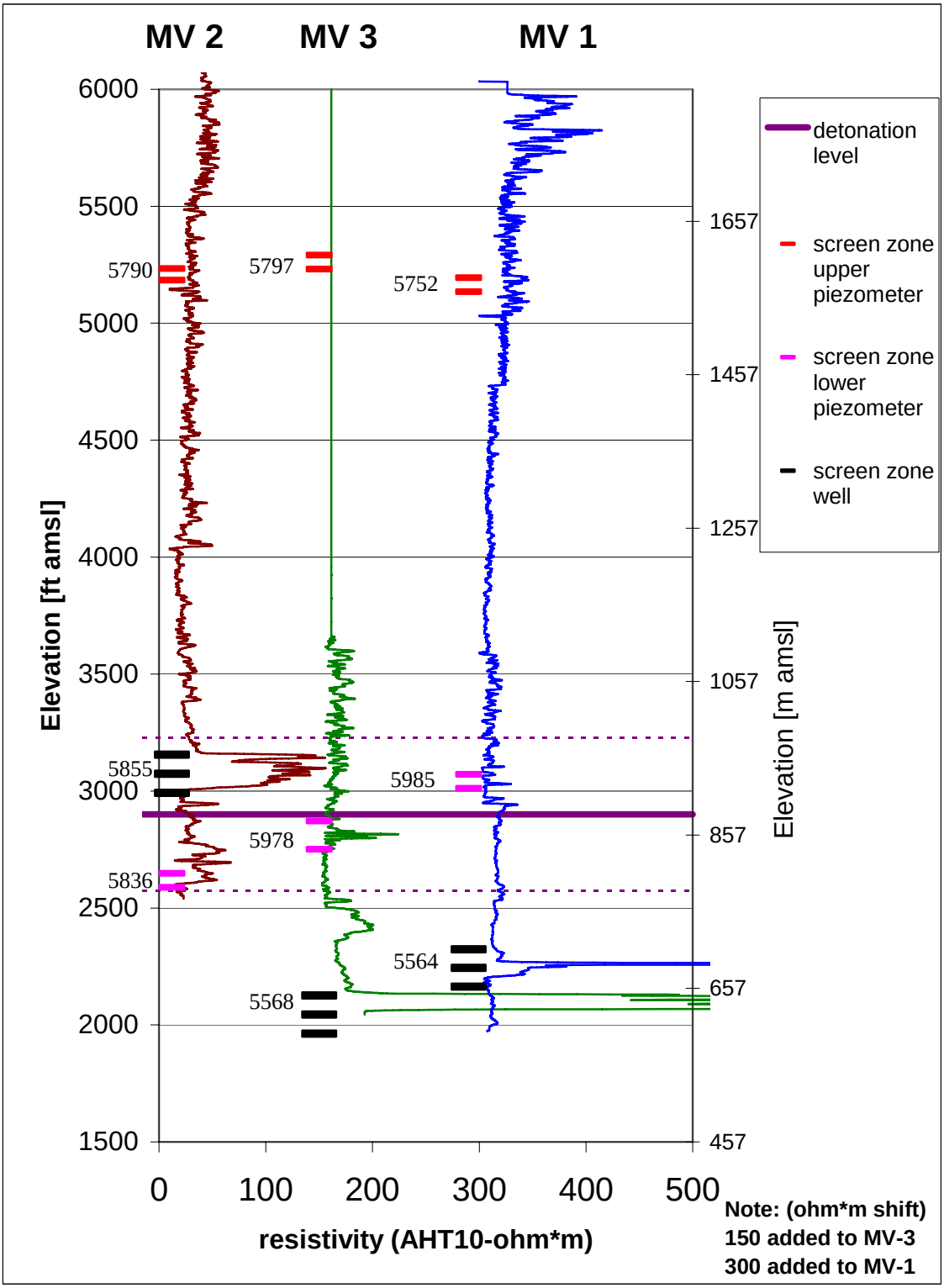


Figure 3. Resisitivity logs from the three MV wells. The high resistivity opposite the well screen zones indicates densely welded tuff (confirmed by drill cuttings). September 2007 head levels (ft amsl) are shown adjacent to the well and piezometer screen zones.

The lithology directly observed during the drilling and inferred from the resistivity logs (Figure 3) generally matches what was used in the CNTA model. Three categories of hydrostratigraphy were simulated in the model (alluvium, tuffaceous sediments, and densely welded tuff). Each of these units was encountered, and no additional hydrogeologic units were identified. Wells drilled during the 1960s indicated that densely welded tuff was a minor component of the volcanic section near the Faultless test site, and this fact was confirmed by the MV well data. In addition, the MV well data indicate that the model was overly conservative with respect to radionuclide migration in the proportion of densely welded tuff simulated below the test horizon. Although one densely welded tuff interval was intercepted near the base of wells MV-1 and MV-3, the data indicate that there is less relatively-high-permeability densely welded tuff and more lower-permeability tuffaceous sediments. This would likely result in a revised model that predicts even less transport than does the current model.

The hydraulic conductivity values obtained from aquifer tests in the three validation wells are within the distributions used in the flow model. Thus, the range of hydraulic conductivity used in the model is validated, but this overlap occurs due to the low conductivities assigned in the model to the tuffaceous sediments. The data indicate that the model was highly conservative (erring on the side of predicting more transport) in its depiction of velocities in the densely welded tuff. Aquifer tests performed on the MV wells indicate hydraulic conductivity values for densely welded tuff are much lower than the values assigned to that unit in the model (Figure 4).

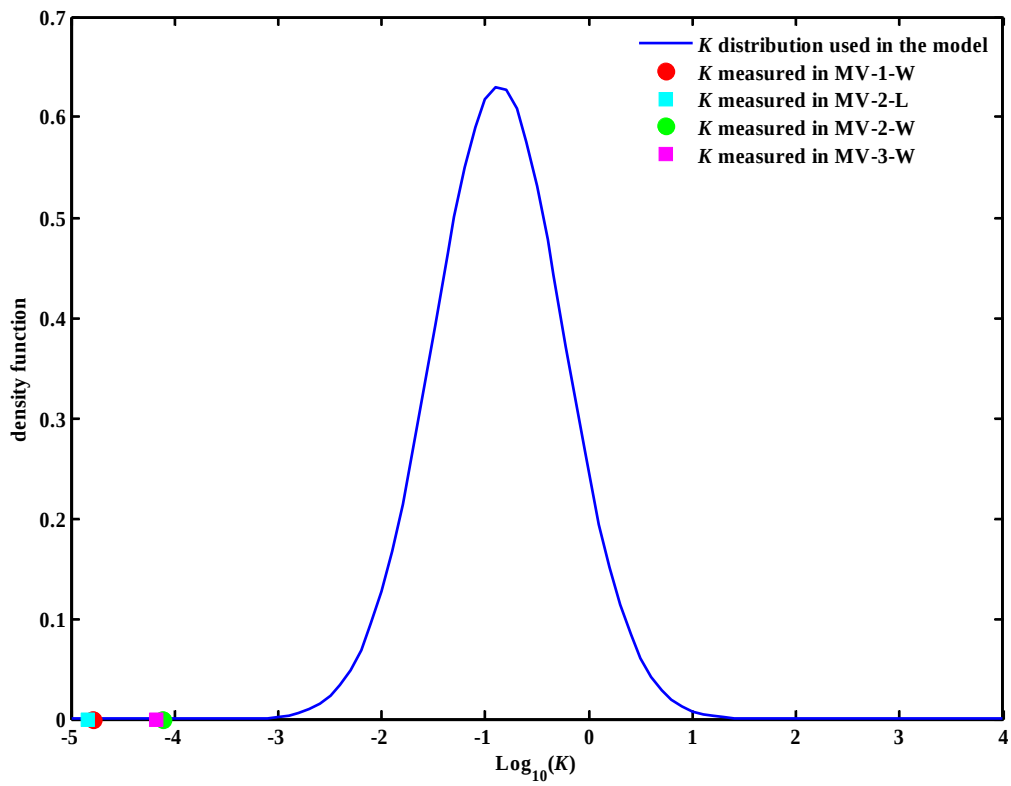


Figure 4. Conductivity distribution for the densely welded tuff that was used in the original CNTA model (Pohlmann et al., 1999) and relation to the measured K values (meters/day) of the densely welded tuff encountered in the three MV wells.

The vertical head distribution currently observed in the wells and piezometers at the MV locations indicates the potential for both upward and downward groundwater flow from the detonation level. (Note that hydraulic head in the cavity/chimney itself remains depressed as a result of the nuclear test such that flow is toward the chimney at present, as water levels recover.) The gradient is largest in the downward direction at wells MV-1 and MV-3, consistent with the downward flow simulated by the model, but the hydraulic situation is complex and some portion of the chimney may experience upward flow. Upward flow could introduce radionuclides into the shallower alluvial aquifer system, where horizontal flow directions are basically directed along the axis of the paleo-valley to the south-southeast. That possibility was not addressed by the monitoring system approved in the CADD/CAP. As part of the enhanced monitoring strategy, new wells are being positioned in the regional direction of groundwater flow within the alluvium. Flow directions in the alluvial aquifer based on measured head levels are presented in Appendix C.

5.6.2 Changes to Recommended Alternative (Revision of Original Section 4.0)

Although the MV well data do not validate the CNTA groundwater flow model, the data do demonstrate factors favorable to the closure of CNTA. The densely welded tuff units encountered at the MV well locations are less prevalent, are thinner, and have a lower hydraulic conductivity than those included in the model. This is significant in that the densely welded tuffs were the only units in the model that resulted in significant transport. Even though the model failed to predict the observed head levels in the MV wells and piezometers, the simulated transport distances are probably more conservative than if parameters comparable to those observed had been used in the model. The MV well data support the interpretation of slow groundwater movement with a limited possibility of radionuclide migration from the detonation zone.

The compliance boundary for CAU 443 is considerably larger than the contaminant boundary (Figure 1). DOE and NDEP agreed that the compliance boundary should mimic the surface expression of the down-drop fault block that subsided after the Faultless test because DOE was concerned about the pre-test nature of the data supporting the groundwater model and wanted to ensure that the boundary encompassed any test effects. The low groundwater velocities indicated by the MV well data make it likely that the contaminant boundary would remain similar to the predictions in the CADD/CAP, despite the adjustment to heads. It is also likely that the current compliance boundary would encompass the transport predictions at 1,000 years of a revised model that incorporates the MV well data. Rather than invest the time and resources required to develop and validate a new numerical model that would still be subject to significant uncertainty, a new strategy is proposed.

The new strategy seeks to validate the compliance boundary using an enhanced monitoring network with a Proof of Concept Monitoring period. Specifically, the new strategy calls for expanding the existing monitoring network. Given the potential processes of prompt injection and the possibility of convective mixing in the nuclear chimney, there is a chance of radionuclide migration into the alluvial aquifer. Even though downward migration from the cavity is believed to be more probable, data from the MV wells do not rule out the chance of upward migration. Wells in the alluvial aquifer are typically 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. The alluvium is not currently

monitored except for head levels in the upper piezometers at the MV well locations. Additional wells in the alluvium are recommended to enhance the overall monitoring network at CNTA. The monitoring network will be enhanced by adding two wells with piezometers screened in the alluvium in the regional direction of groundwater flow within the alluvium to allow for detection of radionuclides that could have migrated upward into the alluvium. Head levels in these wells will contribute to the network monitoring groundwater flow directions at the site to confirm that monitoring points are properly located.

This new strategy seeks to validate the compliance boundary through monitoring rather than validation of a flow model. As a result, no further modeling is recommended. The stability of the groundwater system and lack of transport will be demonstrated through the Proof of Concept Monitoring period for the enhanced monitoring network. The current Underground Test Area (UGTA) flowchart is shown in Figure 5. A flowchart outlining the suggested steps of the new strategy is shown in Figure 6.

5.6.3 Additions to Monitoring Network (Revision of Original Section 5.2)

The current monitoring network as provided in the CADD/CAP consists of wells and piezometers at MV-1, MV-2, and MV-3 (Figure 1). The MV wells are positioned to monitor for detection of radionuclides in the densely welded tuff section below the detonation level. Head levels are monitored in the well and two piezometers (upper in the alluvium, lower in the volcanic section) at each MV well location to provide compliance monitoring of physical parameters and to demonstrate the relative stability of groundwater conditions at the site. Each MV well is sampled annually for radionuclide detection. Additionally, water levels in well UC1-P-2SR (the reentry well drilled into the chimney) have been measured several times a year by the U.S. Geological Survey (USGS) since April 1968 to document the recovery of head in the immediate vicinity of the detonation.

The proposed monitoring network enhancement includes two wells to be installed and screened within the alluvium and the additional monitoring of several existing wells (Figure 7). The new wells will be placed within the compliance boundary southeast of the nuclear test in the regional direction of groundwater flow within the alluvium (the analysis of the lateral gradients in the alluvium is presented in Appendix C). Five seismic reflection profiles (Figure 7) were acquired in October 2007 and are currently being processed. They will be used to refine the new well locations with respect to the graben fault southeast of the detonation. Preliminary results support a southeast flow direction for the alluvial aquifer.

The pre-drill plan is to install a well and piezometer at each location within the same borehole. The well will be screened in the lower alluvium, and the piezometer will be screened in the upper alluvium. This will allow the alluvium nearest the detonation zone to be monitored and the vertical gradient within the alluvium to be determined at each location. The alluvium is expected to be greater than 2,000 ft thick at the planned locations. Proposed design and engineering specifics for the new wells are presented in Appendix E.

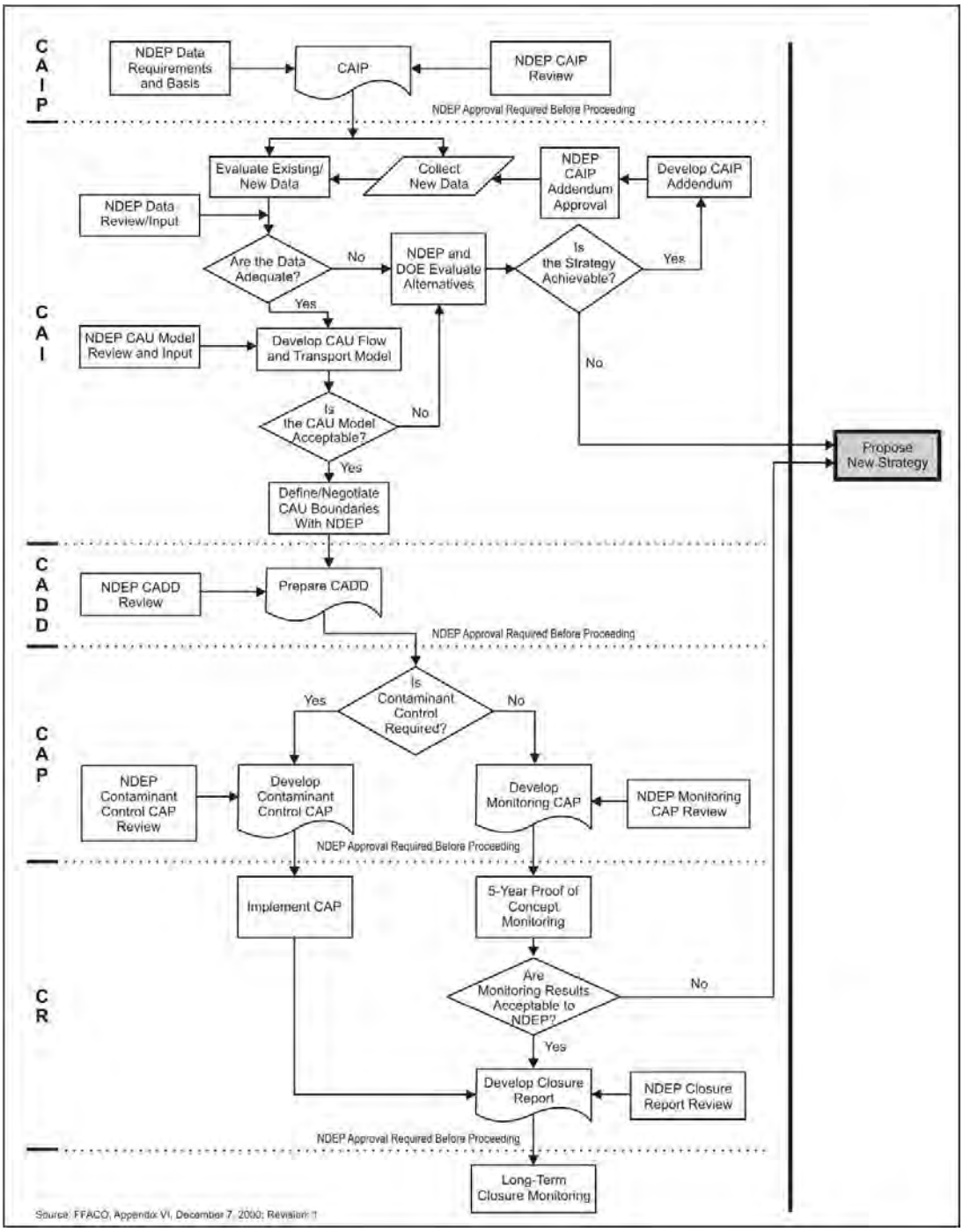


Figure 5. The UGTA flowchart from Appendix VI of the FFACO. CNTA is currently in the part of the process enclosed by the shaded, heavily outlined box.

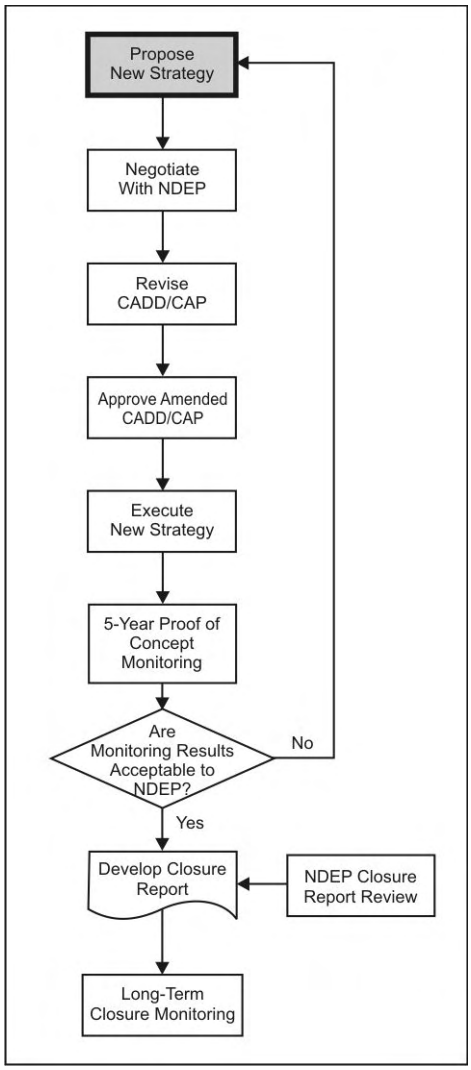


Figure 6. Flowchart outlining the suggested steps of the proposed new strategy for CNTA.

The monitoring of the volcanic sediments will be enhanced by the addition of well HTH-1 south of the compliance boundary. HTH-1 is open from the alluvium down into the volcanic sediments (Appendix D, Figure D−1). Flow testing indicates that flow in the well is upward from the volcanic section and out through perforations in the upper alluvium. This will allow a sample to be retrieved from the volcanic section at this location using a depth-specific bailer. The possibility of recompleting well HTH-1 so that it is only open to the volcanic section is under consideration (Appendix E).

Monitoring hydraulic head in existing wells HTH-2 and UC1-P-1S will augment the new alluvial monitoring network. Monitoring head in HTH-1 is less informative due to the multiple perforated intervals across the entire vertical extent of the well. However, flow logging, temperature logging, and water-chemistry samples from HTH-1 demonstrate that water in the well bore originates in the volcanic units and travels upward to discharge through the uppermost perforated zone in the alluvium (Appendix D). The current plan is to evaluate the possibility of recompleting well HTH-1 so that it is open only to the volcanic section to provide an additional deep-monitoring location. A possible design for recompleting HTH-1 is provided in Appendix E.

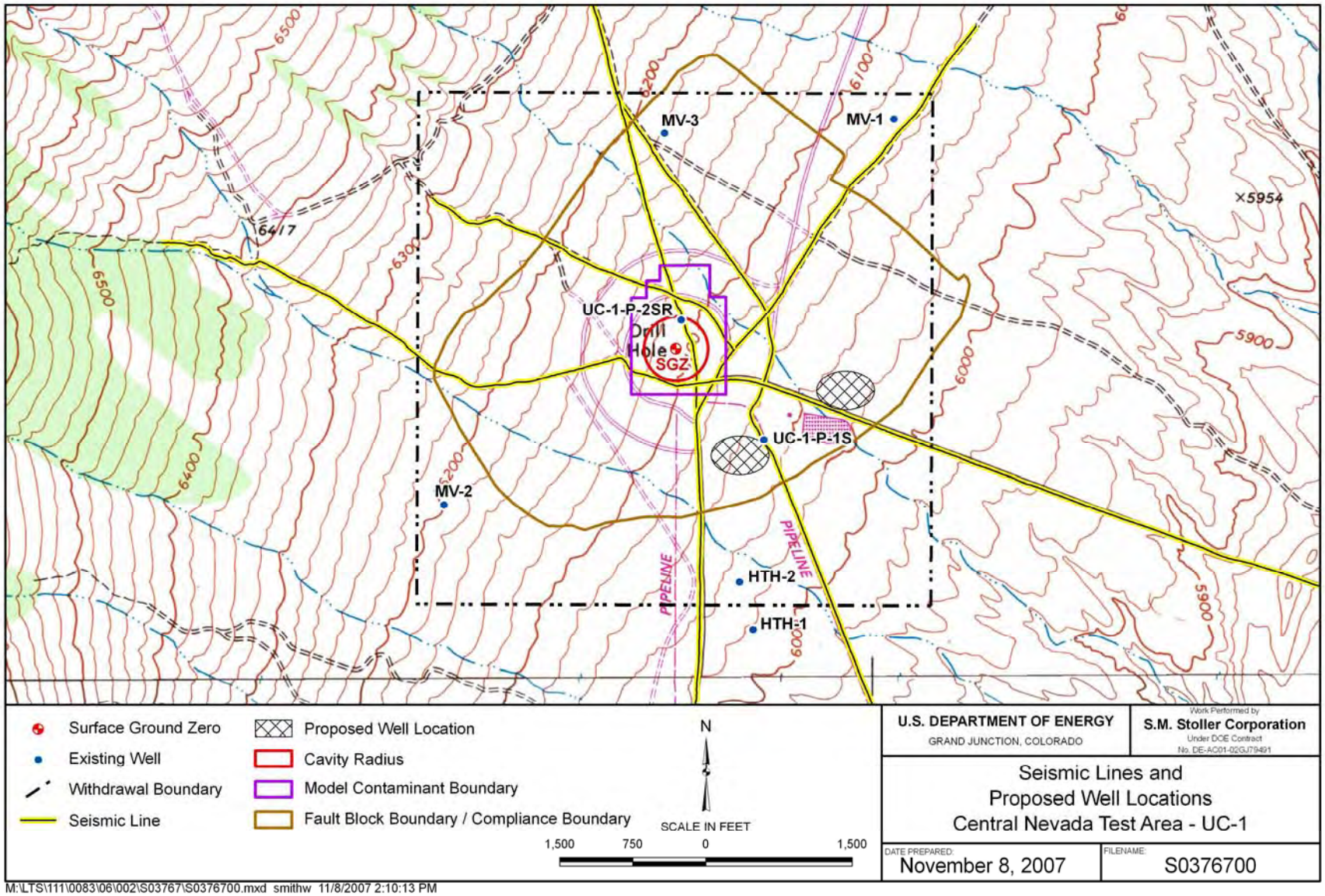


Figure 7. Proposed locations of the two new alluvial wells to be drilled in 2008 and five seismic lines acquired in October 2007.

In summary, the enhanced network will monitor hydraulic head in the existing MV wells and piezometers, in the new wells, and in wells HTH-2, UC1-P-1S, and UC1-P-2SR. Tritium will be monitored yearly in wells MV-1, MV-2, MV-3, HTH-1, and HTH-2 and in the two new wells in the alluvium during the 5-year Proof of Concept Monitoring period. Carbon-14 and Iodine-129 will be monitored in the first and fifth year of the Proof of Concept Monitoring period to provide baseline data for comparison in the future when these long-lived radionuclides are phased into the monitoring program as tritium decays. A summary of the current and enhanced monitoring network is shown in Table 2. The results from the Proof of Concept Monitoring period will be used to guide the specifics of the long-term monitoring network.

Table 2. Summary of the Current and Revised Monitoring Networks.

Location	Current Network	Proposed Network	Screened/Open Unit
MV-1-Upper Piezometer	Head	Head	Alluvium
MV-1-Lower Piezometer	Head	Head	Volcanics (tuffaceous sediments)
MV-1-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
MV-2-Upper Piezometer	Head	Head	Alluvium
MV-2-Lower Piezometer	Head	Head	Volcanics (DWtuff)
MV-2-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
MV-3-Upper Piezometer	Head	Head	Alluvium
MV-3-Lower Piezometer	Head	Head	Volcanics (tuffaceous sediments)
MV-3-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
HTH-2		Head/Radionuclides	Alluvium
HTH-1		Radionuclides	Volcanics
UC1-P-1S		Head	Alluvium
MV-4 (New Well)-Piezometer		Head	Alluvium
MV-4 (New Well)-Well		Head/Radionuclides	Alluvium
MV-5 (New Well)- Piezometer		Head	Alluvium
MV-5 (New Well)- Well		Head/Radionuclides	Alluvium

DWtuff = Densely welded tuff.
Note: Head data from well UC1-P-2SR is measured by USGS.

5.6.4 Sampling Methods

The new MV wells and recompleted well HTH-1 will be part of the Proof of Concept Monitoring network. Each well will be equipped with a dedicated submersible pump to be used for well development, aquifer testing, and subsequent sampling. The new wells will be developed until pH, specific conductance, temperature, and the chemical tag (bromide) added to the drilling fluid are reduced to acceptable levels. Aquifer tests will be conducted on the new wells (screened in the alluvium) and recompleted well HTH-1 (screened in the volcanic section) to determine the hydraulic properties at those locations. It is assumed at this time that the MV wells and well HTH-1 will be sampled following a low-flow sampling methodology that requires monitoring well purge volumes, pump flow rates, water levels within the well, pH, specific conductance, and turbidity as part of the sampling process. The results of the aquifer testing will help determine if this is the most appropriate sampling method for the new MV wells and recompleted well HTH-1.

Wells MV-1, MV-2, and MV-3, which are screened in densely welded tuff in the volcanic section, will continue to be sampled as part of the Proof of Concept Monitoring. According to the CADD/CAP, the sampling of these wells requires the removal of one well casing volume and the stabilization of the groundwater parameters (DOE, 2004). These requirements were established prior to aquifer testing, which showed that the hydraulic conductivity of the densely welded tuff at these wells is lower than expected. The combination of low hydraulic conductivity and well depth makes it difficult to remove the required well casing volume (approximately 3,700 gallons) from monitor wells MV-1 and MV-3. Water levels in these wells draw down to below the lift capacity of the pump (approximately 1,700 ft below ground surface [bgs]) after approximately 3 hours of pumping or after approximately 900 gallons have been removed. A new sampling method that requires the removal of one well screen volume (approximately 550 gallons) and the stabilization of groundwater parameters (pH, specific conductance, and temperature) prior to sampling has been developed and used for collection of groundwater samples (Lyles et al., 2007). The sampling of well MV-2 shall continue as per the original CADD/CAP requirement.

Well HTH-2 is screened in the upper alluvium and will be added to the Proof of Concept Monitoring network. It is equipped with a dedicated pump and will be sampled after the removal of at least one well casing volume and the stabilization of groundwater parameters. If necessary, samples may be collected using a depth-specific discrete bailer in lieu of pumping. In these cases, the bailer should be within the depth of the screened horizon to provide a representative sample. Samples collected using this method will be designated as having a lower reliability than those collected after purging and the stabilization of groundwater parameters.

5.6.5 Quality Assurance and Quality Control

The quality of the monitoring data depend on the use of effective sampling and analysis procedures. Sample collection is performed in accordance with *Sampling and Analysis Plan* (SAP) *for U.S. Department of Energy Office of Legacy Management Sites*, November 2007. The fundamental aspects of this plan are presented below.

The collection of groundwater samples using the low-flow sampling protocol specified in the SAP provides the highest-quality samples. Representative samples are collected by monitoring well purge volumes, pump flow rates, water levels within the well (when necessary), pH, specific conductance, temperature, and turbidity (when necessary) while purging the well. A representative groundwater sample can be collected if the required purge volume has been removed and the water level, pH, and specific conductance have stabilized. Groundwater parameters are measured to establish that samples representative of formation water have been collected, not as empirical parameters within the monitoring program.

Field quality assurance includes the collection and analysis of quality control samples as specified in the SAP. Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. Equipment blanks may be collected after sampling equipment has been decontaminated and before environmental samples have been collected. These blanks are useful in documenting the adequate decontamination of sampling equipment.

Though the contaminant boundary is based on concentrations of 20,000 pCi/L for tritium, 2,000 pCi/L for carbon-14 (^{14}C), and 1 pCi/L for iodine-129 (^{129}I), the quality requirement for the CAP Proof of Concept Monitoring will be the required detection limits as provided in Table 5.1 of the CADD/CAP. The detection limit requirements for ^{14}C and ^{129}I, in particular, are low because these analyses will be used to establish background conditions for comparison during post-closure monitoring.

Subtle variations in hydraulic head may be useful indicators of change in the overall hydrologic system in response to climatic or anthropogenic causes. Thus, the ability to detect trends with a precision of plus or minus a tenth of a foot is the quality requirement for the hydraulic head measurements. The absolute accuracy of the measurement depends on well deviation and is not necessary for monitoring trends in head within a single well. Data quality will be assured through the use of calibrated field equipment (wirelines, transducers, or water level probes).

5.6.6 Modification of the Proof of Concept Approach

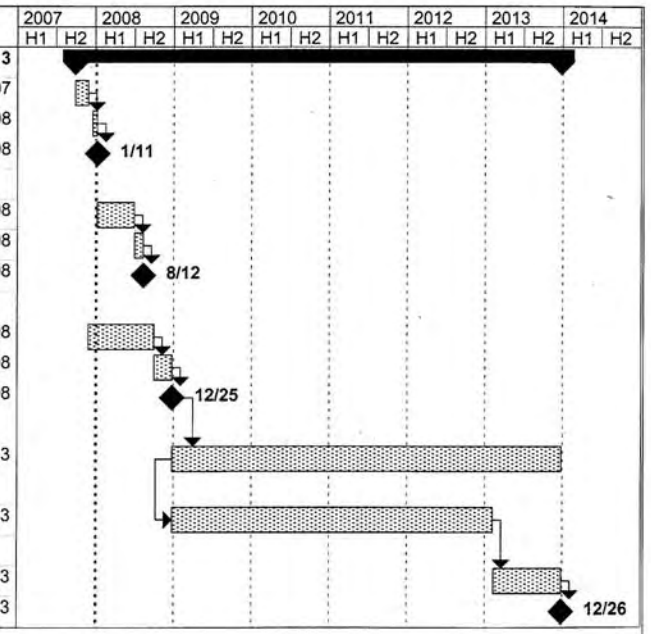
Data from the new monitoring network will be evaluated over a 5-year period to ensure that the groundwater system is stable and that radionuclides of interest do not exceed minimum detectable concentrations[1] or are at or below local background concentrations. The stability of the heads in each unit and the stability of the resulting gradients and consistency of flow directions will be assessed. The effectiveness of the monitoring system will be evaluated with respect to monitor well locations within the flow field of each unit at the site. Temporal changes will be evaluated in light of a conceptual model that includes transient shot effects. The continued persistence and slow dissipation of high heads at the test horizon will confirm the low permeability of the material enclosing the detonation and the interpretation of limited transport from the cavity. The alluvium will be monitored to confirm that upward transport from the detonation level is limited. At the end of the 5-year Proof of Concept Monitoring period, the validity of the compliance boundary will be demonstrated by monitoring results from the proposed monitoring network that indicate radionuclides of interest do not exceed minimum detectable concentrations or are at or below local background concentrations.

6.1 Modified Schedule

Figure 8 shows the modified schedule for the CNTA corrective action, through the Proof of Concept period and the closure report. Note that the 5-year Proof of Concept period is scheduled to begin anew with the construction of the new wells in the alluvium, despite the start date of 2005 in the original CADD/CAP schedule.

[1] Minimum detectable concentrations: Tritium (300 pCi/L), Carbon-14 (5 pCi/L), Iodine-129 (0.1 pCi/L).

ID	Task Name	Duration	Start	Finish
1	**CNTA CORRECTIVE ACTION**	**1629 days**	**Mon 10/1/07**	**Thu 12/26/13**
2	CNTA CADD/CAP to NDEP	45 days	Mon 10/1/07	Fri 11/30/07
3	Prepare Final CNTA CADD/CAP to NDEP	16 days	Fri 12/21/07	Fri 1/11/08
4	Submit Final CNTA CADD/CAP to NDEP	0 days	Fri 1/11/08	Fri 1/11/08
5				
6	Surface Prep Planning	123 days	Fri 1/11/08	Tue 7/1/08
7	Surface Prep	30 days	Wed 7/2/08	Tue 8/12/08
8	Complete Surface Prep	0 days	Tue 8/12/08	Tue 8/12/08
9				
10	Monitor Well Prefield Planning	219 days	Fri 11/30/07	Wed 10/1/08
11	Monitor Well Field Work	61 days	Thu 10/2/08	Thu 12/25/08
12	Complete Monitor Well Field Work	0 days	Thu 12/25/08	Thu 12/25/08
13				
14	Annual Monitoring Data Evaluation	1305 days	Fri 12/26/08	Thu 12/26/13
15				
16	Proof of Concept Analysis	1076 days	Fri 12/26/08	Fri 2/8/13
17				
18	Concept Analysis/Prepare Closure Report	229 days	Mon 2/11/13	Thu 12/26/13
19	Issue Closure Document	0 days	Thu 12/26/13	Thu 12/26/13



Project: CNTA CADD_CAP Addendun
Date: Thu 1/3/08

Task		Rolled Up Task		External Tasks	
Progress		Rolled Up Milestone		Project Summary	
Milestone		Rolled Up Progress		Group By Summary	
Summary		Split		Deadline	

Page 1

Figure 8. Project Schedule.

8.1 Additional References

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Lyles, B., P. Oberlander, D. Gillespie, D. Donithan, and J. Chapman, 2006. *Hydrologic Data and Evaluation for Wells Near the Faultless Underground Nuclear Test, Central Nevada Test Area*, Desert Research Institute, Division of Hydrologic Sciences Publication No. 45219, U.S. Department of Energy, Nevada Site Office report DOE/NV/13609-49, 64p.

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Appendix C

Hydraulic Gradient Analyses Using the MV Well Data

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C1.0 Introduction

Horizontal directions of groundwater flow in the alluvial aquifer at the Central Nevada Test Area (CNTA) Faultless site were estimated from hydraulic head measurements collected at the site in 1997, 2006, and 2007. Five monitoring locations consisting of either wells or piezometers were used in the analysis, though head measurements were not available from all locations on every measurement date. Table C−1 lists the groundwater elevation data used in the analysis and other information about the monitoring locations. Note that, though the open interval elevations are not clearly known for UC-1-P-1S, this well is open to the alluvial aquifer from approximately 230 feet (ft) (70 meters [m]) below the water table to possibly all the way through the alluvium and into underlying tuffaceous sediments.

Table C−1. Groundwater Elevation Data Used in Analysis of Groundwater Flow Directions

Date	Well Name				
	MV-1 Upper	**MV-2 Upper**	**MV-3 Upper**	**UC-1-P-1S**	**HTH-2**
25 Nov 1997 (ft AMSL)	-	-	-	-	5,471.3
15 Mar 2006 (ft AMSL)	5,752.0	5,829.7	5,796.6	5,757.9	-
18-19 Sept 2006 (ft AMSL)	5,752.6	5,780.5	5,796.9	-	-
20-22 Feb 2007 (ft AMSL)	5,752.0	5,787.7	5,796.3	5,756.6	5,469.5
Screen zone top[a] (ft AMSL)	5,190.3	5,229.7	5,287.1	5,758 (est.)	5,526.2
Screen zone bottom[a] (ft AMSL)	5,130.3	5,179.8	5,227.0	5,507	5,025.3
Land surface[a] (ft AMSL)	6,069.2	6,189.8	6,167.0	6,031.2	6,025.8
Easting[c] (ft)	631,164.83	626,58.58	628,812.19	629,830.88	629,583.06
Easting[b] (m)	568,977.6	567,575.3	568,260.8	568,576.0	568,501.9
Northing[c] (ft)	1,416,702.33	1,412,730.07	1,416,558.67	1,413,402.10	1,411,931.46
Northing[b] (m)	4,277,002.9	4,275,787.3	4,276,956.5	4,275,995.6	4,275,546.9

[a]NAVD 1929
[b]UTM Zone 11, NAD 1927
[c]Nevada Central, NAD 1927

AMSL = Above mean sea level
ft = feet
m = meters

C2.0 Methods

Flow directions were obtained by fitting a plane to the available head measurements using multiple least squares regression (Devlin, 2003). This method has the advantage of simultaneously incorporating more wells than are possible in traditional “three-point” analyses. However, because the method presumes a relatively uniform hydraulic gradient and flow direction across the site, two cases were investigated. Case 1 includes all five wells in the analysis. Case 2 omits HTH-2 from the analysis on the assumption that this well is hydraulically isolated from the others by a high-angle fault mapped between UC-1-P1S and HTH-2 that represents the outer boundary of the subsidence block surrounding the Faultless test (Pohlmann et al., 1999). The large difference in heads evident between HTH-2 and the other wells suggests

that this fault may act as a hydraulic barrier to groundwater flow in the alluvium. The flow directions estimated here are assumed to be horizontal within the alluvial aquifer since all five wells are open to nearly the same vertical interval of elevation within the alluvium. Vertical components of flow, if they exist in the alluvium, are not accounted for in this analysis.

Three groups of measurements by date (March 2006, September 2006, and February 2007) are included in each case. Because heads in HTH-2 appear to have been very stable over time, the 1997 measurement is included in the March 2006 and September 2006 groups. Figure C−1 shows the trends in water levels observed at the other four wells based on the measurements used in this analysis. Note that water levels in MV-2 Upper exhibit much greater changes over time than is observed in the other wells. The March 2006 measurement in this well was the highest of all wells, but by September 2006, the water level had dropped below the level measured in MV-3 Upper and remained below the level measured in MV-3 Upper in February 2007.

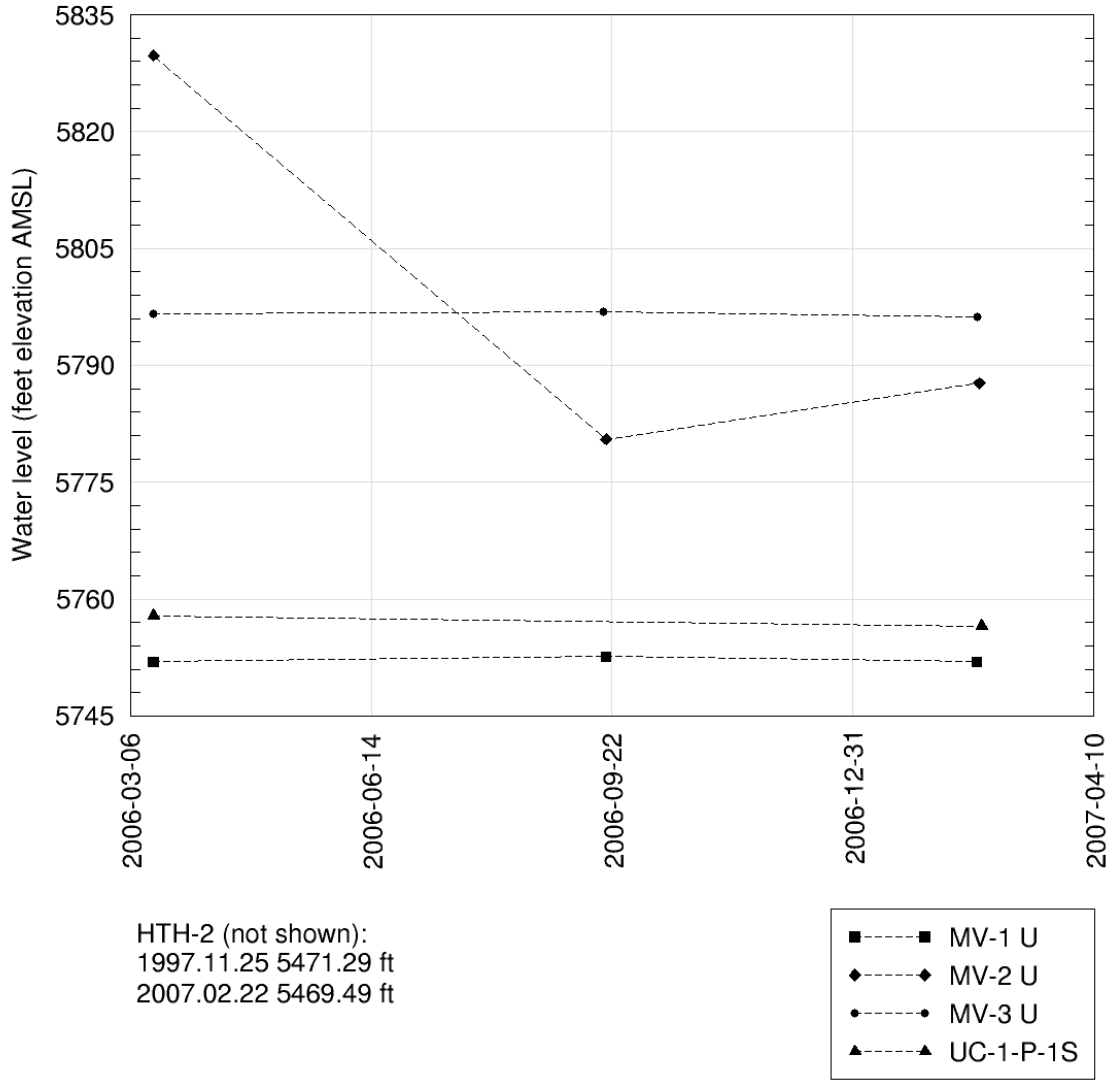

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Figure C−1. Time-Series Plot of 2006 and 2007 Water Level Measurements at Faultless

C3.0 Results

Using heads from all five wells (Case 1) results in an estimated groundwater flow direction toward the southeast from UC-1 at a mean azimuth of 144° (Figure C−2). As shown in Figure C−2, the changing heads measured over time in MV-2 Upper have only a small impact on the estimated direction calculated for three measurement dates.

Removing HTH-2 from the analysis (Case 2), on the assumption that it is hydraulically isolated from the other wells, provides an estimate of flow direction inside the subsidence block. Groundwater flow in Case 2 is directed toward the east-southeast at a mean azimuth of 120° (Figure C−3). The more easterly direction of flow, as compared to Case 1, results from omitting the lowest head (approximately 328 ft (100 m) lower than heads in the other wells) at the southernmost well. In addition, the removal of HTH-2 from the analysis causes the temporal head changes in MV-2 Upper to represent a greater proportion of the overall range in heads observed at the remaining four wells. As a consequence, a larger range in flow directions is calculated. Assuming that heads in this well will stabilize over time, additional head measurements in the future will help refine the estimate of flow direction in alluvium within the subsidence block.

C4.0 References

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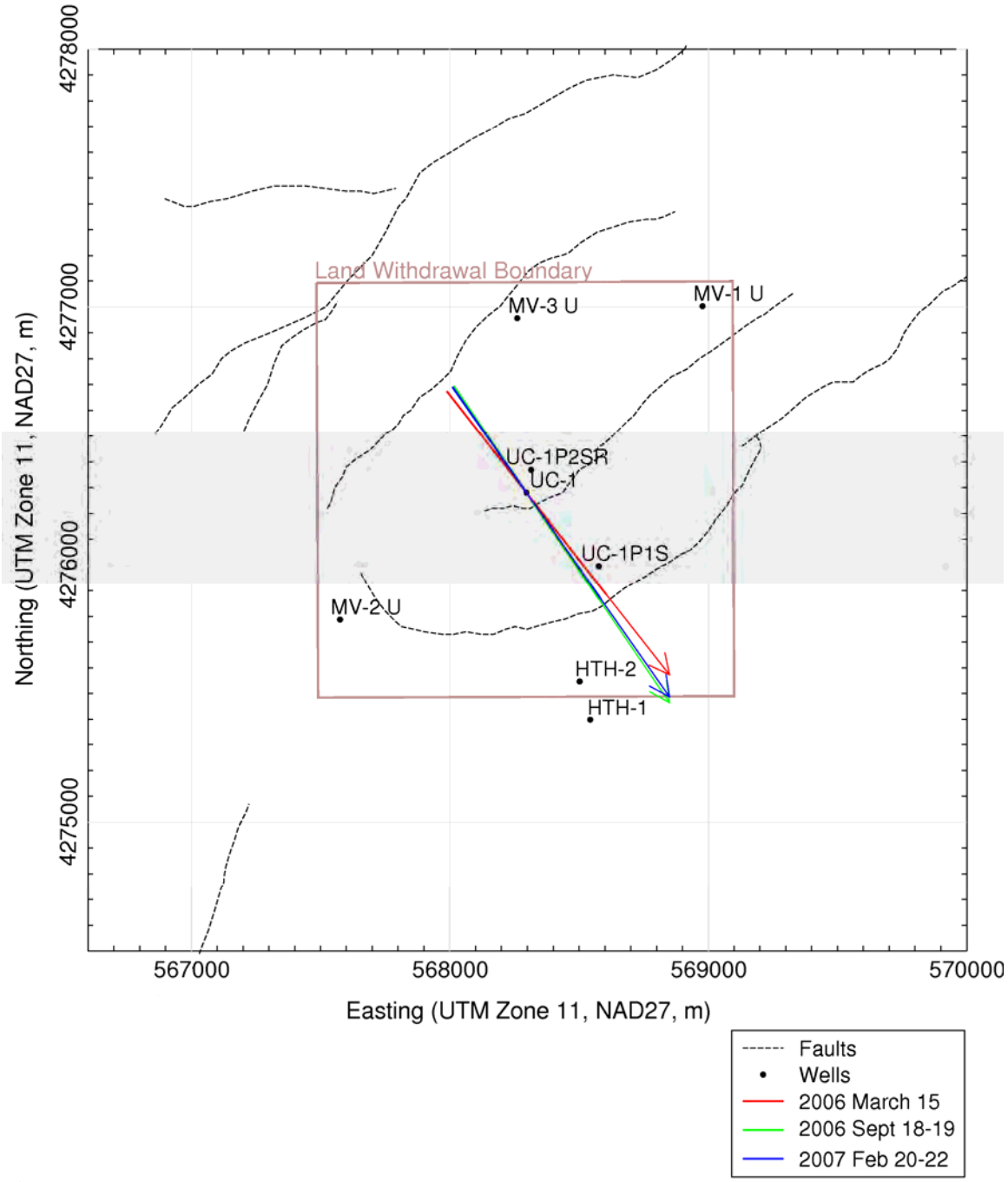

Figure C−2. Groundwater Flow Directions Estimated for Case 1 (All Five Wells). Wells UC-1, UC-1-P-2SR, and HTH-1 are shown for reference only; they were not included in the analysis.

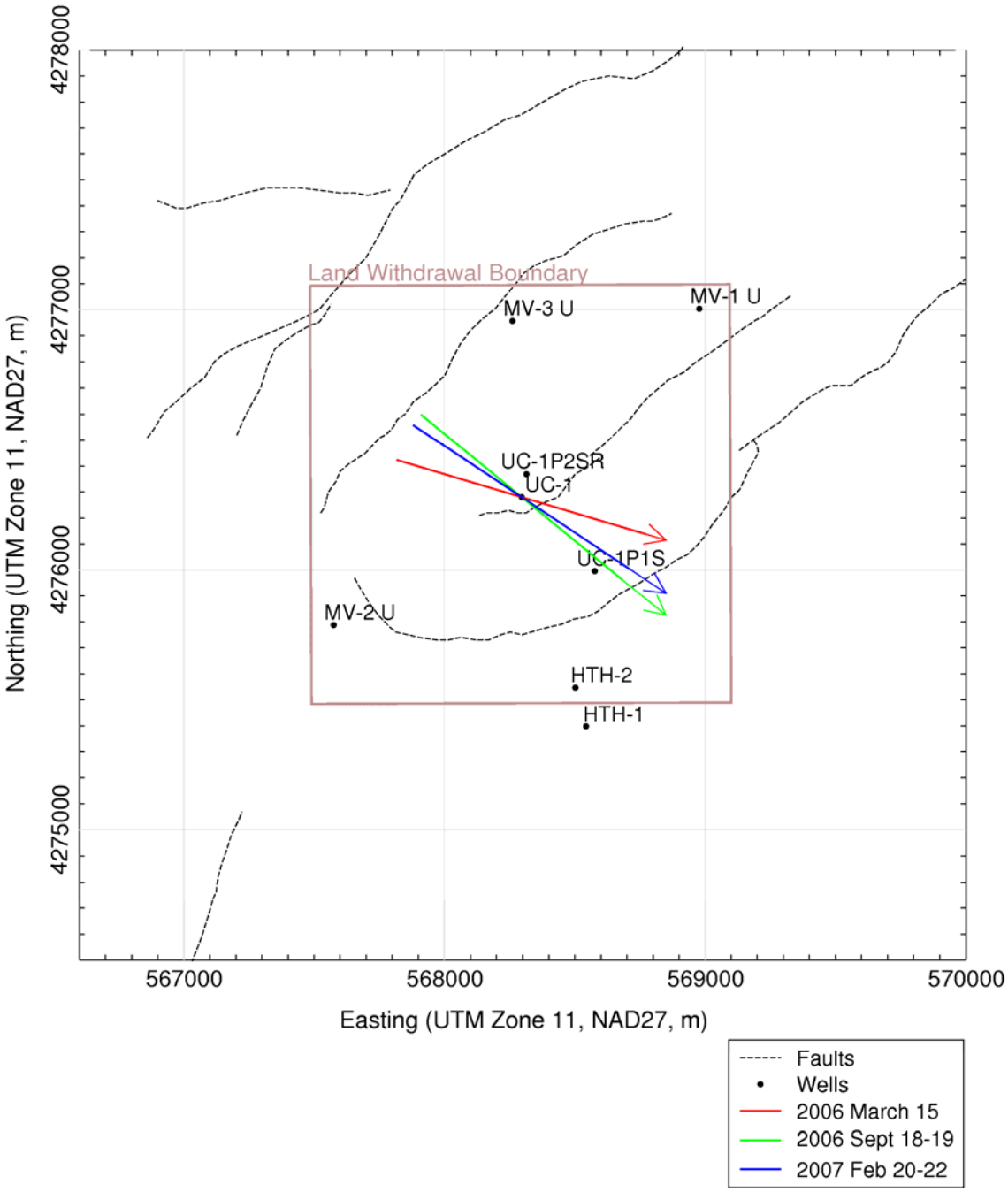

Figure C−3. Groundwater Flow Directions Estimated for Case 2 (HTH-2 Omitted). Wells UC-1, UC-1-P-2SR, and HTH-1 are shown for reference only; they were not included in the analysis.

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Appendix D

Hydrologic Investigations in HTH-1

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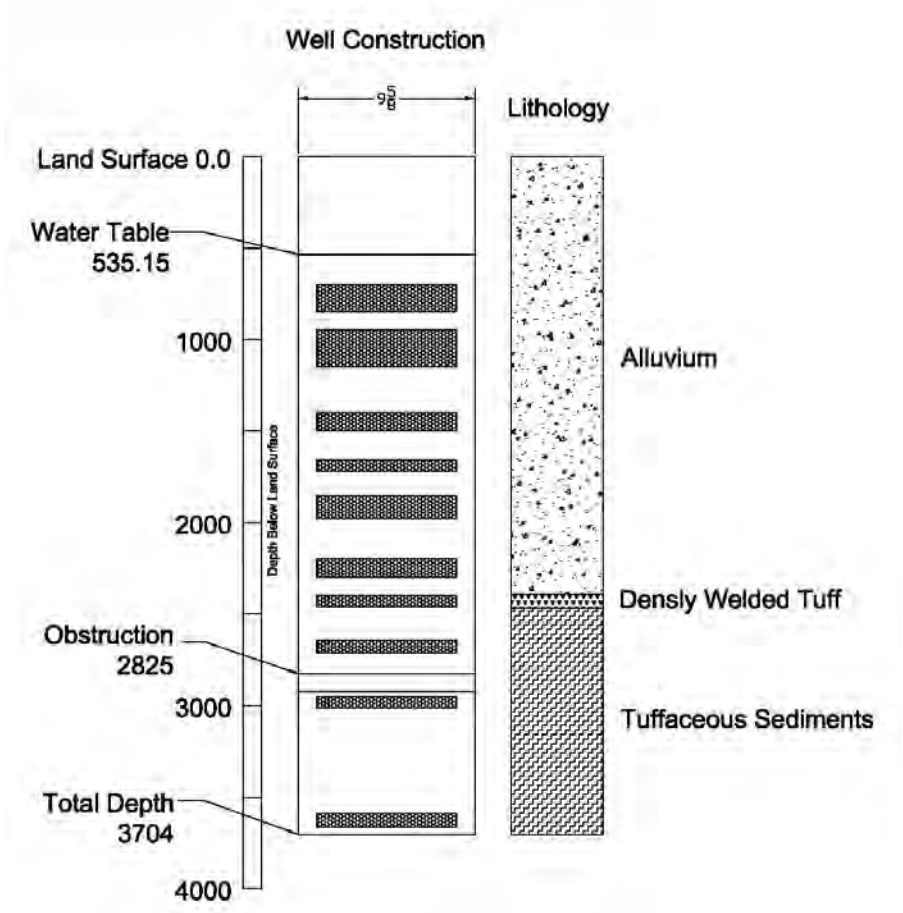
D1.0 Overview

Desert Research Institute (DRI) personnel Brad Lyles and John Healey conducted well logging and water sampling in well HTH-1 at the Central Nevada Test Area (CNTA) on September 6 and 7, 2007. Prior to conducting the fieldwork, a site walk-through was performed, health and safety concerns were discussed, and a tailgate safety briefing was conducted by S.M. Stoller Corporation (Stoller) personnel.

D2.0 Scope of Work

Well HTH-1 has been identified as a potential monitoring well for volcanic hydrogeologic units at CNTA. The well has a complex completion consisting of ten sets of gun perforations below the water table (Figure D−1). Previous well logging conducted by DRI identified vertical water chemistry differences as well as upward groundwater flow within the well. The work performed on September 6 and 7, 2007, included (1) the development of two well logs, the chemistry log, and the non-stressed thermal flow log and (2) the collection of discrete bailed water samples. Results from these measurements are compared to previous observations from well HTH-1.



Note: vertical scale in feet (ft)
horizontal scale in inches

Figure D−1. Completion and Hydrologic Data from Well HTH-1.
Modified from Dinwiddie and Schroder (1971).

D3.0 Field Activities

All well logs and samples from HTH-1 were referenced to a land surface datum. Vertical groundwater flow in the well was measured with a thermal flow meter (TFM), which is a stationary logging tool that has a measurement range of 0.02 to 4 gallons per minute (gpm) (0.08 to 15 liters per minute [L/min]) (Lyles 1994). Repeated measurements were made with the tool at each depth logged in the well. Measurements were made at the same depths measured in previous evaluations (Chapman, Mihevc, and Lyles 1994; Mihevc, Chapman, and Lyles 1995).

The thermal flow meter pulse response times measured during the survey are listed in Table D−1 along with corresponding flow rates and velocities computed from instrument calibration data. Upward vertical flow was observed in the well bore from 2,470 to 900 feet (ft) below ground surface (bgs). It should be mentioned, however, that the magnitude of the upward velocities resulting from the logging may have been underestimated because the post-log inspection of the TFM revealed that the heat grid on the tool was covered with what appeared to be cable insulation shaving (possibly from transducer cable jacketing). This may have restricted flow through the tool but would not change the measured flow direction.

Table D−1. CNTA Well HTH-1 Thermal Flow Meter Survey Results (data collected September 6, 2007)

Depth (ft)	Well Diameter (inches)	Response (seconds)	Standard Deviation (seconds)	Flow Rate (gpm)	Standard Deviation (gpm)	Velocity (ft/minute)	Standard Deviation (ft/minute)
600	8.75	25*	50	0	0	0	0
900	8.75	7.39	1.548	0.09	0.019	0.030	0.006
1,200	8.75	3.14	0.48	0.48	0.073	0.153	0.023
1,510	8.75	3.65	0.782	0.34	0.073	0.109	0.023
1,729	8.75	3.74	0.558	0.32	0.047	0.102	0.015
1,986	8.75	6.38	0.782	0.10	0.012	0.031	0.004
2,310	8.75	8.97	6.38	0.09	0.062	0.028	0.020
2,470	8.75	5.15	3.04	0.10	0.059	0.032	0.019
2,720	8.75	25*	50	0	0	0	0

*Response times greater than 10 seconds are below the instrument's calibration range.
gpm = gallons per minute
ft = feet

The chemistry logging tool was configured to measure the fluid parameters of temperature, electrical conductance (EC), and pH. A static water level of 535.15 ft bgs was measured with the EC sensor. A summary of the chemistry log is presented in Table D−2.

Table D−2. Chemistry Log Summary at Well HTH-1 (data collected September 7, 2007)

	Minimum	Maximum	Range
Depth (ft bgs)	535.6	2824.9	2289.3
Temperature (°C)	19.32	41.33	22.01
EC (µS/cm @ 25°C)	569.5	772.6	203.1
pH (SU)	7.93	8.84	0.91

ft bgs = feet below ground surface
°C = degrees Celsius
SU = standard units
µS/cm = microsiemens per centimeter

Groundwater samples were bailed from selected depths in the well using a sealed discrete sampler. The sampler was decontaminated before each sample was collected by rinsing the sample barrel, water inlet piston chamber, and water outlet with deionized water. Using data from previous chemical monitoring, three different depths (775, 2,250, and 2,675 ft bgs) were targeted for sampling because they were expected to coincide with three distinct chemical zones. The concentrations of major cations and anions in these samples were similar to those in corresponding samples previously collected from the respective depths (Table D−3).

D4.0 Comparison with Historic Measurements

The chemistry logging results from this field program were similar to results from previous logging activities. Temperatures varied the least between this field program and previous ones. The water temperature above 825 ft bgs was warmer during this field logging event than it has been in the past. The cause of this warming is unknown.

Distinct deviations from the geothermal gradient have persisted at well HTH-1 since 1993. As seen in Figure D−2, clear changes in the temperature gradient have always been observed at approximately 825 and 2,410 ft bgs. These deviations are generally indicative of water flowing into the well at the lower of the two depths, then flowing upward and exiting the well at the upper depths.

EC logs taken in 2007 were similar to comparable logs dating back to as early as 1993 (Figure D−3). A subtle change in the EC log was observed at 2,410 ft bgs, and larger changes were observed at 2,650 and 2,735 ft bgs.

Distinct variations in the rate of change of pH with depth were observed in 2007 at depths of 840 and 2,410 ft bgs (Figure D−4). In 1993 and 1997, a significant increase in pH was observed between approximately 2,130 to 2,410 ft bgs. For unknown reasons, this increase was not observed during chemical logging in 1995 and the most recent logging in 2007.

Since 1993, thermal results from TFM logs have consistently indicated upward vertical flow within HTH-1, and upward flow was again detected in 2007. Flow was also previously observed below the lowest accessible perforation in the well, but no such flow was measured during this field investigation (Figure D−5). Vertical flow rates observed during the logging in 2007 were approximately half of the rates previously observed.

There are two potential explanations for the reduced flow rate measurements. First, the previously described collection of debris on the TFM heat grid may have reduced the water flow through the logging tool. Second, all previous TFM measurements were performed with a packer, while the measurements made during this field effort were made with a rubber peddle flow diverter. The packer diverts nearly 100 percent of the vertical flow through the logging tool, whereas the rubber peddle diverter has some inherent leakage, thereby diverting less flow through the logging tool.

Table D−3. Chemical and Isotopic Analyses of Groundwater Samples From Well HTH-1 at the Faultless Site. All units are mg/L unless noted otherwise.

Well	Depth (ft)	Date	T (ºC)	pH[a] (S.U.)	EC[a] (µS/cm)	SiO_2	Ca	Mg	Na	K	Cl	SO_4	HCO_3[a]	CO_3	NO_3	F	$d^{18}O$ (‰)	dD (‰)	^3H (pCi/L)
HTH–1	600	11/14/1993																	<10
HTH–1	775	7/28/1992	23	8.23/8.40	536/545	55.4	3.28	0.1	126	1.52	16.7	33.5	189/238	4.1	<.04	9.4	–15.4	–117	214±7
HTH–1	775	11/14/1993																	<10
HTH–1	775	9/7/1994																	<10
HTH–1	775	10/21/1997																	<5
HTH–1	775	9/7/2007		8.38	560	56.2	3.65	0.10	122	1.30	16.4	34.6	237	3.9	<.01	10.6			
HTH–1	899	11/14/1993																	<10
HTH–1	1050	7/28/1992	26	8.35/8.31	519/539	56	3.1	0.07	125	1.39	16.8	33.4	217/243	0.6	<.04	10.4	–15.4	–117	33±1
HTH–1	1050	11/14/1993																	<10
HTH–1	1450	7/28/1992	26	8.38/8.30	542/542	56.5	3.53	0.07	125	1.37	16.8	33.5	211/244	0.4	<.04	10.4	–15.4	–117	
HTH–1	1644	11/14/1993																	<10
HTH–1	1690	7/28/1992	26	8.27/8.43	516/546	57.5	4.51	0.09	125	1.37	16.8	33.4	220/238	4.7	<.04	10.5	–15.4	–117	
HTH–1	1895	7/28/1992	25	8.34/8.32	524/540	56.8	3.22	0.07	127	1.37	16.8	33.1	211/242	0.9	<.04	10.5	–15.4	–118	
HTH–1	2250	7/28/1992	24	8.44/8.40	516/543	57.1	3.06	0.05	125	1.42	17	33.5	226/237	3.6	<.04	10.5	–15.5	–118	
HTH–1	2250	9/7/2007		8.35	553	57.7	3.80	0.08	124	1.21	16.3	34.8	242	1.8	<.01	10.6			
HTH–1	2430	7/29/1992	24.5	8.25/8.27	509/548	64.3	2.95	0.06	128	1.55	18.2	33.4	199/247		<.04	9.4	–15.4	–118	<10
HTH–1	2431	10/21/1997		8.4	547	67.1	2.77	<0.1	124	1.41	17.2	34.6	240	3	<0.04				<5
HTH–1	2675	7/29/1992	26.5	8.15/8.24	508/561	66.2	2.93	0.07	129	1.55	19.1	34.5	205/249		<.04	10.4	–15.5	–118	
HTH–1	2675	9/7/2007		8.22	560	65.1	3.49	0.08	125	1.31	17.7	35.8	248		<.01	10.2			
HTH–1	2799	5/20/1993		8.17	588	68.4	3	0.1	134	2.16	21.4	38.9	261		<.04				
HTH-1	2799	10/21/1997		8.29	593	69.9	2.9	<0.1	136	1.54	20.5	36.2	260	1.1	<0.04				<5

[a]The first number is a measurement in the field at the time of sample collection. The second number is a laboratory measurement. If there is only one number, it is a laboratory measurement.

ft = ft
T = temperature
°C = degrees Celsius
S.U. = standard units
EC = electrical conductance
(µS/cm) = microsiemens per centimeter

SiO_2 = silicon dioxide
Ca = calcium
Mg = magnesium
Na = sodium
K = potassium
Cl = chlorine

SO_4 = sulfate
HCO_3[a] = bicarbonate ion
CO_3 = carbon trioxide
NO_3 = nitrate ion
F = fluorine
$d^{18}O$ = 180/160 isotope composition relative SMOW

dD = 2h/1h isotope composition relative SMOW
^3H = tritium
pCi/L = picocuries per liter
SMOW = standard mean ocean water

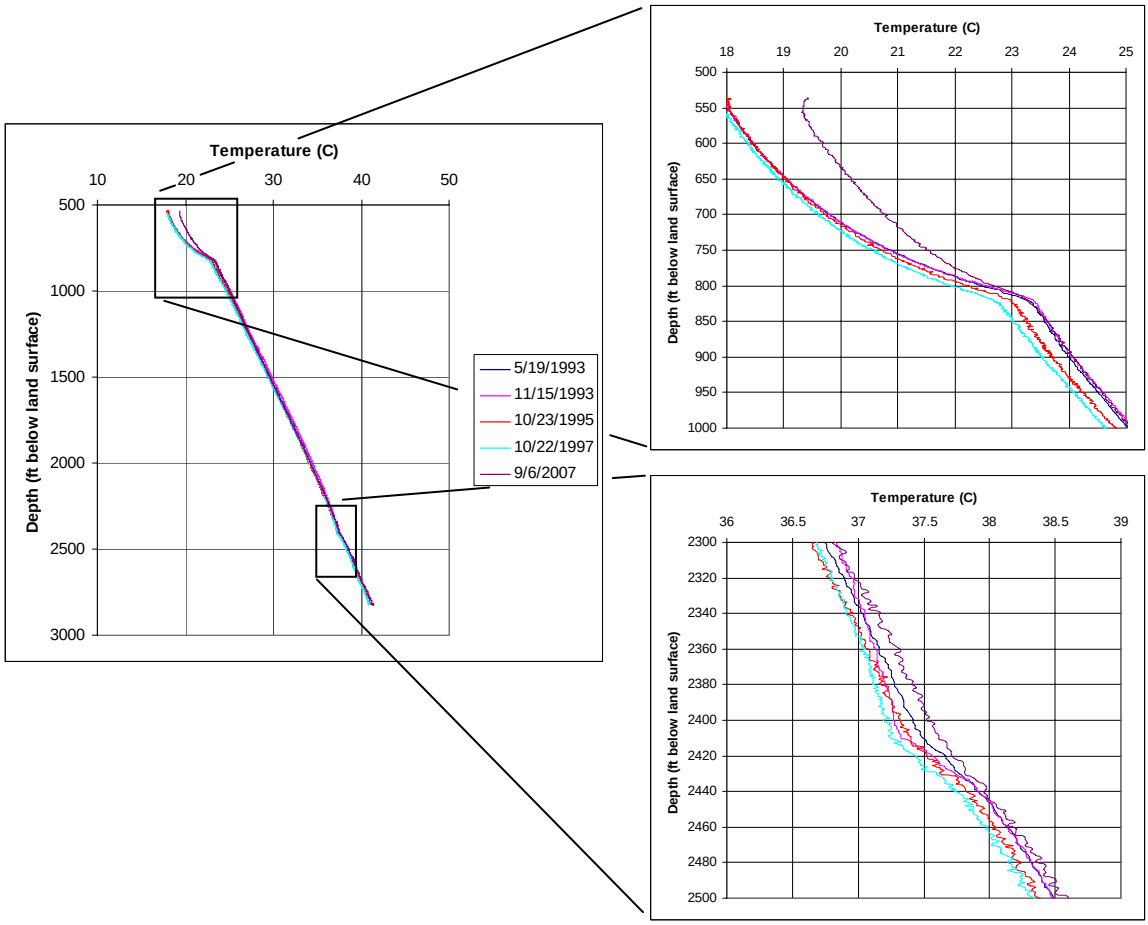


Figure D−2. Well HTH-1 Temperature Logs Since 1993

The chemistry of groundwater collected from each of the three sampled horizons during 2007 was a sodium-potassium-bicarbonate type, similar to the water collected at HTH-1 during previous field investigations and to water sampled from volcanic aquifers in the area (Figure D−6). Note that the upper two samples from the 2007 investigation, from depths of 775 and 2,250 ft bgs, respectively, were collected at horizons where the well is perforated in the alluvium. However, the water in these samples was not a calcium-bicarbonate type, which is characteristic of groundwater in alluvium, as sampled at nearby well HTH-2. This finding supports the flow logging interpretation that water throughout the HTH-1 wellbore originates in the volcanic units and flows upward through the well.

In summary, temperature logs in well HTH-1 have not changed substantially over the past 15 years, and the EC, pH, and chemistry of water in the well have remained relatively similar during the same period. Given the potential for TFM logs during this most recent field investigation to undermeasure vertical flow in the well, the flow rates resulting from TFM logging should be viewed as conservatively low. Actual flow rates are likely to be as high as previously measured.

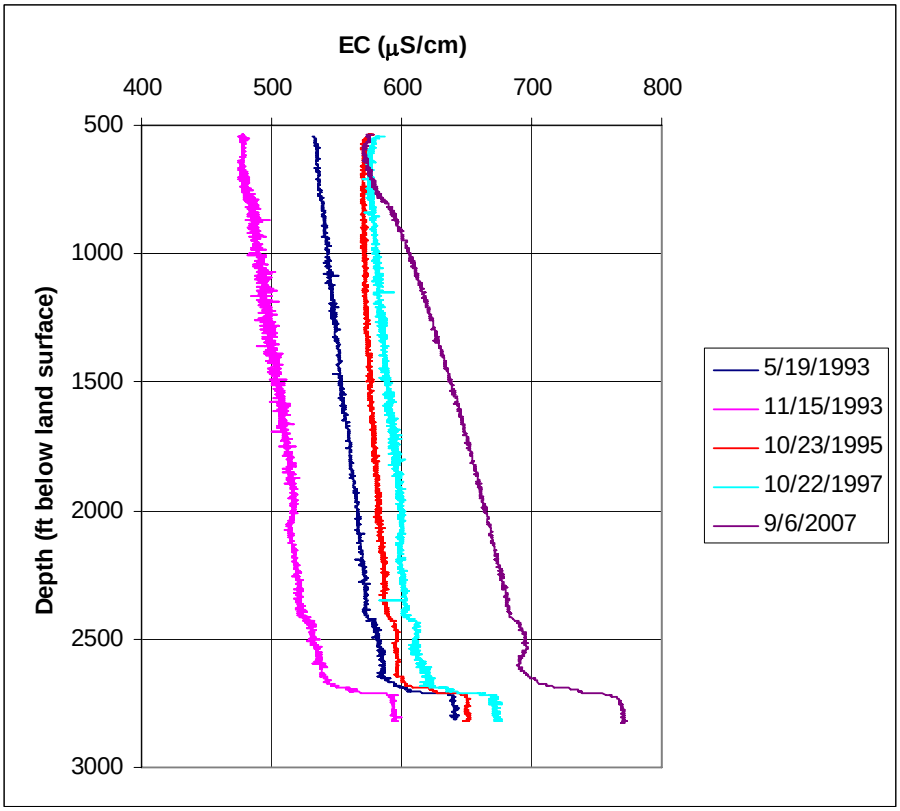


Figure D−3. Well HTH-1 EC Logs Since 1993.

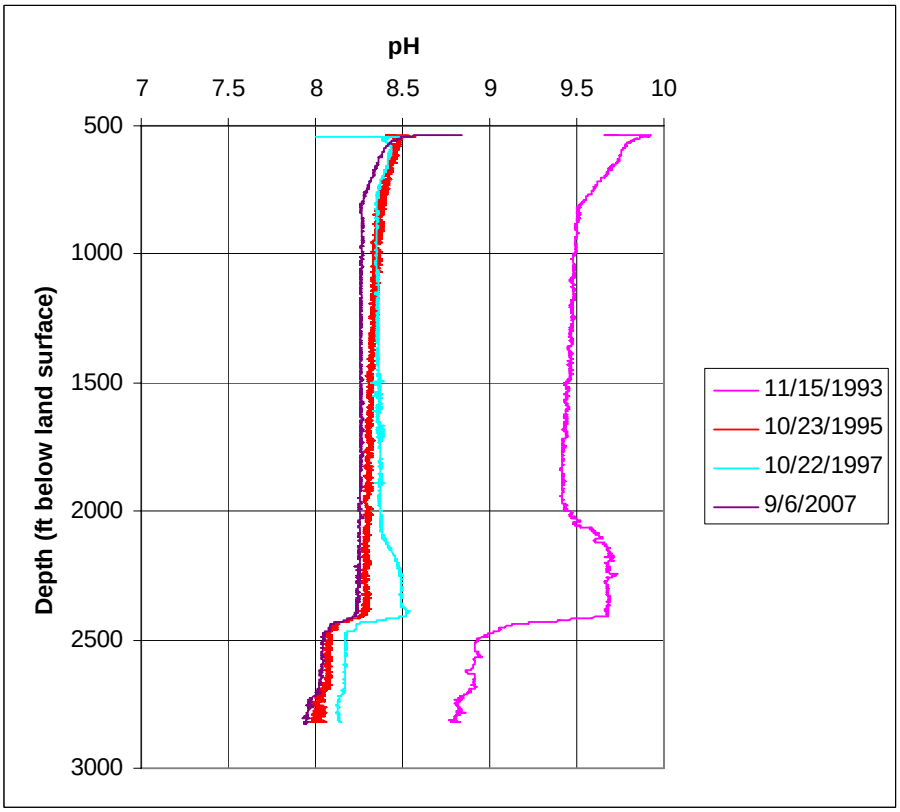


Figure D−4. Well HTH-1 pH Logs Since 1993 to 2007.

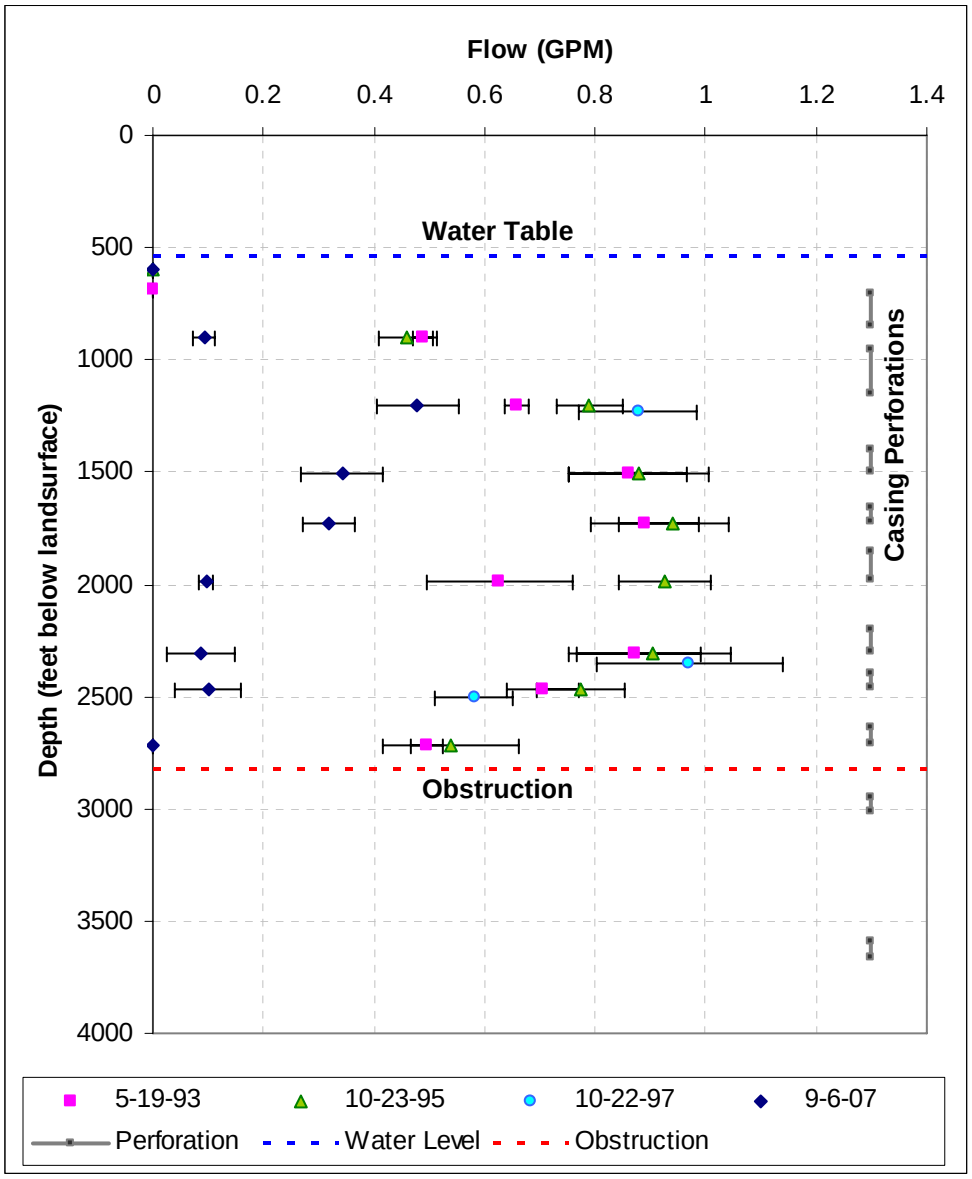


Figure D−5. Vertical flow rates measured at well HTH-1 since 1993. Vertical flow is in units of gallons per minute. Dots represent mean flow rates, and whiskers represent flow measurement standard deviation. The blue dashed line represents the static water level, the red-dashed line denotes an obstruction in the well, and the locations of well perforations are shown with vertical bars.

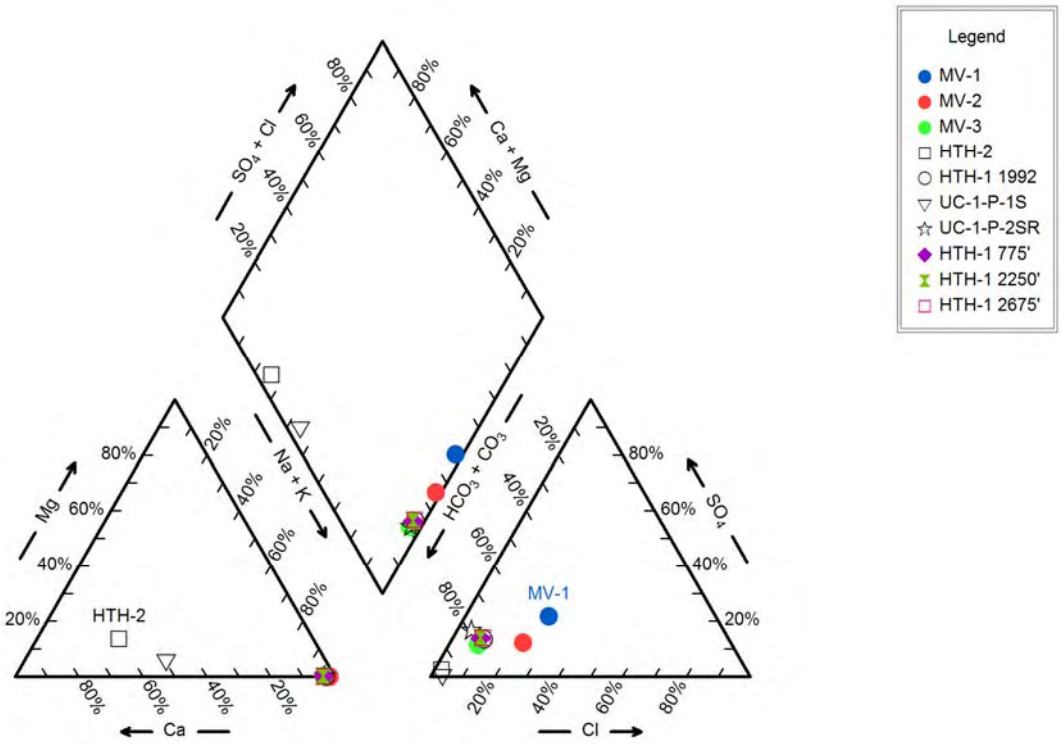


Figure D-6. Piper diagram showing the chemistry of groundwater collected from site wells. Note that the HTH-1 water chemistry in 2007 is virtually identical to the chemistry in a sample collected in 1992 at the well, and is similar to the chemistry observed in wells MV-3 and UC-1-P-2SR.

D5.0 References

Chapman, J.B., T. Mihevc, and B.F. Lyles, 1994. *The Application of Borehole Logging to Characterize the Hydrogeology of the Faultless Site, Central Nevada Test Area*, Desert Research Institute, Water Resources Center report #45119, DOE/NV/19845-35, 36p.

Dinwidde, G.A., and L.J. Schroder, 1971. *Summary of Hydraulic Testing in and Chemical Analyses of Water Samples From Deep Exploratory Holes in Little Fish Lake, Monitor, Hot Creek, and Little Smoky Valleys, Nevada*, U.S. Geological survey report USGS-474-90, 69p.

Lyles, B.F., 1994. "Increased Thermal-Pulse Flow Meter Resolution by Adding a Packer and Computer," *Groundwater Monitoring and Remediation*, Fall 1994: 191–199.

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

Appendix E

Proposed Engineering Specifications and Drawings for Additional Wells

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E1.0 Proposed Engineering Specifications and Drawings for Additional Wells

Two wells will be drilled as part of this amendment to the corrective action for CAU 443. Their proposed locations are shown on Figure 7 of the CADD/CAP addendum, and their working coordinates are given below (State Plane, Nevada Central, NAD27, feet).

MV-4: 29700, 1413200
MV-5: 30500, 1413850

The final locations may differ somewhat due to site considerations during well-pad construction and the final results of the seismic data interpretation.

The pre-drill plan is to install a well and piezometer at each location within the same borehole. The well will be screened in the lower alluvium. A piezometer placed in the annular space of each well will monitor hydraulic head in the upper alluvium, allowing the vertical gradient within the alluvium to be determined at each location (Figure E−1).

Well HTH-1 currently has multiple perforations that extend from the upper alluvium to the total depth of the well. It will be recompleted so that it is only open to the volcanic section (Figure E−2).

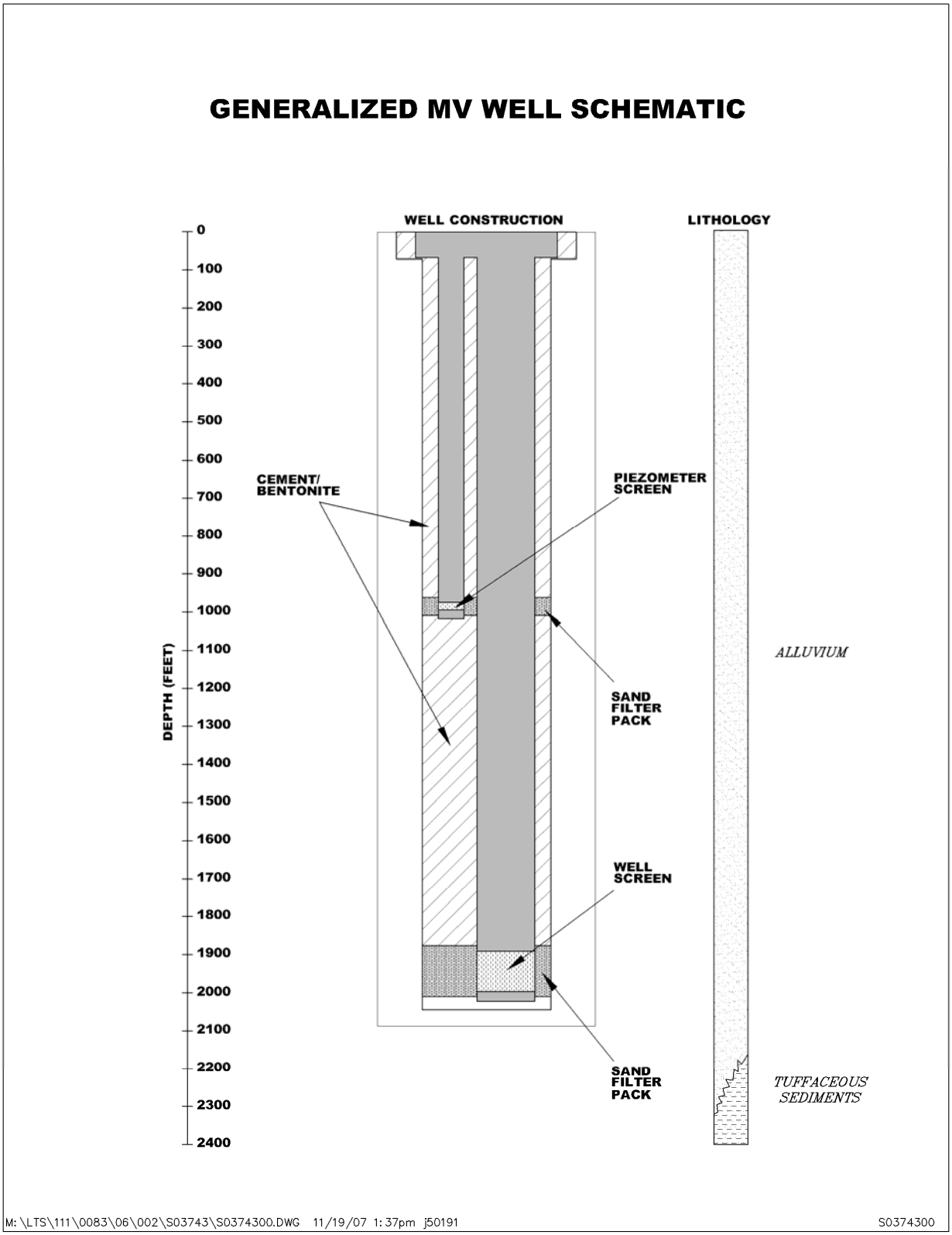

Figure E−1. Generalized MV Well Schematic.

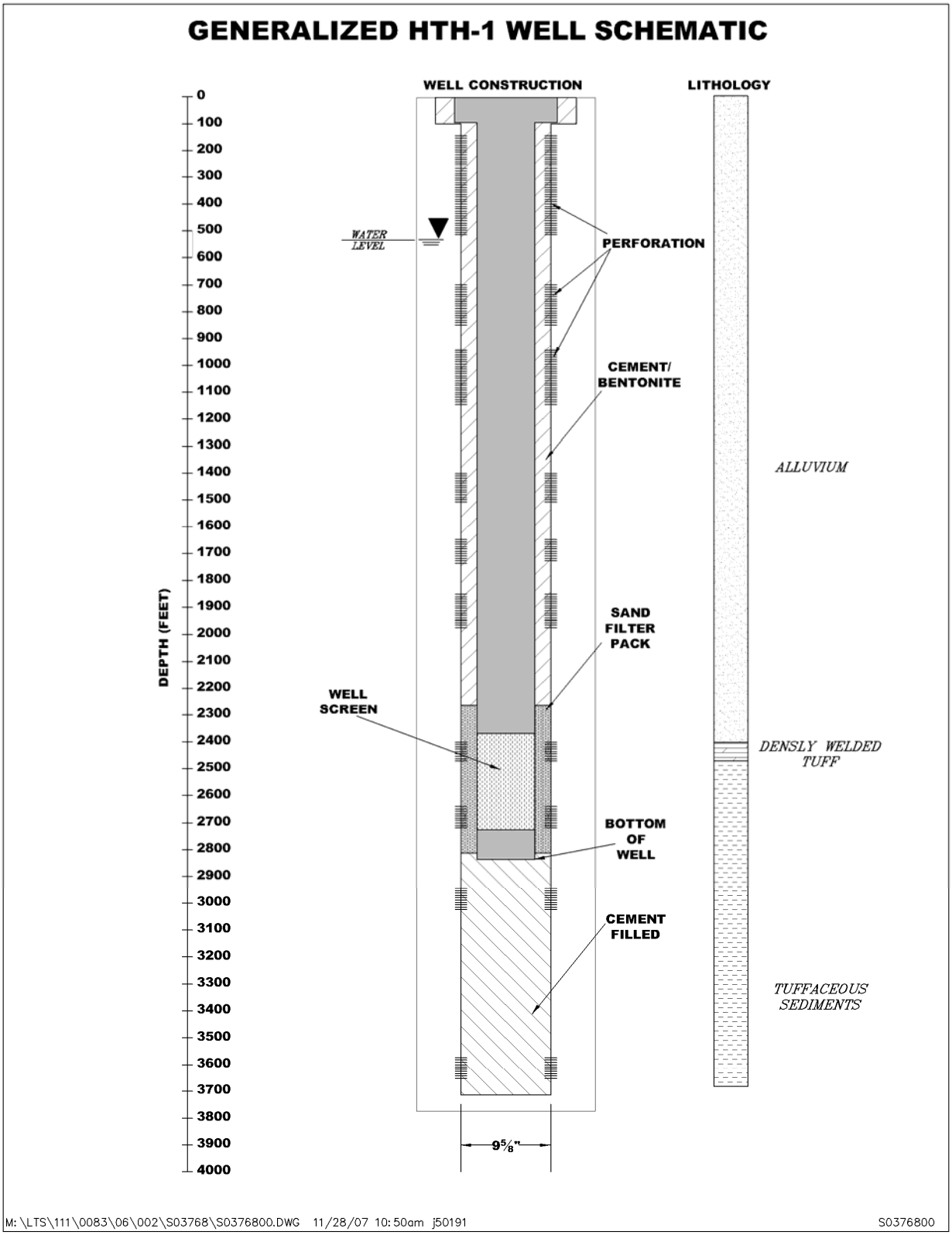

Figure E−2. Generalized HTH-1 Well Schematic.

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Appendix F

Comments from NDEP and DOE responses

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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

Jim Gibbons, Governor
Allen Biaggi, Director
Leo M. Drozdoff, P.E., Administrator

December 7, 2007

Mr. Mark Kautsky
Site Manager
U.S. Department of Energy
Office of Legacy Management
2597 B ¾ Road
Grand Junction, CO 81503

RE: 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, November 2007 Federal Facility Agreement and Consent Order

Dear Mr. Kautsky:

The Nevada Division of Environmental Protection, Bureau of Federal Facilities (NDEP) received the U.S. Department of Energy, Office of Legacy Management's Addendum to the 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, November 2007 (document) on November 30, 2007. Following review of this document, the NDEP has the following comments:

1. The NDEP looks forward to receiving the report detailing the results of the five seismic reflection profiles acquired in October 2007 at the CNTA and referred to in Section 5.6.3 of the document.

2. Section 5.6.5, Fourth Paragraph – It is stated that "the quality requirement for the CAP Proof of Concept Monitoring will be the required detection limits as provided in Table 6 of the CADD/CAP." There is no Table 6 in the CADD/CAP. It is possible that the correct reference is Table 2-3 of the CADD/CAP.

3. Figure 8 – This Figure lists the date for submittal of the Final CNTA CADD/CAP to NDEP as January 31, 2008. However, a November 9, 2007 letter from the NDEP to Mr. Jack Craig established the Milestone Deadline for Corrective Action Unit 443, Central Nevada Test Area – Subsurface Final CADD/CAP Addendum as January 11, 2008. Should the U.S. Department of Energy/Office of Legacy Management require an extension to this Milestone Deadline of January 11, 2008, such a request must be made of the NDEP pursuant to Subpart X.1 of the Federal Facility Agreement and Consent Order (FFACO).

4. Table D-1 and Table D-2: Dates that the presented data were collected should be included in either the Table Titles or the Tables.

If you have questions regarding this matter, please contact Chris Andres of my staff at (702) 486-2850, ext. 232. The NDEP looks forward to receiving the seismic survey results and the Final Addendum.

Sincerely,

T. H. Murphy
Chief
Bureau of Federal Facilities

EAJ/MM/CDA

cc: D. C. Loewer, DTRA/CXT1, M/S 645, Mercury, NV
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Department of Energy
Office of Legacy Management

JAN 0 3 2008

Tim Murphy, Chief
Bureau of Federal Facilities
Division of Environmental Protection
2030 E. Flamingo Road, Suite 230
Las Vegas, NV 89119-0818

Subject: Response to comments on the Addendum to the Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 443, dated November 2007

Dear Mr. Murphy:

The U.S. Department of Energy Office of Legacy Management (DOE-LM) is providing responses to comments from the Nevada Division of Environmental Protection (NDEP) on the Addendum to the Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for Corrective Action Unit 443, dated November 2007. The comments were received in a letter from the NDEP dated December 7, 2007. These comments and DOE-LM responses to comments will be included in Appendix F of the final Addendum to the CADD/CAP.

Responses to comments are provided below:

1. Boise State will be providing a draft report of the seismic survey results in late January 2008. Preliminary seismic results appear to confirm the locations of the proposed alluvial wells shown in Figure 7 of the addendum document. The DOE-LM will provide a copy of the final seismic survey report when received.

2. The correct reference should be to Table 5-1 of the CADD/CAP. The change will be made.

3. The schedule was developed prior to the letter that requested the extension until January 11, 2008. Thanks to the rapid turnaround of comments from NDEP, the addendum will be final prior to the January 11, 2008 deadline. A new schedule with the revised dates will be included in the final addendum.

4. The data presented in Tables D-1 and D-2 were collected on September 6 and 7, 2007. The dates will be added to the table captions.

Please contact me at (970) 248-6018 if you have any questions.

Sincerely,

Mark Kautsky

Mark Kautsky
Site Manager

JAN 0 3 2008

cc:
C. D. Andres, NDEP, Las Vegas, NV
E. F. Di Sanza, WMP, NNSA/NSO, Las Vegas, NV
D. R. Elle, NDEP, Las Vegas, NV
FFACO Group, SNJV, Las Vegas, NV
W. R. Griffin, SNJV/DTRA, M/S 645, Mercury, NV
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D. C. Loewer, DTRA/CXT1, M/S 645, Mercury, NV
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