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Central Nevada Test Area Monitoring Report

prepared by

Brad Lyles, Jenny Chapman, John Healey and David Gillespie

submitted to

Nevada Site Office
National Nuclear Security Administration
U.S. Department of Energy
Las Vegas, Nevada

September 2006

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ABSTRACT

Water level measurements were performed and water samples collected from the Central Nevada Test Area model validation wells in September 2006. Hydraulic head measurements were compared to previous observations; the MV wells showed slight recovery from the drilling and testing operation in 2005. No radioisotopes exceeded limits set in the Corrective Action Decision Document/Corrective Action Plan, and no significant trends were observed when compared to previous analyses.

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CADD	Corrective Action Decision Document
CAIP	Corrective Action Investigation Plan
CAP	Corrective Action Plan
CNTA	Central Nevada Test Area
DOE	U.S. Department of Energy
EM	Environmental Management
FFACO	Federal Facility Agreement and Consent Order
MV	monitoring-validation
NDEP	Nevada Division of Environmental Protection

INTRODUCTION

The Central Nevada Test Area (CNTA) was created to provide a supplemental site for underground nuclear tests that could not be conducted at the Nevada Test Site because of ground motion potential in Las Vegas high-rise buildings. One nuclear test was performed at CNTA: the Faultless test, in January 1968, at a depth of 975 m below land surface. The CNTA was decommissioned as a testing facility in 1973. Activities over the following decades were focused on groundwater monitoring through the Long-term Hydrologic Monitoring Program, operated by the U.S. Environmental Protection Agency.

In the late 1980s, the U.S. Department of Energy (DOE) established an Environmental Management (EM) program to systematically evaluate and remediate locations affected by Cold War activities. For locations in the state of Nevada, EM activities are performed in accordance with a Federal Facility Agreement and Consent Order (FFACO) between DOE, the U.S. Department of Defense, and the State of Nevada (FFACO, 1996). The FFACO prescribes a Corrective Action Strategy for underground nuclear test locations.

For CNTA, the first step in the Corrective Action Strategy was approval of the Corrective Action Investigation Plan (CAIP; DOE, 1999). There were three principal parts to the investigation: collecting data, modeling groundwater flow and contaminant transport, and assessing uncertainty through a Data Decision Analysis. The ultimate objective was development of a contaminant boundary encompassing radionuclide migration through a 1,000-year time period. The investigation primarily relied on information obtained during the nuclear testing time period; new data collection was limited to measurement of water levels and laboratory sorption experiments.

A Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) presented the results of the investigation, the calculated contaminant boundary, a negotiated compliance boundary, and a plan for model validation and monitoring (DOE, 2004). The CADD/CAP required drilling three new boreholes around the Faultless test, and installing monitoring wells and piezometers. The boreholes dictated by the CADD/CAP were drilled during spring and summer 2005, and represent the first major subsurface field activity at CNTA since site decommissioning. Drilling and well construction activities are recorded in a well installation report (DOE, 2006). Aquifer testing and additional data collection and analysis are presented in Lyles *et al.* (2006).

The DOE (2006) and Lyles *et al.* (2006) reports fulfill the CADD/CAP requirement for an initial report to Nevada Division of Environmental Protection (NDEP) discussing findings resulting from drilling, well completion, and well development. An annual reporting frequency is identified after the initial report to provide NDEP with data regarding the analytes and parameters specified for the CNTA subsurface monitoring program. This report is the first of these annual reports.

OBJECTIVES FOR THE MONITORING

The objectives of subsurface monitoring at CNTA are to determine compliance with the CAU 443 compliance boundary in terms of contaminant concentrations, and to monitor the hydraulic system relative to the steady-state assumption of the boundary. Three wells are included in the monitoring network for CAU 443. One of these, MV-3, has a primary function for detection monitoring, while the other two (MV-1 and MV-2) have system monitoring as their primary function. Despite their different focus, all of the wells will be monitored for hydraulic head and will also have groundwater samples collected for radionuclide analysis.

Analysis of the flow and transport model results indicated that the optimum monitoring well location is due north of ground zero at a depth of 1,075 m (100 m below the working point) (Hassan, 2003). This is the approximate location of MV-3. Hydraulic head is monitored to ensure that the groundwater system continues to behave as predicted in the modeling. As a result, wells are located to the northeast (MV-1) and west (MV-2 of ground zero (in addition to due north) to laterally distribute head measurements; and two piezometers are located in each borehole to distribute head measurements vertically.

SITE LOCATION AND GENERAL GEOLOGIC SETTING

The CNTA is in south-central Nevada in Hot Creek Valley (Figure 1). Hot Creek Valley extends approximately 110 km (70 miles) between north-south-oriented mountain ranges, with the valley width ranging between 8 and 32 km (5 and 20 miles). West of the valley is the Hot Creek Range, rising to a maximum elevation of 3,100 m (10,200 ft) at Morey Peak. The valley floor elevation varies from 1,575 to 1,830 m (5,180 to 6,000 ft). The Faultless site within CNTA is on the western alluvial fan at an elevation of approximately 1,860 m (6,100 ft). Hot Creek Valley drains southeastward to Railroad Valley in the vicinity of Twin Springs Ranch, though there is little streamflow on the valley floor except during periods of heavy runoff from the mountain streams.

BOREHOLE AND WELL LOCATIONS

Existing wells and the MV well locations are listed in Table 1. Elevation measurements are to the top of the casing for all wells, except for those listed as “CONC,” which is the top of the concrete; the top of concrete is defined as land surface. Water level elevations are measured with respect to a land surface datum.

The MV wells were drilled and completed as prescribed by the CADD/CAP. Each of the MV wells has a primary well string (designated by a “W” on Table 1) completed within a densely welded tuff and outfitted with a submersible pump. In addition, the wells were constructed with two piezometers: one screened in the alluvium (designated by a “U” in Table 1) and one screened in the volcanic section (designated by an “L” in Table 1). Details regarding the drilling and construction of the MV wells can be found in the CNTA well installation report (DOE, 2006).

The MV wells are generally within 0.8 km (0.5 mi) of well UC-1, nuclear emplacement well (Figure 2); well MV-1 is generally northeast of UC-1, well MV-2 is generally west of UC-1, and well MV-3 is north of UC-1. A photograph of the study area was annotated to show the general location of the CNTA MV wells from the main dirt access road to the site (Figure 3).

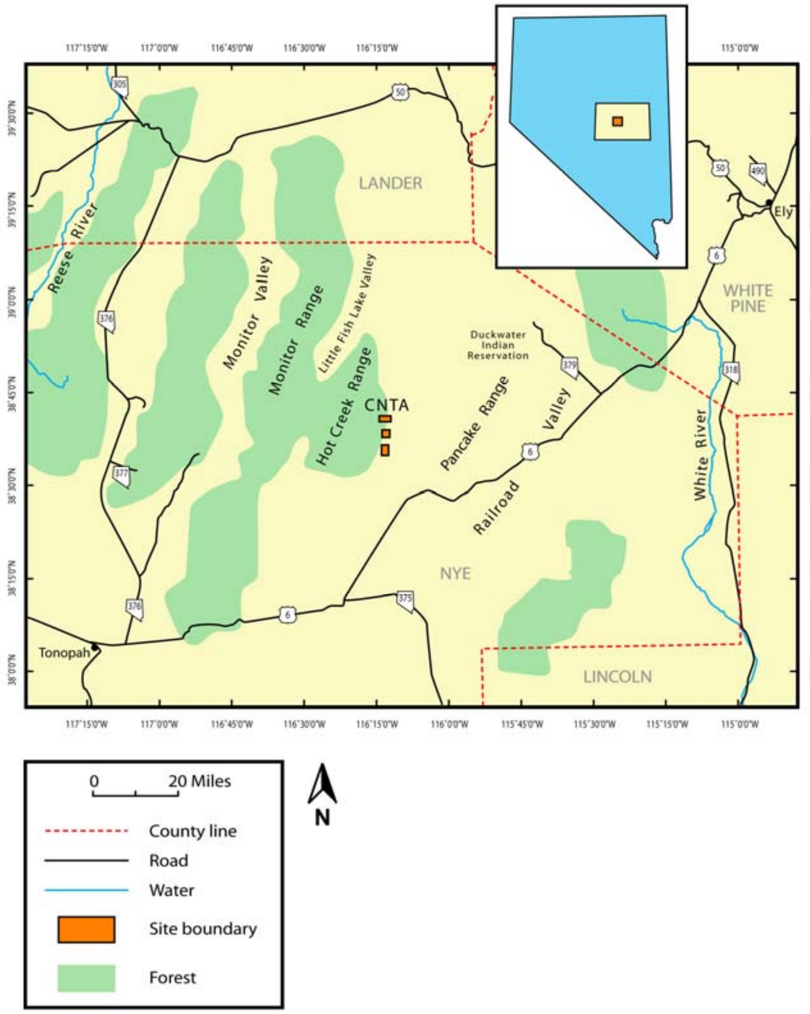

Figure 1. Location of the Central Nevada Test Area in Hot Creek Valley, Nevada.

Table 1. CNTA well location coordinates (UTM-Zone 11, NAD 27, NAVD 29) in meters.

Station	Northing	Easting	Elevation
MV-1 CONC	4277003.27	568977.45	1,849.89
MV-1 W	4277003.05	568977.31	1,850.12
MV-1 L	4277002.93	568977.35	1,850.11
MV-1 U	4277002.86	568977.56	1,850.13
MV-2 CONC	4275787.57	567575.03	1,886.64
MV-2 W	4275787.44	567574.96	1,886.85
MV-2 L	4275787.50	567574.88	1,886.84
MV-2 U	4275787.33	567575.30	1,866.92
MV-3 CONC	4276956.42	568260.47	1,879.70
MV-3 W	4276956.30	568260.56	1,879.90
MV-3 L	4276956.36	568260.66	1,879.89
MV-3 U	4276956.48	568260.83	1,879.91

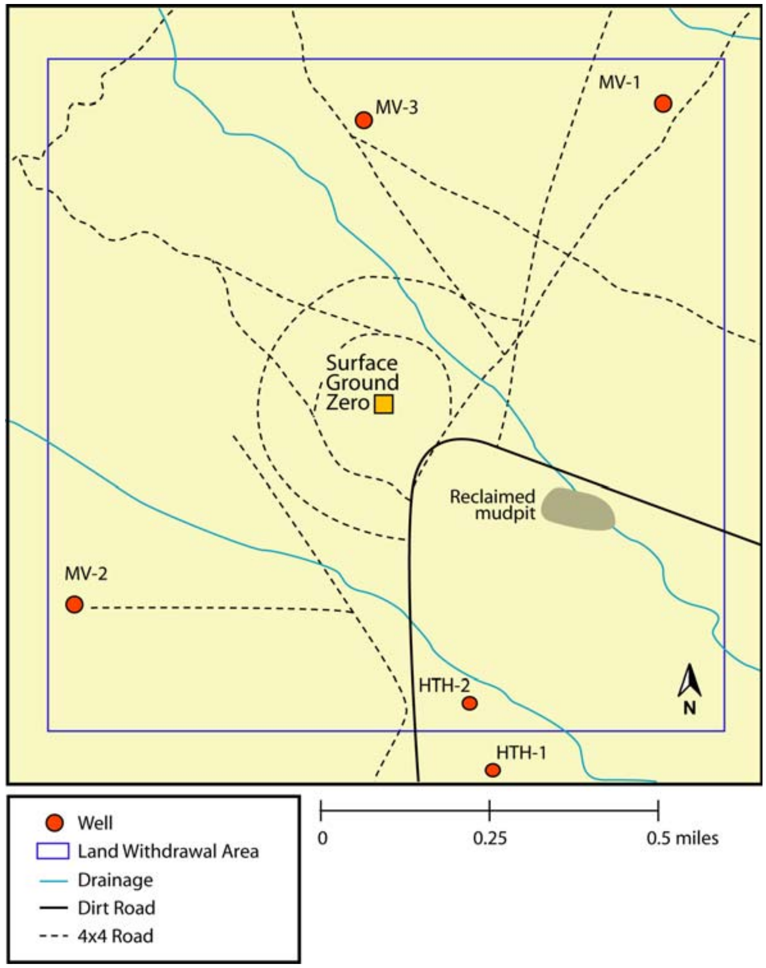

Figure 2. Location of boreholes near the Faultless underground nuclear test.

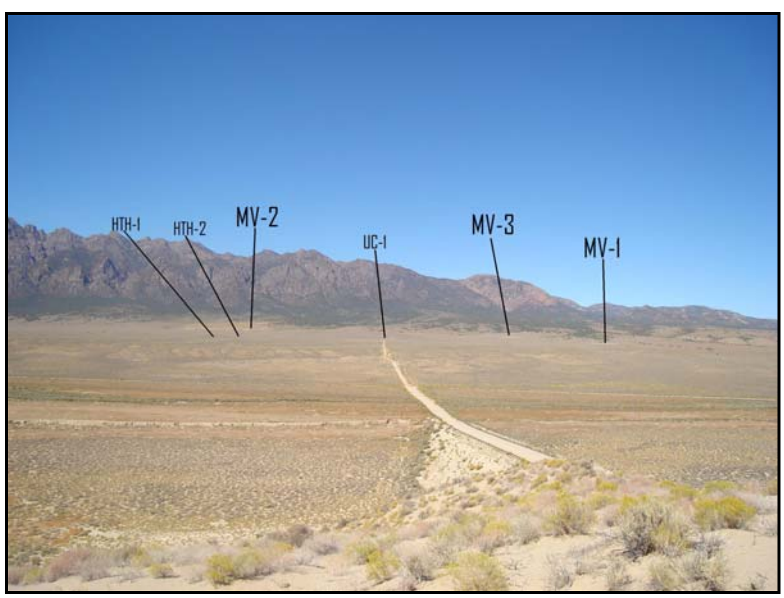

Figure 3. Photograph of the CNTA MV wells; view toward the west along the main access road to the site from Nevada Highway 6.

Well Purge Methods

A sample and analysis plan was developed for the CNTA to guide the use of standard operating procedures to assure quality assurance / quality control of the monitoring program. Radioisotopic analyses of carbon, iodine, and hydrogen were performed on water samples collected from the MV main wells, via submersible pumps. Well purging is the process where a prescribed volume of water is removed from the well prior to samples of that water being collected. The purging process is intended to remove water impacted by the well bore environment and to acquire water that is representative of water within the adjacent geologic formation. DOE (2004) states that a purge volume consists of at least one well volume. Purge volumes are calculated according to the DRI Standard Operating Procedure for Well Purging and Collecting Groundwater Samples (DRI SOP.WPGS). The purge volumes for wells MV-1, MV-2, and MV-3 consist of 14,702, 12,066, and 14,770 liters (L) (3,884, 3,188, and 3,902 gallons [gal]) respectively. In addition to the minimum purge volume, it is required that water quality parameters, consisting of electrical conductivity (EC), temperature, and hydrogen ion activity (pH) of the discharge stabilize prior to samples being collected.

Due to the low production rates from wells MV-1 and MV-3, it is not possible to pump well volumes; therefore, a modified procedure is used to collect representative water samples from these wells. Wells MV-1 and MV-3 are equipped with Grudfos submersible pumps; the pump intakes are set within 15 m (50 ft) of the top of the well screen, but the pumps are only capable of lifting approximately 518 m (1,700 ft) of head (well schematics are included in Appendix A). Due to the low yield of these wells, MV-1 pumps for about 2 hours and yields approximately 4,100 L (1,100 gal) before the pump controller shuts off the pump; similarly, MV-3 can be pumped for about 2.5 hours and yields approximately 4,900 L (1,300 gal) before the pump is automatically turned off. Approximately one-third of this water is recovered overnight, based on hydraulic head measurements. Given the observed discharge rates versus time, it takes about 17 minutes to displace the pump column of stagnant water at MV-1 and about 19 minutes at MV-3. Therefore, the procedure used to purge and sample wells MV-1 and MV-3 is as follows: the first day, pump each well for 2 to 2.5 hours during the afternoon and allow the wells to recover overnight; the next day, pump the wells for 17 to 19 minutes to displace the pump column (monitor field parameters) and collect the samples.

MONITORING RESULTS

As described in the CNTA CADD/CAP, this monitoring program requires the annual measurement of four analytes: hydraulic head, and activities of carbon-14, iodine-129, and tritium. Baseline samples were collected from each MV well in March 2006 as part of the CNTA Drilling and Testing Program (Lyles *et al.*, 2006), and are included here as the starting point of this annual monitoring program.

Hydraulic Head

Hydraulic head measurements for 2006 are summarized in Table 2; water levels are still recovering from drilling, aquifer testing and sampling activities, as seen graphically for wells MV-1, MV-2 and MV-3 in Figures 4, 5, and 6, respectively. Generally speaking, the upper piezometers have changed little over the year and the main wells and lower piezometers are still recovering; it should be noted that the MV-2 upper piezometer was damaged during development and head measurements are highly suspect.

Table 2. CNTA MV well hydraulic head measurements for 2006.

Well Name	Date	Time	Head (m AMSL)
MV-1	6/22/2006	14:16	1,692.8
	9/19/2006	10:32	1,695.8
MV-1 Upper Piezometer	3/15/2006	13:32	1,753.2
	9/19/2006	10:46	1,753.4
MV-1 Lower Piezometer	3/15/2006	13:40	1,801.6
	9/19/2006	10:39	1,809.1
MV-2	3/14/2006	15:47	1,781.9
	9/19/2006	16:40	1,785.9
MV-2 Upper Piezometer	3/15/2006	9:26	1,776.9
	9/19/2006	17:02	1,761.9
MV-2 Lower Piezometer	3/15/2006	9:15	1,752.7
	9/19/2006	16:53	1,780.2
MV-3	3/14/2006	12:25	1,691.3
	9/18/2006	8:50	1,697.0
MV-3 Upper Piezometer	3/15/2006	10:05	1,766.8
	9/18/2006	9:30	1,766.9
MV-3 Lower Piezometer	3/15/2006	10:14	1,820.9
	9/18/2006	8:59	1,821.4

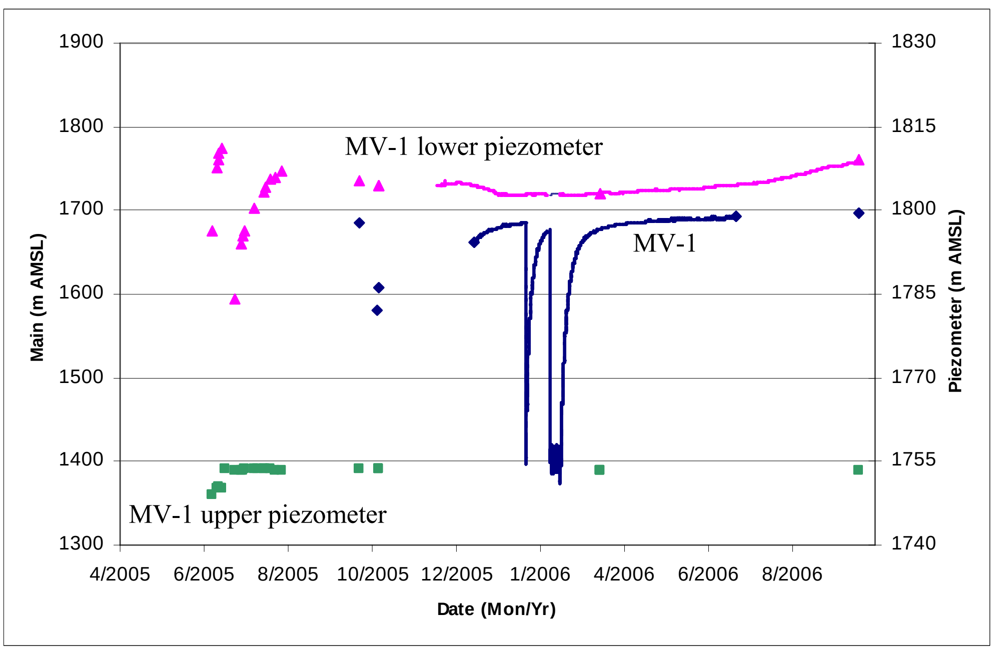

Figure 4. CNTA well MV-1 hydraulic head (meters above mean sea level) versus time (solid lines are from pressure transducer readings, periodic water level tags are shown with marker symbols: MV-1, diamond; MV-1 upper piezometer, square; and MV-1 lower piezometer, triangle).

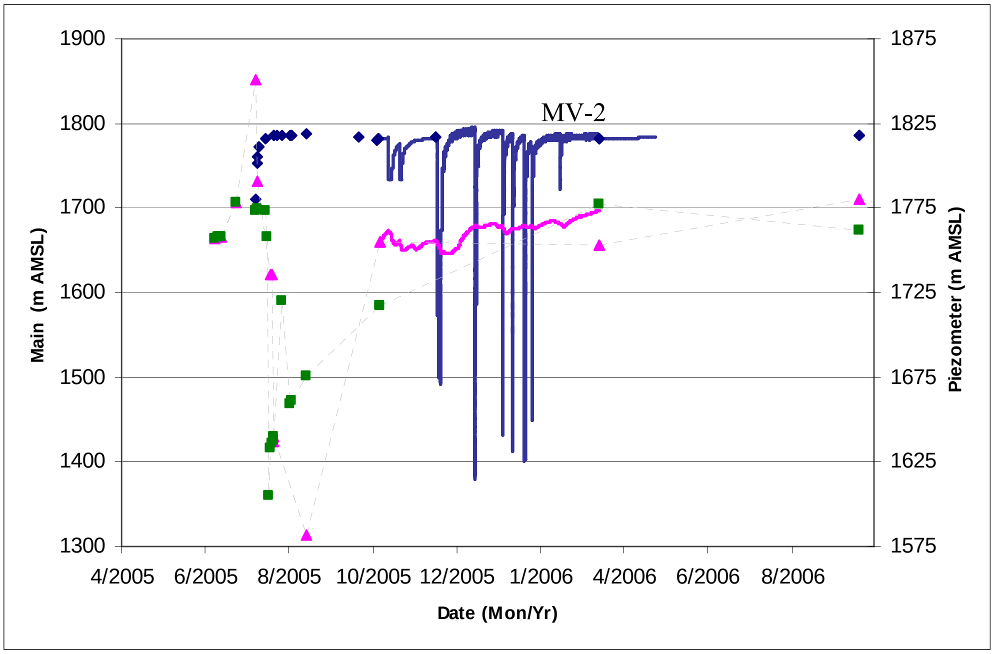

Figure 5. CNTA well MV-2 hydraulic head (meters above mean sea level) versus time (solid lines are from pressure transducer readings, periodic water level tags are shown with marker symbols: MV-2, diamond; MV-2 upper piezometer, square; and MV-2 lower piezometer, triangle).

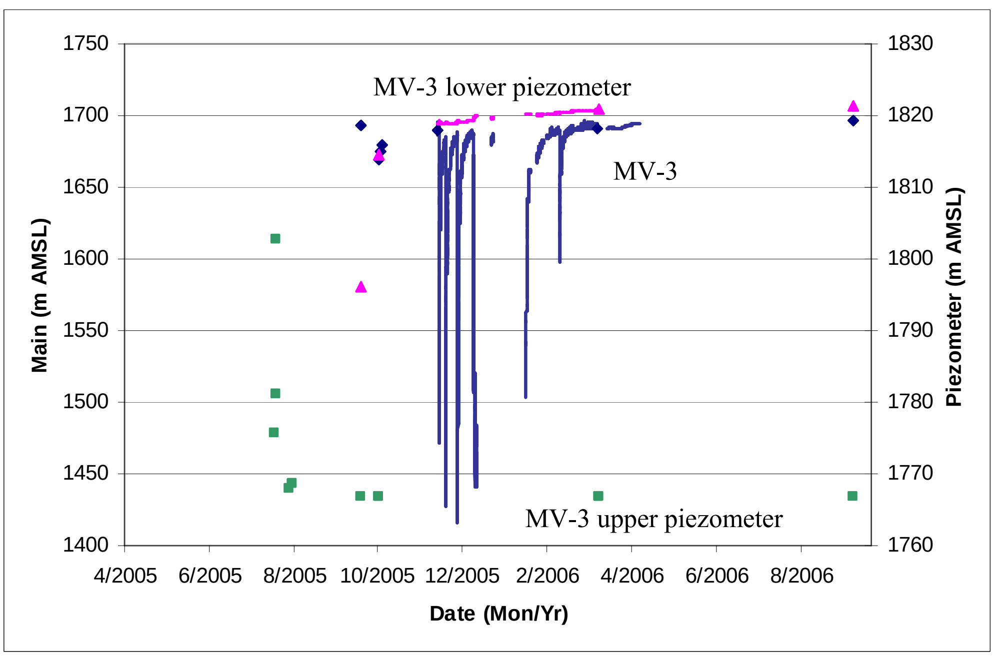

Figure 6. CNTA well MV-3 hydraulic head (meters above mean sea level) versus time (solid lines are from pressure transducer readings, periodic water level tags are shown with marker symbols: MV-3, diamond; MV-3 upper piezometer, square; and MV-3 lower piezometer, triangle).

Radioisotopic Results

The radiochemical monitoring analytes specified by the CNTA CADD-CAP are tritium, carbon-14, and iodine-129. Tritium is identified as the primary radiochemical analyte based on its mobility in groundwater, its abundance in the source term for the first hundred years, and the low detection limit available. Tritium has a relatively short half-life (12.3 years), and the CADD-CAP recognizes that longer-lived radionuclides will gain in importance during post-closure monitoring. Carbon-14 and iodine-129 are specified as long-lived radionuclides for the monitoring program because they are both important in defining the contaminant boundary (Pohll *et al.,* 2003). Although carbon-14 and iodine-129 are identified for later post-closure monitoring, the CADD-CAP suggests that data collected preclosure (during the proof-of-concept period) can be used to establish baseline conditions.

Safe Drinking Water Act (EPA, 2000) radionuclide limits equate to concentrations of 20,000 pCi/L for tritium, 2,000 pCi/L for carbon-14, and 1 pCi/L for iodine-129 (the limit is specified as 0.04 millisievert per year as the total annual dose equivalent to an organ or the whole body that cannot be exceeded from internal exposure to beta particle and photon radioactivity, requiring calculation of dose equivalents and assumptions of consumption rate for determining activity-concentration limits). The detection limits required in the CADD-CAP for the CNTA monitoring samples are 300 pCi/L for tritium, 5 pCi/L for carbon-14, and 0.1 pCi/L for iodine-129. The detection limit for tritium is well below the regulatory limit, but suitable for cost-effective nonenriched analysis. The low detection limits for carbon-14 and iodine-129 are specified during the proof-of-concept period to establish background conditions for comparison during post-closure monitoring.

The analytical results from the groundwater samples collected in February and March 2006 are all many orders of magnitude below the regulatory limits for tritium, carbon-14, and iodine-129 (Table 3). Quality assurance data, including replicate analyses, can be found in Appendix B. The tritium, carbon-14, and iodine-129 analyses for samples collected in September 2006 are comparable to the earlier results.

Table 3. CNTA MV well purge data and radiochemistry results.

Well Name	Date	Volume Pumped (L/gal)	Temp (ºC)	EC (µS)	pH	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
MV-1	2/14/2006	8,346/2,205	19	774	9.88	(1.12 ± 0.05)E-2	(1.5 ± 0.1)E-7	<3
	9/21/2006	4,243/1,121	22.5	1,019	9.55	(5.61 ± 0.10)E-2	(2.9 ± 0.4)E-7	<45
MV-2	3/16/2006	15,315/4,046	20.3	908	10.05	(9.92 ± 0.06)E-2	(2.6 ± 0.1)E-7	<3
	9/22/2006	11,772/3,110	21.5	1,097	10.38	(1.30 ± 0.06)E-2	(2.6 ± 0.3)E-7	<45
MV-3	3/16/2006	5,042/1,332	23	651	8.57	(3.95 ± 0.01)E-2	(2.1 ± 0.1)E-7	<3
	9/22/2006	5,303/1,401	22.8	653	8.66	(5.11 ± 0.01)E-2	(2.2 ± 0.3)E-7	<45

Monitoring Results Summary

During FY 2006, the hydraulic heads in the CNTA MV wells were still recovering from drilling, testing, and sampling activities. Based on the low hydraulic conductivities found in these wells, it may take several years for the heads to equilibrate. No radioactivity above background was detected in the CNTA MV wells, and no time-series trends were observed.

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APPENDIX A. Well Completion Diagrams.

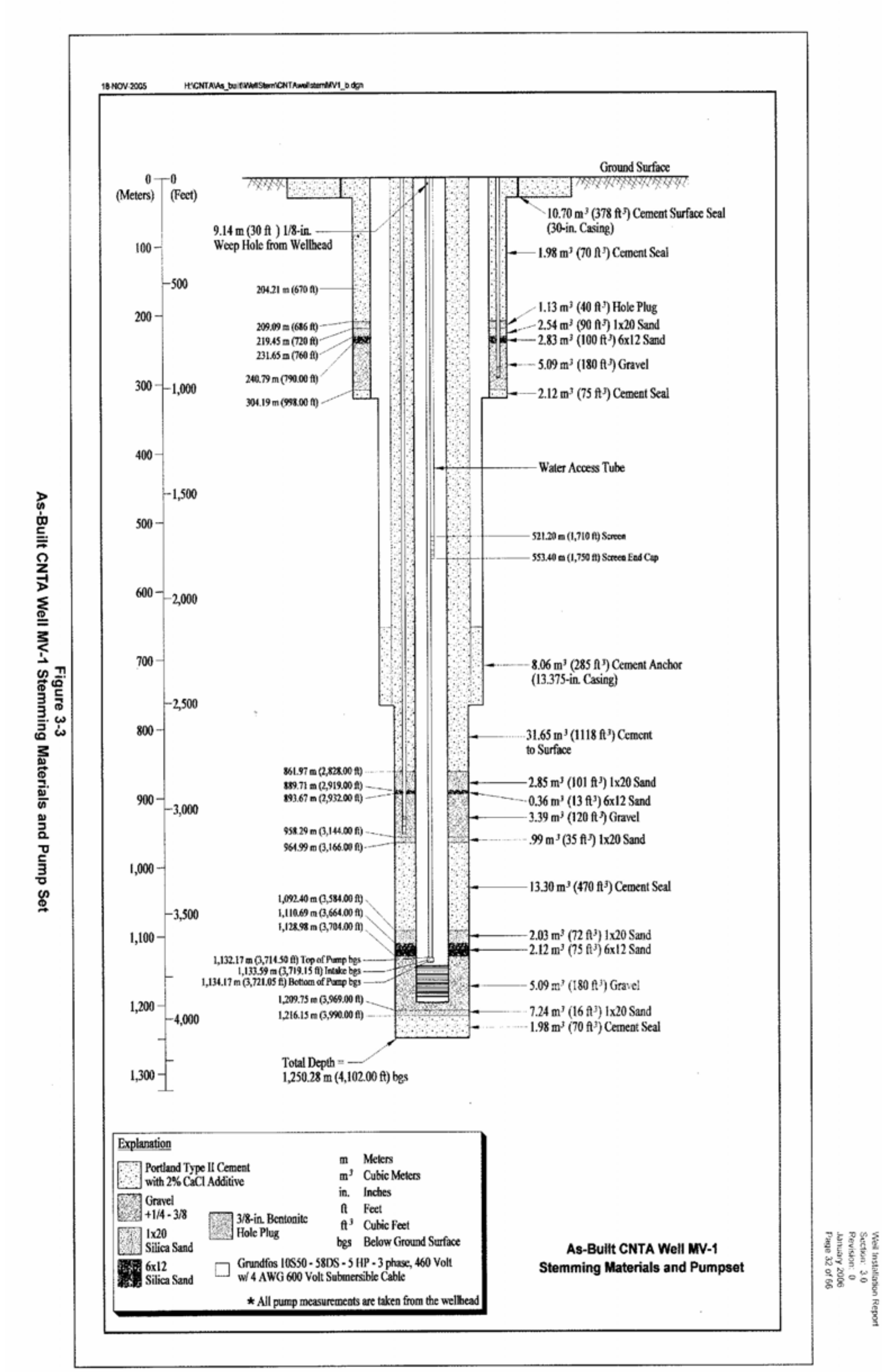

Figure A1. Schematic of Well MV-1 (from DOE, 2006).

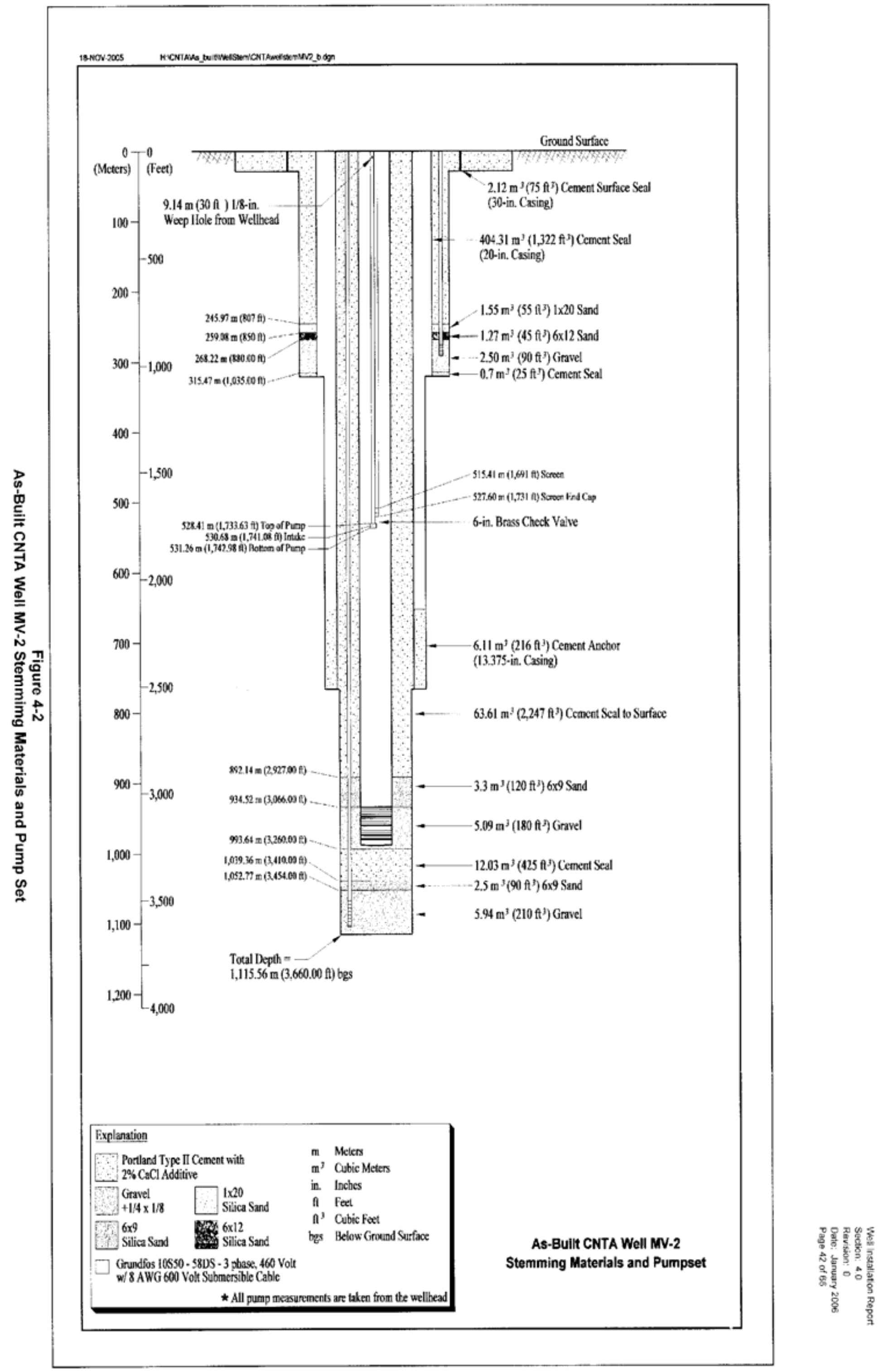

Figure A2. Schematic of Well MV-2 (from DOE, 2006).

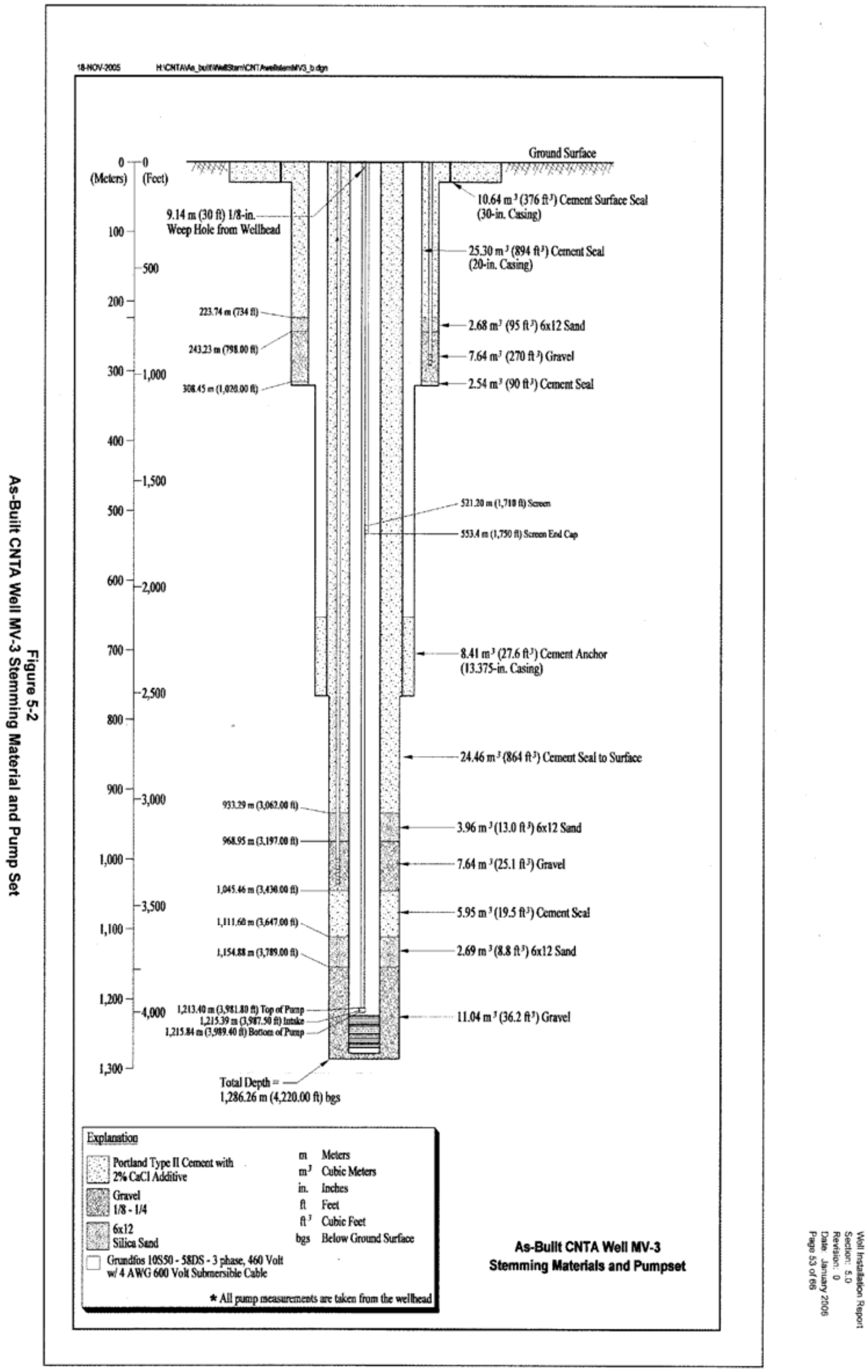

Figure A3. Schematic of Well MV-3 (from DOE, 2006).

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APPENDIX B. Quality Assurance / Quality Control Data.

Table B1. Iodine-129 analysis results (laboratory values were reported in atoms/L, activities were calculated assuming 1E6 atoms/L = 3.791E-8 pCi/L).

Well Name	Sample Date	Time	129-I ($x 10^6$ atoms/L)	129-I ($x 10^{-7}$ pCi/L)
MV-1	2/14/2006	12:30	4.00±0.31	1.51±0.118
MV-2	3/16/2006	10:54	6.80±0.30	2.58±0.114
MV-2 replicate	3/16/2006	10:54	4.46±0.27	1.69±0.102
MV-3	3/16/2006	13:55	5.54±0.27	2.10±0.102

Table B2. Carbon-14 analysis results (laboratory values were reported in percent modern carbon (pmc), an A_o (initial activity of carbon) of 13.56 dpm/gm C NBS OxI was used to convert pmc to dpm/gm C, the HCO_3 concentration was used to convert to dpm/L, assuming 3.7E10 dps/Ci and 1E12 pCi/Ci, the carbon-14 was converted to pCi/L).

Well Name	Sample Date	Time	$\delta^{13}C$ (‰)	^{14}C (pmc)	HCO_3 (mg/L)	C (gm/L)
MV-1	2/14/2006	12:30	-3.37	6.29±0.12	147.5	0.02903
MV-1 replicate	2/14/2006	12:30	-3.36	6.37±0.12	146.5	0.02884
MV-1 replicate	2/14/2006	12:30	-3.5	6.4±0.14	142.5	0.02805
MV-2	3/16/2006	10:54	-2.34	3.93±0.11	210	0.04134
MV-2 replicate	3/16/2006	10:54	-2.23	3.55±0.10	210	0.04134
MV-3	3/16/2006	13:55	-2.71	10.82±0.17	304	0.05984
MV-1	9/21/2006	10:00	-3	27.33±0.21	170.8	0.03363
MV-2	9/22/2006	8:30	-3.5	6.07±0.14	177.7	0.03497
MV-3	9/22/2006	10:01	-3	14.37±0.17	296.1	0.05828

Well Name	Sample Date	Time	^{14}C (dpm/gm)	^{14}C (dpm/L)	^{14}C (pCi/L)
MV-1	2/14/2006	12:30	0.852704	0.0247581	1.12E-2±4.7E-4
MV-1 replicate	2/14/2006	12:30	0.863549	0.024903	1.12E-2±4.7E-4
MV-1 replicate	2/14/2006	12:30	0.867616	0.0243372	1.10E-2±5.3E-4
MV-2	3/16/2006	10:54	0.53277	0.0220235	9.92E-3±6.2E-4
MV-2 replicate	3/16/2006	10:54	0.481256	0.019894	8.96E-3±5.6E-4
MV-3	3/16/2006	13:55	1.466813	0.087776	3.95E-2±1.4E-3
MV-1	9/21/2006	10:00	0.852704	0.0247581	1.12E-2±4.7E-4
MV-2	9/22/2006	8:30	0.863549	0.024903	1.12E-2±4.7E-4
MV-3	9/22/2006	10:01	0.867616	0.0243372	1.10E-2±5.3E-4

Table B3. Field parameter stabilization measurements during well purge activities.

Well Name	Date	Time	Temperature (ºC)	EC (µS)	pH
MV-1	2/14/2006	11:00		914	9.72
	2/14/2006	12:00		912	9.89
	2/14/2006	13:37	19.8	774	9.88
	9/21/2006	9:45	14.7		
	9/21/2006	9:50	16.5		
	9/21/2006	9:55	18.8	1,028	10.05
	9/21/2006	10:00	22.5	1,006	9.62
	9/21/2006	10:05	24.0	1,019	9.55
MV-2	3/16/2006	8:44	19.6		10.04
	3/16/2006	9:15	20.3	923	10.11
	3/16/2006	10:05	18.0	941	10.10
	3/16/2006	10:30	20.3	908	10.05
	9/22/2006	8:25	21.5	1,104	10.32
	9/22/2006	8:29	21.4	1,090	10.37
	9/22/2006	8:34	21.5	1,097	10.38
MV-3	3/16/2006	13:50	21.2	648	8.45
	3/16/2006	14:18	22.5	651	8.57
	9/22/2006	9:55	22.1	650	8.42
	9/22/2006	9:57	22.8	650	8.60
	9/22/2006	10:01	22.8	653	8.66

Table B4. Tritium analysis results. (Scans of the initial samples were performed to determine radioactivity [detection limit 1,000 pCi/L], unenriched analyses were then performed on samples and duplicates [detection limit 300 pCi/L or less], and enriched analyses were performed on the initial samples to establish baseline values.)

Well Name	Sample Date	Time	Tritium Scan (pCi/L)	Tritium unenriched (pCi/L)	Tritium enriched (pCi/L)
MV-1	2/14/2006	12:30	<1,000	<300	<3
MV-2	3/16/2006	10:54	<1,000	<300	<3
MV-2 replicate	3/16/2006	10:54		<300	
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