Department of Energy
National Nuclear Security Administration
Sandia Field Office
P.O. Box 5400
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CERTIFIED MAIL-RETURN RECEIPT REQUESTED

Mr. John E. Kieling, Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Bldg. 1
Santa Fe, New Mexico 87505

Subject: Aquifer Pumping Test Work Plan for the Burn Site Groundwater Area of Concern, June 2016

Dear Mr. Kieling:

Enclosed is the Aquifer Pumping Test Work Plan for the Burn Site Groundwater Area of Concern, June 2016 (Work Plan) that describes the proposed hydrologic investigation of the study area. This Work Plan is being submitted by the Department of Energy/National Nuclear Security Administration and Sandia Corporation to describe the following activities: 1) a pressure transducer network will be installed to establish background fluctuations in groundwater elevations; 2) a step-drawdown test will be conducted to determine the flow rate for a subsequent constant-rate test; 3) a constant-rate test will be conducted to evaluate hydrogeologic conditions in the aquifer; and 4) interval sampling will be performed for nitrate plus nitrite analysis of discharge water from the pumping well.

If you have questions, please contact me at (505) 284-6668 or David Rast of our staff at (505) 845-5349.

Sincerely,

James W. Todd
Assistant Manager for Engineering

cc w/enclosure:
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Sandia National Laboratories

AQUIFER PUMPING TEST WORK PLAN FOR THE BURN SITE GROUNDWATER AREA OF CONCERN

June 2016

U.S. DEPARTMENT OF ENERGY

United States Department of Energy
Sandia Field Office

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AQUIFER PUMPING TEST WORK PLAN FOR THE
BURN SITE GROUNDWATER AREA OF CONCERN—JUNE 2016

Aquifer Pumping Test Work Plan for the Burn Site Groundwater Area of Concern
June 2016

Summary

This work plan is being submitted by Sandia Corporation (Sandia) and the U.S. Department of Energy (DOE)/National Nuclear Security Administration (NNSA) to describe a proposed aquifer pumping test program at the Burn Site Groundwater (BSG) Area of Concern (AOC). This work plan describes the following activities:

- A pressure transducer network will be installed across the study area, and data will be collected to establish background fluctuations in groundwater elevations in BSG monitoring wells. A barometric transducer will also be used to correct for changes in ambient air pressure, and to support mathematical analysis of the degree of hydraulic connection and confinement in the fractured-bedrock aquifer near each observation well.
- A step-drawdown test will be conducted at the Burn Site Well to determine the flow rate to use for a subsequent constant-rate test.
- A constant-rate test will be conducted using the Burn Site Well as the pumping well to evaluate hydrogeologic conditions in the aquifer.
- Interval sampling will be performed for nitrate plus nitrite (NPN) analysis of discharge water from the pumping well.

1.0 Introduction

This section describes the site hydrogeology, study objectives, and scope of activities.

1.1 Hydrogeologic Setting

The following discussion of the hydrogeologic setting is summarized from the *Calendar Year 2014 Annual Groundwater Monitoring Report* (SNL/NM June 2015). Unique features of the BSG AOC, located in the Manzanita Mountains on Kirtland Air Force Base (KAFB) (Figure 1), include elevated concentrations of nitrate in a fractured bedrock aquifer. Nitrate has been detected in the BSG AOC groundwater monitoring network (Table 1) with a historical maximum concentration of 41.9 milligrams per liter (mg/L). This concentration exceeds the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 10 mg/L.

Regionally, groundwater in the Manzanita Mountains flows toward the west from a groundwater divide located several miles east of the BSG AOC. Figure 2 presents the November 2014 potentiometric surface for the BSG monitoring well network. The apparent horizontal groundwater gradient at BSG varies from approximately 0.08 to 0.18, and this large range of gradients indicates that localized controls are produced by a diverse pattern of bedrock fractures and with brecciated fault zones. The low-permeability in the bedrock matrix likely has much less control over groundwater movement. No information is available about vertical flow velocity within the fractured rocks. Vertical movement of groundwater within open fractures and the brecciated fault zones probably occurs as rapid, unsaturated to saturated flow.

Groundwater in the Manzanita Mountains predominantly occurs in fractured Precambrian metavolcanics, quartzite, metasediments (schists and phyllites), and granitic gneiss. Some fractures in shallow bedrock are filled with chemical precipitates such as calcium carbonate, which effectively reduces permeability and may create a semiconfined unit above open fractures in bedrock. The BSG AOC is bisected by a north-south trending system of faults, consisting locally of several high-angle normal faults that are typically downthrown to the east. Faults (where exposed) are characterized by zones of crushing and brecciation. The site conceptual model showing the relationship of geologic and hydrologic features is shown in Figure 3. Based upon drilling activities, the depth to the uppermost water-bearing fracture zones has varied from approximately 124 to 379 ft below ground surface across the monitoring well network. Initial water levels above the screened intervals have varied from approximately 5 to 153 ft due to semiconfined or confined conditions. As a standard practice, each monitoring well is screened across an individual fracture zone, which is interpreted to be at most a few feet thick for the Burn Site. During October 2015, the depth to water across the monitoring well network varied from approximately 108 to 326 ft.

1.2 Study Objectives

The data collected during this pumping test program will aid in determining the following hydrogeologic parameters for the fractured bedrock aquifer.

- **Hydraulic conductivity/transmissivity/storativity**--The hydraulic regime at the site is dominated by fracture flow, with possibly a minor contribution from matrix porosity. The hydraulic test analysis software typically is based on equations that assume flow through porous media, therefore may not be directly applicable to this study. However, if the data plots indicate that the fracture density is sufficient so that the system behaves as a porous aquifer, then hydraulic conductivity and transmissivity will be calculated.

- **Degree of hydraulic confinement**--The rate at which the observation wells respond to the pumping well will indicate qualitatively if the aquifer is confined, semiconfined, or unconfined. In a fully confined aquifer, the pressure signal will reach the observation wells almost instantaneously. In an unconfined aquifer, the cone of depression caused by dewatering will take much longer to reach the observation wells.

- **Hydraulic communication**--The timing and magnitude of response in observation wells will provide an indication of the fracture system configuration. Wells located along the predominant structural grain of the fracture system will be affected sooner and more significantly than wells located across the structural grain from the pumping well.

- **Recharge/discharge barriers or boundaries**-- Recharge barriers (the cone of depression intercepting more permeable materials) and discharge areas (less permeable, or the end of the fracture) will be evident during the analysis of the pumping test data.

- **Gain insight into the source of nitrate**—Interval sampling of pumping test discharge water will help determine if nitrate in the groundwater is a localized or regional occurrence.

1.3 Scope of Activities

For corrective measures at the BSG AOC to be fully evaluated, hydraulic properties of the bedrock aquifer must be assessed. The pumping test will provide useful information relevant to evaluating a potential remedial measure or monitoring strategy. The pumping test will be conducted in accordance with industry standard practices; the EPAs *Suggested Operating Procedures for Aquifer Pumping Tests* (EPA 1993); and Sandia National Laboratories, New Mexico (SNL/NM) Field Operating Procedure

(FOP) 94-60 *Aquifer Pumping Test* (SNL March 1995). The notional schedule for completing the activities described in this work plan is presented in Table 2.

A pumping test involves pumping water from a well at either a constant or variable-discharge rate while monitoring the water-level changes (drawdown) in the pumped well and observation wells. The drawdown, measured in response to the pumping, is used to determine the transmissivity and storage coefficient of the aquifer. After the pumping is discontinued, water-level recovery to the pre-pumping state will also be monitored.

2.0 Aquifer Pumping Tests—Field Activities

The pumping tests will be performed in three phases:

1. Pressure transducers will be installed in observation wells and the pumping well to record long-term background conditions of static water levels in the aquifer system, including evaluation of barometric influences.
2. A step-drawdown test will be performed to determine the optimal pumping rate for the longer-term constant-rate test.
3. A constant-rate test will be performed to evaluate hydrologic parameters of the aquifer near the pumped well, the degree of hydraulic communication with the observation wells, and to document changes of nitrate concentrations in discharge water from the Burn Site Well during pumping.

2.1 Establish Background Conditions

Prior to the step-drawdown test, recording transducers will be installed in observation wells and the Burn Site Well (Table 3). The pressure transducers will be installed at least two weeks before pumping begins for the step-drawdown test. The response to barometric changes in each well is important to discern hydraulic confinement: wells in a fully confined aquifer behave as barometers, whereas wells in an unconfined aquifer do not respond to barometric changes. The calibration of the transducers after installation is verified by reading the output and then raising or lowering each transducer by an exact amount (usually 5 feet) and making sure the transducer output reflects the change in elevation. During the establishment of background conditions, periodic measurements will be collected with a water level meter to verify the data collected by the transducer.

2.2 Step-Drawdown Test

The step-drawdown (or variable rate) test will be performed after background conditions have been determined, and will consist of three steps, or increases, in the pumping rate to approximately 5, 10, and 20 gallons per minute (gpm) for a maximum of two hours for each step or until stabilization of drawdown has been achieved. Once pumping is complete, water level recovery will be measured until static (pre-pumping) water levels are reached. These steps will be conducted sequentially with no recovery period between steps. During the development of the Burn Site Well in 1986, the pump-installation contractor estimated the well had a yield of 20 gpm (note on the well completion diagram for the Burn Site Well, Appendix A). During its occasional use from 1986 to 2003, the well was probably pumped at a steady rate of 9 gpm for filling on-site storage tanks. It is estimated that a pumping rate of 20 gpm would be sufficient to determine the aquifer properties.

A pressure transducer will record drawdown during pumping and recovery. The aquifer will be allowed to recover for at least 24 hours. Transducer data logging intervals will be set to collect water level measurement data from the pumping well at rapid logarithmic intervals so more data points are generated during the initial stage of the tests when the drawdown rate is most rapid. The data from the step-drawdown test will be used to evaluate the efficiency of the well, to determine the qualitative magnitude of drawdown at given pump rates, and to provide generalized aquifer properties (i.e., transmissivity). The aquifer parameters will be used in groundwater modeling. Well efficiency will be determined as described in Groundwater and Wells (Driscoll 1986). Aquifer properties will be determined using graphical methods described in Driscoll (1986) or through the application of step-drawdown test analysis routines available in commercial aquifer tests programs, such as AQTESOLV. The optimal pumping rate for the constant-rate test will be determined by reviewing the step-drawdown test data and will be the minimum rate at which drawdown can be achieved in observation wells.

2.3 Constant-Rate Test

Following analysis of the step-drawdown test, a 24-hour (maximum) constant-rate test will be performed by pumping the Burn Site Well. Once pumping is complete, water level recovery will be measured until static water levels are reached. Nearby monitoring wells will be used as observation wells during the constant-rate test. Both manual and recording transducer water-level will be obtained at time intervals determined by analysis of the step-drawdown test data. Figure 4 illustrates the location of the pumping and observation wells during the constant-rate test. Appendix A contains the well completion diagrams for the pumping well and all monitoring wells, and Table 3 lists the observation wells.

Manual water measurements will be taken when the transducer is installed and when it is removed. Data will be checked every two hours during normal working hours to verify the transducer readings. The constant-rate test will be complete after the rate of drawdown in the well has stabilized, or after a maximum pumping duration of 24 hours. Additionally, valuable data can still be gained from a single well test. If no drawdown is observed in the observation wells, drawdown in the pumping well can be used to estimate the aquifer transmissivity.

Monitoring well CYN-MW4 is outside the expected zone of influence and will continue to be used as a background monitoring well. A pressure transducer will be installed in this well to determine the fluctuations in water level that are not attributable to pumping at the Burn Site Well. Following pumping, the aquifer will be allowed to recover for at least the same length of time as the duration of pumping. Pressure transducers in the pumping well and observation wells will record drawdown during pumping and recovery following pumping. Both pumping and recovery data from wells with an observable drawdown will be used to evaluate the pumping test data. If no drawdown is observed in any of the observation wells, then only the data from the pumping well will be used. The data will be evaluated for spurious data, corrected for regional trends based on the background well, and then subjected to mathematical analysis. The step-drawdown and constant-rate test data will be evaluated using either manual graphic techniques or commercial aquifer test software (AQTESOLV).

2.4 Interval Sampling

In order to assess the extent of nitrate contamination and aid in determination of the source of nitrate, groundwater samples will be collected periodically during the constant-rate test. It is hypothesized that if nitrate concentrations remain high, or increase over sampling intervals, the plume is large and may have a component of naturally occurring nitrate. Conversely, a decrease of nitrate concentration over sampling intervals would suggest the plume is small and only affected by localized activities in the vicinity of the pumping well.

The proposed sampling will be conducted in conformance with applicable field operating procedures (FOPs) for groundwater sampling activities. Groundwater samples for NPN analysis will be collected during the constant-rate test from the discharge pipe at approximately 1000 gallon intervals for 10 samples total (assuming 10,000 gallons total discharge). The sampling schedule for collection of a minimum of 10 interval samples will be developed based on the results of the step-drawdown test. If the final strategy for the constant-rate test is modified to use a volume other than 10,000 gallons, then the total volume will be divided into ten even intervals for this sampling.

All groundwater samples will be submitted to General Engineering Laboratories (GEL) for NPN analysis using Method EPA 353.2. Unfiltered samples will be collected in 125 milliliter plastic containers, preserved with sulfuric acid, and analyzed during the 28-day holding time. Duplicate samples for NPN analysis will be collected at the 5th and 10th intervals. Samples for additional analytes may also be required for waste management purposes.

With some modifications, groundwater sampling shall be performed in accordance with "Groundwater Monitoring Well Sampling and Field Analytical Measurements" (SNL/NM FOP 05-01), and SNL/NM Sample Management Office procedures and protocols. The most notable change to the requirements of the FOP is that standard sampling involves the use of low-flow sampling equipment. For the interval sampling during the pumping test, a high-flow submersible pump will be used to obtain samples. Although field parameters will be measured during sampling, field parameter stabilization will not be required before collecting the sample.

2.5 Management of Discharge Water

Because the pumping rate of constant-rate pumping test will not be determined until the step-drawdown test is completed, the total volume of water produced during these tests is uncertain. For planning purposes, it is assumed that a maximum of 33,000 gallons of water will be produced. This assumes that 4,200 gallons of water will be generated during the step-drawdown test (120 minutes each step at 5 gpm, 10 gpm, and 20 gpm), and 28,800 gallons of water will be generated during the 24 hour constant-rate test (1440 minutes at 20 gpm). The discharge water will be containerized near the well head prior to disposal.

Temporary tanks or tanker trailers will be used to contain the discharge water. After characterization sampling is complete, the following possible disposal paths for the discharge water will be evaluated:

- Disposal to a connection on the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) Publically Owned Treatment Works sanitary sewer system.
- Disposal at an undetermined offsite facility with a permitted ability to accept the discharge water.
- Repurposing the discharge water by one of a number of different means, including: storage in existing onsite aboveground storage tanks for use in Burn Site Operations; transport to the KAFB nitrate abatement system at the Tijeras Arroyo Golf Course; and use for dust suppression along DOE/Sandia maintained roads in the vicinity of the BSG AOC and Coyote Test Field; and use for dust suppression at the DOE National Training Center firing ranges in Lurance Canyon.

Before mobilizing for the pumping test, meetings with stakeholders will be held to determine the best possible option for handling the discharge water and for obtaining required permits. Possible stakeholders to be consulted include the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB), NMED Ground Water Quality Bureau (GWQB), ABCWUA, SNL/NM Facilities Engineering, KAFB, DOE/NNSA, and Sandia.

3.0 Aquifer Pumping Tests—Analysis

The data obtained from the pumping tests will be analyzed using several approaches. Groundwater elevation measurements from the transducers will be imported into AQTESOLV version 4.5. AQTESOLV software is designed to calculate hydraulic conductivity, storativity and other aquifer properties from data sets collected during slug and aquifer (pumping) tests. AQTESOLV can import files generated by commonly used pressure transducers, the data can be manually entered, or cut and pasted from a spreadsheet.

After importation and correction for barometric influence, the data will be analyzed using one or more of the following analytical solutions:

- Theis (1935) type curve solution.
- Cooper-Jacob (1946) straight line solution.
- Moench (1984) solution for an isotropic fractured aquifer.
- Gringarten and Witherspoon (1972) solution for vertical fractures in an anisotropic confined aquifer.
- Barker (1988) solution for an isotropic single- or double-porosity confined aquifer.

Water level measurements from observation wells will be used preferentially to those from the pumping well because drawdown in the pumping well is influenced by well losses, turbulent flow, potential cascading, and variations in the pumping rate. Also, storativity estimates cannot be obtained from pumping well data. Hydraulic connection between wells will be evaluated primarily using drawdown data from the observation wells plotted on a distance-drawdown graph.

4.0 Aquifer Pumping Tests—Reporting

The results of the field work and analyses will be compiled to produce an internal SNL/NM field report. After the internal SNL/NM field report is prepared, the results of the pumping test and analysis will be shared with the NMED HWB in a briefing/presentation. Based on the discussions in the briefing, an Aquifer Pumping Test Final Report will be prepared and submitted to NMED HWB.

5.0 References

Barker, J.A., 1988. *A generalized radial flow model for hydraulic tests in fractured rock.* Water Resources Research, vol. 24, no. 10, pp. 1796-1804.

Cooper, H. H. and C. E. Jacob, 1946. *A generalized graphical method for evaluating formation constants and summarizing well field history*. American Geophysical Union Transaction, vol. 27, pp. 526-534.

Driscoll, 1986. *Groundwater and Wells.* Johnson Division, 1089 pp.

EPA, 1993. *Suggested Operating Procedures for Aquifer Pumping Tests.* Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D. C. February.

Gringarten, A.C. and P.A. Witherspoon, 1972. *A method of analyzing pump test data from fractured aquifers*. Int. Soc. Rock Mechanics and Int. Assoc. Eng. Geol., Proc. Symp. Rock Mechanics, Stuttgart, vol. 3-B, pp. 1-9.

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Theis, C.V., 1935. *The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage*. Am. Geophys. Union Trans., vol. 16, pp. 519-524.

Figures:

- Figure 1. Location of the Burn Site Groundwater Area of Concern
- Figure 2. Burn Site Groundwater Area of Concern November 2014 Potentiometric Surface Map
- Figure 3. Site Conceptual Model of the Burn Site Groundwater Area of Concern
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Appendices:

- Appendix A. Well Completion Diagrams

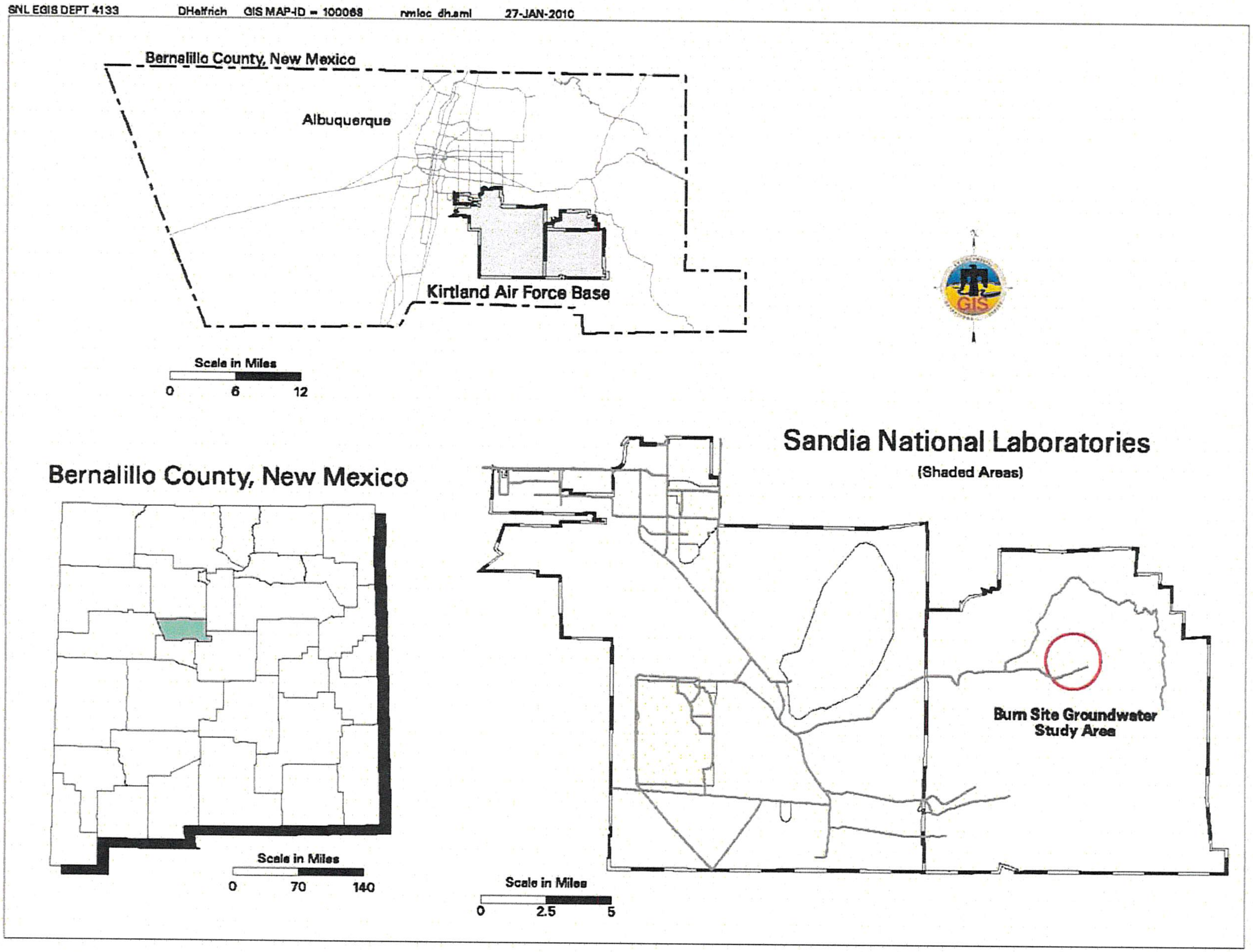

Figure 1. Location of the Burn Site Groundwater Area of Concern

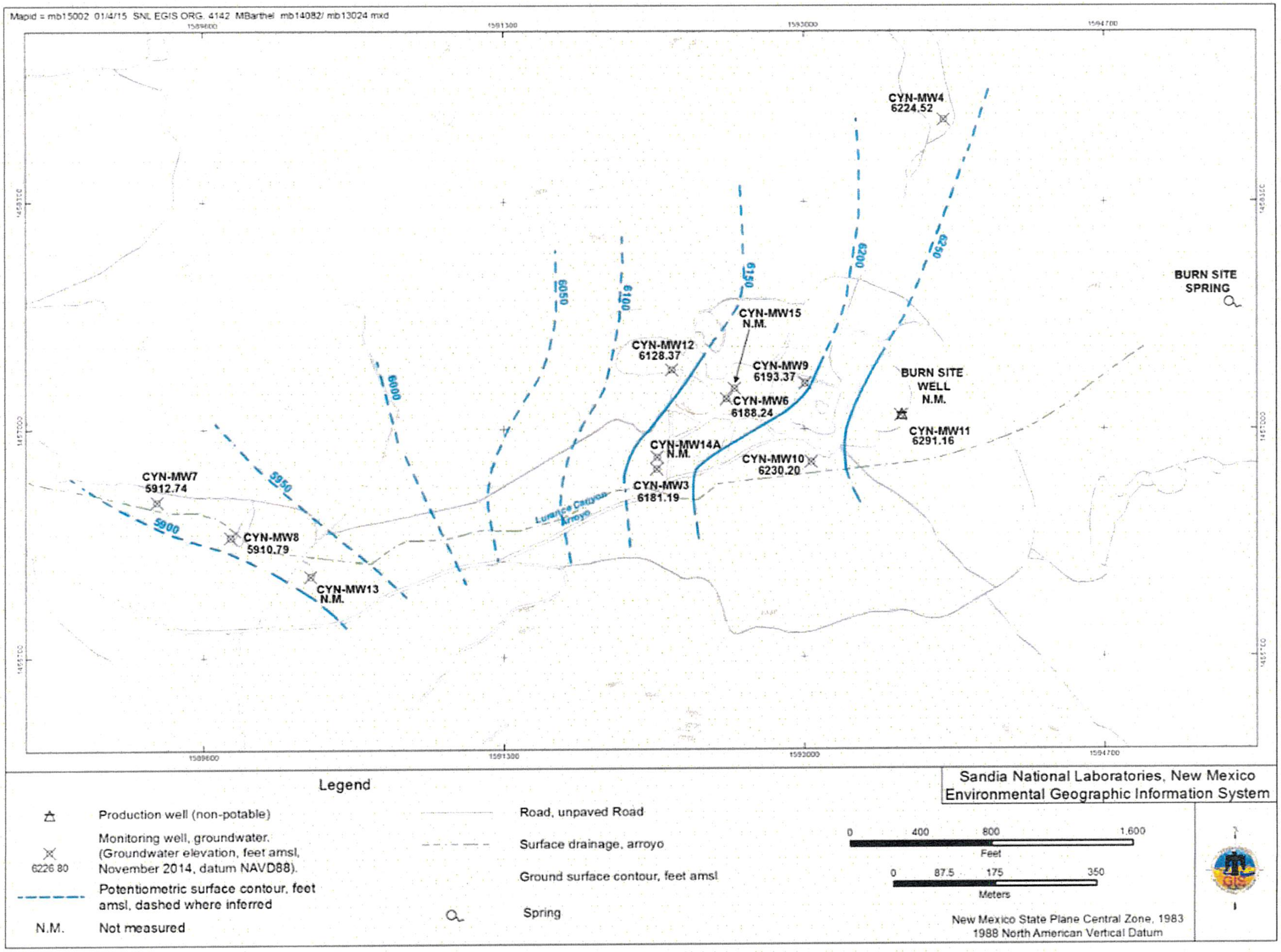

Figure 2. Burn Site Groundwater Area of Concern November 2014 Potentiometric Surface Map

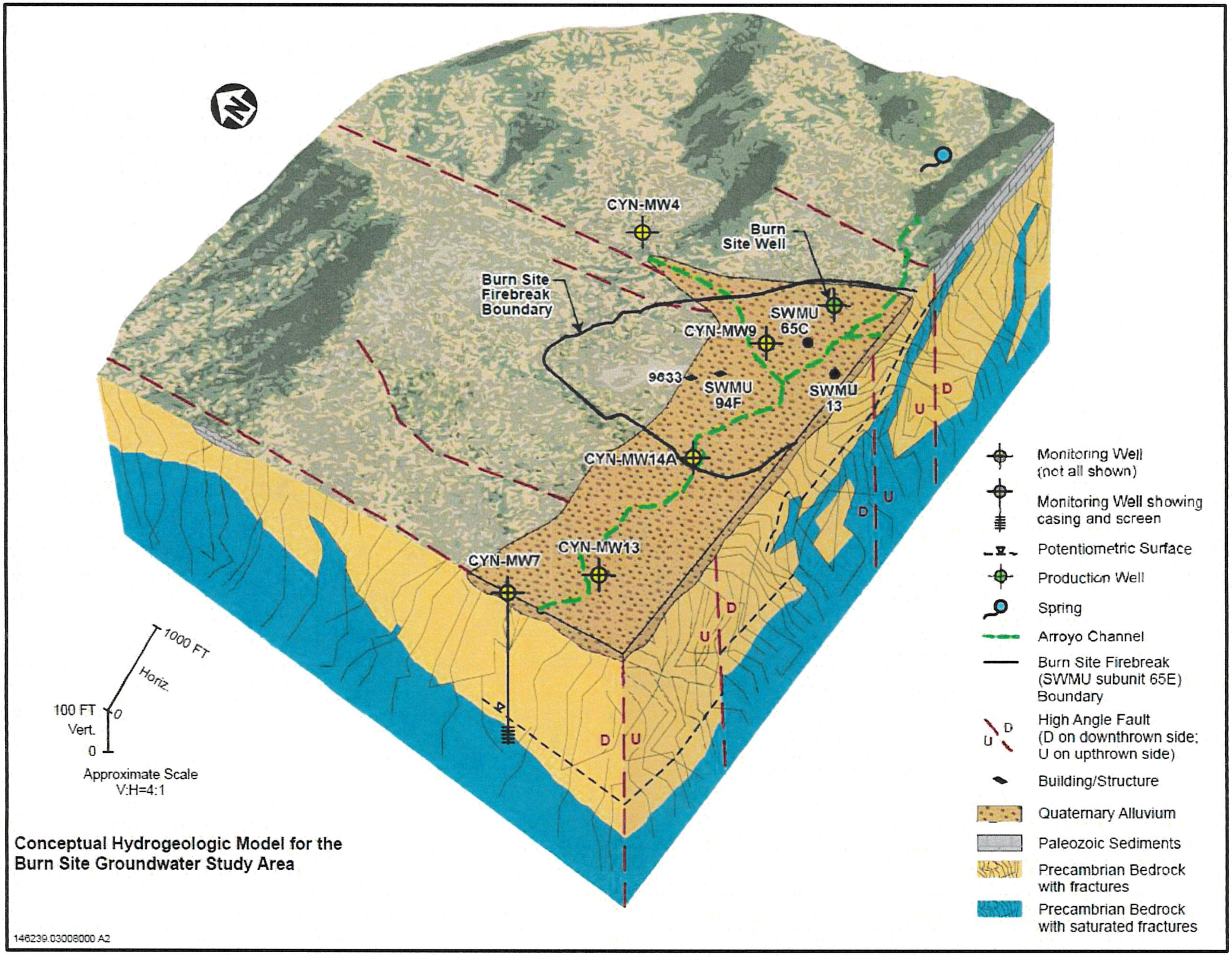

Figure 3. Site Conceptual Model of the Burn Site Groundwater Area of Concern

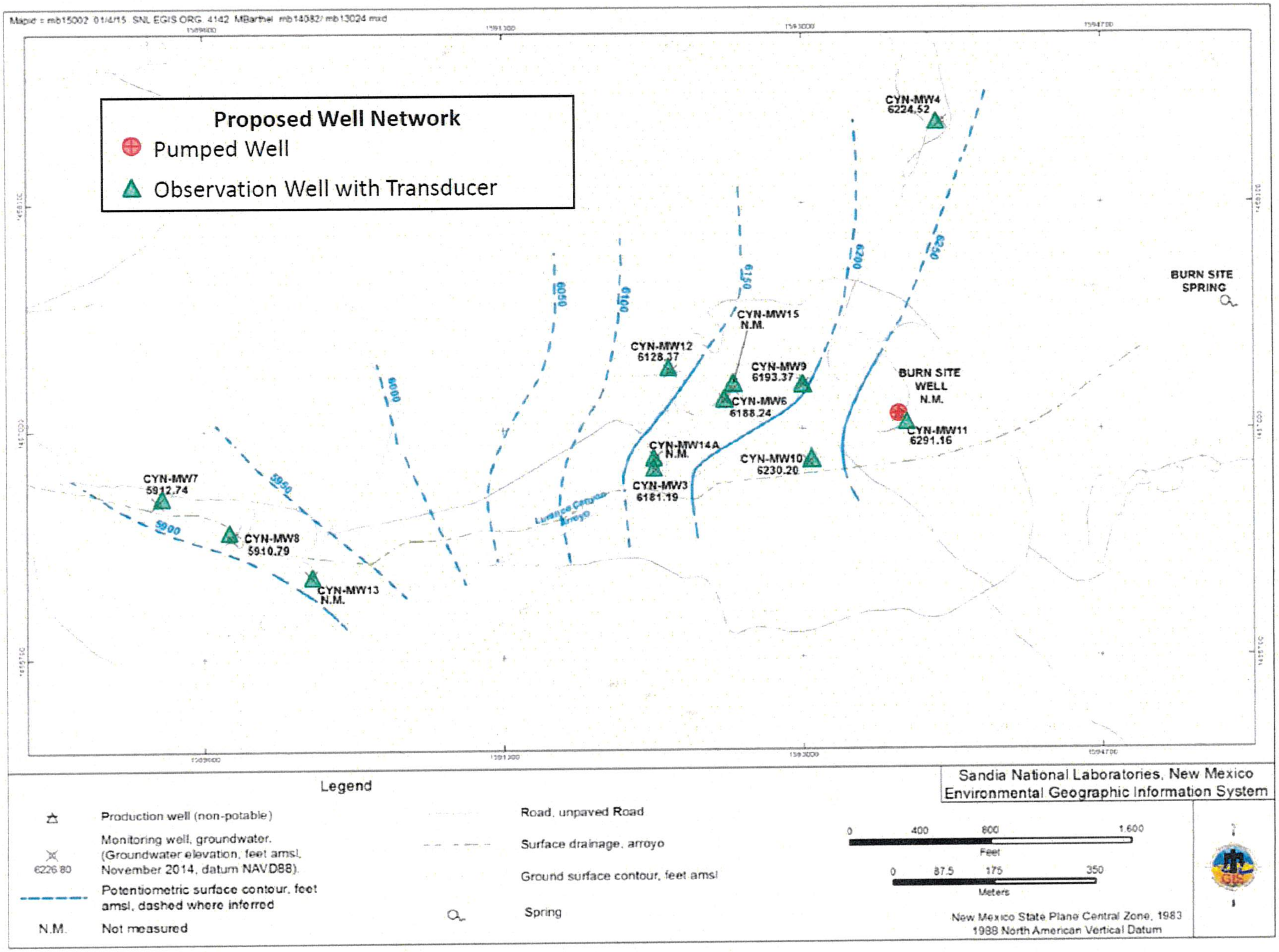

Figure 4. Burn Site Groundwater Area of Concern Proposed Aquifer Pumping Test Monitoring Well Network

Well	Measuring Point (feet amsl)	[illegible]gy of [illegible] Interval (fe[illegible]	Installation Date	P&A Date, If Applicable
Burn Site Well	6374.66	6[illegible]st and granite)	20-Feb-86	
CYN-MW1D	6239.59	[illegible]nitic gneiss)	22-Dec-97	15-Nov-02
CYN-MW2S	6239.41	[illegible]ck (granitic gneiss)	22-Dec-97	15-Nov-02
CYN-MW3	6313.26	[illegible]tamorphics)	18-Jun-99	
CYN-MW4	6455.48	[illegible]quartzite)	18-Jun-99	
CYN-MW6	6343.37	[illegible]tamorphics)	9-Dec-05	
CYN-MW7	6216.35	[illegible]nitic gneiss)	6-Dec-05	
CYN-MW8	6230.11	[illegible]nitic gneiss)	12-Jan-06	
CYN-MW9	6360.67	[illegible]tamorphics)	27-Jul-10	
CYN-MW10	6345.45	[illegible]tamorphics)	28-Jul-10	
CYN-MW11	6374.41	[illegible]tamorphics)	29-Jul-10	
CYN-MW12	6345.16	[illegible]tamorphics)	29-Jul-10	
CYN-MW13	6237.79	[illegible]nitic gneiss)	5-Dec-12	
CYN-MW14A	6315.85	[illegible]etamorphics	4-Dec-14	
CYN-MW15	6344.44	[illegible]etamorphics	18-Nov-14	

Acronyms

amsl = Above mean sea level.
bgs = Below ground surface.
CCBA = Coyote Canyon Blast Area.
CS = Carbon steel.
CYN = Lurance Canyon.
MW = Monitoring well.
P&A = Plugged and abandoned.
PVC = Polyvinyl chloride.

Table 2. Burn Site Groundwater Area of Concern Aquifer Pumping Test Schedule of Activities

Task	Description	Start[a]	Finish
Pre-Field:			
NMED Approval	NMED review and approval of Aquifer Pumping Test Work Plan	June 2016	November 2016
Contractor SOW	Prepare drilling contractor SOW for pump installation/operation, submit for bids	November 2016	December 2016
Award Contract	Evaluate bids, award contract to drilling contractor	January 2017	February 2017
Health and Safety Documents	Prepare Health and Safety Documents including SNL Health and Safety Plan/Work Plan & Controls documents, and Contractor Specific Safety Plan	November 2016	March 2017
Mobilize	Arrange for staffing, equipment, site access, training, etc.	November 2016	March 2017
Field:			
Background Conditions	Establish background hydraulic conditions of the aquifer with the installation of transducer network and data review	March 2017	March 2017
Step-Drawdown Test	Conduct step-drawdown test to determine optimum pumping rate	March 2017	March 2017
Constant-Rate Test	Conduct constant-rate test	March 2017	April 2017
Post-Field:			
Data Analyses	Perform analyses on data collected in three phases of the pumping test	April 2017	September 2017
Field Report	Prepare field report including discussions of field activities and data analysis	April 2017	September 2017
NMED Briefing	Share pumping test data/results with NMED in a meeting	October 2017	October 2017
Final Report	Prepare Aquifer Pumping Test Final Report and submit to NMED	October 2017	April 2018

Notes:
[a] Start dates after the first task are dependent on the date of NMED approval of the Aquifer Pumping Test Work Plan; start and finish dates will shift accordingly.

Acronyms:
NMED = New Mexico Environment Department.
SOW = Statement of Work.

Table 3. Burn Site Groundwater Area of Concern Summary of Aquifer Pumping Test Wells

Well	Screen Interval (feet bgs)	Horizontal Distance from Burn Site Well (Pumping Well) (feet)	Aquifer Pumping Test Use
Burn Site Well	231-341	0	Pumping Well
CYN-MW3	120-130	1,423	Observation Well—Far Field
CYN-MW4	260-280	1,695	Observation Well—Far Field
CYN-MW6	141-161	994	Observation Well—Near Field
CYN-MW7	315-334	4,240	Observation Well—Far Field
CYN-MW8	338-358	3,857	Observation Well—Far Field
CYN-MW9	176-196	575	Observation Well—Near Field
CYN-MW10	150-170	581	Observation Well—Near Field
CYN-MW11	230-250	12	Observation Well—Near Field
CYN-MW12	252-272	1,328	Observation Well—Far Field
CYN-MW13	377-397	3,474	Observation Well—Far Field
CYN-MW14A	264-294	1,416	Observation Well—Far Field
CYN-MW15	160-190	975	Observation Well—Near Field

<u>Acronyms</u>

bgs = Below ground surface.
CYN = Lurance Canyon.
MW = Monitoring well.